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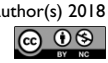

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Creating energy citizenship through material participation

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Abstract

Transitions towards low-carbon energy systems will be comprehensive and demanding, requiring substantial public support. One important contribution from STS is to highlight the roles of citizens and public engagement. Until recently, energy users have often been treated as customers and passive market actors, or as recipients of technology at the margins of centralized systems. With respect to the latter role, critical or hesitant public action has been explained in terms of NIMBYism and knowledge deficits. This article focuses on the production of energy citizenship when considering public participation in low-carbon energy transitions. We draw upon the theory of 'material participation' to highlight how introducing and using emergent energy technologies may create new energy practices. We analyze an ongoing introduction of new material objects, highlighting the way these technologies can be seen as material interventions co-constructing temporalities of new and sustainable practices. We argue that artefacts such as the electric car, the smart meter and photovoltaic panels may become objects of participation and engagement, and that the introduction of such technologies may foster material participation and energy citizenship. The paper concludes with a discussion about the role of policies for low-carbon energy transitions on the making of energy citizenship, as well as limits of introducing a materially based energy citizenship.

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Introduction

Climate change is challenging societies across the globe to re-configure their energy systems. Over the past fifteen years, some social scientists have framed the challenge as a systemic problem to be solved through multi-level governance. According to these scholars, the core solutions involve breaking technological lock-ins by nurturing radical technology niches and stimulating socio-technical regime change (e.g. Geels, 2002; Geels and Schot, 2007; Verbong and Geels, 2007). This focus has allowed for solid conceptualizations of the challenge, but lacks the resolution needed to capture all complexities of the challenge. An often-neglected aspect is that energy transitions will require substantial public support. When addressed, this challenge is frequently conceptualized through the notion of 'public acceptance', but, in our view, the potential agency of diverse publics moves far beyond the accept/reject dichotomy. In this article, we are encouraged by recent attempts to understand the broader energy cultures in which energy transitions unfold (Aune et al., 2016; Sarrica et al., 2016; Stephenson et al., 2010). This includes new sensitivities to the discourses of energy transitions (Lösch and Schneider, 2016), diverse enactments of agency in energy transitions (Åm, 2015; Farla et al., 2012) and the co-production of social and technological change in energy transitions (Chilvers and Longhurst, 2016). This article takes cues from such attempts to understand the diversity of expression, engagement and participation in sustainable energy transitions. Specifically, we address the role of citizens. In doing so, we mobilize concepts from Science and Technology Studies (STS) that aim to shed light on the political aspects of mundane life. The result is a discussion about the relationship between technology, citizens and public engagement in the context of energy transitions.

Until recently, scholars have typically conceptualized the role of people in energy systems as 'energy users', who are mainly customers, passively generating energy demand. In light of this, much policy has aimed to produce 'active consumers', primarily by providing better information and new price signals. This has often been done under the banner of demand side management (DSM), where the goal has been to influence the use of electricity top-down, to make it conform better to the needs of energy utilities and the energy system (Palensky and Dietrich, 2011). Such strategies have been criticized, for example for their 'narrow view of the user as a consumer making conscious rational choices on the energy market from a set of pre-defined options' (Schot et al., 2016: 1). Further, energy users have been interpreted as passive technology recipients at the margins of a centralized system. An example of this is found in discussions about energy efficiency, where much focus has been given to the (slow) diffusion of energy- and cost-efficient household appliances (Jaffe and Stavins, 1994). Hence, publics have often been understood as a barrier to progress, either by failing to take up new technologies, or by responding with selfish criticism of new developments. Such reactions are frequently explained as NIMBYism (Not In My Backyard) and stemming from knowledge deficits

about technological benefits (Besley and Nisbet, 2013; Heidenreich, 2015; Walker et al., 2010).

Today, NIMBY and deficit explanations are losing much of their appeal. Such explanations are misleading and reductionist simplifications of people's potential engagement with new energy technologies, poorly anchored in empirical evidence (see e.g. Aitken, 2010; Devine-Wright, 2009; Haggett, 2011; Wolsink, 2012). As an example, recent work illustrates how complex processes of identity formation and a tendency to 'implant values such as prosperity and modernity' in technologies sometimes lead to the opposite phenomenon: PIMBY (Please, In My Backyard) (Brinkman and Hirsh, 2017: 336). This shows that the understanding and engagement produced through encounters between technologies and publics can take many forms, of which active promotion and active opposition are two of many possibilities.

In this article, our ambition is to theorize more clearly the everyday life potential of citizens in energy transitions. Devine-Wright (2007) has proposed the concept of 'energy citizenship', which, despite its promise as an alternative conceptualization of users or consumers, is under-theorized and remains a relatively empty signifier employed to describe a desired outcome of energy transitions. We aim to develop the concept, by linking the idea of energy citizenship to developments in STS that provide an object-oriented account of the constitution of politics and publics (e.g. Latour, 2005; Marres, 2007). We follow Chilvers and Longhurst (2016), who highlight that participation in energy transitions is 'an *emergent* and *co-produced* phenomenon' where different kinds of collectives might produce different models of participation (pp. 586–587).

Our analysis focuses on three technologies and the processes that unfold as they become part of everyday lives. These technologies are electric vehicles (EV), domestic 'smart' energy technologies (SET) and rooftop photovoltaic solar cells (PV). Hence, we look at distinct sets of collectives centered on mundane aspects of homes and transport, spheres that in traditional Aristotelian political thought have been understood as private and therefore by default non-political. However, recent developments in object-oriented political STS have done much fruitful work to highlight how the messy 'world of things' in the domestic sphere (Marres and Lezaun, 2011: 492), is constitutive of a number of public issues, around which there are different ways of articulating concerns and publics. We are particularly interested in the idea of 'material participation' (Marres, 2012, 2013; Marres and Lezaun, 2011), which refers to a specific mode of engagement distinguished by the fact that 'it deliberately employs its surroundings … and entails a particular division of roles among the entities involved' (Marres, 2012: 2). The entities involved can be things, people, issues and technologies. Thus, material participation is an 'object-oriented' or 'device-centered' perspective that focuses on the role of technologies and material objects for (mundane) participation in political matters of concern. Our discussion circles around how new technologies might offer new ways of enacting concerns when it comes to issues like climate change and sustainability. Drawing upon the concepts of 'energy citizenship' and 'material participation', we discuss how new technologies may anchor new practices with different types of rationalities, different modes of participation, and indeed new ways of enacting energy citizenship in the energy transition. Hence, we link the idea of material participation to the shaping of energy citizenship in order to

better grasp the mechanisms and processes of developing a distinct mode of mundane energy citizenship.

Theoretical perspectives on the role of the public in energy transitions

Many conceptual devices or heuristics touch upon democracy, empowerment, citizen awareness and the roles of the public in energy transitions. Indeed, Sovacool and Hess (2017) surveyed STS scholars and others, and identified an entire arsenal of conceptual tools available, listing 96 theories and conceptual frameworks for sociotechnical change. The typical conceptualization of publics in the energy system has been as customers and passive recipients of technologies at the periphery of a centralized system driven by nuclear, coal, gas or hydroelectric power plants (Devine-Wright, 2007; Schot et al., 2016). With this as a backdrop, much literature has been preoccupied with the relationship between publics and new technologies in terms of siting. How and where should renewable energy technologies be sited to avoid controversy (Barnett et al., 2012)? The implicit goal has often been to form discourses and communication to establish local acceptance. As mentioned in the introduction, user behavior and public action has typically been explained in terms of NIMBYism and knowledge deficits (Barnett et al., 2012; Burningham et al., 2015; Walker et al., 2010).

These standard understandings of publics are problematic. The research literature has established that NIMBY is an ill-defined concept for understanding the way publics make sense of the siting of renewable energy facilities. The NIMBY concept points to an underlying selfishness in publics, who are understood to generally support the common good of more renewable energy, but reject the technologies as soon as they are built near their homes (Aitken, 2010; Haggett, 2011). However, this assumption has been close to impossible to verify empirically (Hoen et al., 2011; Wolsink, 2012). For example, Karlstrøm and Ryghaug (2014) found that political attitudes in terms of party preference explained opposition to renewables, whereas place of residence was less relevant. Wolsink's (2000) statistical analysis shows similar results, leading him to conclude that NIMBY is a 'myth'. Further, the deficit view of the public, that is, the view that the public lacks knowledge, information, trust, interest or simply the 'right attitude', has provoked strong criticisms (Irwin and Wynne, 1996). STS and related fields have shown how public resistance against the agendas of developers and other decision makers is seldom rooted in lack of information, but rather in a deficit of procedural fairness, equity and the possibility of participating in decision-making processes (Haggett, 2008; Hall et al., 2013; Wolsink, 2007). Put bluntly, top-down, centralized planning without local participation and lack of clear local benefits tends to generate opposition, while community energy initiatives and shared ownership models are often thought to receive higher levels of public support (Goedkoop and Devine-Wright, 2016). Nevertheless, studies indicate that planners, industry and other stakeholders involved in renewable energy development tend to imagine the public[1] as generally hostile to new developments. In light of this, public engagement has mainly been considered an instrument to

manage anticipated opposition (Barnett et al., 2012; Ryghaug and Toftaker, 2016; Skjølsvold, 2012) and to 'smooth … the path of potentially contentious technologies' (Barnett et al., 2012). In other words, the deficit model of public understanding of science and technology has continued to be re-created within public engagement initiatives (Wynne, 2006), despite clear scholarly calls for practices of dialogue and public participation.

The most visible manifestations of the move from deficit to dialogue and participation have been the spread of strategies to implement dialogue processes, and the institutionalization of public engagement. Designing successful deliberative fora and knowledge about how to conduct public deliberation processes has been a key concern (Pidgeon et al., 2014). Following this, public engagement has often referred to carefully staged, organized and invited events and exercises, often organized by official institutions such as local and national governments or research councils (Irwin, 2015). These public engagement initiatives have been criticized for being marginal and fragile and for lacking transformative power (Hagendijk and Irwin, 2006). The criticism also includes the research on public engagement, which has been described as being too narrow and with a risk of becoming 'a litany of engagement case studies and evaluations' with limited impact (Stilgoe et al., 2014: 6). Thus, as Jasanoff (2014) and others have argued, it is time to re-open our ideas about publics, science and technology:

> The overwhelming conclusion from two decades of PUS research, … is that PUS as originally conceived framed its object of inquiry too narrowly. It accepted 'science' as a world apart, whether as a body of knowledge or as work in stylized laboratory settings; it imagined a phantom public ignorant of basic factual knowledge and detached from science in its everyday doings; and it sought to bridge the perceived gap between the two with an oversimplified, even cartoonish, notion of 'understanding' that misconceived both what publics know and what they are capable of grasping (p. 22).

Following this line of argument, we are encouraged to think of publics less as pre-existing entities and more as a set of spaces selectively formed around techno-scientific objects and matters of concern (Latour, 2005; Marres, 2007). Thus, we should focus on issue-oriented publics, who come into the political arena to take part in constructing scientific and technological futures (Marres, 2007; Stilgoe et al., 2014). Further, the notion of what constitutes political arenas needs to be expanded to include the mundane and domestic. In this article, we take on this challenge and argue for a broader project of dialogic governance when looking into the way novel collectives of humans and technologies serve to produce distinct modes of mundane energy citizenship. In doing so, we look at forms of engagement where publics and issues are formed around certain techno-scientific objects (PV panels, electric cars and smart meters) through processes of material participation.

In sum, the main body of literature related to the role of public engagement with energy and sustainability transitions has centered around two issues: technology development within a centralized energy system, and siting controversies, especially related to the localization of renewable energy developments such as wind farms.

Less attention has been given to mundane forms of engagement with decentralized technologies often located close to or within the domestic sphere. However, such technologies will likely be central in future energy systems (Berker and Throndsen, 2017; Parag and Sovacool, 2016). Hence, understanding the forms of participation and engagement produced by collectives of humans and these technologies is a key research challenge in the years ahead.

Energy citizenship – Toward a new role for diverse publics?

Devine-Wright (2007) proposes the concept of energy citizenship to move beyond deficit perceptions of publics. The idea of energy citizenship builds on a view of people as active participants to be democratically engaged in sustainable energy transitions. Other scholars have also argued that users play an important role in transitions and should be re-conceptualized as 'important stakeholders in the innovation process shaping new routines and enacting system change' (Schot et al., 2016: 1). The concept of energy citizenship (Devine-Wright, 2007) goes further, however, as people in energy systems are not only conceived as using technologies and influencing innovation trajectories, but also as engaging politically in a more comprehensive way. The concept stresses the hybrid relationships between people and energy technologies and the different roles people can take on: as users, consumers, protesters, supporters and prosumers.[2]

In his definition of energy citizenship, Devine-Wright (2007) stresses both awareness and action aspects:

> 'awareness of responsibility for climate change, equity and justice in relation to siting controversies as well as fuel poverty and … the potential for (collective) energy actions, including acts of consumption and the setting up of community renewable energy projects' (p. 72).

Thus, the energy citizenship concept emphasizes energy consciousness and literacy as well as sustainable energy practices. It also stresses that people can act as social and political actors, and that energy citizens can actively engage as individuals, for example through energy efficiency measures in households, or in larger collectives, for example through engagement with energy policy in climate activist groups (Radtke, 2014), so-called local energy (Hasanov and Zuidema, 2018) or grassroots initiatives (Koij et al., 2018). Here, we focus on mundane technologies located close to or in the domestic sphere. Our focus is on how collectives of humans and such technologies might produce distinct forms of energy citizenship rooted in material participation. This, however, does not mean that energy citizenship cannot be enacted through consultation, formalized political arenas or demonstration events. Such participation, however, will likely be produced by different kinds of collectives than those studied here (see e.g. Hasanov and Zuidema, 2018; Rydin and Natarajan, 2016) and result in the enactment of different forms of energy citizenship.

The concept of energy citizenship has a strong focus on communities and includes practical participation in energy decisions. The gradual shift from centralized and fossil-based production sites to more decentralized and distributed systems based on

renewables will likely make electricity production a mundane matter for increasing numbers of people. This may create new types of interaction between traditional energy suppliers and citizens, producing new roles and actor constellations throughout the system. The decentralization will typically include new modes of renewable energy production (microgeneration), micro grids, local storage solutions, automation, feedback technologies (such as energy displays) and combinations of such technologies (Parag and Sovacool, 2016; Skjølsvold et al., 2017). In sum, we will probably see the emergence of new mundane human-technology energy collectives on a large scale, producing new potential for participation.

Summing up, we see the potential for both a conceptual shift in the theoretical conceptualization of the way we understand energy publics, and a shift in modes of practical political participation in energy transitions. So far, however, to what extent different technologies enable and cater for different forms of participation is not well understood. Paulos and Pierce (2011) argue that active citizen engagement with energy can be achieved by making energy tangible and visible and 'giv[ing] form and meaning to energy with and through material objects', aligning well with the concept of 'material participation' (p. 8). In what follows, we examine how material participation is co-produced in mundane energy collectives, enabling the performance of a certain mode of energy citizenship.

The concept of material participation has grown from a body of STS inspired by what Latour (2005) called 'Dingpolitik'. That is the ways material things enable the configuration of issues, concerns and publics around things, thereby potentially producing new ways of representing diverse interests and voices around such concerns. Material participation, then, can be thought of as a 'specific mode of engagement' (Marres, 2012: 2), which mobilizes human surroundings and prescribes roles to the entities involved: 'things, people, issues, settings, technologies, institutions …' (p. 2). It is a device- or object-centered perspective, focusing on the roles of technologies and material objects in participation. Referring to environmental campaigns attributing the ability to evoke public engagement to material objects, such as energy-efficient lightbulbs or smart meters, Marres has argued that public participation can be understood both discursively in terms of environmental literacy and performatively in terms of mundane material practices. Material objects mediate public participation and through collectives of humans, technologies and specific issues. Simple mundane practices, such as turning off the light, driving an electric car, or doing laundry, might become 'a way of engaging with and acting upon the environment' (Marres, 2012: 66). Technologies that contribute to making invisible energy visible could co-produce increased awareness and environmental action.

Technologies of material participation can co-produce diverse modes of engagement and participation. However, one should not take participation and engagement for granted, and one should not assume that such technologies offer equal opportunities of participation for all. Participatory things, Marres (2012) highlights, are multivalent, which means that in different types of collectives they can produce different things. Technologies that co-produce participation in certain collectives might produce alienations if the collectives are constituted differently. More problematic is the fact that such technologies are probably more likely to become part of

collectives that are already well enabled to participate in transitions due to their geographic, economic or culturally privileged position. Hence, they might serve to entrench or even enforce problematic aspects of the social, cultural and material organization of society, echoing a documented problem in implementing climate change mitigation measures (Sovacool et al., 2015), and renewable energy projects (Yenneti et al., 2016).

Hence, whatever (public) engagement and participation one can observe is situated and limited within geographical, cultural and material constraints. A focus on the role of newly deployed energy-related objects might serve to detect the constraints of potential change, both in terms of who are able to participate through engagement with such objects, as well who are excluded and unable to participate. This, however, does not imply a quest to detect action deficits, thereby once again blaming humans. Instead, it allows us to scrutinize the wider collectives that publics co-construct (Chilvers and Longhurst, 2016), or, in Marres (2012) words, the 'socio-technical-material arrangements that facilitate or rather fail to facilitate environmental action' (p. 80). Thus, we build on earlier research on material participation (Latour, 2005; Marres, 2012; Throndsen and Ryghaug, 2015), and argue that participation involves discursive elements in terms of co-producing environmental and energy-literacy, and performativity in terms of everyday material practices. We also argue that mundane energy citizenship is co-produced mainly through three processes: a) the formation of awareness, b) the formation of new knowledge and literacy and c) new actions and practices. In what follows, we will explore the possibilities and limitations of such an approach.

Research methods

The following discussion revolves around three technology focus areas and the way these technologies become part of new domestic collectives. The technologies are electric vehicles (EVs), domestic smart energy technologies (SETs) and rooftop photovoltaic solar cells (PV). We build on empirical data from several research projects in which the authors of this article have been involved. The goal is to synthesize results from past studies. The data we draw upon are primarily qualitative; consisting of different types of interviews, but it also involves quantitative elements. The data has been gathered in Norway, and to a limited extent Denmark.

We build on 124 qualitative interviews collected between 2012–2017 in addition to information from 1731 applications by prospective solar panel owners, which were obtained in 2016, and a survey of 3654 EV owners from 2016.[3] Electricity consumption in Norway and Denmark resembles the rest of Western Europe, with two important exceptions. First, Norway has nearly 100% renewable energy production, through hydropower. Historically, electricity has been abundant and cheap, e.g. resulting in Norwegians consumers using electricity for space heating and in what Aune (2007) described as a 'comfort-oriented energy culture'. Second, Norway is one of the largest markets in the world for electric vehicles, in part due to generous incentive structures and low electricity prices. In the discussion below, contributions from the international literature have been mobilized to illustrate some of the differently constituted collectives that the technologies might become part of.

The co-production of mundane energy citizenship through material participation

From the discussions above, it is clear that technologies associated with energy transitions enter into very different collectives, from very large to very small ones, and that participation can take many forms. In this section, we focus on mundane and domestic examples of how issues, publics and participation might become constituted around electric vehicles, domestic smart energy technologies, and photovoltaic solar cell panels. Our discussion focuses on individual technologies. However, they are often part of collectives involving combinations of the technologies, which could provide further opportunities for connecting to new issues, new concerns, and through this, new ways of enacting energy citizenship.

The co-production of energy citizenship in collectives with electric vehicles

Our first example is the electric vehicle (EV). At a first glance, the EV might resemble an electric duplicate of its fossil counterpart, having similar form and function. However, as EVs enter into new collectives, human-EV interaction demonstrably facilitates a more active political and practical engagement on behalf of its drivers. This cannot be explained by referring only to the vehicle, but has to do with the relationship between the vehicle and its drivers, and how the vehicle opens up issues around mobility patterns, climate change, air pollution and energy scarcity.

The ways in which such issues are constituted relate to the material qualities of electric vehicles. EVs are powered by a battery, needing to be charged. Thus, depending on age and model, the driving range of most EVs is more limited than that of petrol cars. Hence, for some, EVs actualize energy as a limited resource. EV drivers need to incorporate new attentive practices in order to make the vehicle function as a practical everyday tool of transport. They need to pay attention to battery levels and they must charge the battery whenever needed in a space where charging infrastructure exists (most often at home overnight). Further, they need to plan their trips according to battery status and the availability of charging infrastructure, often less available than petrol filling stations.

These material qualities of EVs can serve to problematize current mobility habits within collectives such as families, who become confronted with current needs and routines when purchasing an EV. In practical terms, potential buyers need to decide whether or not the vehicle is likely to ‘fit’ their collectives’ everyday lives and established patterns of mobility. Through this, EVs open for evaluating understandings of normal mobility patterns and driving ranges, as well as more active engagements with mobility alternatives such as biking, walking and public transport.

Once purchased, the EV, with its batteries and charging infrastructure, enters into collectives of mundane mobility, materializing the issue of energy scarcity. Energy scarcity typically becomes constituted through visual displays in the car indicating the remaining battery level, message boards informing about remaining distance or mobile phone apps providing similar information. At a practical level, EV drivers might become sensitized to minute-by-minute electricity use while driving, as well as to the relationship between the individual vehicle and the broader collective of infrastructures of which the vehicle

is part. In turn, this allows for self-evaluation of the efficiency of driving styles and opens for experimenting with new driving styles to increase energy efficiency.

In some collectives, the introduction of EVs and the actualization of energy and infrastructure scarcity as issues have amplified interest in participating in an energy transition involving energy efficiency or local energy production. EV drivers often express an interest in acquiring in-home battery technologies or local micro-production of electricity (Ingeborgrud and Ryghaug, 2017), and some report an increased interest in energy as an issue (Ryghaug and Toftaker, 2014). Similarly, studies of people who are interested in acquiring rooftop solar panels show that many have become interested in this as a result of acquiring an EV and seeing the possibility of driving on self-produced electricity (Throndsen et al., 2017). This illustrates that the electricity system currently is more open to local tinkering and distributed participation through production than is the case for the system of petrol distribution.

An important aspect for many EV drivers is that it represents a material and discursive actualization of climate and environmental issues (Ingeborgrud and Ryghaug, 2017; Ryghaug and Toftaker, 2014). For many, it represents a concrete and tangible way of acting upon what is considered an abstract problem. In Norway, where most our data have been collected, the EV is a distinctly climate-connected political object, because authorities have provided very favorable economic and practical conditions for EVs. Thus, household EV-collectives also consist of local and national policies that help co-produce participation. This engagement with environmental issues through EVs sometimes takes on unexpected forms, for example in new dialogues (as also pointed out by Marres, 2012). The most obvious way that this happens is through consumption as social performance: EV driving is often seen as performative of environmental concerns, and in this sense, the act of driving an EV can be seen as a political choice, demonstrating for others that it could be a reasonable choice for them, too.

On the other hand, the fact that EVs have been the target of official public policy in Norway has also produced fertile ground for controversy. Many of the publicly sanctioned incentives for driving EVs have been subject to debate over how to best deal with emissions from the transport sector (e.g. Myklebust, 2013). This public controversy has been reported to feed into the mundane aspects of owning and driving an EV. As a consequence, many EV owners report that they are often forced to defend their transportation choices, hence engaging in everyday deliberation over how a future transportation system should look. This has been clearly articulated in interviews with Tesla owners. Teslas are relatively expensive, but have sold in Norway because of their comfort and range, and because subsidies make them affordable for many. In the media, they are sometimes criticized as examples of conspicuous consumption. Indeed, many interviewed Tesla owners say that they acquired their vehicles not because of environmental or climate concerns. By driving the vehicle, and through mundane encounters with criticism, however, many report the emergence of profound environmental attitudes, especially after 'reading up' on environmental and energy related aspects of the vehicle. Armed with new knowledge, some become active proponents of environmental arguments in their local communities, promoting electric mobility, but also other ways of participating in energy transitions. Hence, collectives consisting of electric vehicles, households and their members, politi-

cally sanctioned incentives and controversy can produce a mode of mundane environmental participation in a setting where it would perhaps be unexpected.

The co-production of energy citizenship in collectives with domestic smart energy technologies

In recent years, the integration of ICT (hardware and software) in the energy sector has catered to the influx of a range of new technologies, often described as 'smart' (Skjølsvold et al., 2015). Here we limit our discussion to technologies targeting households. In such collectives, the technologies typically measure, quantify and visualize energy consumption in new ways, often in near real-time, in order to allow for better energy management. One aspect of this is opening new modes of direct communication between electricity producers and consumers. In some instances, the technologies are combined with variants of what is often called demand side response, and with new price structures meant to influence when electricity is used (Fell et al., 2015). In sum, domestic smart energy technologies are intended to transform how, why and when electricity is used within households (Christensen et al., 2017).

Goulden et al. (2014) show how the members of households often display an ambivalent duality in their discussions about smart energy technologies. On the one hand, many highlight how mundane routines such as showering, laundry and cooking are static and very difficult to change. On the other hand, they also evoke instances where smart energy technologies have enabled them to engage with, challenge and sometimes change such routines. When this has been done, energy has been made visible and tangible. Hence, it has been transformed into at least one, and sometimes several, issues around which domestic collectives can become engaged publics. One issue that tends to become articulated is energy efficiency, which might result in participation, e.g. though the identification and replacement of inefficient household appliances. Another issue sometimes constituted is the problem of effect or 'peak load', for example caused by using several energy intensive appliances simultaneously. Participation, here, can consist in shifting the timing of tasks such as laundry or dishwashing (e.g. Friis and Christensen, 2016), but it can also entail more elaborate efforts of establishing rules for when and how energy should be used in the household (Skjølsvold et al., 2017). Such engagement with energy is a contrast to the traditional modus operandi where energy is a static part of a 'background', reachable through properties such as heat and light (see also Hargreaves et al., 2010; Wallenborn et al., 2011).

If the goal is to produce participation, the issue of energy has been shown often to have limited appeal, enabling the formation of publics mainly consisting of technology-focused 'resource men' (Strengers, 2013), i.e. information hungry, resource-optimizing men participating in smart grid pilots and demonstration projects (Abi Ghanem and Mander, 2014; Naus et al., 2014; Skjølsvold et al., 2017). In some instances, the production of such publics might occur at the expense of other potential modes of participation, anchored in the interests and rationalities of more members of a household, or households that are differently constituted than those typically participating in smart grid demonstration projects. A key challenge for technology developers is to produce smart

domestic energy technologies that enable the formation of issues that are relevant to families with children (Nicholls and Strengers, 2015) and elderly persons (Barnicoat and Danson, 2015), as well as making interests gender-inclusive (Sørensen et al., 2011). Goulden et al. (2014) highlight how self-criticism of routines based on domestic smart energy technologies often occurs not based on concern for energy as an issue, but rather as SETs enable local enactment on issues like climate change.

We have observed similar phenomena in studies with participants in SET demonstration projects. Here, too, we have seen how energy becomes visible as an issue to be acted upon through a range of different articulations, from scepticism and pragmatism to enthusiasm (Skjølsvold et al., 2017; Throndsen and Ryghaug, 2015). Smart energy technologies also enable discussions about issues like climate change, the local environment, safety and security (see also Bertoldo et al., 2015). In some instances, this engagement is expressed as explicitly non-private, voicing concerns about how the smart grid taps into public concerns and how it relates to pressing concerns such as social responsibility, inequality and issues of resource scarcity and overconsumption (Throndsen and Ryghaug, 2015). In light of such latent public potential, one can envision radically new forms of relevant communication through domestic smart energy technologies, where explicitly political matters such as climate change, resource scarcity or equity can become issues of concerns to be materially acted upon by new, diverse domestic publics. Such articulations of political agency challenge the instrumental roles smart grids are often envisaged to play in future energy systems (Ballo, 2015; Skjølsvold, 2014), and illustrate their potential in co-producing forms of participation to enable mundane energy citizenship. Thus, domestic smart energy technologies can (at least discursively) provide possibilities for engagement by people who can be both critical and constructive, people who co-produce mundane energy citizenship, e.g. by building a bridge between an abstract climate change issue and the mundane experiences of everyday energy consumption.

The co-production of energy citizenship in collectives with photovoltaic solar panels

It has become increasingly common for ordinary households to own or have access to some means of their own electricity production, typically located on rooftops or in the immediate vicinity of the domestic sphere. An example is the photovoltaic solar cell panel (PV). Like EVs and domestic SETs, the introduction of PVs produces new issues around which domestic collectives can form mundane publics of participation.

PVs first transform the households' role in the energy market. Formerly consumers or users of electricity, people who gain access and ownership to the means of production become so-called 'prosumers', a new kind of actor who sells electricity to the grid and/or produces electricity for self-consumption. In this sense, PVs might enable increased participation through localized, self-owned electricity production. However, we should not mistake this as signifying only a new economic role. When ownership of a resource shifts from being centralized to being local, the resource changes meaning. It might go from being a market object to be purchased by individuals, to becoming a kind of common good (Ostrom, 1990; Wolsink, 2012). The management of such goods is typically a hands-on, practical task, guided by local norms, understandings and practices. Thus, prosumer practices are likely to give a new sort of agency on energy matters to collectives such as

neighborhoods or households. This transformation of energy production from a producer-buyer relationship to a relationship of local resource management is likely to be a constituent of active energy citizenship.

This suggests that locally managed solar power, perhaps more so than stand-alone smart energy technologies, could serve as a tool to enable the re-configuration of practices involving energy use. While numerous studies in recent years (Hargreaves et al., 2010, 2013; Wallenborn et al., 2011) have indicated that it is not straightforward to initiate time-shifting of consumption through better measurements and increased awareness, there are indications that self-production might serve as a strong incentive to shift consumption patterns. For instance, some people who have become prosumers report washing their clothes or dishes while the sun is shining (to decrease their dependence on centralized electricity production) (Christensen et al., 2017). Thus, material participation – through the production of electricity close to the everyday lives of ordinary people – might enable a new kind of sensitivity to the relationship between production and use. This new sensitivity may be used to foster more sustainable resource management practices, which include critical evaluation of existing norms, routines and practices.

As with EVs, solar panels are a visible change in the material constitution of the energy system. This visibility lends itself to the establishment of explicit political action and dialogues in at least two ways. First, cases where solar power is managed in collectives larger than single households require that the involved actors coordinate themselves. Thus, there is a need to communicate in new ways, simply to make the socio-technical set-ups work properly. Second, displaying solar cells on a rooftop involves implicit and sometimes explicit communication. In some studies, people explicitly refer to the visibility of their roof as a way to produce engagement around issues such as climate change and energy production. Hence, as for EVs, PVs might serve to show others that the technology works; they might show that prosumption is a viable and practical pathway to engage more actively with the energy system. Indeed, preliminary results indicate that many who are interested in it conceive of prosumption as a political act that makes new solutions visible and engages other segments of the public in a potential energy transition (Throndsen et al., 2017; see Marres, 2012).

Discussion: Material localization, integration and diversification to promote energy citizenship

Our discussion has focused on the effects of new energy technologies – the electric vehicle, domestic smart energy technologies and new renewable energy production, most notably solar PVs – introduced into domestic settings. We have aimed to shed light on how the introduction of such technologies in different kinds of domestic collectives might co-produce different forms of participation in transition processes. Hence, we have aimed to show how material participation (Marres, 2012) might co-constitute energy citizenship (Devine-Wright, 2007), defined as increased engagement with and participation in low-carbon energy transitions. This is not a deterministic argument: The technologies do not create energy citizenship as such. Rather, we find that there are (processual) qualities within these technologies that allow for integration into existing collectives and anchoring to a range of potential rationalities. We have identified three processual qualities:

Material localization

Electric vehicles, smart energy technologies and new renewable energy technologies are all conduits that transfer or make concrete what has previously been a relatively abstract electricity system, where the primary role of citizens has been to passively consume or not consume. The three technologies above all favor the relatively small, the local and the concrete. EVs have range issues that that create openings for a local resource-sensitivity. Smart energy technologies installed in households provide an impetus for new dynamics in households and neighborhoods. New renewable energy technologies typically produce energy at the location where it is later or simultaneously used.

Integration

We have discussed EVs, smart energy and renewable energy technologies as in three separate 'technology silos'. But, just as important is their ability to link and bundle practices that previously have not been connected. As an example, installing PVs and EVs links practices of mobility to practices of electricity use and electricity generation, all within the localized space of a household, neighborhood or city. Thus, the technologies facilitate engagement and active participation across sectors and fields of interest.

Diversification

The technologies we have discussed appear to be more difficult to standardize than technologies of traditional centralized energy systems. Ordinary citizens may have to give up some of the ease or stability that they previously enjoyed. Therefore, increased diversification most likely requires increased levels of engagement in order for the system to fully 'work'. In addition, the qualities of new, diverse technologies tend to be contested. One could frame this as a challenge in terms of increasing public 'acceptance' of new technologies. However, we find it much more fruitful to see diversification and related controversies as opportunities for producing fertile soil for energy dialogues. Furthermore, diversification allows for a greater degree of flexibility in technology use and hence, enables a greater range of ways of integrating new energy technologies into people's everyday lives.

As connectors or bundlers of interests and practices, technologies such as those discussed in this article have the potential to co-produce energy citizenship, new modes of engagement with environmental issues through material participation. However, our analysis is not intended as a plea for these technologies as catch-all solutions. We have emphasized the situatedness of the development of certain types of energy citizenship. New configurations emerge from old configurations, all situated in specific energy cultures. In the cases of our studies' EVs, SETs and PVs, the old configurations are situated in privileged middle-class ways of living, and thus established collectives that include capital, as well as specific practices and discourses. For these cases, one could argue that material participation allows for energy citizenship in privileged parts of society. Thus, while we consider material participation as generally valuable, we have to look into its negative attributes. For instance, although community participation or empowerment offers an approach for countering exclusion and the dominant interests of some stakeholders, in other situations community leaders, businesspersons or

political elites can use involvement to perpetuate elitism, racism and chronic poverty (e.g. Baker, 2015). We find that taking on an object-oriented perspective helps to bring out and make visible some of the consequences of today's materially-based transitions, both the more and the less positive.

Our discussion here mainly concerns first-order interaction between domestic collectives and new technologies. However, one should not conflate such encounters with the whole political potential of such technologies, particularly as they become increasingly integrated in institutional and industrial collectives. Experiments are being done with new business models and new models of organization with all three technologies discussed in this paper. Are we more likely to have a fleet of autonomous, self-driving electric vehicles functioning like a mode of public transport, rather than as individually owned cars (Chen et al., 2016)? Are we likely to see solar power and prosumers disrupting markets and institutional arrangements in the electricity sector, rendering the regime beyond recognition (Parag and Sovacool, 2016)? When (or if) such conditions emerge, they will constitute yet another element in the domestic collectives of mundane participation, raising a whole series of interesting empirical questions about how they might facilitate or hinder participation and for whom.

Thus, looking closer into consequences of creating energy citizenship through material participation in other locations and among other publics is important for future research. What does a material-based energy citizenship entail for those economically less privileged or living in less technologically advanced areas? Research on climate adaptation has stressed the importance of looking into the political economy of initiatives, pointing to the fact that even seemingly context-specific adaptation interventions at the scale of the household or community can reinforce broader gender roles and class distinctions, or can strengthen the hegemony of markets or actors (Sovacool et al., 2015).

One could argue that what we display in this article is how the privileged 'greenwash' non-sustainable lifestyles through expensive toys. That would be too simple. We would argue that a focus on material localization, integration and diversification could enable design that enables participatory practices for broader groups in society. In Norway, one of the economically most equal and prosperous corners of the world, there are now signs of the electric bike taking on a new role in similar ways as discussed above, but for a much broader segment of the population than that having the financial resources to buy Teslas. The objects we have discussed are parts of larger technological trends (substituting fossil fuel cars for electric ones, installing PV panels, smart grid technologies and home automation systems) that we see spreading over the globe, and that we increasingly expect will become a part of the everyday life of many millions more in the years to come. Thus, having some idea of what these technologies may entail for energy citizenship (or not) is probably a good idea when looking at the challenges ahead of us.

Conclusion

In this article, we argue that the processes of creating energy citizenship go further than the typical attempts to create 'dialogical democracy' as described by Callon et al. (2009: 225). Public engagement exercises have typically taken form as highly organized citizen summits: structured series of workshops or official engagement activities often lead by

external consultants and taking form of consumer research (e.g. Lezaun and Soneryd, 2007). This article aims to explore some of the less 'staged' and organized versions of public engagement, as called for by Irwin (2015) and others. We argue for a more heterogeneous approach, exploring various forms of socio-technical configurations in relation to new and emerging energy technologies.

Our overall goals in this article are to develop and broaden the concept of energy citizenship, to gain an increased understanding of the mechanisms and processes through which energy citizenship may be fostered and to sketch a process for strengthening energy citizenship. Based on empirical studies of EV, SET and PV users, we have displayed cases where politics and technology have become part of everyday life through material objects. We have examined how the introduction of these material objects into people's lives has the potential to shape modes of energy citizenship that may support low-carbon energy transitions. By drawing on these examples from different studies on public engagement with low-carbon technologies, we have described how energy citizenship may be formed. Material objects can contribute to and anchor energy and climate change-related discourses and practices in everyday life, through processes of material localization, integration and diversification. Thus, in order to be able to go from passive users or mere customers to active participants, we will have to think differently about how to engage users and communities with new low-carbon energy technologies. The article stresses the importance of avoiding simplistic and reductionist understandings of users and looks more deeply at how to create energy citizenship.

We identify processual traits of the objects that allow them to become integrated into existing everyday lives and routines, while fostering questioning and politicizing of aspects of these routines. This suggests that there is untapped practical potential in thinking more systematically about the relationship between everyday practice and the technologies that co-constitutes these practices when developing, designing and implementing new technologies. Inspired by the theory of material participation, we point to some possibilities of expanding the understanding of energy citizenship and including new publics into discursively and practically taking part in the low-carbon energy transition. We recognize, though the limits of a materialized energy citizenship, especially in the risk that it creates inclusion of the already advantaged, those with purchasing power and means to acquire new technologies, while excluding others. However, this last point needs further exploration and should be the topic of future studies.

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Notes

1. The terms 'imagined publics' or 'imagined lay persons' have been coined to emphasize that experts often do not have direct access or contact with relevant laypersons or publics, and therefore laypersons or publics are often imagined (Maranta et al., 2003). Imagined publics have been defined as 'shared repertories and expectations (of the public) amongst actors in technical-industrial networks', expectations that are often projected and internalized into both organizational practices and/or working practices (Walker et al., 2010: 943).
2. Similarly, Paulos and Pierce (2011: 1) present the notion of 'Citizen Energy', which extends citizens' relations to energy to become 'more participatory, intimate, personal, social, and emotional'.
3. Please contact the authors for more information about the data collection and its previous publication.

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