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Orchestrating households as collectives of participation in the distributed energy transition: New empirical and conceptual insights

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ABSTRACT

Building on recent dialogue between sustainability transition theories and Science and Technology Studies (STS), this article conceptually and empirically studies and analyses the orchestration of households as collectives of participation in the process of distributed energy transition. Synthesising across past studies, we explore three types of what we call 'collectives of orchestration', relatively durable collectives that work to orchestrate participation at a distance in space and time. These are: a) collectives of policy production and regulation, b) collectives of research, development and innovation, and c) collectives of technology design. We explore how these collectives enroll households, and the ways in which they mediate participation through different strategies and techniques, producing conditions for various modes of participation. We proceed to discuss the co-production of participation in and by households, including ways in which households can re-configure issues around which research and demonstration projects are set up. Through this exercise, we identify four distinct processes through which orchestration is enacted: 1) the production of visions, expectations and imaginations, 2) network construction and re-configuration, 3) scripting and 4) domestication.

1. Introduction

As regions, countries and continents struggle to cope with a set of complex and interlinked environmental challenges[1], the scholarly work to understand the dynamics of social and technical change needed to mitigate such problems is intensifying. Many social scientists have turned to theories of sociotechnical transitions, in particular to those concerning sustainability transitions [2–4] and which address the role of energy in such transitions (e.g. [5,6]).

Recently, work has been done to bring the research literature on sustainability and energy transitions into dialogue with science and technology studies (STS) (e.g. [7–12]). Such work often focuses on the character of public participation in, engagement with and support for transitions. Rather than seeing participation as the outcome of individual choice, STS-contributions tend to emphasise the collective production of conditions for participation. In this article, we build further on these fruitful endeavors to analyse how actors involved in policymaking, research/development and design, work to produce households that participate in the energy transition in new ways.

The paper focuses on unfolding developments in a transition from a centralized system where energy flows from large production facilities to end users, to a more distributed system of energy production and consumption with what we can call smart grid features. These developments include the widespread introduction of ICT technologies, software and sensors throughout the system, enabling new forms of quantification, communication and management of energy flows and processes. This transition also involves the implementation of increasing shares of renewable energy production, such as photovoltaic solar energy panels (PV), batteries and other forms of local energy storage. These developments have been described as a potentially "*fundamental energy transition […], a move away from the* centralized *energy regime […] [to] a decentralized regime*" [81, 1].

Over the past few years, social scientists have greatly advanced our understanding of how users interact with the technologies associated with this transition in domestic settings. This includes in-home displays [13–16], photovoltaic solar cells [17–20] or combinations of new technologies, price regimes and social organisation [21,22]. Such research typically focuses on everyday technology encounters, yielding important insights about the relationship between new technologies and existing practices [23–26].

By contrast, in this paper, we have been inspired by recent conceptual developments [7–9] to study the way in which activity across

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different sites contributes to the production of situations where such technology encounters and other forms of participation occur. In other words, in this paper we highlight the co-production of participation. The authors behind these ideas are concerned with two key processes of co-production. First, they focus on the work of orchestrating collectives of participation, which consists of enrollment and mediation. Second, they are interested in the productive dimensions and effects of participatory collectives in defining what issues are at stake, different models of participation, and finally, who is considered to constitute 'the public'. In sum, this constitutes an interest in 'participation in the making', particularly in the ways in which participation-making entails attempts at producing new forms of social and political order.

We build further on this understanding of participation, through an explicit focus on the work of what we call *collectives of orchestration*, relatively durable collectives that work to orchestrate participation at a distance in space and time. We identify three types of such collectives. These are:

- Collectives of policy production and regulation
- Collectives of research, development and innovation
- Collectives of technology design

Finally, we discuss the co-production of participation in and by households. The remainder of this article is structured as follows: we begin with a brief discussion of the role of STS in studies of sustainability transitions, with a particular focus on how concepts borrowed from the field might contribute to an understanding of agency and participation. We proceed by discussing our methods and data. Empirically, we focus on various attempts to advance the uptake and use of smart energy technologies and small-scale renewables. We then carry out an analysis of three collectives of orchestration and present a discussion on how participation is co-produced in and by households. Based on these discussions, we move on to identify four generic processes of orchestration. We conclude by identifying and arguing for the theoretical and practical implications of our study.

2. STS and sustainability transitions

The study of sustainability transitions is arguably the key interdisciplinary research challenge of our era. The multi-level perspective (MLP) stands out as a successful framework for the study of such transitions, recently affirmed by the publication of its key principles in *Science* [27]. The MLP makes a three-level conceptual distinction between niches, regimes and a landscape [2]. Transitions occur as shifts within regimes, resulting from co-evolutionary dynamics between the levels over time. The framework has been criticised for being functionalistic [28], technology- and market-centred [29], too focused on systems of supply and innovation [30], disinterested in agency, the mundane and controversy [31], and for seeing stable systems where others see unfolding processes [32]. The criticisms have proved productive. MLP scholars have engaged with the ontological and epistemological challenges arising from such critique, which has resulted in more refined models and focus (e.g. [33–36]).

In this article, we are more interested in another avenue of criticism highlighting the diversity of actors and collectives involved in transition work. Science and technology studies (STS) inspire much of this literature through a focus on "*discourse(s), claim(s), material arrangement (s) and set of institutions*" ([10], p. 204). Echoing Latour's [37] plea for scholars to follow actors, this turn in transition studies can be read as a "*refocus methodologically on actors and their transition practices*" ([38], 144). STS-oriented transition studies often deal with the enactment of transition agency [12], which entails studying how heterogeneous sets of actors (can) work to produce social and technological innovation, but also the sites and spaces where technologies are intended to work [38]. Such studies emphasise the importance of doing bottom-up studies of "*the politics involved in actor-networks constructing [and] maintaining*" [82], such as when advocates of solar photovoltaics (PV) work toward "*aligning their innovations with contextual conditions over time*" [83]. In a related manner, Pallesen and Jenle [39] usefully examine the work that smart grid experimenters do to construct, not only the technology itself, but also a new kind of technology user with the calculative agency needed to make such technologies work in practice.

The practical political work to align innovations with contextual conditions and users can be fraught with controversy, e.g. as the very notion of how to interpret the role of energy in societal change is contested (e.g. Rutherford and Coutard [84]). This is often true also between actors and collectives that promote the same technology. As an example, PV proponents tend to understand both the technology and its role in society in different ways [40]. One empirical example is the way Norwegian solar scientists simultaneously work to advance the material quality of the technology and the societal appreciation of its possible application in Norway [38]. Åm [38] finds that one of the ways in which the scientists do this is by constructing Norway as a site where solar power can work, producing so to speak, a public that can participate in sustainability transitions by installing PV. Heidenreich [41] illustrates similar dynamics for scientists working with offshore wind. Parag and Janda [42] allude to similar processes when illustrating that what they call 'middle-actors' work to shape their own operating space both "upwards", "downwards" and "sideways". Lazarevic and Valves' [43] study of actors working to promote the circular economy shows that the most successful actors are those who have been able to institutionalise their narrative about the future, anchoring it with the interests of a large number of other actors. Thus, considered as a whole, such studies suggest that understanding translation [44], a process where actors work to harmonise the visions and interests of other actors with their own, is key to the understanding of transitions (See [45–47] for examples from the transitions literature).

These studies suggest that actor-groups can participate in transition processes in different ways. For instance, solar scientists can work to improve the material quality of solar cells, while simultaneously working to persuade policy makers to improve framework conditions, through translation or what Sørensen et al. [12] call persuasion work and institutional work. This indicates that solar scientists (and others working to promote technology development) can identify different issues around which their engagement is formed, allowing them entry into various collectives where they can participate. Consequently, it is also likely that other kinds of actors work very actively to enroll the same solar scientists into their own agendas. Hence, the unfolding practices and framework conditions of transitions for solar scientists are co-produced [48] through the actions of the solar scientists and through the actions of other actors.

Recently, some scholars have engaged in work that addresses aspects of sustainability transitions through an explicitly co-productionist lens, with a particular focus on the co-production of participation [7–9]. This approach confronts traditional ideas about participation in which pre-defined notions of participatory agency and what participation should entail is enacted through formalised deliberative events (see [49,50] for related arguments). According to this perspective, participation is understood to be constructed in the context of "*emergent socio-material collectives of humans, non-human artefacts, and other elements through which publics engage in addressing collective public problems*" ([8], p. 586). As an example, it has recently been argued that specific forms of energy citizenship can be co-produced in collectives made up by humans and technologies such as electric vehicles, smart meters and solar panels [26].

Chilvers and Kearnes [9] argue that such instances and collectives of participation are on the one hand fundamentally local and shaped by the cultural, political and material specificities of the space where participation occurs, while on the other hand being connected, plugged into wider circuits of actors and networks across scales. Hence, collectives of participation, in their account, are relationally

Table 1
Description of data mobilised in analysis.

Data from	Type of data	Location	Published	N
Smart Grid Centre of excellence research and industry leaders	Individual interviews	Norway	Skjølsvold, Fjellså and Ryghaug [86]	9
Solar PV pilot project operators + PV pilot participants	Individual interviews	Norway	Not published	4 operators, 11 participants
Feedback technology users	Filmed household tours	Norway	Skjølsvold et al. [51]	13
Individuals interested in installing PV	Questionnaire/ application form	Norway	Throndsen et al. [52]	1731
Smart grid pilot project operators	Individual and group interviews	Norway	Skjølsvold and Ryghaug [53]	16
Smart meter and feedback technology users	Focus groups	Norway	Throndsen and Ryghaug [54]	13
Design workshops and research meetings	Participant observation	Italy/Germany	Skjølsvold and Lindkvist [55]	2 design workshops + 6 months of project observation
Policy debate	Document analysis + interviews	Norway	Skjølsvold [87]	3 interviews + large corpus of text

interdependent with other collectives, and could be understood as a "*web of connections*" ([9], 52), forming ecologies of participation. Such ecologies, the authors highlight, are shaped by and constituted in specific historical, material and cultural spaces. In turn, they shape the same spaces, and the elements that serve to stabilise or destabilise order, e.g. standards and controversies.

The orchestra has been used as a metaphor to advance how we understand the complex ordering of participation (see [8,9]). Orchestration used in this sense, consists of two processes: First, enrollment, which "*refers to the way in which different (human and non-human) actors are drawn into a particular form of participatory collective practice and definition of the issue at stake*" ([8], 591). The second is mediation, which refers to *"the way in which a participatory collective is held together by different devices, processes, skills, or 'technologies of participation'"* ([8], 591).

In what follows, we will explore the work in actor constellations that explicitly aim to enroll other actors in new participatory practices in order to advance the distributed energy transition. In doing so, we are particularly interested in techniques and strategies targeting households. Thus, we are interested in zooming in on processes of enrollment and mediation in order to uncover a broader repertoire, or a typology of orchestration practices and processes. Through this exercise, we uncover three types of relatively durable actor constellations, which in this context can be understood as *collectives of orchestration*. Such collectives are primarily identified through the activities in which they engage.

On the one hand, the activities of these collectives are often anchored in a very localised space or institutional setting, where actors participate in the transition through engagement with concrete issues. Examples could be working to understand how the electricity grid handles the influx of solar PV, working to produce a new piece of hardware or working to produce a new standard or piece of legislation. In doing so, these collectives perform acts of participation. A common trait for the identified collectives is that they all also target and aim to transform the practices and collectives of actors beyond their own "*immediate site and situation*" of participation, and that they seek to format the participation of other actors at a spatial and temporal distance. It is in this capacity that they become collectives of orchestration. Thus, our conceptualisation of participation builds further on and adds empirical and conceptual flesh to the co-productionist understanding of the phenomenon already elaborated by Chilvers and Kearnes [9], and Chilvers and Longhurst [8]. A recent study introduces a useful conceptual distinction between the energy system as constitution and the spaces and ecologies of participation, which exist within this constitution [7]. Our approach allows us, on the one hand, to see how collectives form around and participate in transforming aspects of the system as constitution, while on the other hand, to highlight how new constitutive devices are intended to produce participation elsewhere (in our case, within households).

3. Methods

The analysis in this paper revolves around what are arguably three collectives of orchestration, in other words, actor collectives that exist over time and orchestrate and/or are enrolled into specific collectives of participation. Our analysis builds on a) the re-analysis of past case studies, and b) the analysis of recently collected and unpublished data. Our goal is mainly to synthesise across projects, studies and sources of data. The studies in question did not have an explicit focus on the orchestration of participation. Rather, they looked more broadly at innovation processes, policy production, design and mundane domestic life with new energy technologies. Despite this diversity in foci, the relationship between techno-scientific development or policy developments and the participation and engagement of different kinds of publics has emerged as a common theme across the projects and studies. Thus, to understand this phenomenon, we have re-visited past material, focusing explicitly on strategies of public engagement or activation across these sites and actors. Our approach did not entail a full re-coding of all collected data. Rather, we a) conducted a structured re-reading of past published articles, and b) conducted a focused search in the corpus of data for instances where the relationship between the activities of the actors and the participation of publics were discussed. This resulted in four broad clusters of activities, statements and groups of actors, which corresponds to the three types of collectives of orchestration discussed below, the fourth cluster being the households themselves. The data analysed is primarily qualitative, consisting of individual interviews, focus group interviews, filmed guided tours, participant observation and document analysis. The corpus also includes the analysis of 1731 application forms that were filled out by households who sought to become participants in a PV pilot project. The data have been collected in Norway with the exception of extensive participant observation at project meetings and design workshops in Germany and Italy. Table 1 presents a description of the data.

Our analysis secures a broad overview of actors involved in the distributed energy transition, and the ways in which they work to orchestrate households as collectives of participation. While the data have primarily been collected in Norway, many of the interviewees and activities discussed were embedded in broader international endeavours such as Horizon 2020 research projects or international industry consortia. Thus, our analysis should portray recognisable situations throughout and beyond Europe. The primary weakness of our approach is that the original research was not designed explicitly to study the orchestration of participation, and that we do not cover the full spectrum of potential collectives of orchestration or collectives of participation. In particular, none of the cases we cover here are bottom-up, grassroots organised energy collectives or similar initiatives. Such collectives of participation and orchestration might have different characteristics than those studied in the current article, and represents an important avenue of future research.

4. Orchestrating collectives of participation in the distributed energy transition

Rhetorically, European policy makers have raised the status of electricity consumers as actors in the energy transition. Through documents like the EU strategic energy technology plan and the EU's recent policy package to further energy efficiency across the continent, consumers have been framed as the active hearts of future energy systems,[1] a status indicating that households are expected to participate in the transition in new ways. Rather than framing this as an issue of individual choice, we will now move on to analyse how actors across three distinct collectives work to orchestrate such acts of household participation. We make a conceptual distinction between collectives of participation as outlined by Chilvers and Longhurst [8], and *collectives of orchestration*, where the latter is a relatively stable and durable collective actively working to transform participatory practices at a spatial and temporal distance.

4.1. Collectives of policy production orchestrating participation

The standard interpretation of policies and regulations is as "drivers" or "barriers" to technological implementation [56]. For Chilvers et al. [7], policies can be interpreted as part of the energy system as constitution, thus being part of formatting potential modes of participation. More concretely, policies and regulations are also textual products of diverse epistemic collectives. These are collectives of participation, in the sense that they form around an issue (e.g. a perceived need to respond to a problem through producing new regulations), and work to produce the piece of text through a variety of tools and resources. Thus, they seek to transform elements of the energy system as constitution, in turn also orchestrating households as collectives of participation. The following account is based on a case study on the development of regulations for smart electricity meters in Norway [87], and a reading of subsequent policy debates.

A collective, or techno-epistemic network [57] working to regulate or enforce the implementation of advanced or smart electricity meters emerged around 1998 when scenarios in a Norwegian white paper envisaged "two way communication" between customers and electricity producers as a way to improve market efficiency by increasing the self-awareness of customers. The problem around which this collective initially formed was what was viewed as a set of market inefficiencies, which hampered new investments in the system and led to sub-optimal behaviour amongst a range of actors; including end users or customers (see also Karlstrøm, [85]). In the early years of the work to promote new electricity meter technologies, scattered voices argued that implementing new, advanced meters should be mandatory. In the winter of 2002/2003, this argument gained momentum during a particularly cold and dry winter with high electricity prices and escalating peak load problems [58]. Hence, this collective of policy production, which consisted of a mix of parliamentary politicians, industry actors and bureaucrats, primarily worked to make advanced meters or so-called smart meters mandatory in order to improve market conditions and make the electricity system more efficient. Many of the acts of this collective did not target households but rather aimed to enroll electricity producers, distribution system operators or other actors in or around the energy system constitution.

During the dry and cold period of 2002/2003, however, it became clear that this collective would also target and work very actively to enroll households. The concept of 'end user flexibility' was introduced to illustrate how regulating the introduction of smart meters would work to transform practices across time and space. The advanced meters, it was stressed, would be the mediation device serving as enablers of flexibility. As an example, the leader of the social democratic party, and later prime minister of Norway, Jens Stoltenberg, said to one of the largest daily newspapers in December 2002:

> *"Covering peak electricity loads is expensive. It is important to award smart consumption. All you need to do is install new electricity meters, and make a system of differentiated prices"*[2]

In practice, much of the work throughout the period was done through the production of reports that quantified the potential economic benefits of introducing smart meters in all Norwegian households. In the reports it became clear the actors in the collective of policy production had framed the households as a passive group of consumers, in other words, in line with the historically dominant understanding of energy users [59]. Producing a regulation that made smart meters mandatory was seen as a necessary step in an overall process that would orchestrate the participation of households in entirely new ways. As The Norwegian Water Resources and Energy Directorate concluded in one of their reports from the period:

> "*The directorate seeks to increase the total end user flexibility in the Norwegian power market. Hourly electricity metering and to-way communication can contribute to achieving this goal*"[3]

The perceived necessity of implementing smart meters became clear through reports that emerged from the decade long work of this collective of policy production. Beyond relatively sterile economic descriptions, a central activity was to produce vivid future visions for the same reports, which typically consisted of two distinct depictions of the Norway of the future. The first future was one in which advanced meters enabled household access to information about electricity consumption, combined with more accurate, real-time price signals. This would presumably result in elaborate behaviour changes and active consumption, producing typical examples of what Chilvers et al. [7] call dominant participatory collectives (behaviour change and user-consumers). The participation was seen as essential for realising a future, sustainable Norwegian energy system.

Simultaneously, proponents of the new electricity meters produced visions of an alternative future without advanced meters and household participation. The absence of advanced meters, here, preserved electricity consumers as passive non-participants in the energy system transformation, resulting in a narrative about a future Norway that needed to invest heavily in a combination of polluting gas-fired power plants and electricity grid infrastructure. A Norway without new modes of participation in this narrative would be a non-sustainable Norway.

Throughout the period, the visions of how the new electricity meters would transform both the electricity system, and how households could participate in this transformation evolved. From being understood as a new mode of communication between electricity suppliers and customers, reports about future electricity meters gradually framed the meters as the cornerstone of a new transformative infrastructure, 'the smart grid'. This also entailed an expansion of the kinds of issues that this collective of policy production worked to address, which now included innovation in the ICT and electricity sector more broadly, often coupled with business opportunities and the need to solve efficiency challenges in other areas such as entertainment or healthcare. One of the first visions resembling current smart grid ideals was seen in a report by the Norwegian Water Resources and Energy Directorate in 2006:

> "*Services that could be delivered by infrastructure for two way*

[1] For an example of a press releases showcasing rhetoric of 'consumer centric' transition see: https://ec.europa.eu/energy/en/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition.

[2] Dagbladet, 16.12.2002.

[3] Report no 18, 2004: Toveiskommunikasjon i det norske kraftmarkedet. Er det hensiktsmessig med tiltak fra myndighetene for å fremskynde en utbygging? *[two way communication in the Norwegian power market. Should the authorities advance a roll out?]*.

communication, that are not included in the grid services provided by grid operators could be: a) alarm, health and safety services, b) load management, c) energy consultancy services, d) broadband, e) IP-telephony, f) various forms of entertainment"[4]

Framed in this way, an increasing number of actors began supporting the technology (see Skjølsvold [98] for a detailed analysis of arguments). Once a sufficient number of actors had been enrolled and mobilised as supporters, the visions became what Lösch and Schneider [60] have described as tools for coordination. In the end, the result was a piece of regulation that made the implementation of advanced electricity meters mandatory from 2019.[5]

Thus, this collective of policy production formed around a desire to optimise the electricity grid, orchestrated participation in the distributed energy transition as a market activity in which households would engage in behavioural change and be flexible user-consumers. More recently, indications that this process of orchestrating household participation as behavioural change and user-consumers is still ongoing. In Norway it can be observed in the energy regulatory agency's deployment of yet another regulation, outlining new rules for grid tariffing for electricity end users. The new tariff aims at having consumers even out their electricity consumption, which in turn will reduce peak loads in the grid and, in time, reduce overall grid cost for consumers. The regulatory agency wants the grid companies to shape future tariff structures according to an arrangement called 'subscribed power'. As the name indicates, the grid companies are obliged to provide customers with the option of setting a maximum level for their power outtake (measured in kWh/h). All consumption exceeding this level will be charged by a premium. According to the regulatory agency, the new tariff will better reflect how costs are incurred in the electricity grid since the trend over the latter years shows that capacity use far outpaces energy use. The new tariff will be mandatory by 2021 and is enabled by data from the new metering infrastructure. It is a departure from the current grid tariff, which is based on a fixed fee in addition to aggregated energy consumption in kWh.

4.2. Collectives of research, development and innovation orchestrating participation

Research, development, and innovation are key activities for advancing the distributed energy transition. A central mode of working in this respect is to produce experiments, pilots and demonstration projects [61]. This section is based on recent research that we have conducted in and around pilot and demonstration projects in Norway [52–54], and on recent interviews with demonstration or pilot project operators.

Experiments, pilot and demonstration projects are temporary yet quite stable collectives that tend to coalesce around the issue of verifying technological solutions or configuration under more realistic conditions than those found in research or company laboratories. Further, they often explicitly or implicitly address the issue of how to scale up the technologies and configurations [62]. It is around such issues that the collectives of research, development and innovation studied here participate in the energy transition.

Orchestration at a distance has been understood as part of such activities for some time, e.g. in studies that understand experimentation as a form of governance [63]. In the cases we discuss below, orchestration of households is an integral aspect of research and development, as this orchestration involves producing settings or situations within which the developed technologies are intended to work. How do such collectives work to enroll households? Arguably, they primarily do so by producing new networks that consist of visions, people, organisations and technologies, or through the re-configuration of existing networks. In what follows we will look at some illustrative case studies to highlight the diversity of how the participation of households are orchestrated.

Our first example (based on Skjølsvold and Ryghaug [53]) is the recent establishment of a new neighbourhood in southern Norway, a joint effort between one of Norway's largest construction companies, the local DSO and several research institutes. This neighbourhood consisted of apartments and houses that were to be sold on the real-estate market. At the same time, the neighbourhood served as a research pilot, the goal of which was to gain practical experience with how domestic smart energy technologies, micro generation (PV) and electric vehicle charging might interact with the broader energy system in practice. This was the key issue around which the collective was organised. The orchestration of households in this instance was carried out using several techniques. First, it was the framing of the neighbourhood as a model village for green living that was primarily used to enroll households, a sort of framing that has proven successful in other cases [64]. Houses and apartments were listed at a considerable premium price compared to similar homes, but targeted an environmentally and technologically interested demographic who would live technologically and practically different lives than one could expect in other neighbourhoods. Hence, the households were orchestrated as what Chilvers et al. [7] call diverse participatory collectives, where dwellers would be interested and innovative, and perhaps politically engaged as energy citizens [26], or organised in what is sometimes called an energy community [65].

This framing was coupled with an elaborate technological set-up, where solar panels, smart electricity meters, electric vehicle chargers, air-pump tumble-driers, automation-technologies (e.g. for ventilation) and in-home displays would serve as technological mediators stabilising the new households as collectives of participation. Based on environmental and technological interest, coupled with economic motivations, the households were expected to constantly make active choices with respect to energy, by responding to real-time information, concerning the desirable timing of activities like EV charging, washing or cooking. As noted by one of the project managers, orchestration, here, was explicit: the goal was to enable a modern and green lifestyle:

> *"So, what we do is actually to shape people and minds in the way that they feel that this is a place where it is possible to live, it is possible to create a sustainable future here, without having to wear rags"* (Interview with project manager February 2014).

A contrasting example was found in the same study [53], but in western Norway, where another collective of research, development and innovation had emerged. The actors in this collective had found common ground in the prospects of introducing technologies for automating some aspects of electricity consumption, information technologies and technologies of universal design. The goal was, on the one hand, to enable energy conservation and to shave peak electricity consumption, and on the other hand, to increase the security of people in need of special care such as elderly or disabled people living at home.

Orchestration of participation, here, was of an entirely different character because households were understood as being composed of a series of deficiencies. When the inhabitants were imagined as elderly, they were represented either as lacking the competence or cognitive capacity needed to understand the energy system and/or their own safety. On the other hand, the collective firmly wanted to avoid developing solutions that only catered to a health-oriented niche. Households composed of people from outside the elderly demographic, however, were also understood as deficient in terms of competence, moral or interest. Enrollment of both the elderly and a more general user group was thus done by mobilising the concept of simplicity. On the one hand, this would entail automated participation where choices

[4] Report no 6, 2006: Automatisk måleravlesning og toveiskommunikasjon Styringsinstrument eller avlesningsautomat? *[Automatic metering and two-way communication. Government instrument or reading automat?]*.

[5] See https://lovdata.no/dokument/SF/forskrift/1999-03-11-301/KAPITTEL_4#KAPITTEL_4 for the text of the Norwegian regulation.

associated with heat, lighting and ventilation were delegated to technology. On the other hand, when active input was sought by household members, the focus was on introducing simple, often one-click tools associated with thermal comfort, hydration and health. Hence, participation in this project was orchestrated, not around issues such as energy, the environment, or climate or market optimisation, but around issues of convenience, personal well-being and security.

Recent interviews conducted with nine research and industry leaders in a Norwegian smart grid innovation centre of excellence [86], confirm an ambivalence in thinking about potential modes of household participation in the energy transition. On the one hand, these actors highlight that participation today is low, and that it needs to increase in order to advance the distributed energy transition. Participation, for these actors, is primarily interpreted as something that will lead to flexible consumption, an asset that is deemed necessary for the electricity grid to be able to handle the influx of intermittent renewables. This is an issue that this collective works to address locally. It does so in many ways, and only a few of which entail orchestrating households.

When working to enroll households, these actors typically assume a set of deficiencies and capabilities on their behalf. They attempt to enroll households through a combination of nurturing capabilities and rectifying deficiencies by weaving a new network of visions of change, technologies and modes of organisation around and within the household. The first deficiency concerns information, which households are understood to lack. Providing information though technologies like in-home-displays, mobile phone apps or web portals, are strategies mobilised to enroll households in participation through behavioural change, as also noted by Chilvers et al. [7]. As a research leader in the innovation centre of excellence noted:

> *«The consumers need information. Yes, they need information and training, I think, before they will do anything at all»* (Interview with research leader, 2017).

Second, households are interpreted as deficient in attitudes or interest. This combined with an understanding of them as economically motivated, leads to attempts at providing households with new, strong price incentives such as power tariffs. As noted by a leading professor of electrical engineering:

> *"So, the tariff will likely determine if people decide to move their consumption […] If people do not save large amounts of money, nobody will bother"* (interview with professor, 2017).

Thus, participation is orchestrated as a combination of user-consumption and behaviour change, where the household in many ways can be re-conceptualised as a sort of time-market, where *not* performing certain actions at certain times becomes a commodity that households can sell and DSOs can buy.

The concept of flexibility as discussed above is often paired with the notion of prosumption, which captures the idea that households also produce and sell electricity. The Norwegian electricity system has historically been characterised by a very stable supply of hydropower. There is therefore a great deal of uncertainty amongst many actors concerning how the grid will respond to new, small scale and intermittent production. Recently, we have conducted interviews with leaders of pilot projects in Norway that work specifically to understand how the grid will handle this new intermittent production. The following section is based on these interviews. In order to address the issue of the relationship between the grid and PV, the actors must enroll households.

In our interviews, the actors highlight that they mainly do this through appealing to an imagined future, in which prosumption is a vital element in transforming the participation of ordinary households in the energy system. As noted by one of our interviewees:

> *"It is an entirely new role, and it turns the traditional value chain upside-down. They begin to deliver electricity to the grid, and demand other services. Monitor their own production, compare production and consumption. They want more data, more information, a better basis for decisions"* (PV pilot project operator, 2017)

As it stands, this form of participation is explicitly framed as a non-economic activity and a contrast to the notion of participation through consumption as identified by Chilvers et al. [7] because the panels are quite expensive and the prices of produced electricity low. Thus, the actors, on the one hand, appeal to what they suspect is a latent interest in PV as a technology, and on the other hand, a vivid narrative about a future in which the prosumer role of households is both disrupting the traditional relationships in the energy system, and an important factor in a sustainability transition. Households, then, are orchestrated as innovative and interested publics in the terminology of Chilvers et al. [7].

4.3. Collectives of design orchestrating participation

In the discussion above, we have seen the centrality of orchestrating household participation through producing networks of material things, organisations and visions. Collectives of design form around similar concerns, but are anchored more concretely in the production of the specific things from the previously discussed networks. Hence, collectives of design produce interfaces, switches, apps, screens and other concrete objects. The issue around which they form relates to how these technological objects should be shaped to do effective work in the kinds of networks discussed above. The following discussion is based on the work in Skjølsvold and Lindkvist [55] consisting of participant observation in a process where designers worked to produce the interface of a platform meant to enable sharing of solar power in neighbourhoods in Germany and Italy.

In STS, design has been understood as a form of orchestration at a distance for a long time, through the notion of scripting [66], which more recently also has been linked explicitly to the production of public participation [67]. The orchestration of participation through design is arguably a two-step process of (1) producing visions of future technology use [68,69], and (2) translating the consequences of such visions into concrete objects.

Through participant observation, we identified four future user characters, which the observed designers imagined as universal enough to do productive work in both Italy and Germany. These users were seen as deficient or capable in quite different ways. The first character was described as 'greedy', a trait translated into participation through a rational form of consumption, as has commonly been identified in the research literature [70]. The second character was understood as politically motivated and green, driven by a desire to mitigate environmental problems and participate politically as a citizen, a mode of participation increasingly identified as promising (e.g. [26,71]). The third character is 'simple', disinterested in technology or energy, whose main motivation is comfort and convenience. Participation for this group was framed as attitude and behavioural change, one of the more common modes of participation [7]. These characters were understood to participate in the transition as individuals. Further, some designers imagined a 'social' or collective user, imagined to operate in groups (multi-person household, neighbourhood, community). This character was understood to participate primarily through two mechanisms: competition or cooperation, modes of acting that are increasingly given prominence in the transitions literature (e.g. [36]).

In the observed project, technologies were scripted to provide impulses of change and participation for these imagined future users. The greedy users were expected to participate as economically rational consumers, or through behavioural change. As was noted by one actor in a discussion we observed; "*If there is one thing we know about human beings, it is that they are governed by greed!"* (9th October 2013). This translated into visual devices focusing on numbers (money saved, money earned, kilowatt hours), and graphs communicated via in-home

displays, apps, or websites, providing information on consumption and production levels as well as costs and income. Non-participation was considered a market failure, and the scripts in question were attempts to enroll and stabilise both market and transition participation. Green and politically motivated users were enrolled through scripts that provided information about CO_2 savings, also communicated through apps, displays and websites, thus providing what could be understood as means to enact energy citizenship through material participation [26]. 'Simple' users were enrolled through scripts that minimised the need for active input, e.g. as pre-programmed household settings like 'night' or 'vacation'. Participation, here was largely delegated to technology, under the assumption that their disinterest would be a threat to the system (see also [7]).

As noted, the designers also imagined users of a social character, operating in groups. Participation for these groups was understood to be of a distinctly different character than for those noted above. First, scripts targeting groups like multi-person households and neighbourhoods tried to enroll users by exclusively focusing on political engagement and citizenry concerning environmental issues. In the project studied, these issues were presented on an online platform that consisted of two elements. On the one hand there was an interface shaped like a game, where participants could either cooperate ('how many trees can your neighbourhood save') or compete ('can you reduce your CO_2 emissions more that your neighbours?'). On the other hand there was a discussion forum, where platform users would be encouraged to discuss openly their experiences with solar energy, energy savings and environmental issues in general. Hence, when addressing collectives rather than individuals, the designers explicitly aimed at enrolling and mediating participation by nurturing a sense of community around energy issues and involving interested citizens.

4.4. Co-production of participation in and by households

Until now, we have seen households indirectly as representations, in networks or through work to enroll and mediate their participation in quite diverse ways. This might give the impression that households are mere puppets, easily manipulated into pre-defined modes of participation in the distributed energy transition. This, however, would greatly understate the agency of households as collectives, and their role in co-producing conditions of participation in the transition. From an STS perspective it is not surprising that technology users are active, that they innovate, and ascribe different meaning to the same technologies through processes of domestication [72], as has also been shown in the context of living with the high tech equipment of the distributed energy transition [73,74]. In what follows, we will look at two illustrative cases to a) show the direct links and interdependencies between collectives of orchestration and collectives of participation, and b) show how households may not only be orchestrated, but also orchestrators of potential modes of participation in other collectives.

Our first illustration is based on a study of the relationship between a Norwegian PV pilot project, and the households that this pilot attempted to enroll as participants [52]. The project sought to recruit fifteen households, mainly based on strict technical criteria such as roof angle, roof size and level of shadow on the building. The issue that the PV pilot project wanted to resolve seemed simple: how would the distribution grid handle the loads from the intermittent PV? An application form consisting of a questionnaire of strictly technical matters was posted online. Potential users, then, were framed as technically interested publics [7]. In addition to the technical data, the questionnaire contained one open box where applicants were asked to provide "other relevant info". The project operators received 1731 applications, and our analysis is based on a reading of the qualitative statements in this box. Thus, it is an analysis of the very moment at which households become enrolled as prospective participants. But at the same time, the statements provided illustrate how the households work very actively to enroll the PV pilot into their own agenda.

The households did this primarily by attempting to re-orchestrate the issues of engagement that the PV pilot project was formed around. Rather than accept the pilot as a technical test, many respondents rephrased the issues at stake, arguably in an attempt to enroll in the pilot project as participants in a more explicit and radical project of political participation. Many respondents pointed to the high visibility of their own households, arguing that the pilot should serve to engage broader segments of the population in a dialogue on new forms of electricity production. As one applicant noted: "*good exposure for the project at Tyholt. The building is one of the closest* neighbours *to the Tyholt Tower, so everybody up there will look down on the PV system"* (respondent no. 541). Another applicant noted: "*I'M INTERESTED ☺ The house has a location which will make the project very visible. Can easily be seen from the passing trains, and from the road next to us"* (respondent no. 102).

Others proposed that the pilot project could become part of an agenda for educating future generations about energy issues. Another common theme was introducing the pilot project as a way to advance new, technologically oriented and participatory lifestyles, where technologies like electric vehicles and solar panels might mutually strengthen a collective form of material participation in an effort to address the climate issue. As one applicant noted: "*We are very interested in this. We have an electric vehicle and it would be extremely motivating to charge this with our own solar power!*" (respondent no. 266). Interviews with pilot project operators, indeed, confirm that the diversity of responses came as a surprise, and that it inspired new ways of thinking about what similar projects could, and should entail in the future. Hence, while the pilot project was undoubtedly successful in enrolling participants, the responding households re-interpreted what their potential participation might entail, in turn, re-shaping the future work of pilot operators.

Our second illustrative example is based on a set of interviews in households that participate in the distributed energy transition by living with a set of smart energy technologies [51]. The households had been provided with in-home-displays and apps, foregrounding prospective users as individuals, focusing on potential monetary savings, and savings in kilowatt-hours through a speedometer indicating when consumption should be reduced. Hence, households were enrolled through attempts to mitigate perceived knowledge deficits that might lead to behavioural change, and through attempts at stimulating new forms of electricity consumption as participation.

Many of the participants indeed highlighted that the technologies had educated them with respect to the character of their own electricity consumption. For some, the increased knowledge enabled what we might call participation through interested consumption, in the form of replacing old water heaters or household appliances with more energy efficient alternatives. For many households this resulted in reduced electricity consumption. As participation, this can be characterised as a one-off choice, which in turn might delegate future agency on energy issues in the household to technology, a point that others have claimed might actually lead to less engagement, not more [14].

In many instances, participation as described above followed the script, in the sense that the events (learning, purchasing new equipment) were performed by an individual household member, typically a man. In several instances, this person in turn attempted to enroll and orchestrate the remaining household members in similar patterns of participation. As an example, the showers of teenagers could be subjected to new internal reward regimes, in an attempt at stimulating behavioural change. Negotiations about new rules for when and how electricity should be used were often common, with attempts at producing restrictions on the use of several electricity-intensive appliances at once as a typical example (e.g. washing machine and oven), again an attempt at instigating what was understood as behaviour change. This frequently resulted in conflicts between household members over the character of potential participation, the logics guiding participation and the limits of behaviour change. In turn, participation was often abandoned all together.

4.5. Discussion: four processes of orchestration

This discussion illustrates the complexity of the distributed energy transition and describes the work of a) collectives of policy production and regulation, b) collectives of research, development and innovation and c) collectives of technology design. The collectives on the one hand work to address very localised issues, and on the other hand they work to orchestrate households at a distance in space and time. They do so through efforts to enroll households to participate in a variety of ways (e.g. behavioral change, consumption, interest, innovation, citizenship), and through mediation techniques where they attempt to stabilise collectives of participation. From this exercise, it is possible to distill four ideal typical processes through which enrollment and mediation occur in the context of the distributed energy transition. These four processes are:

The production of visions, expectations and imaginations: For the three collectives discussed above, mobilising the future as a resource is central to the enrollment of households and other actors as participants, as has also been illustrated in past research [75]. Policy makers produce scenarios in which technology choices lead to different worlds, where different issues matter. Researchers and technology developers envision more local futures, where households or neighbourhoods are re-shaped through new technologies and new modes of participation. Designers envision how future users interact with their technologies. Households produce their own vision of what a good future life might entail, which might not necessarily include participation as envisaged by other collectives. Working constructively with such frictions appears as a key challenge across sectors and societal domains over the coming years.

Network construction and re-configuration: In attempts at enrolling households as participants, the three collectives above tend to re-cast the households, weaving networks of new technologies, organisations, issues and price mechanisms around and within them. The networks are typically constructed with the intention of nurturing specific capabilities (e.g. technological interest, economic motivation, environmental attitudes) or amending perceived deficiencies (e.g. knowledge, moral, interest). Studies indicate that prospective participants often find the proposed modes of participation too limiting (e.g. [52,54]), suggesting that there is significant practical potential in building networks that nurture more radical and political capabilities and other often untapped modes of participation.

Scripting: Inscribing visions of future users in concrete technology objects is an important way of enrolling and mediating households into specific modes of participation, as has been illustrated in the past [76]. Scripts within the domestic smart energy domain have previously been shown to reinforce participation as consumption [70]. Our discussion above reveals a broader repertoire of scripts, but a challenge is that technologies tend to target individuals, which makes participation through these technologies difficult for collectives like households. Producing scripts that explicitly address the multitude of rationalities, motivations and practices embedded in collectives is a major challenge for making technology.

Domestication: The work to enroll and mediate collectives into specific forms of participation through technology does not entail reducing the agency of the households or those living within them. As we have seen, households make sense of technologies in different ways, which means that they domesticate technologies differently. Understanding this kind of user diversity has been called for within the transitions literature [59,77]. In our analysis, we have also seen how households engage in work that might re-orchestrate the work in other collectives, illustrating a co-productive relationship in which households are both orchestrated and orchestrators.

5. Concluding discussion: ecologies of participation, contestation and orchestration

This article has built further on recently established links between the sustainability transitions literature and STS, focusing particularly on the orchestration of participation in the distributed energy transition. Through a focus on policy production, research and development and design, we have come to see participation as a phenomenon beyond individual choice and technology encounters, but rather as an ensemble of carefully orchestrated activities, distributed across an ecology of participatory collectives. Further, we have also seen how the households have an active role in shaping their own modes of participation, and that they are important for shaping wider spaces of participation, including their potential role as co-orchestrators of the work in other collectives. Thus, we have come to see participation as a truly co-produced and distributed phenomenon.

The analysis has theoretical and practical implications. Theoretically, the analysis serves to raise some challenges to the MLP [2], because the phenomena discussed are not easily categorised within the niche-regime scheme. If one follows the MLP strictly, one would expect transitions in the organisation of participation to grow out of protected or nurtured niches, or through new practices formed in alternative energy communities gradually breaking into and destabilising regime-level norms and behaviours. Through our narrative, we see how any instance of participation is in fact partially produced through the work of what in MLP terms would be regime actors (e.g. policy makers, large construction companies, DSOs). Thus, our focus on co-production, orchestration and situated analysis provides a messier narrative, where the potential relationships between those who nurture and those who are nurtured becomes more complicated. By working to enroll policy makers, researchers and technology developers or designers, households can also partake in nurturing or stimulating more radical participatory practices amongst actors who work to develop future smart grid technologies. In this article, we have seen one example of how they do so by re-casting what the pilot operators saw as a purely technical issue, as an issue of public engagement or education. The agency of technology users in general and households in particular when it comes to re-shaping their own context, however, is a blind spot in transition studies. STS and related schools of thought are particularly well equipped to explore this further in future research.

The practical implications of the insights from our study are substantial, but also surprisingly simple. On one level, our discussion highlights the merits of linking different forms of practice across collectives, epistemic foundations and through different technologies and objects. Our analysis here is in line with that of other scholars, suggesting that the production of such links and networks are currently done in ways that are too conservative, too uniformly rooted in dominant understandings of participation [7]. In other words, there are very strong networks of policies, institutions, research programs and new technologies supporting participation as individual consumption and behavioural change, while the networks around more experimental and radical forms of participation are weaker. Thus, we should not think that simply linking existing policymaking, R&D, design and households would serve to activate households in radically new ways.

Instead, an ecological understanding of participation opens up to a broader view of what experimentation in this domain might entail, as something beyond testing new technologies in and around households. Experimentation to increase participation in the distributed energy transition might also entail trying out new ways of producing policy, standards and regulations, new modes of working within R&D, and experimental design practices. Some interesting efforts have already been undertaken in this direction, e.g. though attempts at orchestrating participation differently through speculative design [78], storytelling [79] or through more experimental forms of formal governance [80]. In other words, active tinkering and work to transform collectives, actions

and events across wider participatory spaces would also likely result in radically new forms of orchestration of participation, which will be necessary if we are to produce radically new forms of active participation in the energy transition.

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