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Imagining energy futures: Sociotechnical imaginaries of the future Smart Grid in Norway

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ABSTRACT

A future "Smart Grid" is increasingly being embraced in energy policies as a promising energy scenario for the future, with the introduction of "smart" electricity meters being seen as the first step. In Norway, this process is happening without much public debate. Discussions of complexity and uncertainty related to the future Smart Grid are mainly taking place within a network of actors with recognized expertise. Based on empirical data from interviews and documentary analysis, this paper describes sociotechnical energy imaginaries of a future Smart Grid in a Norwegian context from within this network of experts, which is conceptualized as a techno-epistemic network.

The future imaginaries of smart meters and a future Smart Grid are mainly technological and economical, and they are partly permeated by national imaginations. They connect the past and the future by providing solutions for current challenges in the energy supply system, which reflect current institutional and technological structures. The imaginaries also include constructions of the public, or "consumers", which has implications for the communication to the public. The paper suggests that increased openness and the inclusion of multiple perspectives and ways of knowing, inspired by post-normal science, could facilitate more careful consideration of potential social implications.

1. Introduction

A future "Smart Grid" is increasingly being embraced in energy policies as a promising future energy scenario. EU policy documents, for example, describe smart energy infrastructure as central for addressing the societal challenge of transitioning to an energy-efficient low-carbon economy (e.g. [1] EC). New and emerging energy technologies are often accompanied by high hopes and expectations for the future (see e.g. [2] Skjølsvold), and the Smart Grid is no exception: Visions of a smart electricity grid promises solutions for most current challenges in electricity production and distribution, describing this as necessary technological progress, which will get us closer to a sustainable energy future. Jasanoff and Kim ([3,4]) highlight that the capacity to imagine futures is an important element of social and political life, and use the concept of "sociotechnical imaginaries" to describe such collective visions of desirable and feasible (technoscientific) futures. Through the lens of this theoretical concept, the collective visions of the future Smart Grid in a Norwegian context will be critically analyzed and explored as *sociotechnical energy imaginaries*, based on empirical data from interviews as well as documentary analysis.

Many countries are now introducing "smart" electricity meters, which are considered to be the first step of the journey in pursuing the captivating future energy scenario of the Smart Grid. Smart meters allow for adding a "digital dimension" to the current electricity grid, making new and detailed information available by frequently and automatically measuring electricity consumption. In Norway, smart meters are going to be introduced to all households by 2019 ([5] NVE; [6] MPE), with very limited possibilities of opting out ([7] NVE). The introduction process is based on a regulatory framework determined by the national regulator (NVE) and the operational responsibility for installing the smart meters belongs to the network companies, which constitute a regulated monopoly. The cost of the smart meter investment will be paid by the consumers, through an increase in the transmission tariff; a fee paid to the network company by the end-users. This tariff is set by each individual network company, but has to stay within limits determined by the national regulator NVE ([8] NVE). The introduction of smart meters was initiated even though this was not found to be socioeconomically beneficial ([9] ECON). In the empirical material for this paper, informants described how the

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"belief in a future" was decisive for this decision, which illustrates that the future imaginaries of the Smart Grid are performative.

A retrospecting study by Skjølsvold [2] describes a transformation of the imagined futures of 'advanced electricity meters' in Norway, since discussions about this new technology started around 1998. During the first period of discussions (1998–2003), future accounts of these meters worked as what Skjølsvold calls "stagesetting devices", sustaining debate and enrolling new actors in the debate. From around 2004, the future accounts took on a different form of agency, becoming performative "regulative tools"; with an impact on present formulation of new regulations. This was due to a gradual change in the understanding of what these electricity meters could become in the future, symbolically, practically, and cognitively: The meters went from being regarded as relatively simple information devices, to being seen as a complex hub of information, delivering an array of potential services which could restructure electricity consumption practices. Skjølsvold [2] calls these performative future accounts "translative futures". The electricity meters became "smart meters" and a 'first step' of a larger future vision of the Smart Grid.

The transition to a future Smart Grid can be described as a large-scale technoscientific field of innovation, requiring a physical, technological and social reconfiguration of the entire energy supply system. This entails potentially substantial consequences for individual consumers and has comprehensive social implications. In many countries, grassroots resistance has emerged with the introduction of smart meters, emphasizing concerns related to privacy, security, health and costs.[1] In Norway, smart meters and the future Smart Grid has not yet become a topic for broader public or political debate[2] (see also [10] Inderberg), and signs of grassroots resistance have been minor.[3] Part of the explanation for the relative lack of debate seems to be that discussions regarding the future Smart Grid and the introduction of smart meters mainly are taking place within a network of actors with recognized expertise, competence and knowledge. This can be conceptualized as a techno-epistemic network.

The concept of techno-epistemic network originates from Haas' [11] notion of "epistemic community". Haas' ([11]: 3) defines an epistemic community as "a network of professionals with recognized expertise and competence in a particular domain and an authoritative claim to policy-relevant knowledge within that domain or issue-area". This notion is suitable for knowledge-intense contexts, for example, with knowledge workers united by a shared set of normative and principled beliefs and practices. Rommetveit [12] has introduced the concept of 'epistemic network', which allows for a hybridity of roles and (professional) identities across science-policy boundaries, as well as more heterogeneity and porosity than the concept of epistemic community. In contexts of technoscientific innovation, such as the transitioning to a future Smart Grid, such a network can be conceptualized as a *techno*-epistemic network.

The members of a techno-epistemic network share a dedication and commitment for realizing a technoscientific innovation, related to a specific societal challenge. Following this, anyone responding to or contesting a grand societal challenge, by engaging in innovation activities with others, is in principle a potential member of a techno-epistemic network. The network can have great diversity (e.g. connecting domains such as law, politics, science or industry) and include different constituent networks, for example at different scales. Although commonly building on existing forms of expertise, technologies and infrastructures, new relations can emerge between different forms of relevant expertise across national, sectorial and disciplinary boundaries. Sociotechnical imaginaries, such as the imaginaries of the future Smart Grid, can serve to guide and coordinate action across different parts of a techno-epistemic network. However, it remains an empirical question whether and to what extent such a conceptualization is meaningful for networks of actors in different contexts of technoscientific innovation ([13] Rommetveit et al.). The informants for this study were part of the techno-epistemic network of Smart Grids in Norway. This national network is quite heterogenic and includes (but is not limited to) actors working in network companies, industry organizations, research organizations, technology development companies and regulating- and political authorities.

Inderberg [10] describes that the driving forces behind the introduction of smart meters in Norway were the energy sector, due potential benefits for the energy industry, as well as EU policies and developments (see e.g. [1,14] EC). He argues that the process of developing smart meter regulations included technical expertise from the electricity sector, while consumer organizations had quite limited influence. This argument resonates well with results outlined in this paper; informants emphasized that technical professionals should be consulted if decisions related to smart meters were to be made,[4] and the experts' imaginaries of the future Smart Grid mainly emphasize solutions for the energy industry for dealing with current challenges in the energy supply system. However, the communication to the public about the introduction of smart meters and the future Smart Grid strongly emphasizes potential benefits for consumers. This could also be contributing to the lack of public debate, since this communication does not include information about uncertainties or potential social implications. Following this, there is a gap between what is being communicated to the public and the experts' imaginaries of the future Smart Grid.

This paper argues that part of the reason why this gap exists, is the way 'consumers' are being imagined or constructed. Placing smart meters in individual households gives consumers a central role in the future Smart Grid scenario, and hence perceptions and assumptions about 'consumers', such as how consumers might behave or what they might be willing to accept, are part of the imaginaries of the future Smart Grid (see also e.g. [15] Verbong et al.). The concepts of *'imagined publics' and 'imagined lay people'* (see e.g. [16] Barnett et al.; [17] Walker et al.; [18] Welsh and Wynne; [2] Skjølsvold) are drawn on in this paper on for discussing this construction of consumers as part of these future imaginaries, and how such imagined publics can be decisive for choices being made in the process.

Collective technoscientific visions have better chances of becoming widely shared if they allow for multiple interpretations ([19] Berkhout). While sociotechnical imaginaries of the future Smart Grid often include some common characteristics, they

[1] See for example http://stopsmartmeters.org/, http://stopsmartmeters.com.au/ or http://stopsmartmeters.org.uk/.

[2] The Norwegian Data Protection Agency stated in the media that the introduction of smart meters entails challenges for privacy, data storage and data protection. Beyond this, however, the topic has not been subject to much public or political debate.

[3] Some grassroots resistance does exits, such as a Facebook group, two petitions and a webpage. The webpage describes links to similar social movements in other countries. However, the extent of supporters of these initiatives ranges from just 238–344 members or signatures (as of June 29, 2015). There have also been examples of critical remarks from consumers in newspapers (see e.g. the newspaper Bergens Tidende (BT), August 26, 2012; ' Lite smart for forbrukerne').

[4] In Norwegian, the term "fagfolk" is used about technical professionals. An incident referred to by several informants is when the Minister of Petroleum and Energy suggested rolling out smart meters in the middle part of Norway sooner than the deadline for the rest of the country (see also [21] Throndsen). The reason stated was that this was a particularly weak supply area ([22] MPE). However, the proposal was never put into practice, due to resistance from the network companies. Several informants emphasize that the politicians should have asked the technical professionals before putting such a proposal forth.

are also contextual, varying across scales and domains. Physical, economical, institutional and cultural dynamics (see e.g. [10] Inderberg; [15] Verbong et al.; [20] Verbong and Geels) or national imaginations ([3] Jasanoff and Kim) can be significant for the construction of imaginaries. Inderberg [10] argues that institutional structures, energy-source portfolio, degree of liberalization and interests have been significant contextual factors for Norway's energy policy on "advanced metering".[5] This call for a situating of the future imaginaries of the Smart Grid in this specific national context, as a backdrop for the description and discussion of these imaginaries:

Norway has extensive hydropower resources, and was consuming more electricity per inhabitant than any other population in the world as early as in the 1920s. The industry started out quite fragmented, with highly engaged local municipalities and a large degree of public ownership. However, developments towards national coordination, centralization and market-based trading started taking form in the 1970s. The first of many confrontations between energy state agencies and nature conservation lobbyists also occurred around this time[6] ([23] Skjold). In the aftermath of the oil crisis in 1973, policy-makers constructed 'consumers' as economic rational actors, but with a knowledge- and moral deficit ([25] Karlstrøm et al.). Furthermore, energy policies called "energy economization"[7] were introduced, rooted in ideas from economic theory, with an emphasis on cost-efficiency, implying economically optimal energy consumption and production ([24] Skjølsvold et al.).

The fragmented local electricity distribution with a plethora of small and medium-sized providers, combined with state ownership and control of the top level of the transmission grid, made Norway particularly well-suited for a transition to market trading.[8] In 1991, a progressive power market reform was launched, making Norway one of the first countries to establish a free market for power. In the years leading up to this reform, a majority of policy-makers[9] constructed 'consumers' as economic rational actors, and the previous moral and knowledge deficits were no longer emphasized ([25] Karlstrøm et al.). This pioneer liberalization process can be seen as part of a broader shift towards increased free trade characterizing this period: European integration was progressing with the establishment of an internal market well underway, with goals of liberalizing electricity sectors in member countries and promoting cross-national trade. Soon after, Norway also joined the European Economic Area (EEA) and established the first international power exchange with Sweden, called 'Nord Pool' ([23] Skjold).

The energy sector is still a generator of strong sentiments of local involvement and nature conservation,[10] but has come a long way since its early days: Both the energy sector and the energy infrastructures are now highly centralized and institutionalized, with shared values, norms and regulations. The significance of market rationality has gradually increased, leading up to what nowadays seems to be a widespread support for market logic. The constructions of consumers as economic rational actors have in more recent years been coupled with an emphasis on changing the technological basis of households by subsidizing investments in preferred energy technologies. This seems to be partly based on instances where the prices of electricity have increased, but not resulting in the desired changes in the electricity consumption of consumers.[11] This emphasis on technology makes the moral deficit of the 70s irrelevant; it is no longer a goal to support thriftiness or reduce comfort ([25] Karlstrøm et al.). Yet, electricity savings now seem to be more important than cost-efficiency for Norwegian consumers, due to environmental concerns and values ([26] Karlsen and Ryghaug).

Climate and energy policies continue to be attuned to market measures, rather than technology development or system transformation ([27] Boasson). An example is the market-based green certificate scheme established together with Sweden in 2010, which encourages new production of renewable energy, financed by consumers through an increase in the electricity bill ([28] MPE; [29] NVE). Arguably, an emphasis on market logic comes at the expense of political governance and intervention ([23] Skjold). Skjølsvold et al. [24] notes that Norway lacks a "grand narrative" for the role of decentralized renewable energy and argue that the dominance of market logic has left the governance of renewable energy mainly in the hands of market participants, contributing to a challenging situation for the implementation of new renewable energy technologies. Additionally, the centralized institutional and technological structures could potentially impede the adoption and diffusion of new decentralized renewable energy sources and technologies ([30] Christiansen; [31] Wolsink).

The energy sector's centralized and institutionalized character also manifests itself to some extent in the introduction process of smart meters. Throndsen [21] discusses some of the challenges faced by the network companies when trying to make sense of this major innovation and restructuring process. Even though the energy industry was a driving force for the introduction of smart meters ([10] Inderberg), the increased complexity with the transformation of the imagined futures of this technology (see [2] Skjølsvold) entails that the network companies now become innovation actors ([21] Throndsen), which is quite far away from their traditional role (see e.g. [32] Arends & Hendriks).

After outlining the methodology and theoretical concepts, the imaginaries of the future Smart Grid and the imaginaries of 'consumers' will be described and discussed. Following this, it is suggested to move towards "closing the gap" between the current communication to the public and the expert sociotechnical imaginaries. Inspired by the perspective of post-normal science (e.g. [33–35] Funtowicz and Ravetz; [36,37] Ravetz), it is argued that a more open, transparent and participative, or what Giddens [38] would call 'socially robust', process could be beneficial for addressing the complexity and uncertainty that characterizes this kind of technoscientific innovation. Such an approach holds the potential to increase democratic legitimacy and/or facilitate more careful consideration of potential social implications.

2. Methods and data

This study combined documentary analysis of policy and regulatory documents with in-depth semi-structured interviews.

[5] As seen in Skjølsvold ([2]) retrospecting study, "smart meters" has mainly been called "advanced metering" or "advanced metering infrastructure" (AMI) in Norway.

[6] Protests were related to a project in a place called Mardøla in 1970 and involved civil disobedience.

[7] In Norwegian: "Energiøkonomisering" (ENØK).

[8] It is a crucial condition for creating a power market that no single operator should own or control the core transmission grid. The state owned the top level of the transmission system through the state company Statkraft, established in 1986 to manage the power production ([23] Skjold).

[9] The majority was the center-right government. A minority opposition of policy-makers (the Labour Party and Socialist Left Party) emphasized consumers' right to buy electricity at a "reasonable" price ([25] Karlstrøm et al.).

[10] A recent example is a conflict in Hardanger from 2005–2011, which got national and international media attention. Plans for constructing new power lines over a scenic fjord in Western Norway resulted in extensive public resistance and grass-roots protests, emphasizing environmental perspectives. These power lines were referred to by the protesters as "monster" power lines (in Norwegian: "monster-master").

[11] In the winter of 2002–2003 there was a crisis of supply of electricity and hence increased prices of electricity. This did not lead to significant changes in the electricity consumption of consumers. Following this, the need to change the technological basis of households was emphasized ([25] Karlstrøm et al.).

Documents related to science, technology and power, such as public hearings, policy reports or national policies for regulation of new technologies, can describe national visions of desirable futures driven by science and technology and are useful for examining sociotechnical imaginaries ([39] Harvard STS Program; [3] Jasanoff and Kim; [40] Jasanoff). Relevant documents were identified through literature searches, official webpages and dialogue with informants. Documents identified included national and EU policy documents, national public hearings and an extensive number of relevant reports. In addition, a total of 13 semi-structured interviews with 14 informants were conducted, each lasting for 1-2 hours. These were audio recorded, transcribed and coded by the interviewer. The interviews included quite broad and open initial questions, such as how the informant imagined the future electricity grid.

Since discussions of smart meters and a future Smart Grid mainly were taking place within the techno-epistemic network of Smart Grids in Norway, this network was the starting point for selecting interviewees. An initial mapping showed that this network was relatively extensive, including for instance actors working with smart meters in about 140 network companies, in national industry organizations, within regulating and political authorities, and within companies and organizations doing research, analysis and technology development. Hence, purposive sampling based on the strategy of *maximum variation* was used ([41] Bradshaw and Stratford), in order to get participants with different backgrounds and a variety of perspectives. It was also a priority to include participants with firsthand experience from pilot projects on smart meters or Smart Grids. This was combined with *snowballing*. The suggestions made by informants of other relevant actors who could be potential interviewees also gave empirical weight to the idea of conceptualizing these actors as a network.

The interviewees included 5 informants from 4 different network companies, working specifically with Norwegian pilot projects and programs related to smart meters, 1 informant from the industry organization Energy Norway, 1 informant from the Norwegian Smartgrid Centre, 2 informants from the Norwegian Water Resources and Energy Directorate (NVE), 1 informant working with research on Smart Grids for the grid operator Statnett, 2 informants from the Ministry of Petroleum and Energy and 2 informants working with research on Smart Grids within SINTEF (an independent and non-commercial research organization). There was a majority of male informants (11 out of 13). This reflects that a large part of the national techno-epistemic network works within the energy sector, which is a male dominated sector.[12]

Following Jasanoff and Kim [3] , language was seen as an important medium for the construction of imaginaries and recurrent discursive elements were identified. When the world is envisioned by actors who have the capacity to materialize such visions, discourses (or institutionalized modes of representation) can be important, since imaginaries can be constrained by present and historically produced conditions ([42] Smith: 463). The material was coded using the program Atlas.ti; first descriptively, based on key topics for organization of the material, and then by analytical codes of interpretive themes for analysis. This included 'descriptions or framings of the future Smart Grid' and 'imaginations of the public' for example. The analysis was attentive to scripting[13] of issues and effects of truth. Describing imaginaries requires a generalization of nuances: The majority of informants from network companies and industry organizations used technical terminology to a larger extent than the other informants, and the informants from the authorities[14] applied a larger degree of economic or neoliberal terminology. Furthermore, the informants working as researchers talked more about the social dimension of the Smart Grid than the other informants.

3. Theoretical concepts: sociotechnical imaginaries and imagined publics

Future visions and expectations for what is attainable through science and technology are embedded in social organization and practices, and almost always include implicit shared understandings of what is considered to be 'good' or desirable; such as what constitutes "public good" or a "good" society, or how science and technology could meet public needs ([3] Jasanoff and Kim). Commitments to such shared understandings can reconfigure actors' sense of possible spaces of action, as well as the sense of rightness of action ([40] Jasanoff). The concept of sociotechnical imaginaries was coined by Jasanoff and Kim ([3]: 120), and can be used to explore how actors' produce future visions or imaginaries that describe desirable and feasible futures. Studying imaginaries entails being attentive to how they link past and future times, enable or restrict actions in space, and naturalize ways of thinking about possible worlds ([40] Jasanoff).

Sociotechnical imaginaries can be embedded in or produced by a variety of individual or collective accounts of potential futures across scales (see e.g. [40] Jasanoff; [42] Smith; [45] Pickersgill; [46] Kuchler). Imaginaries can guide and coordinate action across techno-epistemic networks ([13] Rommetveit et al.), establish the need for political decisions, justify new investments in science and technology, promote certain technological pathways or justify the inclusion or exclusion of citizens. Following this, imaginaries can have a performative dimension, taking on a form of agency which can shape the present ([40] Jasanoff; [2] Skjølsvold). Future imaginaries are not a neutral construct; they are framed in a certain way, and some aspects are included while other aspects are being left out ([2] Skjølsvold). Some actors have more power than others to project their imaginations ([47] Harvard STS Program).

We can also learn about future imaginaries by turning to the related strand of literature called the 'sociology of expectation'. This literature studies the informal production and circulation of expectations of science and technology, including how such expectations are structured, how they grow or deteriorate, and how they can affect decision-making processes ([48] van Lente; [49] Borup et al.). Part of this literature explores collective expectations or visions of future possibilities of technoscience, and is hence closely related to the concept of sociotechnical imaginaries. For instance, this literature shows how expectations of a promising technoscientific future can raise attention or legitimize investments ([49] Borup et al.), transcend uncertainty by providing direction in complex contexts ([50] Rip and Kemp) or have a coordinating effect within networks of technological development, serving to mediate across boundaries of different domains and scales ([49] Borup et al.; [51] Konrad). It is also highlighted that early technological expectations can be technologically deterministic, downplaying organizational and cultural factors ([49] Borup et al.), and how overarching visions can face contestation when more specific projects take form ([52] Eames et al.).

In their discussions of sociotechnical imaginaries, Jasanoff and Kim ([3]: 142) include expert's perceptions of the public. In this

[12] The energy sector has had about 20% female employees since 2004 ([43] SSB).

[13] Scripting refers to how actors construct stories or events as examples of a general pattern by referring to their routine character, or like the story or event is an exception from a general and common pattern. This can give the impression that an event or action was 'unavoidable' and therefore appropriate or acceptable ([44] Silverman).

[14] This includes informants from the Ministry of Petroleum and Energy and from the Water Resources and Energy Directorate (NVE).

paper, such perceptions of the public are conceptualized as constructed or *imagined publics*. Literature on imagined publics has typically dealt with the relationship between publics on the one hand and science, policy and technology development on the other hand ([16] Barnett et al.; [18] Welsh and Wynne). Perceptions or imaginaries of an anticipated 'public' can be invoked for various purposes within technical, industrial and policy networks ([17] Walker et al.; [2] Skjølsvold; [25] Karlstrøm et al.). Imagined publics or "imagined lay persons" can be given agency in processes of sociotechnical change and be present at key decision-making points in evolving trajectories of technology development, which can be essential for the framing of lay-expert interactions ([17] Walker et al.; [53] Maranta et al.). Barnett et al. [16], for example, found that preferences for public engagement mechanisms often were a function of the specific characteristics attributed to imagined publics. The "energy consumer" is an integrated part of the imaginaries for the future Smart Grid, often constructed as a rational Resource Man, who is intended to both realize and significantly benefit from this sociotechnical change ([54] Strengers). Ideal expectations of future users and their attributes can even be literally and materially scripted into technologies and sociotechnical systems (see e.g. [55] Woolgar; [56] Akrich; [57] Carlson; [58] Latour; [49] Borup et al.).

4. Results and discussion: sociotechnical imaginaries of the future Smart Grid

This section will explore the expert imaginaries of the future Smart Grid, from within the national techno-epistemic network. This includes descriptions of perceived current challenges for the energy supply system, as well as how the future Smart Grid provides solutions to these challenges. Furthermore, it includes descriptions of how the public or 'consumers' are constructed within these future imaginaries and the way this construction of consumers underpin some of the choices being made in this process of sociotechnical change.

4.1. Solving current challenges: security of supply and integration of decentralized renewables

The imaginaries of the future Smart Grid seems to be closely linked to *security of supply*. Simply put; a relatively secure energy supply means having few black-outs and quite reliable energy production that can match the demand at all times. Several informants describe how Norwegian society is becoming increasingly dependent on constant access to electricity. A frequently used example is the cold winter months and how many households rely on electricity for heating:

> You could tolerate a blackout in 1955, when almost everyone had a wood stove, more easily than you can tolerate it today. The requirements for the quality and security of delivery are much higher today than they were back then, and this is constantly developing, in accordance with the needs of society.
>
> *Smart meters/Grids expert working in the industry organization.*

Following this, security of supply is singled out by several informants as the most important task for the network companies. The companies also get financial penalties if a long-lasting black-out occurs. An illustration of the importance of this aspect is how several informants describe that the security of supply in Norway as currently being over 99 percent, with just marginal uncertainty. The surroundings of the grid, such as nature and weather (see for example [59] Statnett) are described as a main source of uncertainty and hence a potential source of errors in the grid. Smart meters are considered to be a useful tool for dealing with such uncertainty in the security of supply:

> The power supply system must be as secure as possible. At the same time, we have to add requirements for financial efficiency. You know, a 100 percent security of delivery would be way too expensive. But we are high above 99 (...) getting those last tenths would be disproportionally expensive, because it means that there should not be an outage during a thunderstorm (...) But if that happens, AMI [red: Advanced Metering Infrastructure] makes it easier to handle it.
>
> *Smart meters/Grids expert working in the industry organization.*

Informants also describe how detecting such errors currently is a manual process, but that they can be detected and dealt with faster by using the smart meters. Some envision that this will become a completely automated process in the future, which is sometimes referred to as the Smart Grid being a "self-healing grid":

> With regards to Smart Grid, one of the visions is what is called (...) a self-healing grid. This means that the grid, when something breaks, it manages to isolate the error by itself. So just the failing part will be disabled; the rest is switched back on, without any people out there working in the field. It happens automatically.
>
> *Smart meters/Grids expert working in a large network company*.

The introduction of smart meters is also described as part of a development towards a tighter integration and interdependence of European countries with regards to electricity, as a result of an expected future expansion of renewable energy production and an increasingly more integrated European energy market. This is contradictory, however, to the emphasis on security of supply, which is described as a *national* interest and concern:

> The alternative [red: to increasing the proportion of renewable energy sources] for Germany is to buy energy from other countries, and that has some different aspects to it: You do not trust everyone equally (...) and if you do trust your neighbor a lot, you still know that if there is a crisis, and he has to choose between himself and you... Not everyone would share fifty–fifty in that scenario, even if you guys were good friends. And that's the way it is internationally as well, every country needs to have control of their energy supply, in order to have security of supply.
>
> *Smart meters/Grids expert working in industry organization.*

Due to Norway's extensive hydropower, the country does not have to rely on decentralized renewables in order to have a national energy supply based on renewable energy. Following this, introducing smart meters is described as being less critical for Norway than for most other European countries. However, it is still emphasized that the Norwegian energy supply system is "connected to Europe", both through physical infrastructure and through the European energy market. Some informants express that Norway needs to adapt to all EU requirements for smart meters, since this could be necessary for participating in the European electricity market. Some potential functionalities of the smart meter are also considered by informants as "obvious" functionalities, with references to EU developments. It is often mentioned that there is not much leeway for introducing solutions that would be "specific for Norway",[15] and specifying national smart meter requirements

[15] In Norwegian: "Særnorske løsninger".

is considered almost unnecessary (see e.g. [60] THEMA). Comparisons are also made with smart meter processes in other European countries; especially of "how smart" the smart meters are in other countries. It is emphasized that it is important to be "at the forefront" in Europe, avoiding "primitive" technological solutions. As outlined earlier, Norway was also what we can call a "European frontrunner" in liberalizing the energy sector and establishing an international power trade (Nord Pool), so this is not a new idea. This study does not explore further why this aspect is emphasized. However, one could speculate whether this might be considered a way of getting increased influence on European agendas, despite Norway's geographical location a bit on the outskirts of central Europe, and not being a member state of the EU. There are frequent references to Norway as the "green battery" of Europe, and that Norwegian hydropower can serve as balancing power for Europe:[16]

> Being able to release Norwegian flexibility in the production system, which can be sold abroad to a much higher price (. . .) This can be offered to a European market, which screams after that kind of capacity. (. . .) AMI [red: Advanced Metering Infrastructure] (. . .) contributes, so Norway can sell this regulatory capacity.
>
> *Smart meters/Grids expert working in the industry organization.*

This illustrates how the imaginaries of the future Smart Grid partly are permeated by national imaginations; Norway is considered to be a green battery and is also sometimes described as a "green energy nation" due to its hydropower (despite its large petroleum sector[17]). Realizing this green battery vision, however, would require massive investments in transmission cables to Europe ([24] Skjølsvold et al.).

The focus on Norway already being "green" also seems to imply that increasing decentralized renewables would be somewhat superfluous, which could be a barrier for an expansion of renewable energy production. Some informants highlight that decentralized energy production is unreliable, because of fluctuations in weather conditions. However, many informants expect a certain increase in decentralized renewable energy production due to the markedbased green certificate scheme for renewable energy. The smart meters are seen as crucial for connecting such decentralized renewable energy production to the grid. This is sometimes referred to as a "paradigm shift", going from today's centralized one-way production and distribution of electricity, to a two-way production and distribution. It is also envisioned that the future grid would be able to automatically connect or disconnect such decentralized energy production, depending on the demand at any given time. This is sometimes described as a way of reducing or eliminating "the risk of human error". This kind of increased automation due to utilization of information from the smart meters is often what is referred to in descriptions of how the future Smart Grid will be "more intelligent".

The idea of consumers becoming 'prosumers', producing electricity in their own households or communities and possibly sending excess electricity back to the grid, seems to often be a central aspect of visions of a future Smart Grid. In the Norwegian context, however, this is often not included as part of the the future imaginaries. When asked about prosumers, some informants highlight the technical difficulties with connecting renewable energy production from prosumers to the grid. It is also highlighted that this could add to the workload for the network companiesl; the companies might have to assist consumers, due to consumers' lack of necessary knowledge and expertise. Some informants explain that they do not think many consumers would want to become prosumers, with references to surveys which conclude that electricity is a low-interest product. In the few instances when prosumers are included in descriptions of the future Smart Grid, financial incentives are strongly emphasized as a necessary precondition. Hence, consumers are being constructed as economic actors, with a knowledge deficit as well as an engagement deficit. Part of the explanation for this might be the centralized institutional structures of the energy sector: Considering the smart meter as a way of advancing renewable energy applications through increasing the autonomy of end-users does not necessarily fit with current technological and institutional structures (see also [30] Christiansen; [31] Wolsink). Some studies also suggest that Smart Grid stakeholders might assume that current structures and division of tasks between actors will remain more or less the same in the future ([15] Verbong et al.; [10] Inderberg).

This section has highlighted how national interests and imaginations are significant for the construction of imaginaries of the future Smart Grid, with national security of supply being strongly emphasized. The Smart Grid imaginaries also entail an increased interdependence between other countries, but this is less of a concern in the Norwegian context due to the extensive hydropower. However, this might be a barrier for a realization of the Smart Grid vision in other national contexts. It is also evident that the future Smart Grid is a technological vision: Avoiding "primitive" technological solutions is emphasized and technology is seen as providing the grid with intelligence, while humans sometimes are seen as a source of unwanted errors. Technology is also considered to be a tool for combating uncertainty which could potentially cause errors, such as uncertainty caused by nature or weather. The idea that technology can provide control over nature reflects tendencies of technological optimism. However, early technological expectations can be technologically deterministic ([49] Borup et al.). Lastly, the potential for consumers to become 'prosumers' is generally not included as part of the future imaginaries. This could be related to the centralized institutional structures of the energy sector, as well as the way consumers are being constructed; as economic actors with a knowledge deficit and an engagement deficit.

4.2. Solving current challenges: peak demand and increase in EVs

In line with the emphasis on national security of supply, the importance of investments for maintaining and upgrading the electricity grid is frequently mentioned. The dimensioning of the grid has to be on a par with what is called 'peak demand'. This concept refers to the times when the overall electricity consumption is high and the demand hence reaches a "peak". Informants describe how the overall electricity consumption and peak demand follows certain patterns during the day in line with everyday social and cultural practices. Several informants use the analogy of rush hour on a freeway to explain how peak demand is decisive for the dimensioning of the grid and grid investments: In the electricity grid, there cannot be a queue during "rush hours". Hence, it is necessary to build enough "lanes", through grid investments, to avoid any queue. A frequently mentioned concern is an expected future increase in the number of electric vehicles (EVs) due to Norway's generous subsidy policy[18], and in fast chargers for these EVs. This is considered to increase the challenge of peak demand in the future:

[16] The 'green battery' is a multi-faceted idea (see e.g. [61] Gullberg). This aspect was the only dimension of the 'green battery' highlighted by informants in this study.

[17] About 30 percent of the national budget came from the petroleum sector in 2012, for example ([62] MPE).

[18] Norway has quite a generous support and subsidy policy for EVs, consisting of a tax exemption package and driving and financial privileges, which has gradually been implemented in the last 10–15 years. The sales of EVs has increased over the

Using an electrical vehicle does not mean using less energy. (. . .) This consumption will come in addition to the consumption we have today. (. . .) It is a different kind of consumption. When you recharge an electrical vehicle, you suddenly need large amounts of energy and if the electrical vehicle is going to have a future, you cannot wait a day to recharge (. . .). This means that you suddenly have the need to move large amount of energy very quickly, which means you get fast chargers (. . .). You get a whole new situation in the grid, if this becomes dominating.

Smart meters/Grids expert working in a large network company.

The future Smart Grid is considered to make it possible to postpone or reduce costly investments in grid infrastructure. The frequent smart meter measurements of electricity consumption in households enable market-based pricing of electricity, and thereby also new market mechanisms and incentives for consumers. This is referred to by informants as "establishing a demand-response regime", and it is seen as a significant change from the current estimated stipulation of prices. With pricing based on market fluctuations, electricity will become more expensive during periods of high demand. With the demand-response regime, consumers will have access to price information, and hence be able to change their consumption patterns in line with variations in energy prices. This is sometimes referred to as "peak shifting" by "applying consumer flexibility". Many describe this as a possible solution for the challenge of the expected future increase in EVs, since price signals might encourage consumers to charge EVs during the night, for example, and possibly discourage frequent use of fast chargers. Participation in the market and the opportunity to adapt to price signals is seen as an advantage for consumers. Several informants point out that consumers currently do not pay enough attention to electricity prices in everyday electricity consumption, as well as when choosing an electricity provider. The demand-response regime is hence seen as a way of ensuring a well-functioning market for electricity production. In this context, consumers are constructed as economic rational actors, but with an engagement deficit. The measures used for achieving behavior change are mainly financial incentives. Verbong et al. [15] describe how empirical evidence of the potential of financial stimuli is mixed, and that a variety of variables can influence residential energy consumption, such as daily routines, individual preferences, social relations in a household or the way a technology is embedded in daily practices. Furthermore, as we have seen, environmental values seem to be of importance to Norwegian consumers ([26] Karlsen and Ryghaug).

The current requirements for smart meters in Norway is to have hourly measurements, with functionality for increasing this to measurements every 15th minutes ([7] NVE). However, many informants express expectations of even more frequent measurements in the future and some mention the possibility of real-time measurements. A higher frequency of measurement is usually characterized as "technologically more advanced", and hence a better option for being "at the forefront" and for avoiding future reinvestments. Smart meters that have been introduced in other countries with a relatively low frequency of measurements are referred to as "primitive", or even "turtle" solutions (Sweden and Italy being commonly used examples). Frequent measurements give more detailed information and thereby increased control of the energy supply system. However, as the Norwegian Data Protection Agency has pointed out, this increased control, through more surveillance of the grid, also entails increased surveillance of activities inside individual private households. So the increased control comes at the expense of privacy. This is mainly described as a technical issue, which will be dealt with at a later stage.

"Consumer flexibility" is a key concept that illustrates the central role of consumers in the imaginaries of the future Smart Grid. It is often stated that consumers should contribute to the energy supply system by "proving flexibility". This entails what is referred to as having a "more correct" consumption profile; electricity consumption in line with the marked-based price signals. It is emhasized that consumers mainly will be focused on advantages for themselves as individuals, and hence they would not understand "the big picture" of the importance of security of supply for the society as a whole. Consumers' economic rationality and lack of knowledge is perceived as an impediment for an understanding of the "public good":

The lack of understanding of the benefits of grid investments is an important factor which delays and, in the worst case, results in abandonment of socioeconomically desirable grid investments. It is therefore a need to increase the knowledge about the value of the grid in the public space ([64] THEMA: 96).

Due to the combination of low electricity prices and relatively high salaries in Norway, many informants express doubts as to whether consumers actually would change their electricity consumption patterns based on the information from price signals, because the financial incentives would not be substantial enough. Some informants describe how the consumers are "spoiled" with cheap electricity prices. Following this, it is emphasized that the introduction of price tariffs will be necessary, in order to amplify the financial incentives considerably and possibly achieve the desired behavioral changes:

It will still be voluntary. But it will require an effort from you. (. . .) Then maybe someone will find out that boiling rice is cheaper than boiling potatoes, right? Because it takes fifteen minutes instead of half an hour, you can get that kind of effects.

Smart meters/Grids expert working in a large network company.

Such an interference in people's everyday habits in their private homes through the use of financial incentives, could also be considered a reduction of the privacy or freedom in homes. The concept of 'consumer flexibility' entails a commodification of individual behavior in households: 'Flexibility' in individual behavior can be "offered" by consumers in exchange for economic benefits and then be "applied" by network companies. However, this is not necessarily a fair trade; different households will have various financial situations, and financial incentives and price tariffs as a means to achieve desired behavior change will hit some households harder than others. Financially vulnerable households might not have the choice of "offering flexibility", but rather feel forced to adapt. One informant describes that it is a challenging situation already for some financially vulnerable households during winters with high prices:

We know that in those years, for example in 2010, when the price was very high, like in January and February. There are some older people, for example, who use almost no electricity at all, and get pneumonia. (. . .) Almost every year, someone dies because they have not paid the electricity bill, and they [red: the network company] turn off the electricity. There are some tragedies every year. So some people do care about the electricity bill.

Smart meters/Grids expert working in a large network company.

last few years; from 1,4 percent of the new car sales in 2011, increasing to 5,5 percent in 2013, for example ([63] Holtsmark & Skonhoft).

Following this, the interest or engagement deficit in the construction of consumers seems to not necessarily apply to the financially vulnerable households. However, this topic seems, to some degree, to be *silenced*[19] and hence it is not discussed much. Some informants point out how fixed-price options for financially vulnerable households would result in a less well-functioning market, and some highlight that this aspect will be dealt with at a later stage.

This section has shown how the future Smart Grid is characterized by economic rationality, which is in line with the gradually growing significance of market logic in the Norwegian energy sector. "Consumer flexibility" is considered to be a central tool for reducing peak demand and for meeting the challenge of an expected future increase in EVs. This gives consumers a central role in the imaginaries of the Smart Grid, but consumers are constructed as economic rational actors with an engagement deficit. An emphasis on technologically advanced smart meters which generates detailed information has implications for privacy. However, this is often reduced to being seen as a technical issue. Furthermore, the aspect of how this will affect financially vulnerable households, is to some extent silenced. These two examples of social implications that are not being adequately addressed illustrate the need for including a broader range of expertise and perspectives beyond the current network of energy experts in this sociotechnical innovation process, thereby possibly becoming more sensitive to potential social implications ([38] Giddens; [34,66] Funtowicz and Ravetz).

4.3. Automating the home: Consumer flexibility without consumers?

The smart meter is also seen as central for instrumenting the home, and for a development towards Smart Homes. Increased automation in households is expected to make it easier for consumers to change their consumption patterns. "Smart" appliances are expected to become more common. Informants describe that it is expected that such appliances will be possible to turn on or off automatically through the smart meter, in accordance with price changes and the overall demand for electricity:

> You need to instrument your house. (. . .) If you get the brain [the smart meter] in, it is easy to instrument it. Because it will recognize everything (. . .), like sensors and be able to get things started, services and so on.
>
> *Smart meters/Grids expert working in a medium-sized network company*.

This reflects a construction of consumers which includes an engagement deficit and a continuation of the descriptions of Karlstrøm et al. [25] of the introduction of policies emphasizing the need for changing the technological basis of households. It is imagined that smart appliances, or certain elements of the Smart Home, also could be remotely steered and controlled by external actors. as examples of such external actors, informants mentioned the network companies as well as actors within a new market of supplementary services, which is expected to emerge. Some also highlighted that using such supplementary services usually would entail sharing personal smart meter data with third-party actors. The conceptualization of homes as 'Smart Homes' and the possibility of external steering makes the border line between *public* energy infrastructure and *private* homes more blurry, which call for considering the implications of such a change for the privacy of the home. However, in a study from the Netherlands, it is considered unlikely that end-users would trust an external party to have control over home appliances (Verbong et al. [15]).

Thermal loads, such as domestic hot water cylinders or heating in floors, are often highlighted with regards to remote steering. Informants explain that such loads could be turned off for some time without considerable change being noticed in the household. There is some concern, however, related to the risk of not being able to remotely switch the thermal loads back on after they have been remotely switched off. This functionality has proved to be challenging in demo tests. However, many informants emphasize that technology will develop fast and probably solve this issue later on. Furthermore, it is often highlighted that EVs could be used for increasing flexibility, by using the batteries in the vehicles for energy storage and also making this flexibility available for remote steering by external actors. Even though several informants explain that this possibility of using EV batteries as storage capacity is not available or economically feasible yet (see also [31] Wolsink), it is again emphasized that technology will develop fast and provide solutions. There are differing views on whether or not some form of consent from individuals would be needed for doing such remote steering. It is also envisioned that external steering of consumption in households could be made mandatory by the authorities in the future.

A switch will be installed as part of the smart meter roll out in Norway ([7] NVE), making it possible to remotely shut down the electricity in a household. It is emphasized by several informants that this switch is an EU requirement, and hence a necessary functionality. There are, however, different perspectives on the switch functionality: Many describe that it will be useful for remotely turning off electricity when someone moves from one house to a new one, which today is done manually. Another aspect highlighted is that the switch will be useful for cases where customers have not paid their electricity bills and the electricity hence needs to be turned off. The personal safety for the employees who have the job of manually turning off the electricity in such situations is mentioned as a concern, which in the worst cases can experience being threatened. Some informants express concerns, however, such as the possibility of hackers getting control of this functionality and hence being able to turn off the electricity in households or whole neighborhoods. A related concern is unauthorized access to personal smart meter data through hacking. Another potential challenge outlined is the risk of turning off health-related equipment in homes which might need electricity to function. Another perspective is the idea that access to a minimum of electricity should be a right for everyone, regardless of whether the electricity bills are being paid, especially since some households rely on electricity for heating:

> (. . .) Even if you cannot pay the bills, you should be entitled to get enough electricity delivered to have light and heating, at least in one room in the residence, right. So that you do not freeze to death and so it is not dark.
>
> *Smart meters/Grids expert working in a large network company*.

This section has described imaginaries of the future instrumented Smart Home, which is expected to make it easier to achieve desired changes in electricity consumption patterns. The constructions of consumers include an engagement deficit. Furthermore, it is imagined that Smart Homes partly could be externally steered, which can be seen as a way of getting closer to the goal of "peak shifting" without actively engaged consumers. This potential for external steering makes the border line between the public energy infrastructure and private homes more blurry. Some

[19] In discourse analysis, silence refers to how frameworks of understanding always conceal as much as they reveal about the world. Identifying silences is an integral part of discourse analysis ([65] Waitt: 236).

Table 1
Comparison of the communication to the public and the future imaginaries of the Smart Grid within the techno-epistemic network.

	(1) Communication to the public	(2) Future imaginaries of the techno-epistemic network
(i)	Customers will get a more correct invoice and not have to manually send in data about their electricity consumption. Today, the invoice is based on stipulated data, but with the smart meters in place, more accurate data will be available.	With regards to automatic measurements and smart meter data, the importance of enabling a demand-response regime and consumer flexibility is emphasized. The benefits for consumers of automatic measurements are described as being of marginal importance. Some hightlight that a more correct invoice as a result of the smart meters potentially can improve the relationship between the network companies and their customers: Firstly, because the data no longer would be stipulated. Secondly,some point out that the customers only would get one invoice, which would include the costs of both the transmission tariff and of their electricity consumption. Increases in the transmission tariff are often contested and causing public debate. The new invoice is expected to make the transmission tariff "less visible" for consumers. Increases in this tariff are often contested and causing public debate.
(ii)	The information becoming available about electricity consumption will enable the network companies to assist customers in a better way, if they have any complaints or questions regarding their invoice.	One informant explains that complaints about the quality of delivery of electricity today often give an outcome in favor of the customer and hence result in a monetary compensation from the network company. It is pointed out that it would be a benefit for the network companies to be able to check the validity of complaints by using the data from smart meters. Following this, more complaints might get dismissed.
(iii)	The customers will be able to reduce their electricity bill by changing their consumption patterns.	The potential for customers to save money on their electricity bill is generally not considered to be very significant: "(. . .) maybe you can treat yourself with four or five extra lager beers a year, for the money you save, and this can contribute to changing attitudes." *Smart meters/Grids expert working in a large network company* It is expected that price tariffs will be introduced, which entails stronger incentives for changing consumption patterns in the future.
(iv)	Consumers can use the new information available to reduce their overall electricity consumption, which is beneficial for the environment.	The main emphasis in the future imaginaries is not to reduce the total electricity consumption, but rather to reduce "peak demand" in order to achieve an more balanced electricity consumption overall during the day. "Consumer flexibility" and "peak shifting" is seen as central for achieving this. Environmental aspects are less emphasized: "AMI [Advanced Metering Infrastructure] has not been developed because of environmental aspects. (. . .) AMI has not been made with the intention of making us more environmentally aware." *Smart meters/Grids expert working in a large network company* Some informants point out that encouraging the public to use less electricity than they do today would be an unpopular message to communicate, both for politicians and for representatives from the energy sector.
(v)	It will be easier for the consumers to change their supplier of electricity.	This is also included in the imaginaries of the Smart Grid, but it is not emphasized that this is a benefit for consumers. It is seen as important in order to ensure a well-functioning market for electricity production.
(vi)	The consumers can produce their own electricity and earn a profit from selling the surplus energy, becoming what is called a "prosumers". This can expand Norway's renewable energy production.	It is usually considered to be rather unlikely that it will become widespread to produce electricity in households, due to a lack of expertise and engagement. When this is included as part of the future imaginaries of the Smart Grid, the need for financial incentives is emphasized.

potential challenges of this functionality are being discussed within the techno-epistemic network, including whether the external steering will work as planned and the possibility of unauthorized access to the steering/control or to smart meter data through hacking. To a large degree, such potential challenges are seen as technical issues and there are tendencies of technological optimism, with an emphasis on new technology providing solutions. As have been suggested earlier in this paper, these tendencies could possibly be counteracted by including a wider range of expertise and perspectives in the decision-making process, inspired by a post-normal approach (e.g. [34] Funtowicz and Ravetz).

4.4. Communication to an imagined public

As we have seen, the main emphasis in the future imaginaries of the Smart Grid is on potential solutions for the energy industry to current challenges in the energy supply system. The communication to the public, however, emphasizes the potential advantages for individual consumers. Table 1 illustrates this gap between the imaginaries of the techno-epistemic network and the communication to the public.[20] Preferences for public engagement can be a function of characteristics attributed to imagined publics ([16] Barnett et al.). The communication emphasizing benefits for consumers seems to reflect the construction of "consumers" as economic actors who would be focused on individual benefits.

The communication to the public could hence be seen an attempt of achieving public acceptance of smart meters. Many informants describe previous experiences of trying to get public acceptance for necessary grid infrastructure investments as

[20] The first column was constructed based on a summarizing of documents, brochures and webpages with communication to the public related to the on-going introduction of smart meters. The second column was constructed based on the interview data with informants from the techno-epistemic network.

challenging. Previous public debates related to increases in the transmission tariff that end-users in pay to the network company (because of grid investments) is highlighted, as well as recent protests against the construction of power lines in the Hardanger area in Norway.[21] The costs for introducing smart meters will be covered through an increase in the transmission tariff ([5] NVE), so some of the informants express concerns about whether the customers will understand how the benefits of the smart meters legitimizes the increased cost. Grassroots' resistance has not emerged so far in Norway, but some informants mention protests that have happened in other countries when smart meters have been introduced.

The grassroots resistance that has occurred in other countries can provide us with important lessons with regards to public acceptance of smart meters, which also go beyond cost-related issues. In the Netherlands, for example, the introduction of smart meters was met with resistance. This was mainly due to privacy issues as well as a lack of democratic legitimacy, since decision-making to a large extent happened behind closed doors. Lessons learned from this case could include a need for open and transparent communication, and inclusion of a variety of interests and perspectives ([67] Cuijpers and Koops; [68] Hoenkamp et al.). Hess [69] describes that the development of strong communication and outreach programs has been part of the standard policy responses to opposition against smart meters in the US. However, he suggests seeing the public opposition as an opportunity to develop innovations in system design that could reduce conflict in a long-term perspective, rather than aiming to "educate" consumers based on assumptions of knowledge deficits.

Parallels can also be drawn between the 'imagined public' in this case study and Wynne's ([70,71]) descriptions of implicit deficit models of the public and assumptions about 'typical publics', which can structure scientific discourses. Wynne ([71]: 220) emphasizes how institutions can cultivate their own trustworthiness by being self-reflexive with regards to their own assumptions. This could contribute to making normative assumptions or commitments more explicit, and hence to opening them up for open examination and debate (see also [18] Welsh & Wynne). Giddens [38] points out that this kind of openness cannot simply be seen as an exercise for communication experts, but should be broadly encouraged and recognized institutionally. Opening up the decision-making process to other actors with a variety of interests and perspectives, could be one way of potentially democrating and strengthening the legitimacy of this technoscientific innovation process (inspired by e.g. [34,66] Funtowicz and Ravetz; [72] Frame and Brown). This calls for moving towards "closing the gap", between the sociotechnical imaginaries of the future Smart Grid and the communication to the public, by facilitating broad dialogue and debate which could contribute to more careful consideration of social implications.

5. Conclusion

A national techno-epistemic network is in the driver's seat of process of comprehensive sociotechnical innovation towards a future Smart Grid, entailing physical, technological and social reconfiguration of the energy supply system. The performative future imaginaries of the Smart Grid are partly permeated by national imaginations and are to a large extent technological and economical; entailing on increased surveillance of the grid and utilization of new data. With discussions to a large extent being contained within the techno-epistemic network, and communication to the public strongly emphasizing potential benefits for consumers, this radical transformation is now gradually starting to take form without public debate.

The future imaginaries of the Smart Grid is based on the narrative voices of the techno-epistemic network, providing solutions which reflect current institutional and technological structures and keep these structures relatively intact. The Smart Grid is described as a necessity for technological progress, enabling increased automation and control of the grid. The future imaginaries include some techno-optimist tendencies, such as ideas of technology providing control over uncertainties caused by nature, as well as providing "intelligence", and solving potentially challenging social issues. Furthermore, the Smart Grid energy imaginaries are underpinned by market logic, which has been a significant characteristic of the Norwegian energy sector the last few decades. This is encapsulated in the concept of "consumer flexibility", which entails a commodification of individual behavior in households. The future Smart Grid provides increased control of the energy supply system for the energy sector through increased flexibility from consumers.

The gap between the future imaginaries of the techno-epistemic network and the communication to the public seems to partly be based on the way consumers are being constructed within the techno-epistemic network. Imaginaries of consumers as economic rational actors can be traced back to the early 70s in Norway and are still prevailing. The use of financial incentives in order to achieve behavior change and reduce 'peak demand' is key in the future imaginaries of the Smart Grid. However, the construction of consumers also include knowledge and engagement deficits. Following this, instrumented and externally controlled Smart Homes are included in the imaginaries, which can be seen as a way of reducing peak demand without actively engaged consumers.

There is an underpinning tension between (i) the techno-epistemic network's emphasis on the security of supply as a public good on the one hand, and (ii) the autonomy and privacy rights of individuals on the other hand. Several examples in the empirical material show how the former seems to come at the expense of the latter. Potentially substantial social implications, such as privacy, security, external control of appliances within private households, health-related issues, environmental perspectives and consequences for financially vulnerable households, are not being sufficiently addressed and to some extent also being reduced to technical issues.

This illustrates that the complexity of this technoscientific innovation process call for including different kinds of competencies and expertise, beyond the current core network of energy experts. The introduction of smart meters has been met with public resistance in many countries, for example in the Netherlands. In the Dutch case, this was mainly due to privacy issues and a lack of democratic legitimacy. The lessons learned included a need for a more open and transparent communication to the public and the inclusion of a variety of interests and perspectives ([67] Cuijpers and Koops; [68] Hoenkamp et al.).

Encouraging institutional self-reflexivity with regards to assumptions and commitments, as well as more open communication about future imaginaries as well as the decision-making process could be a way of potentially increasing democratic legitimacy and possibly contributing to institutional trustworthiness ([71] Wynne; [38] Giddens; [68] Hoenkamp et al.). Addressing complexity by the recognition of a multiplicity of legitimate perspectives (inspired by [34,66] Funtowicz and Ravetz) and including a larger degree of public participation and dialogue could fascilitate increased sensitivity to social implications, and in that sense contribute to a more "socially robust" process. As stated by Collins and Evans ([73]: 136); "*it is rare to find a technological decision that calls for nothing more than the opinions of specialists*".

[21] See footnote 10 in the introduction.

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