Ref. Ares(2017)5847458 - 29/11/2017

# CANDID

**Checking Assumptions aND promoting responsibility In smart Development projects**

| | |
|---|---|
| Deliverable: | D2.2 |
| Title: | Scientific Publication (Working Paper) |
| Work package: | 2 |
| Due: | 30.11.2017 |
| Submitted: | 29.11.2017 |
| Author: | Antti Silvast, Robin Williams, Charles Raab, Andrey M. Elizondo Solano, Andres Dominguez (EDIN), Kjetil Rommetveit (UiB), Alessia Tanas, Niels van Dijk (VUB) |
| Type: | Public |

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 732561.
Work programme ICT-35-2016: "Information and Communication Technologies: Topic:Enabling responsible ICT-related research and innovation "

# Promoting Responsible Designs and Users in Smart Grid Projects

*Working paper*

## Introduction

'Smart' development projects and initiatives have been proposed as offering a solution to an increasing range of current social challenges, from the impacts of climate change to energy issues, citizen participation, the ageing population, and ensuring economic growth. The vehicles of this development include but are not limited to sensor devices, wearables, the Internet of Things (IoT), mobile applications, big data applications, cloud computing, and a variety of information and communication technologies (ICTs). These devices promise an increasing convergence of virtual, social, and physical aspects of our societies by bringing about online communications and interconnectivity, pursuing desirable societal futures in so doing.

A key in discourses of 'smart' technology development is enabling new kinds of routines and practices whether in households, government branches, or infrastructure provision. Smart discourses configure technology users with certain characteristics and attributes, with a particular emphasis on promoting self-management to tackle big societal challenges. Our paper, based on the H2020 CANDID EU research programme (Grant No. 732561, www.candid.no), contributes to this work by drawing upon insights from Science and Technology Studies (STS) and related social science and humanities scholarship, examining the experiences of experts working in collaborations between social science and humanities and ICTs. We argue that these experiences and disciplines contain valuable insights that could be taken into account by innovators, researchers, and policy-makers pursuing 'smartness'.

As this paper discusses, various actors (including, for example, researchers, associations, branches of government, and household members) make different representations of the 'users' of smart technologies. These representations play important functions, since they serve to frame and structure management, organisation, and the development of technical innovation, and also figure prominently in communications aimed at other actors, including 'society' at large. The aim of Responsible Research and Innovation (RRI) is to align the perspectives and actions of the variously implied actors with a view to their societal and ethical sustainability and acceptability (Bessant, 2013; von Schomberg, 2013). Thus, there is also a strong need to articulate these different meanings and representations of 'users'. This is even more so due to the additionally strong ethical role of the 'user', not just as an organisational principle, but as the claimed beneficiary of innovation, and as the holder of rights (consumer and fundamental, i.e., privacy). This paper aims to contribute to this work of the articulation of users, with a view to the possible alignment of actors in line with recent work on RRI (e.g. Jirotka *et al.*, 2017; Rommetveit *et al.*, forthcoming).

The key smart technologies this paper investigates are *smart grids* – electricity infrastructures that involve the increasing use of information and communication technologies (ICTs) to collect data – and *smart energy meters* – one of the main component of smart grids, installed in domestic buildings, businesses, and other sites of energy usage demand. Smart grid projects are informed by representations of future technological capabilities that innovative devices and technological developments are designed to enact (Borup *et al.*, 2006; Schick & Winthereik, 2013). These projects are closely coupled to anticipations of new kinds of energy 'users', uses, and behaviour enabled by smart grids. This paper aims to advance STS perspectives on smart grid technologies by addressing two overarching questions. It explores, first, 1) *the promissory work being done by smart grid development projects* and, second, 2) *whether, and if so, how that work provides a way to identify the needs of actors and build a bridge toward achieving them*. The paper contributes to a considerable body of research in STS on user-technology relationships (see Oudshoorn & Pinch, 2003; Hyysalo *et al.*, 2016) and the technological, social, and policy assumptions and implications of smart grids and meters (e.g. Wolsink, 2012; Darby, 2012; Nyborg & Røpke, 2013; Strengers, 2013; Skjølsvold *et al*., 2015; Ballo, 2015; Bulkeley *et al*., 2016; Throndsen, 2017; Lovell *et al*., 2017; see overview in Sumpf *et al*., 2017).

The structure of this paper is as follows. We first explain our conceptual positioning on smart energy technologies, starting from policy programmes and moving to reviewing earlier social science and humanities scholarship on these topics. The next part introduces the case and then presents it in two sections – focusing on the representation of almost anyone being 'user' of smart grids and smart metering firstly and discussing this understanding in the next section considering how challenging it has been to anticipate the needs of very different individuals and communities connected to the putative smarter energy system. The last section concludes by bringing forth our recommendations and views and suggesting possibilities for further work in research and development of smart grids from the perspective developed in this paper.

## Conceptual positioning

### *Policy programmes and benefits of smart energy*

Smart grids have been an objective of major energy investment and infrastructure modernisation policy programmes (e.g. Executive Office of the President of the United States, 2011; UK National Infrastructure Commission, 2016). The needs of one kind of actor – the energy 'end user', 'final user', consumer, or other related terms – are prominent among the promises concerning these programmes. In EU policy documents, deploying smart grids and metering promises new possibilities for self-managing energy consumption, improved energy efficiency among final consumers, and transition to more consumer-centric energy systems (e.g. European Commission, 2011; 2014; European Parliament & Council, 2012). The smart metering rollout in the United Kingdom by 2020, as part of a wider digitalisation in energy systems, has been linked with accurate automatic billing and real-time energy consumption feedback, these being services which are expected to greatly benefit domestic end-users (Helm, 2017).

In practice, however, there has been considerably more diversity, dispersion, and breadth concerning who and what the 'users' and uses of smart grid might be. For example, UK analyses (BEIS, 2016; see Figure 1) predict that energy consumers will enjoy about one-third of the benefits of smart metering, mainly by enhanced energy efficiency behaviour and energy savings (BEIS, 2016: 11). This promise premises upon by all final users – whether microbusinesses or householders – saving money and energy by getting nearly real-time information on their energy use and costs. To carbon saving and air quality, the benefits of this and increased efficiency in the energy system are a little under 10 percent of the total. But the same figures foresee that the majority of the UK's total financial benefits will be in the energy system: realised among energy suppliers and their operational cost savings and to some extent energy network operators and in the shifting of energy usage demand during peak loads.

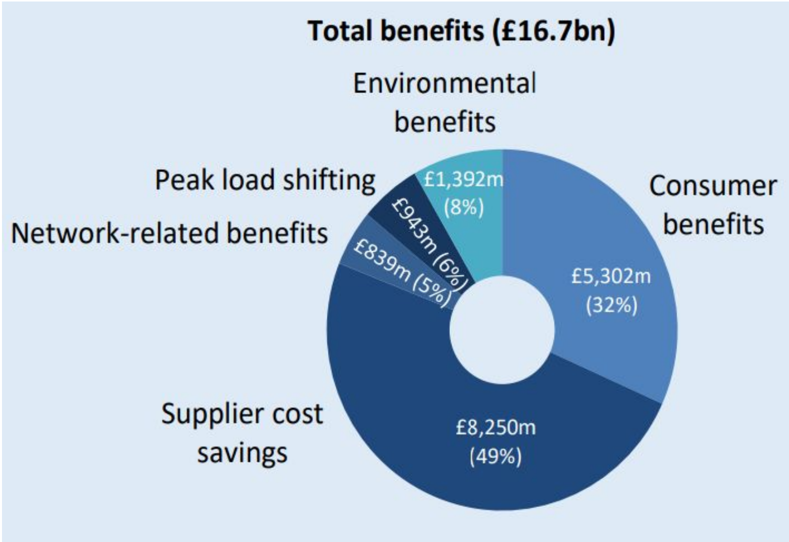


Figure 1. The total benefits of UK smart metering programme. *Source*: Helm, 2017: 65, original data from BEIS, 2016.

The UK's smart metering rollout is expected to cost 11 billion GBP, mainly for the smart meters themselves, their installation, their in-home displays, and new communications infrastructure. With the cost in view, the UK Parliament has called for evidence of benefits of smart meters to householders and businesses, especially in the light of the expected annual cost savings in domestic electricity and gas use via smart meters (UK House of Commons, 2016: 26). The technical specifications in industry standards of smart meters are also being developed, from SMETS 1 ("Smart Metering Equipment Technical Specifications 1") to its next version SMETS 2. One concern of this development has been ensuring the switching of energy supplier with a smart meter retains 'smart' functionalities, consequential especially as smart energy projects are underpinned by promises of enabling more economic behaviour such as consumer choice (Strengers, 2013).

Meanwhile, in some countries, people have reacted to and opposed smart energy meters in avoiding information overload, or out of concerns over privacy, protection of their personal data, or particularly in the United States and Canada, health worries. The Netherlands, California, UK, and Canada have seen either anti-smart meter campaigns, law suits against smart metering, critical reports by consumer organisations, or motions passed by governments (van der Horst *et al*., 2014). In cases like this, the supposed 'users' of smart grid resist technology – without necessarily having used it first – on the premise that it constitutes an intrusion on their rights. Von Schomberg (2011), who is based at DG Research and Innovation of the European Commission, uses the Dutch consumer pressure against smart metering – which led to legislative changes – to illustrate how such situations mandate more proactive consideration of all societal actors in technology design i.e. Responsible Research and Innovation:

> These concerns (on privacy grounds) could have been avoided if societal actors had been involved in the design of technology early on. ‘Privacy by design’ has become a good counter example in the field of ICT by which technology is designed with a view to taking privacy into account as a design principle of technology itself. (von Schomberg, 2011: 12.)

At the same time, many countries such as Italy, Finland, and Sweden enrolled smart metering seemingly with little contestation. But even there, some members of the broader population have been reluctant to adopt new energy services offered by smarter systems, for example in Finland (Kahma & Matschoss, 2017), where there is a full rollout of smart meters and automatic meter-reading systems.

*User-technology relationships*

Smartness and its supposed beneficiaries invite us to consider much more carefully how ‘users’ – whoever they may be – and their ‘needs’ – whatever they might be – may be met by smart grid projects. We argue that STS scholarship that has focused on user-technology relationships for decades (e.g. Bijker *et al.*, 1987; Akrich, 1992; Oudshoorn & Pinch, 2003; Oudshoorn *et al.*, 2004; Stewart & Williams, 2005; Hyysalo & Johnson, 2015; Hyysalo *et al.*, 2016) provides a very promising vantage point for this aim. There are several matters of debate that the STS of ‘users’ opens up: who or what the ‘users’ of technology are expected to be; in which manners do designers represent and relate to these ‘users’ and how they understand their characteristics; and how ‘users’ may articulate technologies similarly or differently than in the envisaged designs and shape back the design process in so doing.

Considering the meaning of the term ‘user’, a main contribution of this STS literature has been addressing the ‘user’ not merely as an identifiable person in the sociological sense – however important that may be – but as an entity relational to the designers of technology (Oudshoorn *et al.,* 2004). This relationality means that researchers and developers tend to represent and bridge toward ‘users’ in myriad ways during technology’s design, whether it be via business models, market studies, consumer panels, co-design workshops, or even just their common sense (Hyysalo & Johnson, 2015). This kind of representation of ‘user’ is also directly relevant in thinking about large energy systems and their sustainability. While the idea of users as source of innovation is not new, the notion of ‘active users’ seems to have accelerated in the recent years, alongside aspirations of more responsible innovation that involves multiple players – from conventional companies to final users – in planning for more sustainable services and systems (see Bessant, 2013).

We believe that the development strategies that this responsible innovation will need are directly consequential for the rollout of smart metering and smart grids. The paper makes an overarching contribution to the study of smart grid technology and the related STS literature by utilizing and advancing these perspectives. First, we briefly review the growing body of literature in STS on smart grids and meters and discuss the position that these works have taken on the ‘users’ of smart technologies.

*Smartness and desirable technological advances*

An important context of smart grids and smart meters comes from within the wider push of making many aspects of our society 'smart', where 'smartness' is defined by a certain kind of modernism, meaning increased rationalization and individuality. In earlier STS research, smart grids, their 'users', and uses often relate to these advances as such: for example, in projects of smart urbanism, resilience and self-healing of energy systems, integration of smart grids with smart home technologies, integration of digital and non-digital infrastructure, and data sharing between various actors. Studies tell us that smart energy constitutes an entire 'smart' ontology that enacts new data-driven relationships between energy producers and users (Strengers, 2013). Smart grids enable more intelligent management of electricity networks, especially to cope with intermittent renewable energy sources such as wind and solar (Verbong *et al*., 2013). Smart grid and smart meters are key in wider transitions to 'smart' urbanism (Luque, 2014; Powells *et al*., 2016). At the level of households, smart meters also promise to be central in enabling information flows in the 'smart' home (Hargreaves *et al*., 2013; Wilson *et al*., 2015).

In pointing to desirable technological advances, this research area is closely related with a commonplace theme in STS, the *sociology of expectations* (Borup *et al.*, 2006) – wishful enactments of desirable technological futures – and *socio-technical imaginaries*. Ballo (2015: 12) applies the concept of socio-technical imaginaries in order to "explore how actors produce future visions or imaginaries that describe desirable or and feasible futures" in smart grid projects. The Norwegian smart grid initiatives which she studied mainly draw upon two 'visions' that she separates and labels as 'technological' (e.g. adding electricity grids with intelligence, utilizing new data) and 'economical' (e.g. adding electricity grids with market logic, offering new possibilities for energy consumers) that are also nationally bounded. Other works have used the concept of imaginaries to explore how smart grids also produce visions of very different smart grid 'users' (Throndsen, 2017), which we touch upon below.

*The configuration of the 'user'*

As STS research makes clear, a common argument for developing smart energy projects has been in producing new kinds of energy use behaviour. While the evidence for this change is still being gathered, smart grids are meant to allow individual energy users to become more rational and reflective and to start to interact and transact with energy producers and markets in a new way. It is expected that individuals' behavioural changes will be provided by the smart technologies such as smart meters, driven by energy and cost savings (Strengers, 2013; Groves *et al*., 2016). Similar 'preconfiguration' of certain kinds of users in smart energy industry standards and energy policies has also received attention (e.g. Darby, 2012; Pullinger *et al*., 2014; Schick & Gad, 2015). Throndsen (2017), reviewing literature on smart grids research papers, claims that 'preconfigurations' of residential smart grid user fall within three wide categories: economic configuration (making 'users' more active in an economically rational way); technical configuration (automation of energy consumption and bypassing active forms of use); and social science configuration (evaluating imagined users against 'real' ones, whoever they may be).

Current STS research on user-technology relationships talks about similar themes by saying that users are relational entities to technology design (Hyysalo & Johnson, 2015) or that technologists ‘configure’ users (Oudshoorn *et al.*, 2004). But the topic of predetermining the user in technology projects is long-standing in STS scholarship. Since Steve Woolgar in the 1980s and Madeleine Akrich a few years after (see Oudshoorn & Pinch, 2003), we have known that technological artefacts contain *scripts* of how they are supposed to be used and by whom with specific competences, motives, tastes, aspirations, morality, and so forth. However, what sometimes tends to be forgotten is that the analysis of scripts was not meant to predetermine the setting of technology use, and technological scripts are indeed only very rarely able to determine how technology will be used (Akrich, 1992). In practice, when technology leaves the laboratory or other development setting, it is confronted by other pre-configurations and reconfigurations by users working alongside the pre-configurations by developers (Hyysalo, 2010). Much of the next branch of research works from this premise and unearths how these reconfigurations happen in practice with smart energy technology.

*Actual individual users and households*

Since classics, social science and humanities scholars have made sustained attempts in critiquing other models of behaviour, especially the rational actor models developed by neoclassical economics (Wagner, 2001). Strictly speaking, mainstream economics is interested in the efficient allocation of resources rather than the conditions that hold social order together (Silvast, 2017a). Sociology research typically questions such economic assumptions, but to recent research on user-technology-relationships, it would hardly be surprising that developers are a priori not fully capable of predicting how technology will be used, at least exactly, or always representing the kinds of actors that will use it (Stewart & Williams, 2005). Indeed, many social science scholars of smart grids and smart meters have reacted to types of ‘preconfigurations’ of user above and its models. They have highlighted the diverse and often unpredictable ways in which consumers engage with smart energy, most typically in their homes (e.g. Nyborg & Røpke, 2013; Hargreaves & Wilson, 2017; Winther & Bell, forthcoming) but also partially as part of wider such as residential areas (Bulkeley *et al.*, 2015).

These are valuable insights especially to understand why supposed ‘users’ may wish to become ‘non-participants’ of the smart grid, for example in smart grid demonstration sites (Throndsen, 2017). But another possible consequence of this research – perhaps unintended – is that while it often speaks about addressing ‘actual users’ or ‘real users’, it can relate to these users only in a specific way: rather than by assuming them to be rational agents whether technologically or economically, by social research methods such as fieldwork, semi-structured interviewing, or surveys. Thus, from the literature reviewed this far, seemingly only two main positions on user-technology relationship open up: either focusing on “actual sociological users” or “users preconfigured by technology designs” (Oudshoorn *et al.*, 2004). We need to go further than this to understand the diverse potential user-technology relationships in smart grid development projects.

*Overcoming the gap between user configurations and actual users*

Examples from smart grid development challenge the user-technology relationship seen in simplistic terms. For example, the problem of how socially acceptable smart grid and smart meters are and the associated protests (Wolsink, 2012) suggests a case where users do not simply passively accept preconfigured technology, or simply use it in unanticipated ways.

Rather, public protests actually mediate between the dissatisfaction of end users and the rationality of expert decision-makers (Alapuro, 2011) and may influence future designs when made into court cases and laws, although this has been a rather fractured and reactive form of mediation.

The putative risks of smart energy technologies suggest a similar conclusion – for example their alleged vulnerability or privacy issues (Verbong *et al.*, 2013), or cyberattacks against smart grids (e.g. European Commission, 2013; Eurelectric, 2016). They articulate a powerful risk that could provoke more anticipation, engagement, reflection, action, or *responsibility* (Jirotka *et al.*, 2017; Rommetveit *et al.*, forthcoming) concerning the society-wide impacts of smart energy innovations.

Within a similar context, STS research on information infrastructure (e.g. Edwards *et al.*, 2007; Pollock & Williams, 2009) has shown that the diversity of potential future users and uses of such infrastructure often overcomes its developers and creates the risk of them rolling out already legacy systems. To this end, those involved in building such information systems have adopted more experimental development strategies that continuously 'configure' and 'manage' their communities of 'users'. These communities are also often more fine-grained than the prior configurations suggest and can articulate their demands in ways unforeseen by designers, which may then feed back into future designs (Stewart & Williams, 2005; Pollock *et al.*, 2016; Mozaffar, 2016).

All of these examples and literature seem to call for a more dynamic way to characterise the relationship between producers and users in smart grid projects. The paper sheds more light on the advantages of these STS concepts by studying user-technology relationships in smart grid projects, drawing upon results from a consultation among smart energy experts in the EU. We develop a theoretical contribution to this debate by presenting a new more dynamic position on user-technology relationships: focusing on the diversity of representation of 'user' in smart grid projects and highlighting what kind of attention there is to 'final users' and use in these design efforts, which respond to the need of allowing more 'active users' via smart energy innovations.

**Case: user and design configurations in smart grid development projects**

Our case comes from the CANDID project's consultation on smart energy infrastructure, partly collected by written evidence, and partly by semi-structured interviews based on the preference of the respondent. A total of 71 invitations were posted and 21 responses received, making the response rate 30 percent. The majority of respondents (16) were academic researchers on smart energy, and the whole dataset has a balanced mix of engineering experts (12) and those representing social science and humanities (9). Outside universities, the studied experts (5) worked for associations (e.g. energy conservation, smart energy campaigns, citizens' advice) and a consultancy. Men were overrepresented (13 men v. 8 women). Most of the studied experts were based in the UK, which was our main focus, but the materials also contain a number of responses from Finland, Austria, Italy, and Australia. The consultation form contained an extended explanation of the research project followed by nine open-ended questions. These focused on different kinds of user of smart energy; their capabilities and constraints in adopting smart energy technologies; how the design process of smart energy technology takes users into account; protection of their privacy; and possible national variations in smart energy, especially in the EU. In addition to this, a selection of the subjects participated in the wider CANDID research project's one-day workshop where we introduced our preliminary findings and elaborated them further in a roundtable discussion. This paper draws upon both the results of the consultation and the results from the workshop discussion.

**Representing and relating to the 'user' in smart grids**

*Everyone is a 'user'*

The CANDID findings show that various kinds of professional are expected to benefit rather directly from 'smarter' technologies. At the same time, one of the main promises of smart development projects has been that money will be saved, especially in offering people smart energy meters and cost savings. But this is only the starting point once one considers how adding smartness could offer benefits to the whole electricity supply chain.

In terms of electricity suppliers – companies that generate electricity, distribute it, sell it to customers, or all of these – among the key cost benefits is access to information from the smart metering device: these devices reduce the expenses from dedicated human meter-readers visiting people's locations of energy use, as the smart meter enables two-way communications between suppliers and final users. While this cost saving is doubtlessly a major factor, there are myriad other possibilities as our informants envisioned. For one thing, smart metering will let the suppliers access an abundance of new data, which may impact upon their energy supply-demand balancing in turn, as suppliers can then more accurately predict the amount of electricity they will need in order to meet demand. For instance, adding 'smartness' to electricity grids might create new ways of trading energy in contrast to the situation at the moment, where if their predictions of demand are not accurate, suppliers need to purchase energy at the last minute, often at a very high or unpredictable price (Silvast, 2017b). Suppliers could also use the increased 'smartness' to offer new added-value services to their consumers – for example, time-of-use tariffs of electricity that vary according to the hour. In planning terms, the new data from the smart meters will potentially let the suppliers know which areas of the electricity grid need infrastructure reinforcements, with the detailed consumption data unpacking new demand patterns.

For distribution network operators – the companies and utilities that manage the electricity grid which distributes electricity from the generators to the customers – access to smart meter data is relevant in network optimisation and planning: smart measurements will allow identification of power outages and faulty equipment closer to real time and their location. If smart grids are to allow the active participation of electricity demand in the power markets, so-called demand-side flexibility, this could also transform network management and reduce costly infrastructure investment needed otherwise. In practice, demand-side flexibility would require infrastructure investment to allow for the bi-directional flows in energy systems. It is also an area where consumer interest still needs to be explored, as an energy economist who had ran public workshop on this topic told us:

> I think a factor might be consumers' interest towards reducing their bills, however it was when we did public workshops for example on that, people don't see the trade off in terms of higher electricity bills versus flexibility that they need to create. I think

> consumers real interest is in terms of reducing their bills but we don't know whether they are prepared to a degree to take part in flexibility that smart grid at this stage.

These infrastructure visions are tangled up with broader sets of technological development and associated issues. Some experts now anticipate that peak consumer demands in electricity will become an increasing problem, for example, via the adoption of electric vehicles and restrictions on conventional cars. A researcher of machine-learning in energy areas suggested that this might even trigger more central control in the future: over the next 10 years, utility companies may wish to put recharging electric vehicles under their own control, so that peak demand when everybody gets home from work does not stress the electrical grid too much. Similar problems arise from the transition to renewable energy sources (e.g., wind and solar) that are intermittent and difficult to predict, creating issues for supply-demand balancing as well as for maintaining stable electricity grids.

Starting from smartness, a whole chain of policy problems and visions emerge and shape why smart grids are important for society. A head of an applied research energy institute in mainland Europe explained this policy dynamic:

> We should ask though why decarbonisation is so important. Decarbonisation is following the top issue of climate change. We have an important driver for decarbonisation itself. The other issues that are in the decarbonisation target of the European Commission or at a world level, for example that environmental aspect of pollution, so several new countries are deciding one after the other, switch off date, more cars, fewer by gasoline. The main driver not of climate change but of the environmental issues, so to protect the consequences to have polluted cities.

Either directly or indirectly, these policy priorities put particular strain on the infrastructure of the electricity grid to withstand unpredictability. The informants thought that smartness may offer one pathway for minimising the risk of outages and inadequate service.

Not only does this increased 'smartness' potentially benefit the conventional electricity suppliers and network operators, there could also be an opportunity for a host of service providers to enter the power markets through a smart grid. Developers of ICT systems might produce software that translates energy consumption data into something more meaningful for the final consumers. For instance, we might think about the 'gamification' of smart meters for changing energy behaviour, whereupon techniques of game-playing are introduced to energy feedback information so that consumers engage with it more actively. One researcher told us about special energy demand flexibility games that had been exhibited at a local science museum as a part of a research project.

Finland, with its full digital automatic meter reading across the country, has seen a number of new automation and analysis programs, offered by emerging companies that draw on the data from the smart meters. However, our informant released no details on whether these programmes were under payment from the users or whether users 'paid' by means of handing out their data. This is consequential as the European Commission (2012) defines energy consumption data as people's 'personal data'. Such profiling technologies are also where some scholars see privacy issues as particularly pertinent (Hildebrandt, 2015).

These smart innovations might be framed more than just technically as building new markets for energy consumers and generators to engage in. At this point, the smart grid concept begins to show how it blurs the boundaries between suppliers and customers, as indeed, potentially everyone is a 'user' of 'smartness'. Companies known as 'next generation intermediaries' have begun to offer platforms where electricity consumers can sign up and get their tariffs switched automatically. Other market platforms could transform energy use so that it is not only based on consumption, but on actually participating in energy system flexibility and getting billed in terms of that offered flexibility. A smart meter generally allows for 15 minute readings (depending on the country), which may not be an adequate resolution for triggering savings among consumers, especially those that both produce and consumer energy, so-called *prosumers*. A new device called a *submeter* will allow for nearly real-time readings, which special consultancy services require for giving accurate 'tips' to end users on how to achieve savings.

More broadly, the category of intermediaries includes price-comparison websites whose access to smart meters could let them tailor services to the needs of the consumer. Smart metering is also of potential consequence for the advent of smart homes, in which consumer access devices can link directly to smart meters in home area networks. With this, the smart meter could once again introduce new benefits to providers by letting them offer new services to the final consumer.

All in all, the discourse of adding 'smartness' to energy systems suggests considerable benefits to practically everyone in the energy supply chain. But this suggestion gets to the heart of an important issue. Smart developments are part of wider infrastructure visions as we said – and one of these, over the past decades, has been liberalisation of energy supply systems and creation of competition within their provision, where energy markets are segmented so that those willing to pay can be offered higher-quality infrastructure services (Graham & Marvin, 2001). In a similar way, the 'flexible consumers' enabled by smart grids may be the affluent populations, owning for example electric vehicles, ground heat pumps, or smart homes (Schick & Gad, 2015). To some respondents it seems, variations of service were inherent to liberalised provisions. Other informants recognised this issue and reflected on it rather extensively, suggesting new forms of innovation which could consider it more proactively, as we show next.

*Who are the 'final users'?*

While our participants often spoke about different industrial 'users' of smart energy, in the majority of cases, when our informants mentioned the 'user', they actually meant *final users* such as households, individuals, or in some cases, energy-using communities. Our subjects wanted to pursue specific work to identify their needs and build a bridge toward achieving them. With a few exceptions, their concept of the 'user' also clearly changed in explaining this issue: away from the user as embedded in the two-way web of smart energy systems, to associating users very closely with 'real people out there', using sociological characteristics such as type of household, age, region, income, trust and risk perception, other attitudes, and even vulnerability.

Put simply – which promotional materials on smart meters often mention – smart grid and smart metering allow end users to monitor their energy use and thereby potentially save money. Especially those with high income could benefit from other services that are rolled in with the smart grid: for example, smart homes or other automation systems. But as one researcher of smart grid innovations pointed out, at present the financial benefits of active energy management are mostly for major commercial energy users, such as large retail chains.

> The most active users in my understanding are large energy users, e.g. large retail chains. They have been interested in engaging in demand response and selling their flexibility. Demand response has been traditional in large industries already before smart metering.

Understanding the benefit to ordinary households, whoever they may be, seems to draw upon different premises to many of our informants.

One common theme, as one termed it, was giving more consideration to "social uses of technology" via the smart grid – which produces a different relation to 'users' from the economic considerations of money saving. To him, it was possible to imagine 'users', or even 'citizens', taking control over energy and how it enters their lives via 'smartness'. In a two-way loop, users could give their energy data to energy providers, providers would better understand the needs of consumers, and there would be potential for new types of services. There is a fine-grain, but important distinction between telling people that they use more energy and making this information meaningful in myriad ways in the context of everyday practices. A researcher engaged in machine-learning explained that

> basically people say they want information that they can use, so if they know that they're spending a relatively large amount of money on say taking really long showers, then they know they can do something about it. Whereas if they're told you're using a lot of gas right now, it doesn't really help them because they don't know what it's going on.

The social uses could further be extended to communities of energy users – such as community-owned wind turbines that might use data about energy to understand how their turbine impacts upon the wider energy system.

Another related emergent example of this – and a typical element of visions for a smarter two-way energy system – is the onset of energy storage via batteries, notably in households. Energy-efficient batteries that offer storage have promised to transform how people plan for their energy use and hence their need for continuous energy provision. Energy companies could, in turn, actively educate people to use these storages with the help of smart meters. All this promises to realise the potential of demand-side flexibility – still challenging currently, as many everyday routines are not malleable nor that flexible in time – as part of energy and smartness. In this way, the relation to 'user' shifts, from envisaging money savings, to anticipating what their everyday practices would be like with increased 'smartness' in energy systems. An informatics researcher summarised this interest in batteries and the malleability of everyday routines:

> What would change the whole thing but what costs a lot of money is storage of energy in your home, because then you could plan. Then you could say I'm going to take all overnight or I'm going to have an intelligent battery that just charges when it's

> cheap and then I'm going to spend the electricity later. Then you can think of very smart things. But when you can't store, I don't have so many devices where I can even choose the time. I would say the only one is the washing machine and the dishwasher. There's not that much. The other things, you need light when you need light, there's not that much you can do, electronics is the same.

At the same time, final users are not a new consideration to industries such as electricity supply and there have certainly been long-term attempts within industries to comprehend the needs of energy consumers. In other words, 'user' relations existed before the smart grid but some of our informants became reflective on how far these efforts could work in the context of 'smartness'. Energy supply companies engage in market research that aims to segment customers, identify their interest in different products, and their preference for billing models that are also linked with their acceptance of 'smartness'. However important understanding these segments is, technology co-design is a slightly different matter. One informant argued that that designs of smart energy tend to start from the technology as such first – for example, smart meters or smart grids – and only then from the problems that they are meant to address – for example, rising peak demands.

In temporal terms, many of our subjects suggested that users are often brought into the smart energy development at a late stage, where they can tweak functionalities, but not thoroughly change designs. This remark appeared even if our consultation asked about protests against smart metering, where, for example in the Dutch case, public resistance was mobilised and did make a difference to the legal design of smart metering (von Schomberg, 2011). Having said that, it should be added that many stakeholders pursuing 'smartness' are not as such responsible for designing smart meters or installing them, as an association told us. Public campaigns, electricity distribution operators, energy suppliers, or government regulators can certainly mediate between designs and uses, but the manufacturing of the smart meters lies with the metering industry. Even their powers to influence designs are limited as the responsibility for user interfaces is often with other actors – as an UK representative told us:

> Making smart energy meters often has little direct relation to energy end users in their homes. First, the manufacturers do not sell smart meters directly to the public. The end users, for their part, will be very rarely looking directly at their energy meter even if it is 'smart' meter. The meter may be placed under the stairs or other difficult locations to see. There are other companies making In-Home Displays (IHDs) and apps on the phone for these smart meters. They do engage in market research. There have been a few companies that both manufactured meters and the IHD for it but in the UK's next Smart Metering Equipment Technical Specification (SMETS) 2.0, no companies are present that do both.

A more proactive consideration of end users might, for example, offer them chance to 'reject' smart technology. In fact, as one subject thought, there may be no technical reason for a smart meter not to include a switch that would shut down the smart functionality and make the meter a conventional kilowatt-hour meter once again. However, it would be difficult to find an energy provider that would actually implement such functionality, even in countries where final users are allowed to reject the enrolling of smart meters to their homes.

More generally, one informant questioned whether people are asked to be just bystanders and spectators of smart energy projects, instead of their co-producers, co-decision-makers, and problem solvers. People have capabilities to be both, but the advantage of the latter is that this introduces an element of 'pull', rather than just 'push', to these technologies. Speaking in terms of Responsible Research and Innovation (RRI), medical companies already involve very different stakeholders when thinking about what drugs to develop in the first place. In contrast, he felt that developing smart energy tends to listen first to the interests of businesses and universities. To him, representation of 'users' shifted to representation more generally in important debates on people's lives. Then again, another informant, also a social science researcher of smart energy, thought that there are complex matters in energy systems that cannot be solved by just consumer panels or co-design workshops.

> Architects for example may think that cities need to be built from the expert starting point. One could likewise say that the electricity grid is very complex and needs expert input. There are questions around users and using that cannot be solved in small-scale workshops – they are to be solved democratically.

Clearly, hence, the representation of 'users' is not just a matter of having more active discussions and meetings with them. According to our subjects, the matter could be resolved by long-term research that seeks to understand better the end users and uses of energy more generally. Again, the understanding of energy demand is hardly a new problem for manufacturers and the energy industries. But when they have tried to model energy-using behaviour, energy experts sometimes encounter the difficulty of anticipating what 'general human behaviour' is like. This may not matter that much at the aggregate level when multiple energy demands are combined; but it does have impacts when individuals and households are at stake, which is precisely the reason to data-intense technologies to personalize predictions.

Against this backdrop, our research subjects suggested that the types of housing stock in different regions, the access to infrastructure (especially internet connection), lifestyle-based choices, household economics, and even the very fact that it is not just individuals, but often every person in a household who affects energy choices, all shape the possibilities that people will see in smart energy technologies and increased flexibility. One technical researcher thought that more knowledge of energy consumption could even provoke stress or exposes new issues in the family. In a recent study, anthropologists showed how new in-home displays of smart meters brought complex social dynamics into being, "regarded as an ally by those members most concerned with saving on household electricity consumption by providing objective evidence of costs linked to specific practices" (Winther & Bell, forthcoming: 13). The list of non-technological factors, as literature on offering people energy feedback and its impacts has suggested (see e.g. Strengers, 2013; Winther & Bell, forthcoming), is most likely to be even more extensive than this. But for the present purpose, this view among our informants shows us how difficult they found to 'know' who the 'final users' of smart energy and smart infrastructure are in all their sociological diversity – and how for them, that pursuit of knowledge required the adjustment of existing technological knowledge, or even replacement.

Indeed, studies that our informants had engaged in also revealed reluctance among some ‘final users’ to favour smart energy. The ‘users’ worried about intrusion into their private lives, perceived lack of data security and compromised privacy, and feared that energy providers could start to control their appliances, amid displaying lack of trust in energy companies (and often also the energy market regulators). In our CANDID workshop, one informant who works for a civil rights organisation used the example of smart meters in the Netherlands, and argued that users sometimes find it difficult to understand what these meters are capable of doing – some consumers phoning consumer associations were even uncertain whether their meters were ‘smart’ or not (Tanas, 2017).

Another informant pointed out that relatively few ordinary people have the interest or the capacity to go online and analyse their meter readings all the time in order to save energy. The potential issue of smart projects creating social divisions had also been recognised by final users, not just researchers: some people are apprehensive about smart technologies as they worry that these technologies will mainly be targeted at urban, affluent regions rather than low-income, rural people, for example. Indeed, as ‘smartness’ targets people in a very general way, it brings forth possible conflicts of interest between them.

Altogether, as persuading users to become more active participants in ‘smartness’ tends to be slow and sometimes subject to resistance, some informants found considerable appeal in innovations that automate energy use – for example, by letting an autonomous agent switch residential energy tariffs, as explained before. A developer of this automation said that it is an essential element in smartness, notwithstanding few exceptional individuals that are willing to give constant attention to their energy usage.

> We simulated a number of different time of use tariffs. The important bit about those sort of things is that actually you have to have or I think you have to have automation where you have that sort of variability. I think people, apart from the very few enthusiasts, who might be interested in doing it manually, no one will do it otherwise. So with the increased complexity of variable use, variable tariffs, you have to have the corresponding automation otherwise it’s just not going to… they go hand in hand for me, I guess is what I'm saying.

As this example shows, automation offers a more plausible way for users to control electricity use – rather than imagining a domestic consumers that checks prices all the time, it could provide a space for deliberation, for example people delaying use of household devices to save money.

A key concept that summarised the capabilities and thoughts of ‘end-users’, according to our respondents, was *trust*: whether in energy supply or network companies, or government regulators overseeing these companies. In this regard, one subject thought that to consumers there seems to be something inherently different between a smart sensor bought from the internet and a smart meter that gets installed by the energy supplier, provoking images of risks of control and monitoring, whether that actually happens or not. To industries and governments rolling out smart meters, trust could become an instrument, sometimes even a strategic goal, to be attained by privacy by design, impact assessment, and public participation methods, often inscribed in reputation management strategies.

Especially, vulnerable customers that have difficulty in paying their energy bills could pose a further question to the smart energy and smart infrastructure. Somewhat contradictorily, low-income people could have the most to gain by reducing their bills, but our informants recognised that they will need very specific support to understand and interpret the smart meter information. As a researcher of smart energy innovation and consumption pointed out, “low-income people might make use of smart meter readings to reduce their bills, but often struggle with so many other problems that this is not their main priority.” An association told us that in the UK, vulnerable groups suffering from fuel poverty “are often locked in to prepayment metering. With switch to a smart meter, these actors can gain the most.” There thus is a potential mismatch between preconceptions of these ‘users’ and actual situations of use, and a learning-by-using process is called upon. This might require multiple iterations between technologists and ‘users’: for example, sending field agents to families with low income to discuss their budget management or creating special ‘energy offices’ that translate the ideal of money saving into the contexts of management of energy consumption at home.

With these kinds of examples, the aspiration of understanding the ‘user’ has taken almost a full turn from the visions and promises that started our analysis. It seems that once smart projects envisage diverse ‘users’ of smart grid to be anyone at all, they also discover their very variability and how well, and if so, the different conditions of use might have been understood by technology designers. Then, social learning processes and methodologies are called upon as particular people in a sociological context can be difficult to relate to without specific work of bridging toward them.

**Conclusions**

By studying smart grid development projects and drawing upon insights from the social science and humanities, and the experience of experts working between these fields and ICTs, we can now bring forward a number of views and recommendations that take these issues further.

This paper focused on how smart grid development projects represent the ‘user’ of smart grid and smart metering technologies. We showed that there are varieties of ‘users’ of smart grids in such projects, only some of them conventional ‘final users’ such as households. Energy suppliers, electricity distribution operators, next generation intermediaries, automation analysis software providers, price comparison web sites, smart homes, and several others are coupled to the promises of smart grid that as such get shaped by broader infrastructural visions, such as decarbonisation and cost minimization. Yet, in the majority of cases, the studied experts still envisioned the user – often a household – as actually the ‘final user’, or a person in the sociological meaning. In different ways, this user was expected to become an ‘active’ innovator of smart energy, not merely a passive energy usage demand, but a consumer that saves money and energy by smart technologies, or even becomes a more active participant of energy provision altogether.

This point is where smart systems encounter a difficulty that social scientists, including those in our study and many energy experts in industries and governments, well know about. The problem corresponds with the ‘users’ and uses of most large-scale infrastructures, the typical example being the Internet (Edwards *et al.*, 2007). In a system that envisions connecting anyone that uses energy – practically millions of consumers – it is very hard to know who each single individual 'user' is and what they need exactly (CANDID, 2017). The large infrastructure, as such, has its own goals from ongoing management to balancing supply and demand, maintenance, cross-border exchange, and maintaining capacity. Serving the needs of each individual is a trade-off against these various systemic goals of energy provision. With these issues in view, energy industries and manufacturers have needed to produce different 'supposed' users that helps them to design, produce, and market their products.

In contrast to what is sometimes assumed, social science and humanities are not merely suggesting that all of these 'supposed' users are replaced with input from 'actual users' or 'real users'. As important as checks like that can be, as Hyysalo and Johnson (2015) argue, equating all 'users' with real people out there closes off options in human-centred design of technology. There are more nuanced tools from Science and Technology Studies and social science and humanities, which help us open up user-technology relationships, rather than close them off, as has been done for decades in this scholarship.

In the context of smart energy, we would first like to suggest that the representations of 'users' are more frequently explored in development projects. In so doing, more discussion is needed on why certain representations of user work and in what operating conditions. This discussion could ask, for example, how far individual users are economic rational calculating agents and when do individual or family habits create a mismatch to this expected behaviour. We could then also ask when these active agents should be replaced by automation, how often, and what the benefits of that would be, also in enabling more economic behaviour. A related consideration is whether everyone is willing or even able to become an active participant in energy system flexibility and also what it implies if they do not. There is considerable merit in thinking of energy users as 'citizens' that participate in important energy issues, but our results also suggest that experts do not find this relation to users necessarily always solves all complex issues in the energy system. Again, the question of where this boundary between an active and a passive 'user' is drawn requires more scrutiny in relevant design processes.

Understanding thus what the different representations of 'users' are – and where the boundaries of these supposed uses lie – provides important input for proactive or Responsible Research and Innovation (RRI) of smart energy systems. For policy-makers, innovators, and researchers pursuing smartness, exploring who the communities of 'user' are like would also allow new ways to manage those communities. Here, the large body of work on information infrastructure offers many further cues – where the potential users and uses of systems are often so diverse that developers have begun to engage in experimental development strategies, for example, that seek to grow systems little by little by solving current demands and attending to future needs. Much research and development work remains to be done in understanding the broader usage and implications of smart energy technologies from these perspectives.

**References**

Akrich, M. (1992). The De-Scription of Technical Objects. In Bijker, W. & J. Law (eds) *Shaping Technology/Building Society: Studies in Sociotechnical Change*. Cambridge, MA: MIT Press.

Alapuro, R. (2011). Goods, Res Publica, Actors Networks and Collective Action. In Kharkhordin, O. & R. Alapuro (eds) *Political Theory and Community Building in Post-Soviet Russia*. London: Routledge.

Ballo, I. F. (2015). Imagining Energy Futures: Sociotechnical Imaginaries of the Future Smart Grid in Norway. *Energy Research & Social Science* 9: 9-20.

BEIS (UK Department of Business, Energy & Industrial Strategy) (2016). Smart Meter Rollout Cost-Benefit Analysis Part I. August 2016.

Bessant, J. (2013). Innovation in the Twenty-First Century. In Owen, R., J. Bessant & M. Heintz (eds) Responsible innovation. Managing the responsible emergence of science and innovation in society. Chichester: John Wiley & Sons.

Bijker, W., T. P. Hughes & T. Pinch (1987, eds). *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. Cambridge, MA: MIT Press.

Borup, M., N. Brown, K. Konrad & H. van Lente (2006). The Sociology of Expectations in Science and Technology. *Technology Analysis & Strategic Management* 18(3-4): 285-98.

Bulkeley, H., G. Powells & S. Bell (2016). Smart Grid and the Constitution of Solar Electricity Conduct. *Environment & Planning A* 48(1): 7-23

CANDID (2017) The CANDID manual: Integration of SSH perspectives into ICT smart development projects aiming for Responsible Innovation. CANDID Project deliverable D5.2.

Christensen, T. H., K. Gram-Hanssen& F. Friis (2012). Households in the smart grid: existing knowledge and new approaches. In Hansson, L., U. Holmberg, & H. Brembeck (eds), *Making Sense of Consumption: Selections from the 2nd Nordic Conference on Consumer Research 2012*. Göteborg: Centre for Consumer Science, University of Gothenburg. Conference on Consumer Research 2012.

Christensen, T. H., A. Ascarza, W. Throndsen, K. Gram-Hanssen & Freja Friis (2013). The Role of Households in the Smart Grid: A Comparative Study. *European Council for an Energy Efficient Economy (ECEEE) Summer Study*.

Darby, S. J. (2012). Metering: EU Policy and Implications for Fuel Poor Households. *Energy Policy* 49: 98-106.

Edwards, P. N., S. J. Jackson, G. Bowker & C. P. Knobel (2007). Understanding infrastructure: Dynamics, tensions, and design. Workshop report.

Eurelectric (2016). Smart Grid Cyber Security. Brussels: EURELECTRIC.

European Commission (2011). Smart grid. From Innovation to Deployment. SEC(2011) 463 Final.

European Commission (2012). Commission Recommendation of 9 March 2012 on preparations for the roll-out of smart metering systems. 2012/148/EU.

European Commission (2013). Cyber Security of the Smart grid. Summary Report. Expert Group on the Security and Resilience of Communication Networks and Information Systems for Smart grid.

European Commission (2013). Benchmarking smart metering deployment in the EU-27 with a focus on electricity. COM(2014) 356 final.

European Parliament & Council (2012). Directive on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC. 2012/27/EU.

Executive Office of the President of the United States (2011). A Policy Framework for the 21st Century Grid: Enabling Our Secure Energy Future. June 2011.

Graham, S., & Marvin, S. (2001). *Splintering urbanism: networked infrastructures, technological mobilities and the urban condition*. Psychology Press.

Groves, C., K. Henwood, F. Shirani, C. Butler, K. Parkhill& N. Pidgeon (2016) Energy Biographies: Narrative Genres, Lifecourse Transitions, and Practice Change. *Science, Technology, & Human Values* 41(3): 483-508.

Hargreaves, T. & C. Wilson (2013). Who Uses Smart Home Technologies? Representations of Users by the Smart Home Industry. *European Council for an Energy Efficient Economy (ECEEE) Summer Study*.

Hargreaves, T. & C. Wilson (2017). Domestication of Smart Home Technologies. In *Smart Homes and Their Users*. Cham: Springer.

Helm, Dieter (2017). Cost of Energy Review: Independent report for the UK Government.

Hildebrandt, Mireille (2015). *Smart Technologies and the End(s) of Law: Novel Entanglements of Law and Technology*. London: Edward Elgar Publishing.

House of Commons (2016). Evidence Check: Smart metering of electricity and gas. Science and Technology Committee.

Hyysalo, S. (2010). *Health Technology Development and Use: From Practice-Bound Imagination to Evolving Impacts*. London: Routledge.

Hyysalo, S. & M. Johnson (2015). The User as Relational Entity: Options that Deeper Insight into User Representations Opens for Human-Centered Design. *Information Technology & People* 28(1): 72-89.

Hyysalo, S., T. E. Jensen & N. Oudshoorn (2016, eds). *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. London: Routledge.

Jirotka, M., B. Grimpe, B. Stahl, G. Eden & M. Hartswood (2017). Responsible Research and Innovation in the Digital Age. *Communications of the ACM* 60(5): 62-68.

Kahma, N. & K. Matschoss (2017). The Rejection of Innovations? Rethinking Technology Diffusion and the Non-Use of Smart Energy Services in Finland. *Energy Research & Social Science* 34: 27-36.

Lovell, H., M. Pullinger& J. Webb (2017). How do Meters Mediate? Energy Meters, Boundary Objects and Household Transitions in Australia and the United Kingdom. *Energy Research & Social Science* 34: 252-259.

Luque, A. (2014). The Smart Grid and the Interface between Energy, ICT and the City. In Dixon, T., M. Eames., M. Hunt & S. Lannon (eds) *Urban Retrofitting for Sustainability: Mapping the Transition to 2050*. London: Routledge.

Mozaffar, H. (2016) User Communities as Multi-Functional Spaces: Innovation, Collective Voice, Demand Articulation, Peer Informing and Professional Identity (and more). In Hyysalo, S., T. E. Jensen & N. Oudshoorn (eds). *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. London: Routledge.

Nyborg, S. & I. Røpke (2013). Constructing Users in the Smart Grid – Insights from the Danish eFlex Project. *Energy Efficiency* 6(4): 655-670.

Oudshoorn, N. and T. Pinch (2003). *How Users Matter: The Co-construction of Users and Technology*. Cambridge, MA: MIT Press.

Oudshoorn, N., E. Rommes & M. Stienstra (2004). Configuring the User as Everybody: Gender and Design Cultures in Information and Communication Technologies. *Science, Technology, & Human Values* 29(1): 30-63.

Pollock, N., & Williams, R. (2010). E-infrastructures: How do we know and understand them? Strategic ethnography and the biography of artefacts. *Computer Supported Cooperative Work (CSCW)*, 19(6): 521-556.

Pollock, N., R. Williams & L. D'Adderio (2016). Generification as a Strategy: How Software Producers Configure Products, Manage User Communities and Segment Markets. In Hyysalo, S., T. E. Jensen & N. Oudshoorn (eds). *The New Production of Users: Changing Innovation Collectives and Involvement Strategies*. London: Routledge.

Powells, G., H. Bulkeley & A. McLean (2016) Geographies of Smart Urban Power. In Marvin, S., A. Luque-Ayala & C. McFarlane (eds) *Smart Urbanism: Utopian Vision or False Dawn?* London: Routledge.

Pullinger, M., H. Lovell, and J. Webb (2014). Influencing Household Energy Practices: A Critical Review of UK Smart Metering Standards and Commercial Feedback Devices. *Technology Analysis & Strategic Management* 26(10): 1144-1162.

Rommetveit, K., N. van Dijk, K. Gunnarsdottir, K. O'Riordan, S. Gutwirth, R. Strand & B. Wynne (forthcoming). Working Responsibly across Boundaries? Some Practical and theoretical lessons. In von Schomberg (ed.) Handbook of Responsible Innovation. London: Edward Elgar.

Schick, L. & B. R. Winthereik (2013). Innovating Relations–or Why Smart Grid is not too Complex for the Public. *Science & Technology Studies* 26(3): 82-102.

Schick, L. and C. Gad (2015). Flexible and Inflexible Energy Engagements – A Study of the Danish Smart Grid Strategy. *Energy Research & Social Science* 9: 51-59.

Silvast, A. (2017a). Energy, economics, and performativity: Reviewing theoretical advances in social studies of markets and energy. *Energy Research & Social Science* 34: 4-12.

Silvast, A. (2017b). *Making Electricity Resilient: Risk and Security in a Liberalized Infrastructure*. London: Routledge.

Skjølsvold, T. M., M. Ryghaug& T. Berker (2015). A Traveller's Guide to Smart Grid and the Social Sciences. *Energy Research & Social Science* 9: 1-8.

Strengers, Y. (2013). *Smart Energy Technologies in Everyday Life: Smart Utopia?* Berlin: Springer.

Sumpf, P., M. Klemm, W. Throndsen, C. Büscher, R. Robison, J. Schippl., C. Foulds, K. Buchmann, A. Nikolaev & T. Kern-Gillard (2017). Energy System Optimisation and Smart Technologies – A Social Sciences and Humanities Annotated Bibliography. Cambridge: SHAPE ENERGY.

Tanas, A. (2017). CANDID – WORKSHOP WITH PEERS. Barcelona 26.09.2017. Minutes Break-up session about Module 2.

Throndsen, W. (2017). What Do Experts Talk about When They talk about Users? Expectations and Imagined Users in the Smart Grid. *Energy Efficiency* 10(2): 283-297.

Verbong, G., S. Beemsterboer& F. Sengers (2013). Smart Grid or Smart Users? Involving Users in Developing a Low Carbon Electricity Economy. *Energy Policy* 52: 117-125.

Stewart, J. & R. Williams (2005) The Wrong Trousers? Beyond the Design Fallacy: Social Learning and the User. In Rohracher, H. (ed.) *User Involvement in Innovation Processes: Strategies and Limitations from a Socio-Technical Perspective*. Munich: Profil-Verlag.

UK National Infrastructure Commission (2016). Smart Power.

van der Horst, D., S. Staddon & J. Webb (2014). Smart Energy, and Society? *Technology Analysis & Strategic Management* 26(10): 1111-1117.

Wagner, P. (2001). *A history and theory of the social sciences: Not all that is solid melts into air*. London: Sage.

Wilson, C., T. Hargreaves & R. Hauxwell-Baldwin (2015). Smart Homes and their Users: A Systematic Analysis and Key Challenges. *Personal and Ubiquitous Computing* 19 (2): 463-476.

Winther, T. & S. Bell (forthcoming). Domesticating in Home displays in selected British and Norwegian Households. Accepted for publication in *Science & Technology Studies*.

Wolsink, M. (2002). The Research Agenda on Social Acceptance of Distributed Generation in Smart Grid: Renewable as Common Pool Resources. *Renewable and Sustainable Energy Reviews* 16(1): 822-835.

Von Schomberg, R. (2011). Towards Responsible Research and Innovation in the Information and Communication Technologies and Security Technologies Fields. A Report from the European Commission Services.

von Schomberg, R. (2013). A Vision of Responsible Research and Innovation. In Owen, R., J. Bessant & M. Heintz (eds) *Responsible innovation. Managing the responsible emergence of science and innovation in society*. Chichester: John Wiley & Sons.