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Smart grids - the future electricity grid for everyone? : A literature review of potentially vulnerable smart grid users

Energy systems are currently being reshaped, a transformation primarily motivated by the introduction of intermittent energy resources, altered user patterns and increased demand for electricity security and quality. Policy makers and authorities frequently propose that these challenges can be handled through the introduction of so-called smart grids. Smart grids is a fuzzy object in the making that lacks a precise definition. A common characteristic of this configuration is however increased digitalization. A smart grid can be understood as a digitalized electricity grid, meaning that the current electric grid becomes "smart" as it is interlaced with ICTs (Nyborg & Røpke, 2013; Verbong, Beemsterboer, & Sengers, 2013; Wissner, 2011). The transformation of the energy system does however not only entail a technological upgrading, rather smart grids can be understood as a socio-material project with far-reaching societal implications since the configuration suggests altered relations between actors in the energy system. Smart grid stakeholders in particular urge for an altered role of electricity users in their envisioned energy system (Goulden, Bedwell, Rennick-Egglestone, Rodden, & Spence, 2014). They suggest that users should take on a more active role that for example include alteration of energy usage to meet the needs of the grid, to become aware of how, when and on what they use electricity or to produce their own electricity through solar panels or small-scale wind power plants (Verbong et al., 2013). The most commonly portrayed smart grid user is active, tech-savvy, economically aware and information-hungry (Mah, van der Vleuten, Hills, & Tao, 2012; Strengers, 2013; Verbong et al., 2013). In this literature review I turn attention to households who do not fit into such an idealized version and who rather risk being neglected or even excluded in future smart grid developments. I bring together literature on "digital divides" and "energy justice" to discuss how vulnerability take form in relation to smart grids and I seek to shed light on how these vulnerabilities can be prevented. The discussion focuses on smart energy technologies for the home.

Electricity users in relation to smart grids, smart meters and smart home technologies

Despite the wide attention directed towards smart grids, it can still be conceptualized as connected to different connotations since they mean "many things to many people" (Hledik, 2009:30) and are characterized by a large degree of interpretative flexibility (Christensen Haunstrup, Gram-Hanssen, & Friis, 2013). Smart grids are soaked in various promises and, as an anticipated saviour to numerous problems, they appear as "jack(s) of many trades" (Skjølsvold, Ryghaug, & Berker, 2015:1). Although the meaning of smart grids can differ both within and between countries, certain aspects reoccur in many of the descriptions. In general terms, a smart grid can be understood as a digitalized electricity grid, meaning that the current electric grid becomes "smart" as it is interlaced with ICTs that add intelligence to the "dumb" grid (eg. see Nyborg & Røpke, 2013; Verbong et al., 2013; Wissner, 2011).

The smart meter can be considered a key component of the smart grid as it can measure energy consumption in real-time and send information back to suppliers. The end-user do however not interact with this device directly, meaning that its installation does not grant that users will engage with energy related issues (Darby, 2010). Therefore, smart meters are often installed together with so-called In-Home Displays (IHDs). IHDs come in a variety of different forms (eg. see Fischer, 2008) but one conventional design involve real-time, historical and cumulative numeric information of the household's electricity consumption displayed in both energy and monetary terms (Buchanan, Russo, & Anderson, 2015). Their installations are by stakeholders motivated with the "expectation that providing consumers with IHD based feedback will equip them with the information they need to help reduce their overall energy consumption […] shift it away from periods of peak demand, and/or respond flexibly to periods of "over" supply" (Buchanan et al., 2015:89). Although there is a wide variety of how these displays are designed they all seem to be based on the logic behind the information-deficit model (Hargreaves, 2018). This model is based on the assumption that if electricity users receive more and improved information, they will change their attitudes, behaviours and choices (Wilhite & Ling, 1995). A common strategy among designers of smart energy technologies for the home is to boost such behavioral changes through economic figures of energy consumption. Smart grids are frequently valued for their opportunities to introduce flexible consumption, and such configurations often involve some kind of Time of Use (TOU)- tariff that offer an electricity price that varies during the day, week and year with the overall objective to move consumption from times with high demand (High price) to times with low demand (low price). There are different kinds of configurations that are designed with the purpose to enhance users' engagement with their energy consumption. While some only provide feedback others enable the user to manage their energy consumption in their home through automatic solutions (van Dam, Bakker, & van Hal, 2010). Highly advanced monitoring and automatic systems through which the user can observe and interact with energy consuming devices in their home rest on assumptions of users who are actively engaged with technologies in their homes. The culmination of such an ideal user is "data-driven, information-hungry, technology-savvy home energy manager, who is interested in and capable of making efficient and rational resource management decisions" (Strengers, 2013: 51).

Other ideas of smart grid users rather propose that householders do not need to be engaged with their electricity consumption, since automatic solutions can supersede the user through "tak[ing] care of most of the demand response underneath the nose of a happily ignorant user" (Throndsen, 2017:289). Such an approach suggests that users do not need to be involved or informed in when or how to alter consumption patterns since technologies can take care of this task for them. This position is commonly supported with arguments that householders neither have the time nor interest to engage with their electricity consumption (Hamilton, Thomas, Park, & Choi, 2012). However, technologies are not neutral but rather enable different kinds of participations in public matters, they grant participation different logics (Marres, 2012). Automatic solutions materialize participation according to the logic of "involvement made easy" and are designed with the aim that everyday practices should become environmentally friendly without demanding or resulting in any change in the state of the things, settings or things involved: the shift is simply a “change of a no change” (Marres, 2012). In this way automatic solutions tend to evoke users who are detached from the societal implications that smart grids are associated with.

Policymakers, designers and utility suppliers have so far conceptualized users “needs” from a rather narrow horizon, primarily focusing on economic gains and information enhancements. Actors from industry and governments primarily emphasize economic and technological conceptualizations of smart grids which imply a rather slim perception of what this sociotechnical configuration entails and can enable (Sovacool, Kivimaa, Hielscheaa, Hielscher, & Jenkins, 2017). Stromback, Dromacque, and Yassin (2011) however stress that designers’ ability to meet the needs of the electricity user is essential for a successful implementation of demand side programs, concluding that “[m]eeting a need is the foundation of consumer engagement. The technology is a support” (:71). Recent research have thus questioned smart grid stakeholders suggestion that households will embrace smart energy technologies (Raimi & Carrico, 2016). Such findings suggest that it is important to recognize that households use smart energy systems in a social context that are embedded in wider societal structures (Hargreaves, Nye, & Burgess, 2010; Nyborg, 2015). Previous studies have also found that feedback from energy monitors do not necessarily lead to positive responses, as they can also evoke feelings of disempowerment, guilt and anxiety as users are faced with for example environmental problems of which they feel that they could do very little to change (Hargreaves et al., 2010). Previous studies further suggest that different households but also different members of a household interact with feedback systems in various ways, and have noted that engagements for example varies due to age and gender (Hargreaves et al., 2010; Hargreaves, Nye, & Burgess, 2013; Nyborg, 2015). Such findings imply that smart grid users are not all the same, and do not use technologies in equal ways.

Vulnerable smart energy users

One strand of literature on users who do not fit the idealized smart grid user attend to groups who actively chose not to become users, i.e. those who engage with active resistance. These users express concerns about potential negative impacts of smart energy technologies and refuse them for example due to integrity reasons, potential health risks, concerns about losing control of their energy consumption, concerns for utility costs or due to a lack of trust in the actors providing the products or services (Hess, 2014; Kahma & Matschoss, 2017). These studies thus recognize non-users rights in relation to smart energy technologies, and they question the assumption that “access [to a technological innovation] is always better than lacking it” (Neice, 2002:67).

In contrast to these studies this text focuses on electricity users who have not chosen to actively resist smart energy technologies but nevertheless risk becoming neglected when these technologies are designed, developed and rolled-out. It is important to distinguish between different groups of non-users, since “have nots” are not the same as “want nots” (Wyatt, 2003). The dominant assumption by policy makers is that non-users eventually will become users and tend to suggest that the entire world shares the same path of development, i.e. that some groups are currently ahead but eventually they will all follow the same track (Wyatt, 2003). However, non-use of smart energy technologies is a much more heterogeneous issue than what this widely spread diffusion model suggests, in other words non-use is not necessarily a consequence of delayed uptake performed by so called laggards (Kahma & Matschoss, 2017). This is also a question of that some users risk to be left behind, but what does this neglection imply?

One way to discuss what such a division could imply is to turn attention to all the benefits that smart grid stakeholders attach to this emerging technology. In particular, smart grids are by stakeholders frequently valued for their opportunities to empower electricity users (eg. see Swedish Coordination Council for Smart Grid, 2014). Enhanced empowerment is for example associated with increased access to detailed information about energy consumption patterns, enhanced ability to adjust consumption to price fluctuations and the opportunity to participate as an active player on the energy market by selling home-made electricity. Given these associations, it is important to ask whether empowerments will decrease for those individuals who do not use smart energy products and services. Another important issue that arise in relation to smart energy technologies relates to the question of being part in the construction of a future society or not. In the early days of the internet, having access was frequently associated with being part of a high-technology future (Wyatt, 2003), and it is likely that similar associations are constructed in relation to access to smart energy technologies. Having access is thus a question of social justice, but what this imply is however a complex matter. Previous studies have found that in particular, lower-income and older householders, can react rather defensively on request to reduce their consumption further, arguing that they should not be made to feel guilty over their consumption levels as in comparison to other households or industrial actors they are not nearly as wasteful (Hargreaves et al., 2013). This is in line with findings from Buchanan, Banks, Preston, and Russo (2016) that reports from focus group interviews that explore the public's perception of smart meter implementations in the UK. They found focus group participants who raised concern of how such a roll-out would affect vulnerable groups in society for example articulated as "Elderly people, disabled people, how are they supposed to get their heads round it?" (:94). The study showed that part of this concern was based on that smart meter services often require technological capabilities that vulnerable groups might lack. Another perspective of uneasiness that focus group participants raised on this matter concerned that it was unfair to delegate responsibility for environmental problems to already vulnerable groups (Buchanan et al., 2016). Such findings suggest that it is not only a question of having access or not, but rather a question of that smart energy technologies could not be constructed in accordance to the logic that "one model fits all"

These matters remind of those that previously been discussed by researchers studying the so-called "digital divide". Servon and Nelson (2001:279) stress that "[A]ccess to information technology and the ability to use it [have] increasingly become part of the toolkit necessary to participate and prosper in an information based society." Such an analysis emphasizes that access to this toolkit and the ability to use influence individuals possibilities to thrive in the current society. One core discussion in relation to the digital divide concerns inequalities in having access to digital services and products or not, so called "information haves" and "information have-nots" (Wresch, 1996). Such a dichotomous understanding of the digital divide have characterized conventional conceptualizations of the problem: either you have access to ICT or you do not. This have made political ambitions to focus on bridging the digital divide by providing ICT to those groups who currently are lacking (Selwyn, 2004). Selwyn (2004) however problematized this strict division by asking questions of what is meant by ICT, what is meant by access and how do access to ICT relate to use of ICT. Selwyn (2004) argues that physical access to a technology does not mean that individuals feel that they have the ability to make use of this technology and urge that the relationship between access and use should be recognized as a multifaceted matter. To begin with the concept of access can be conceptualized as a much more complex than solely dividable into two dichotomies. Rather Wilhelm (2000) argues for "various shades" of marginality and identifies "core access", "peripheral access" and "non-access". Exclusions should thus not solely be understood as a question of having access to a technology alone rather the digital divide should also be conceptualized in terms of what people get access to when using the technologies, in other words the focus should be on the content rather than on the technologies (Selwyn, 2004). Similar issues also arise in relation to smart energy technologies, and the baseline for this text is that it should not only be a question of what users get access to but also a question of individuals' needs, capabilities and interests. Thus, in relation to smart energy technologies it is necessary to ask what this new configuration means not only in terms of what kind of technologies it contains, but also in terms of what kind of information, services and resources the configuration provides for households who do not fit the idealized user.

A frequent analysis in research about digital divide is that being excluded from ICT is not solely related to one technology alone , rather it can mean that individuals or groups simultaneously are excluded from many of the advantageous that are accompanied with ICT (Selwyn, 2004). This is a consequence of that ICT plays such a large role in how contemporary societies are designed and structured. Digital exclusions are thus not isolated to one issue alone, but rather it is a aggregation of various exclusions in society (Umecon, 2016). Selwyn (2004) argues that the digital divide to a large extent relate to differences in Technological Capital that constitutes of three parameters: *Economic capital* to purchase the ICT software and hardware, *Cultural Capital* to be able to invest time in acquiring ICT skills or the socialization into ICT use, *Social Capital* that encompasses networks of technological support for example from family, friends, neighbors but also online help facilitates.

Since smart grid rests upon digitalization there is a clear risk that exclusion tendencies related to smart energy services and products will follow similar patterns that are prevalent in digital exclusions. Previous studies on smart grid users have hinted about potential vulnerable groups but the amount of literature that exclusively focused on this group is scarce. Sovacool, Kivimaa, Hielscher, and Jenkins (2017) present a literature review on academic articles published on smart meter installations in UK written between 2008 and 2017. When exploring how these articles present potential challenges, they note that a clear majority focused on technical challenges, while consumers issues such as vulnerability or resistance were to a large extent ignored (Sovacool et al., 2017). There are however a few examples of studies that mention that smart energy technologies can increase vulnerability among certain groups of electricity users. Elderly and low income (Nicholls & Strengers, 2015a; Sovacool et al., 2017), sole parenting women, renting households (Nicholls & Strengers, 2015a) the ill, people living in social housing, those who are less educated and those living in rural areas (Sovacool et al., 2017) reoccurs as potentially vulnerable users in literature on smart meters, smart grids and In Home Displays (IHDs). Also households with children are recognized as potentially vulnerable (Nicholls & Strengers, 2015b). The UK Department of Energy and Climate Change have conducted an extensive study of households with smart meters and IHDs. They found that certain groups were more vulnerable than others and concluded that these are “likely to need more help if they are to obtain the full benefits of smart metering “ (UK Department of Energy and Climate Change, 2015:23). Especially vulnerable groups were according to this study “older smart meter customers, those from lower social grades, those with the lowest total annual household incomes (below £16,000), those with no formal qualification and those who lived with someone who had a long-term health condition or disability.” (UK Department of Energy and Climate Change, 2015:23). The current literature hint on why these groups are especially vulnerable but few studies have exclusively explored their needs, perceptions and behaviors (Barnicoat & Danson, 2015; Buchanan et al., 2015; Sovacool et al., 2017). In the following I provide an overview of the findings from previous studies of smart energy technologies and potentially vulnerable groups.

Elderly households

Literature on digital exclusions identify elderly people as an especially vulnerable group. One of the recurrently mentioned reasons for this is that this group of actors often lack internet access and the required hard wares such as computers, smart phones or tablets. Other reasons relate to a lack of interest or literacy. Nicholls, Strengers, and Tirado (2017) report from a study were households were handed 'off-the-shelf' smart home control devices and after several months they conducted follow-up interviews on the householder’s interaction with the technologies. They found that none of the householders above 55 years old were still using their smart energy technologies, these householders for example claimed that the technologies were confusing, difficult to install or not useful. Nicholls et al. (2017) therefore conclude that smart energy technologies are less appealing or suitable for older households. Barnicoat and Danson (2015) conducted a study especially focused on elderly peoples’ perceptions of and behaviors in relation to energy saving instruments, including sensors and display monitors. The study showed that the installed IHD did not provide information that the elderly found informative, and neither did it enhance their knowledge of how to save energy in their homes. Neither did this group of people support the often expressed claim from policy makers that customers should switch suppliers in order to decrease their electricity bills. This group frequently argued that such engagements are not worth the hassle. The study also found that the elderly people told stories of a childhood with very little money, and that this enforced energy saving behaviors that they still engage with (Barnicoat & Danson, 2015). Another complementary finding can be seen in a study of a Swedish smart grid demonstration project that find that retired people were overrepresented among those that voluntarily signed up for participating in the project that involved home installation of smart energy technologies (remote steering and detailed information of consumption patterns on computers/tablets/smart phones). Actors in charge of the project argue that one the reasons for this is that retired people seem to have the time for engagements that younger individuals might lack (Wallsten, 2017).

Low-income households

Internet access and hard wares are necessary tools for smart grid users, but such equipment cost money that not everyone can afford, especially households with low income might not prioritize such expenses. This group is also overrepresented as actors who suffer from energy poverty or so-called fuel poverty. The European Commission stresses that energy poverty is a critical issue that needs to be recognized and urgently handled across many member states. In a report published by the European Commission energy poverty is referred to as "the situation where individuals are not able to adequately heat (or provide necessary energy services) in their homes at affordable cost" (Pye & Dobbins, 2015:1). The European Commission however point out that different member states define this concept slightly different and that it also can include individuals who may be at a disadvantage when buying electricity (Pye & Dobbins, 2015:1). Grevisse and Brynart (2011) stresses that it is likely that the conceptualization of how dignified living conditions, affordable energy costs and reasonable temperatures for heating differs within the European Union. For example the Scottish Government define fuel poverty as it applies to those households that must spend more than 10% of their income on energy to maintain a temperature of 21 degrees in their living areas 9 hours per day on weekdays and 16 hours per day on weekends, for vulnerable people (elderly, sick etc) the numbers are 23 degrees in the living area 16 hours every day (Scottish Government, 2018)

Very little is known on how household with low-income levels or those suffering from fuel poverty react to feedback systems (Buchanan et al., 2015). Some previous studies suggest that vulnerability is not a consequence of non-use for this group of actors, on the contrary low-income households might be an overrepresented category of users in those studies were users have not need paid for the technologies themselves. Nicholls et al. (2017) showed that people that had trouble paying their electricity bills were overrepresented in the group of households that had tried the smart energy technologies handed to them, and that half of them continued to use these devices. They speculate on whether having a low income might influence the value that households attach to a product that was given to them without any costs, or whether their usage is rather due to that they have the time and persistence to make them work (Nicholls et al., 2017). These findings are aligned with Liddell (2015) that report from low-income families' experiences when moving into newly built energy efficient homes equipped with smart electricity meters and IHDs. A few studies suggest that low-income households rather experience vulnerability as they through smart energy technologies can decrease their energy consumption to unhealthy low levels. Hargreaves et al. (2010) reports from a study on how UK households make use of energy monitors installed in their homes. The article emphasizes that these systems can cause stress for low-income households or those suffering from fuel poverty, an anxiety that should not be underestimated as they "quite literally, watch their money being spent" (:6114). They found one householder who described that his wife, "could kind of feel the money seeping out every time she had the boiler on. And to be honest beating herself up over it, you know. 'I can't have it on because I'm wasting money, but I'm cold" (:6114). The finding that smart energy technologies can be detrimental for householders living with small economic margins is an issue also recognized in other studies. Some studies report on practices that low-income households have in order to reduce their electricity expenses, that for example includes going to bed early to avoid using heat, applying bubble wrap over windows, prioritizing energy bills over food and medicines (Nicholls et al., 2017). Other examples are householders that in their attempts to reduce electricity consumption cause family disharmonies, disagreements and frustrations (Nicholls et al., 2017). Buchanan et al. (2015) stress that a potentially disastrous outcome of IHDs and feedbacks would be if people's health were at risk and emphasize that researchers and policy makers need to make sure that such harmful impacts on vulnerable groups are prevented.

Taking income into account is especially important when it comes to smart energy technologies since households with high income tend to use more electricity than households with less money, and high-income households also contributes more to high demand peaks than their low-income counterparts (Bulkeley et al., 2016). In this sense households with high income influence the need for a smart grid more than households with lower income.

Immigrants

Immigrants is a group of users that is recognized as especially vulnerable when it comes to digital exclusions (Umecon, 2016), bus as far as I know there have not been any studies that exclusively report on how this group interact with smart energy technologies. Immigrants can be considered especially vulnerable since they for example can have fled from countries that lack a widespread digital infrastructure and might therefore have little experience of using digital services and products (Umecon, 2016). However, it important to recognize that immigrants is a highly heterogeneous group with large differences in for example level of education, background, income level etc.

Families with children

Another kind of smart grid user that previous studies recognize as being neglected in smart grid implementation is those who cannot easily shift consumption to the cheapest hours and thus rather end up losing money on a ToU-tariff. Nicholls and Strengers (2015b) report from a study on daily practices and possibilities to shift electricity consumption in time among Australian families with children. They found householders who argued that they cannot easily alter their energy consuming practices as these routines for example are coordinated around the institutionalized time for childcare, schools and work. The article also found householders who prioritized meeting the needs of their families over the possibility to reduce their electricity costs. Nicholls and Strengers (2015b) conclude that TOU does not offer enough incentives for families with children and rather argue for non-financial incentives and urge for more research on how practices link together in order to create electricity consumption peaks. These findings are correlated to those found by Nyborg (2015) that report from 49 households that tested smart grid equipment. The study found difficulties in following the actions suggested by the technologies as some householders had difficulties in altering the time of washing since kids need to have cloths for tomorrows activities while others reported that the pilot study resulted in tensions in the families as some family members felt surveilled by others (Nyborg, 2015). Difficulties for families are also found by Wallsten (2017) who show a gendered difference among the family members involved in a smart grid demonstration project, the man possess the technology (the smart phone) that scripts the households activities performed by the woman – a script that she eventually refuses to follow.

Rural areas

Another vulnerable smart grid user recognized by previous studies is households living in rural areas. In a literature review on smart meter installations in UK, Sovacool et al. (2017) find two kinds of vulnerabilities that were much less discussed: “increased rural peripheralisation” and “externalities and lifecycle impacts”. The latter group refers to lack of discussions of the environmental problems that occurs when obsolete equipment are exported to vulnerable groups in foreign countries, while the first group refers to that smart meter implementations are primarily conducted in cities, while homes in the countryside are not equally preferred in such rollouts. Sovacool et al. (2017) argue that homes in rural areas, are in relation to their counterparts in cities already marginalized and one aspect of this is uneven distribution of high-speed internet connection. They further discuss that homes located in rural areas are more spread out than in cities, which require more travel mileage and persons hours to achieve smart meter roll-outs and as a result of such conditions suppliers tend to prioritize urban areas with homes that are more accessible and concentrated. In their discussion they refer to Blowers and Leroy’s (1994) concept of “peripheralisation” and argue that outcome of such processes is that rural areas become even more marginalized and excluded from digital innovations (Sovacool et al., 2017). Blowers and Leroy (1994) define “peripheralisation” as a condition that is prevalent among communities that often are geographically remote and characterized by powerlessness, economic marginality and social isolation.

Furthermore, blackouts are more frequent in rural areas than in cities and Swedish rural grids currently have a worse delivery security than power grids in urban areas (Swedish Energy Markets Inspectorate, 2016). Power outages are not only inconvenient they also cause increased costs for the affected society. The Swedish Energy Markets Inspectorate, (2016) shows that socially important functions, such as hospitals, air, road and rail transport are affected by power outage. These interruptions can give very high indirect costs, for example, for major industries and by preventing people from getting to work. For individual homes, power outages not only prevent the usage of electrical gadgets, but can also cause food in the fridge and freezer to be destroyed and during the winter it may cause cold homes as well as damaged water and heat lines areas (Swedish Energy Markets Inspectorate, 2016). From that perspective rural areas are already marginalized in matters of electricity issues. Since a smart grid implementation is frequently motivated with that it would increase electricity security makes it especially important to not neglect rural areas in such a roll-out.

Final remarks

In this short text, I have explored previous studies on potentially vulnerable smart grid users. I have found that the amount of literature on this matter is rather limited but due to the reported findings this is a matter that needs further recognition. However, it is worth mentioning that different countries have different ways of tackling vulnerability, but also different conditions of what vulnerability implies for the individual. Little is known on how to prevent certain groups to become neglected or left out in future smart grid roll outs; there are not enough knowledge on the needs, capabilities and interests of this group of actors to prevent future exclusions. Furthermore, research on how smart grid stakeholders such as service providers, technology developers or utility companies reason about vulnerable groups is very limited. All in all, this literature review suggests that there is a need for more studies on this urgent matter.

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