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Transition to Smart Grids: A Psychological Perspective

Ellen van der Werff, Goda Perlaviciute and Linda Steg

Abstract A transition to smart grids requires a wide range of changes in household energy behaviour. In this chapter we discuss four key issues important for understanding and promoting behaviour in smart grids. First, we need to identify which behaviour needs to be changed. A transition to smart grids involves changes in a wide range of energy behaviours, including the adoption of sustainable energy resources, energy-efficient technologies, and automated control technology; investments in energy efficiency measures in buildings such as insulation; and user behaviour. Second, we need to know which factors influence behaviour in smart grids. We discuss the role of motivations and contextual factors. Third, it is important to test effects of interventions aimed to promote smart energy behaviours. Interventions can be aimed at changing the actual costs and benefits of behaviour, or at changing people's perceptions and evaluations of different costs and benefits of behavioural options. Fourth, we need to understand which factors influence the acceptability of energy policies and energy systems changes aimed to promote smart grids. In this chapter we address important findings from psychological studies on these topics.

1 Introduction

Smart grids involve substantial changes in energy infrastructures, technologies and user behaviour. To develop reliable, sustainable and affordable smart grids, it is not sufficient to develop new infrastructure and technologies (Goulden et al. 2014; Oldfield 2011; Wolsink 2012; Verbong et al. 2013). In fact, smart grid technologies and infrastructure will only realise their full potential if people find them acceptable and if they change their behaviour accordingly. To enhance efficiency and sustainability of smart grids, the supply and demand of (renewable) energy needs to be

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matched and overall energy consumption needs to be reduced. To achieve this, changes in a wide range of behaviours are needed, including the adoption of sustainable energy sources and technologies, the adoption of smart grid technologies and energy-efficient appliances, and changes in user behaviour. We will refer to these behaviours as smart energy behaviours. A key question is: which factors influence whether people engage in these different behaviours, and how can these factors be addressed to motivate and empower people to actively participate in smart grids? Social sciences can play an important role in answering these questions (Geelen et al. 2013; Gangale et al. 2013; see also Sovacool 2014). Social scientists can study which factors influence behaviour in smart grids, and examine how these factors can be addressed in energy policy and energy system changes. Besides, social scientists can study which factors determine the effectiveness and acceptability of technologies and policies aimed to promote the efficiency and sustainability of smart grids.

In this chapter, we review psychological studies aimed at understanding and promoting behaviour in smart grids by individuals and households. We propose a general framework, comprising four key issues:

1. identification and measurement of behaviours that need to be changed to promote smart grids,
2. examination of factors underlying smart energy behaviours, including the adoption of sustainable energy resources, energy-efficient technologies, and automated control technology; investments in energy efficiency measures in buildings such as insulation; and user behaviour.
3. designing and testing interventions to change behaviour needed to optimise smart grids, including information, financial incentives, regulations and technological changes,
4. studying factors underlying public acceptability of energy policies and changes in energy systems aimed to promote smart grids.

We discuss important findings from psychological studies on these four topics.

2 Which Behaviour Changes Are Needed to Promote Smart Grids?

Smart grids typically rely on renewable energy, which can be produced on a local level by so-called prosumers. It is therefore important to understand what motivates people to produce and use renewable energy sources. Besides, since the production of renewable energy sources fluctuates across time, energy supply and demand needs to be matched to secure a stable and efficient grid. To achieve this, consumers can either accept or adopt technologies to store renewable energy (e.g., electric vehicles, batteries) or shift energy use to times when renewable energy sources are abundant (e.g., when the sun is shining). Shifting energy use to times when renewable energy is available can either be done autonomously or by installing

technologies that automatically switch specific appliances on or off on the basis of the available energy supply (e.g., Gellings and Samotyj 2013; Kobus et al. 2013). An important question here is under which conditions consumers are willing to accept and adopt different ways of demand and supply matching. Finally, the efficiency of smart grids will be enhanced if consumers would reduce their overall energy use. Hence, we need to understand under which conditions consumers are willing and able to reduce their energy use.

Various studies have examined behaviours relevant to smart grids, including the adoption of renewable energy sources such as solar or wind energy (see Perlaviciute and Steg 2014, for a review), investment in innovative technologies such as electric vehicles (Bockarjova and Steg 2014; Noppers et al. 2014), using appliances when energy is abundant (Kobus et al. 2013), and the adoption and use of specific components of smart grids (see Sintov and Schultz 2015, for a review). However, such behaviours are typically studied in isolation. Yet, smart grids require changes in a wide range of energy behaviours, as we explained above. Hence, an important question is how these different types of behaviours are related, and how changes in a broader range of smart energy behaviours can be realised. A key issue here is whether and under which conditions engagement in one type of smart energy behaviour is likely to spillover to other behaviours (Truelove et al. 2014). Some studies have found evidence of negative spillover effects, in which case engagement in smart energy behaviour reduces the likelihood of subsequent smart energy behaviours. For example, people were more likely to increase their energy consumption after reducing their water use (Tiefenbeck et al. 2013). Such effects are likely when individuals think that engagement in one sustainable behaviour legitimates not acting sustainably in another occasion (Kaklamanou et al. 2015). Yet, literature suggests that such negative spillover (or rebound) effects may be small and generally not fully offset the efficiency gains of the initial measure (Fronzel et al. 2012). Still, little is known about which processes underlie negative spillover effects, and how to prevent negative spillover or 'rebound' effects.

Interestingly, other studies have found positive spillover effects, suggesting that initial smart energy behaviour makes it more likely that people engage in other smart energy behaviours. For example, individuals who recycled were more likely to buy organic food and use environmentally-friendly modes of transport one and two years later (Thøgersen and Ölander 2003). Also, green buying promoted subsequent recycling, the use of public transport, car-pooling, printing on both sides, saving water, and switching off lights (Lanzini and Thøgersen 2014). Such positive spillover effects are likely when people relate the initial sustainable energy behaviours to themselves, thereby strengthening their environmental or energy-saving self-identity (Van der Werff et al. 2013, 2014a, b). More particularly, when people realise they engaged in smart energy behaviours (or more generally pro-environmental behaviours), they are more likely to see themselves as a pro-environmental person, which motivates them to engage in pro-environmental or energy saving behaviours in subsequent situations. An important question is under which conditions such positive spillover effects are most likely. Also, as yet it is not clear how stable positive spillover effects are, as long-term effects have typically not been considered.

3 Factors Underlying Behaviour in Smart Grids

Interventions aimed to encourage behaviours to promote active participation in smart grids will be more successful if they target important antecedents of such behaviours, and remove significant barriers to change. Hence, it is important to examine which factors affect the likelihood that people engage in behaviours that increase the efficiency and sustainability of smart grids and the acceptability of smart grids. In this section, we discuss two general factors that underlie smart energy behaviour: people need to be motivated to engage in the relevant behaviours, and they need to be able to do so.

3.1 *Motivations*

Whether or not people engage in behaviours needed to promote smart grids will depend on their motivation to do so. People will be more motivated to engage in these behaviours when they evaluate the consequences of such behaviours more favourably, that is, when they believe that the behaviour has relatively more benefits and less costs. In this respect, they are likely to consider individual as well collective consequences of behaviour, as we illustrate below. Next, we discuss general motivational factors, notably values, which affect how people evaluate and weigh the costs and benefits of behaviours, and which choices they make.

Individual costs and benefits reflect consequences that affect people's self-interest, for example financial costs, time, pleasure, and comfort. People are more likely to engage in smart energy behaviour when they believe such behaviour has relative low individual costs and high individual benefits, resulting in overall positive evaluations of the relevant actions. Some behaviours that increase efficiency of smart grids are perceived to be somewhat costly. For example, people think that renewable energy sources are rather expensive, which could hinder their adoption (cf. Perlaviciute and Steg 2014). A study revealed that financial costs are a strong predictor of preferences for energy systems; financial costs appeared to be more important than the level of control over smart grid technologies, and whether renewable energy was produced on a central versus local level (Leijten et al. 2014).

Interestingly, while privacy concerns with regard to energy use monitoring technology such as smart metering may hinder acceptability of such technology (Krishnamurti et al. 2012; Hess 2014), a study found that privacy concerns may be underpinned by the costs and benefits that people expect from such technology for them personally (Bolderdijk et al. 2013c). More specifically, privacy concerns were most prominent when people anticipated negative individual consequences (e.g., paying more for energy use) from implementing the monitoring technology, suggesting that privacy concerns may depend on expected consequences of such technologies for people. Communicating the individual benefits of such technologies (e.g., possibility to save money) may thus alleviate privacy concerns.

Besides instrumental costs and benefits such as prices, time, and comfort, people also consider affective and social costs and benefits. For example, people are more likely to engage in pro-environmental behaviours when they expect to derive pleasure from such behaviour (Gatersleben and Steg 2012). People may also engage in smart energy behaviour when they expect that others would approve of it (Harland et al. 1999), or when they think others engage in these behaviours too (Nolan et al. 2008). Moreover, people may engage in behaviours that support smart grids when they expect that the particular behaviour enhances their status, particularly when the behaviour is somewhat costly, to signal to others that they have sufficient resources to make altruistic sacrifices (cf. Griskevicius et al. 2010). People are more likely to adopt smart grid components such as electric cars and renewable energy systems when they evaluate their symbolic aspects, that is, the extent to which these innovations signal something positive about the owner or user to others and themselves, more favourably (Noppers et al. 2014). Positive symbolic outcomes may thus encourage people to adopt various smart grid components, even when some instrumental drawbacks are present, which is often the case in the early introduction phases of smart grids. Interestingly, behaviour can have a larger signalling value for prestige and identity effects when it is somewhat costly. When smart energy behaviour is very easy, convenient or profitable, it is hard to claim that you engaged in the behaviour because you care for others and the environment. In contrast, when engaging in smart energy behaviour is somewhat costly or effortful, it is more likely to signal that you care about others and the environment (Van der Werff et al. 2014a).

Some smart energy behaviours have clear individual benefits, which may promote such behaviour. Examples are saving energy at home or switching energy use to times when tariffs are low, which both save money. Furthermore, renewable energy systems may enhance people's status, as described above.

People not only consider individual consequences of behaviour, but also consequences for others and the environment. Smart energy behaviours typically benefit the environment as they result in a reduction of CO₂ emissions (Steg et al. 2014a, b). Many people care about the environment, and take environmental considerations into account when they make decisions (Steg and De Groot 2012). People are motivated to see themselves as morally right, and to do the right thing, which may encourage smart energy behaviours (Bolderdijk et al. 2013b). Indeed, several studies revealed that moral considerations, affect energy behaviour, such as the purchase of energy-saving light bulbs (Harland et al. 2007), electricity saving at work (Zhang et al. 2013), and energy saving behaviours at home (Van der Werff and Steg 2015). Interestingly, engaging in smart energy behaviour may make people feel good because they derive pleasure and satisfaction from doing the right thing (Venhoeven et al. 2013). People may even physically feel warmer by engaging in smart energy behaviour, because such behaviour boosts the self, a phenomenon known as a warm-glow effect (Taufik et al. 2014).

Engaging in smart energy behaviour such as reducing one's overall energy use to match demand and supply of (renewable) energy, is likely to strengthen environmental self-identity, that is, the extent to which a person sees himself or herself as a

pro-environmental person (Cornelissen et al. 2008; Van der Werff et al. 2013, 2014a). Interestingly, environmental self-identity is particularly strengthened when people engaged in pro-environmental behaviours that are somewhat costly or uncommon, probably because such behaviours are more likely to signal how pro-environmental a person is (Van der Werff et al. 2014a). As indicated above, a strong environmental self-identity is likely to encourage positive spillover effects, increasing the likelihood that people engage in a wide range of behaviours that increase the efficiency and sustainability of smart grids. People may engage in smart energy behaviours when such behaviours are somewhat (but not too) costly or effortful, as this boosts their self-concept (Taufik et al. 2014; Van der Werff et al. 2014a).

An important question is to what extent people consider and weigh individual and collective considerations of smart energy behaviour, and which factors enhance the likelihood that they will consider different individual and collective consequences in the choices they make. Values appear to be an important factor in this respect. Values reflect life goals or ideals that define what is important to people and what consequences they strive for in their lives in general (Schwartz 1992). Values can affect a wide range of evaluations, beliefs, and actions (Steg et al. 2014a, b). Four types of values have been found to be relevant for people's evaluations and behaviour in smart grids: hedonic values that make people focus on pleasure and comfort, egoistic values that make people focus on safeguarding and promoting one's personal resources (i.e., money, status), altruistic values that make people focus on the well-being of other people, and biospheric values that make people focus on consequences for nature and the environment (De Groot and Steg 2008; Steg and De Groot 2012; Steg et al. 2014b).

Values affect how important people find different consequences of smart grids, and how they evaluate these consequences. More specially, people focus on consequences of smart grids that have positive or negative implications for their important values (Parkhill et al. 2013; Steg et al. 2014b). For example, the stronger their biospheric values, the more positively people evaluated renewable energy sources, which are generally seen as having positive implications for one's biospheric values, such as reducing CO₂ emissions (Perlaviciute and Steg 2015; Bidwell 2013). In contrast, stronger egoistic values were related to less positive evaluations of renewable energy sources, which are likely to have negative consequences for one's egoistic values, such as being expensive and intermittent (Perlaviciute and Steg 2015). Interestingly, people evaluate various costs and benefits of renewable energy sources in line with their overall value-based judgements, even if these costs and benefits are not particularly important to them based on their key values. For example, the stronger their biospheric values, the more positively people evaluated personal consequences of renewable energy sources such as financial costs (Perlaviciute and Steg 2015), while stronger altruistic values led to more positive evaluations of effects of wind energy developments on local landscape (i.e. wildlife, noise, and scenic views) and local economy. People seem to base their evaluations of smart grids on aspects that are most relevant for their important values, which guide their acceptability ratings, and possibly behaviour.

These value-based acceptability judgements may further affect the evaluation of other characteristics of smart grids, which may be less important to people based on their values. In other words, people are likely to evaluate smart grids in an overly positive or negative way that is in line with their value-based judgements. A thorough understanding of which values actually underlie people's evaluations and acceptability ratings is therefore crucial for developing effective intervention and communication strategies.

People are more aware of environmental problems caused by their behaviour when they more strongly endorse biospheric values, or less strongly endorse egoistic values (Nordlund and Garvill 2002; Steg et al. 2005; Stern et al. 1995). This in turn influences their choices. As explained before, many smart energy behaviours have positive collective consequences, and negative individual consequences. In line with this, research revealed that in general, people have more favourable evaluations of and are more likely to engage in smart energy behaviours if they strongly endorse biospheric and, to a lesser extent, altruistic values, while they are less likely to do so if they strongly endorse egoistic and/or hedonic values (see Steg and De Groot 2012 for a review). Strong biospheric values also strengthen environmental self-identity (Van der Werff et al. 2013; Gatersleben et al. 2012), which in turn increases the likelihood of positive spillover effects, as explained earlier.

3.2 Contextual Factors

In general, people care about the environment, and strongly endorse biospheric values. Despite this, many people do not consistently engage in smart energy behaviour. How can we explain such a value-behaviour gap? Besides a lack of motivation to do so, smart energy behaviour can be inhibited by various other factors. First, people may not know which behaviours are needed to optimise smart grids (Steg et al. 2015). Second, contextual factors may inhibit people to engage in value-congruent actions. Contextual factors define the costs and benefits of different energy behaviours thereby influencing individual motivations (Steg and Vlek 2009; Stern 1999). In some cases, contextual factors inhibit people to act upon their biospheric values and moral considerations (Abrahamse and Steg 2011; Diekmann and Preisendörfer 2003). For example, shifting energy use in time can be effortful when people have to control their appliances autonomously, which may result in less smart energy behaviours (see Sintov and Schultz 2015, for a review). Technologies can be implemented that automatically switch apparatuses off and on at different times, thereby balancing energy supply and demand. However, a study in the Netherlands showed that people prefer making changes in energy use themselves rather than relying on technology to make these choices for them (Leijten et al. 2014). Also, costs may inhibit smart energy behaviours. For example, people may not have sufficient financial resources to purchase solar panels or other smart grid technologies. In such cases, subsidy schemes can be implemented that make investments in smart grid technologies more affordable. By doing so,

contextual factors facilitate smart energy behaviour, and support individuals' biospheric values and moral considerations. Contextual factors even may make some behaviours simply impossible (e.g., Corraliza and Berenguer 2000). For example, laws may be in place that prohibit people to sell their excess of self-produced solar energy to their neighbours, or the lack of charging stations may inhibit the use of electric vehicles.

Besides defining the costs and benefits of smart energy behaviours, contextual factors can serve as cues that activate specific values in a particular situation, making it more likely that these values steer decision making in that situation (Steg 2015; Steg et al. 2014a). Values are more likely to affect behaviour when they are activated in a particular context, making it more likely that people base their decisions on these values. For example, bikini models or chocolate can activate hedonic values; status symbols or signs of money can activate egoistic values; while religious symbols, statues of Justitia and environmental symbols can activate altruistic and biospheric values (Lindenberg 2012; Perlaviciute 2014). Also, high behavioural costs are likely to activate values related to these costs, notably hedonic and egoistic values, which makes it less likely that people act upon their biospheric values (Steg et al. 2014a; Steg 2015). Furthermore, signs of immoral or norm violating behaviour by others can activate hedonic and egoistic values, making altruistic and biospheric values less influential in the particular situation. The opposite is true for cues that clearly signal that others respect norms and acted morally right (Steg et al. 2014a; Steg 2015).

4 Interventions to Promote a Transition to Smart Grids

Various studies have examined which interventions are effective to change energy behaviours. Below, we review the literature on interventions to encourage smart energy behaviour. We first discuss structural strategies that aim to enhance people's ability and motivation to engage in smart energy actions by making such actions more attractive via incentives. Second, we discuss psychological strategies that aim to increase people's ability and motivation to engage in smart energy actions without actually changing their costs and benefits.

4.1 *Structural Strategies*

As indicated earlier, smart energy behaviours may involve some degree of effort, discomfort or can be financially costly. For example, investing in solar panels involves initial financial investments, and shifting your energy consumption in time by autonomously switching off appliances can be a hassle. This implies that smart energy behaviours are oftentimes not rewarding or pleasurable, at least in the short term. Yet, perceptions of costs and benefits of behaviour are not always accurate. In

such cases, it may be sufficient to change the perceptions of costs and benefits of options via information strategies that aim to correct such misperceptions (Abrahamse and Matthies 2012).

It is often assumed that people are not willing to engage in sustainable behaviours unless some personal benefits are involved. This suggests external incentives are needed to motivate people to engage in smart energy behaviour, such as subsidies on solar panels or smart devices, or special arrangements such as free parking spaces for electric cars (cf. Bolderdijk and Steg 2015). In addition, compensation can be provided to motivate local communities to host renewable energy infrastructure (e.g. wind farms), who face possible risks and costs of these infrastructures (e.g. visual hinder and noise), we will elaborate on this in the section on distributive fairness. Alternatively, external incentives could make excessive energy use, particularly at certain times of the day, more costly or less pleasurable, for example, by introducing taxes or laws and regulations. Also, a transition to smart grids may involve the introduction of dynamic pricing (Clastres 2011). With time-of-use-pricing energy tariffs are differentiated, resulting in lower tariffs at times where a lot of renewable energy is available (e.g., when the sun is shining), and higher tariffs when energy supply is low which may change energy use accordingly (Kobus et al. 2013).

Incentives that are aimed at changing contextual factors that define the costs and benefits of sustainable energy choices are often necessary when smart energy behaviours are very costly (Steg and Vlek 2009), as even people with strong biospheric values will be unlikely to engage in such behaviour. For example, few people would be willing to purchase a smart energy appliance if it is twice as expensive as other options. Yet, strategies that mainly incentivise behaviour may be less effective than sometimes assumed, and can sometimes even be counter-effective (see for a review Bolderdijk and Steg 2015). In fact, incentives provide a fickle basis for consistent smart energy choices when employed in isolation. They make people focus on immediate personal costs and benefits of behaviour, thereby activating hedonic and egoistic values rather than biospheric values (Steg 2015; Steg et al. 2014a). Consequently, people may particularly engage in the relevant behaviours when such behaviour is extrinsically rewarding (De Groot and Steg 2009). For example, it was found that financial incentives promoted eco-driving, but that these positive effects disappeared as soon as the incentives were removed (Bolderdijk et al. 2011). In addition, external incentives can inhibit positive spillover effects when subsequent actions have no clear external rewards, which is not uncommon in the energy domain (Thøgersen 2013). For example, people who considered economic rather than environmental reasons for car-sharing were less likely to engage in another sustainable behaviour on a following occasion (Evans et al. 2013). Similarly, if people engage in smart energy behaviour because they follow rules or regulations, rather than because they freely chose to do so, the behaviour may not be attributed to the self, and hence weaken rather than strengthen environmental self-identity, which can inhibit positive spillover. For example, when appliances are operated via automated control systems people are less likely to switch them off (Murtagh et al. 2015). Therefore, people

may not attribute the smart energy use to the self, which may make it less likely that they will next take a shorter shower or reduce the thermostat setting. This implies that many different incentives need to be implemented to encourage wide-scale behaviour changes needed to realise smart grids, each increasing the relative attractiveness of the specific behaviour targeted. Such a strategy is overall not efficient and cost-effective. In addition, external incentives are not likely to result in behaviour changes when such changes are perceived not to be worth the effort (Bolderdijk and Steg 2013b, 2015). Many single smart energy behaviours yield small benefits and are therefore perceived as hardly worth the effort (Dogan et al. 2014). For example, unplugging a single coffee machine or microwave would save less than 6 € a year. In sum, although targeting extrinsic motivations by introducing incentives may be needed to promote some smart energy behaviours, such incentives are not likely to encourage people to engage in the many behaviours needed to increase the efficiency and sustainability of smart grids.

4.2 *Psychological Strategies*

Therefore, it is also important to employ strategies that target or enhance motivations to engage in smart energy behaviour. Strategies that target and strengthen individuals' intrinsic motivation to engage in smart energy behaviour may be particularly promising in this respect, as these strategies are more likely to result in durable behaviour changes.

First, information can be provided aimed to change consumers' beliefs about the pros and cons of smart energy behaviours, and to increase their awareness of environmental problems caused by their behaviour. Such information may enable and motivate consumers to change their behaviour. Research suggests that providing general information about energy problems and energy conservation generally results in an increase in knowledge and awareness (Bradley et al. 1999; Staats et al. 1996), but this increase in knowledge does not necessarily motivate them to change their behaviour accordingly (Abrahamse et al. 2005; Staats et al. 1996). Information is more likely to encourage smart energy behaviour when it resonates with people's central values. For example, an environmental campaign increased knowledge among all exposed to the campaign, but only resulted in stronger pro-environmental intentions and increased environmental policy support for those who strongly endorsed biospheric values (Bolderdijk et al. 2013a). Similarly, interventions aimed at strengthening public support for smart grids will be more effective if they target values that underlie people's evaluations and acceptability ratings. For example, educating people about the environmental consequences of smart grids may not motivate them to change their energy behaviours, if, based on their egoistic values, they mostly focus on energy price and/or quality of energy supply. In this case, introducing subsidies for adopting renewable energy or improving the functionality of smart grids could be more motivating for people; such strategies could at the same time enhance intrinsic motivation to support

lasting changes in behaviour, as explained above. More generally, information strategies have been more successful when they are tailored to specific characteristics of the target population (Abrahamse et al. 2005, 2007). Besides, information is more likely to change beliefs and behaviour if people evaluate the source favourably and trust the source (Clayton et al. 2015).

Second, people can be informed about which personal actions are effective to increase the efficiency and sustainability of smart grids by providing them with feedback about their energy use or energy savings. Feedback appears to be an effective strategy for reducing household energy use (Abrahamse et al. 2005), although some exceptions exist (see Fischer 2008). Feedback on household energy use is considered to be an important part of smart grids. It is therefore essential to understand under which conditions feedback is most likely to motivate people to engage in behaviours that optimise smart grids. Feedback is more effective when it is given immediately after the behaviour occurs, and when it is provided frequently, as this enhances people's understanding of the relationship between the feedback and their behaviour (Geller 2002). Smart meters offer possibilities for providing immediate and frequent feedback on household energy use via different means such as websites, mobile phones, and home displays (Sintov and Schultz 2015). Smart meters, however, typically provide feedback on overall energy use, which might still tell little to people about how they can reduce their energy use. In this respect, feedback on a more detailed level, for example, on an appliance level, may be more effective (Fischer 2008; Ehrhardt-Martinez et al. 2010). Furthermore, with dynamic pricing, smart meters may provide people with feedback on current energy tariffs, and ways to save costs by shifting energy use in time. People may not always be motivated or able to consciously process feedback on their energy use. When they lack the motivation or resources to consciously process information and feedback on their energy behaviours, ambient persuasive technologies can be offered that promote behaviour change without the need for user's conscious attention and hence with little cognitive effort (Midden and Ham 2012). For example processing interactive lighting feedback, such as a light that turns green, is less cognitively demanding than processing factual feedback, such as statistics on your energy use, and may facilitate and motivate people to engage in smart energy behaviour even in cognitively demanding situations.

A range of social influence strategies can be employed to encourage smart energy behaviours (see Abrahamse and Steg 2013, for a review). Social influence occurs when one's emotions, beliefs or behaviour are influenced by others. Social influence approaches that make use of face-to-face interaction appeared particularly effective, such as block leader approaches, and behaviour modelling. Block leader approaches, in which case local volunteers help inform other people in their neighbourhood about a certain issue, seem to be one of the most effective social influence strategies. Block leader approaches are more effective when the relevant social network has more ties (Weenig and Midden 1991). Behaviour modelling, in which case confederates or "models" demonstrate a recommended behaviour, appeared to be an effective strategy to encourage sustainable behaviour too (Winett et al. 1985).

Commitment making is another effective social influence strategy, in which case people make a promise to engage in smart energy behaviour. Also, implementation intentions appeared to be successful in promoting behaviour changes, in which case people not only promise to engage in smart energy behaviour, but also indicate how and when they will do so. Importantly, both strategies appear to have long-term effects on behaviour (see Abrahamse et al. 2005; Abrahamse and Steg 2013; Lokhorst et al. 2013, for reviews). Commitments are more effective when made in public rather than private (Abrahamse et al. 2005). Although little is known about the processes through which both strategies promote behaviour changes, one plausible explanation is that they strengthen personal norms. Once people committed themselves to engage in smart energy behaviour, they are motivated to act in line with their promise, as they want to (appear to) be consistent (Abrahamse and Steg 2013). Evoking cognitive dissonance between individuals' reported attitudes and behaviour is another strategy using people's desire to be consistent. For example, people who first reported a favourable attitude towards energy conservation, and later were made aware of their relatively high energy usage, significantly reduced their energy use (Focella and Stone 2013).

Social influence strategies that generally operate in a fairly anonymous way, such as descriptive norm information, social comparison feedback, and group feedback, can also encourage sustainable behaviour, but are less effective than strategies that rely on face-to-face interactions (Abrahamse and Steg 2013). Descriptive norm information entails that individuals receive information on the behaviour of others, while social comparison feedback involves receiving feedback about one's own performance relative to the performance of others. In case of group feedback, people receive information on the performance of a group. Descriptive norm information and social comparison feedback is not very effective when people figure out that most (significant) others do not act sustainably. In fact, if individuals learn that most others do not engage in smart energy behaviours, providing feedback on the behaviour of others may even be counter effective, as people are likely to follow this norm (Brandon and Lewis 1999; Schultz et al. 2007). Another factor that influences the effects of descriptive norm information and social comparison feedback is credibility of information on the behaviour or performance of others. For example, it would be unwise to communicate that most others engage in smart energy behaviours while it is obvious that this is not actually the case (cf. Terwel et al. 2009).

Besides informing people about the smart energy behaviour of others, they can also be reminded of smart energy behaviours they themselves already engaged in. As explained earlier, such strategies are likely to strengthen one's environmental self-identity, particularly when one's previous behaviours clearly signal that one acted pro-environmentally, thereby promoting subsequent smart energy behaviours (Van der Werff et al. 2014a). As discussed above, the latter is more likely to be the case when people are reminded of a range of actions they engaged in, or when they are reminded of behaviours that were somewhat costly or unique. This implies an interesting paradox. On the one hand, it may be important to stress that many others engage in smart energy behaviour, as people are likely to act in line with such descriptive norms. Yet, on the other hand, stressing that only few people engage in smart energy

behaviour can also encourage smart energy behaviour, via a different process, by strengthening one's environmental identity after engaging in such behaviours.

5 Acceptability of Smart Grids

Smart grids can be promoted via different energy policies and changes in energy systems, which should be acceptable to the public. We already discussed how values can influence perceived costs and benefits of smart grids. Besides, public acceptability depends on how and by whom a transition to smart grids is developed and implemented. We describe three factors that play a crucial role in this respect, namely distributive fairness, trust in involved parties, and public engagement and participation.

5.1 *Distributive Fairness*

Acceptability of the transition to smart grids does not only depend on the benefits, costs and risks, but also on how these benefits, costs and risks are distributed among groups involved, which reflects perceived fairness. Smart grid solutions will be seen as unfair if certain groups in society face most of the costs, while other groups mainly enjoy the benefits; this may reduce their acceptability (Schuitema and Jakobsson Bergstad 2012). For example, communities hosting renewable energy technology such as wind farms may experience noise and visual hinder, while the possible benefits such as reduced CO₂ emissions, affordable energy, and energy independence are shared on a national or even global scale. As a consequence, people may oppose these technologies.

Fair distribution of costs and benefits can be pursued in multiple ways, which are not mutually exclusive. First, risks and costs of smart grids can be reduced as much as possible in order to enhance fairness and secure public acceptability. For example, technical solutions can be sought to reduce the noise caused by wind turbines, and costs of renewable energy sources can be reduced via subsidies. A second (parallel) strategy to pursue a fair distribution of costs, risks and benefits is providing additional benefits to those exposed to most costs and risks. For example, individuals can be financially compensated, or developers of renewable energy projects could establish local funds that can be used to reduce energy bills for local people, to stimulate local economy, or to create or expand local facilities (Walker et al. 2014). Offering reductions on energy prices for example increased people's willingness to host wind farms (e.g. Groothuis et al. 2008). It has been proposed that collective benefits (e.g. investing in local facilities) are less likely to be seen as 'bribes' by citizens than individual financial compensations (e.g. one-time payments to residents; Ter Mors et al. 2012). However, this proposition has not been empirically tested. Interestingly, the amount of compensations may be less important for perceived fairness and

acceptability judgements than who will benefit from the compensation. For example, people prefer royalties from a wind energy project to be allocated to local funds rather than to state funds (Krueger et al. 2011). This is probably because it is seen as more fair when local communities benefit from hosting energy infrastructure (cf. Schuitema and Steg 2008). Yet, financial compensation to local funds will not enhance acceptability and may even backfire when these compensations are perceived as attempts to ‘buy local support’ (Walker et al. 2014; cf. Ter Mors et al. 2012).

5.2 Trust in Involved Parties and Acceptability

A transition to smart grids entails multiple aspects, including complex energy technology, that go beyond the knowledge and expertise of consumers. People therefore need to rely on other parties, such as energy companies, governments, and scientists, to form their opinion on smart grids. Trust in involved parties will especially affect evaluations and perceptions when people have little knowledge about new systems or solutions, which is the case for smart grids (cf. Siegrist and Cvetkovich 2000). The extent to which people trust involved parties can influence acceptability of smart grids (cf. Ngar-yin et al. 2012; Huijts et al. 2012; Perlaviciute and Steg 2014; Steg et al. 2015). Lack of trust in energy companies can also strengthen privacy concerns related to smart metering technology, which can weaken public support for these technologies (Butler et al. 2013). Similarly, public distrust in national governments can hinder the implementation of energy policies, such as dynamic pricing schemes aimed at balancing the energy supply and demand (Mah et al. 2012). Yet, lack of trust may not always result in lack of support for proposed changes. For example, people expressed much support for a sustainable energy transition, but at the same time they expressed their concern whether energy companies are capable of realising sustainable energy transitions in a way that aligns with societal and environmental values (Butler et al. 2013).

5.3 Public Involvement

Smart grids are likely to rely more strongly on decentralised and local energy production. This changes the role of consumers from passive recipients to active producers of energy, so-called prosumers. Smart grids may also require more active public user involvement in planning, developing, and implementing smart grids. Public involvement comprises different dimensions, varying from one-way communication from developers to consumers to active public involvement in decision-making processes, which can have important implications for public acceptability of smart grids (cf. Devine-Wright 2011; Steg et al. 2015). Technocratic top-down decision making processes may inhibit public acceptability of smart grids, while collaborative approaches taking people’s interests and concerns into account

in which people actually have a say enhance acceptability of energy policies and changes in energy systems (Devine-Wright 2011; Wolsink 2007). Acceptability of smart grids is likely to be higher if people have been actively involved in the decisions-making process, as this enhances legitimacy of the decisions made (U.S. National Research Council 2008; Schuitema and Jakobsson Bergstad 2012).

6 Conclusion

In this chapter, we discussed factors influencing behaviour in smart grids. We proposed a general framework to study ways to understand and encourage smart energy behaviours needed to promote the efficiency and sustainability of smart grids, comprising four key issues. First, we argued that smart grids involve changes in a wide range of energy behaviours, including the adoption of sustainable energy resources and energy-efficient and smart technology, and changes in energy use behaviour. We indicated that it is important to consider the conditions under which engagement in one smart energy behaviour is likely to promote engagement in other smart energy behaviour, resulting in positive spillover. Second, we proposed that it is important to examine main factors underlying these different types behaviours and acceptability of smart grid solutions needed to optimise smart grids. We discussed two main factors influencing such behaviour that are closely intertwined: motivations and contextual factors. Third, it is important to understand factors influencing the effects of different interventions aimed at promoting smart grids by changing important antecedents of smart energy behaviours. It is not only important to study structural strategies that are aimed at changing the actual costs and benefits of behaviour, but also psychological strategies that affect how individuals perceive and evaluate different pros and cons of behavioural options. Fourth, smart grids will probably not be implemented when they are not supported by the public. Therefore, it is important to understand which factors affect the acceptability of a transition to smart grids. We discussed that acceptability judgements not only depend on the perceived benefits, costs and risks of smart grids, but also on trust in the parties involved. Besides, perceived fairness plays a role, which depends on the distribution of benefits, costs and risks across groups in society, and the level of public involvement in the decision making process.

Points for Discussion

- How will the difficulties of stimulating smart energy behaviour at the individual and household level affect the introduction of smart grids at the community level? Can a smart grid for, say, a city of more than one million inhabitants be built and implemented if only a proportion of the population actively supports it? What would be needed?

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