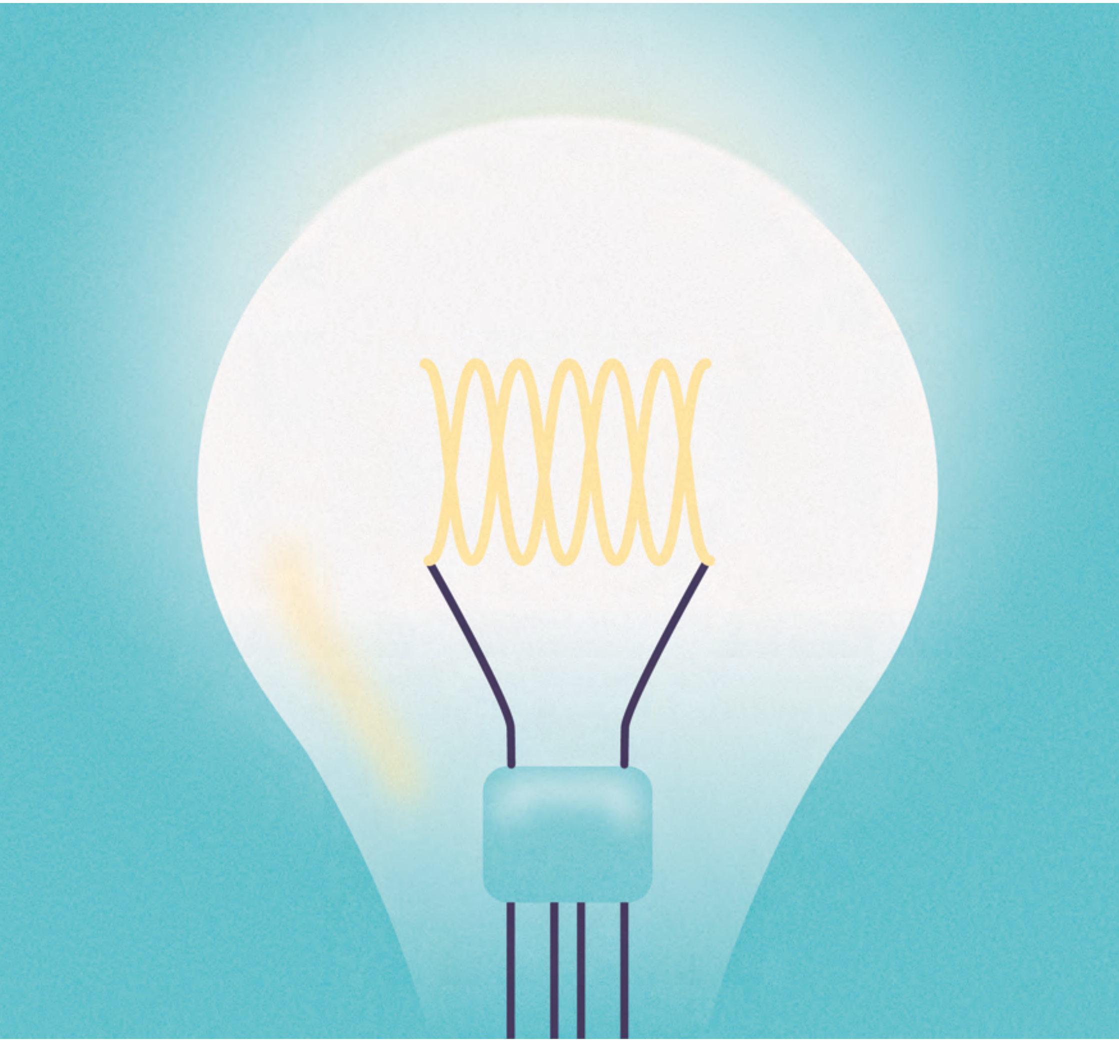
Maison des Sciences de l'Homme PARIS-SACLAY

ACTES

ÉNERGIES « NOUVELLES » ET SOCIÉTÉ

LA TRANSITION ÉNERGÉTIQUE ACTUELLE À LA CROISÉE DES CHEMINS ET DES SAVOIRS



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A Systematic Review of Qualitative Studies on Residential Consumer Experience with Smart Meters and Dynamic Pricing

Penelope Buckley

Résumé

La littérature qualitative concernant l'étude de l'expérience des consommateurs avec les compteurs intelligents, ainsi que les incitations qui y sont associées, est analysée afin d'identifier les barrières à leur acceptation et à leur adoption. L'acceptation est un élément clé car les ménages doivent d'abord être prêts à installer des compteurs intelligents chez eux. L'adoption permet quant à elle de savoir si ces dispositifs peuvent être efficaces. Parmi les barrières identifiées, il y a le fait que les ménages ne font pas confiance aux compagnies d'énergie. Ils ne savent pas comment agissent les compteurs intelligents et comment ils peuvent les utiliser à leur profit. Ils trouvent que la tarification dynamique est complexe et lorsqu'ils ont le choix, peu d'entre eux optent pour cette tarification. L'effet sur la consommation de ces dispositifs est souvent de courte durée, les économies monétaires étant rarement suffisamment élevées pour encourager des changements de comportement persistants et les ménages étant contraints de faire un feedback selon leur niveau de confort personnel – sur lequel ils ne sont pas prêts à faire des compromis – et les rigidités de leur vie quotidienne. Grâce à cette analyse, différents segments cibles de consommateurs de ces compteurs intelligents sont identifiés.

The average residential consumer has learnt to be a passive user of electricity. For this consumer electricity has an invisible quality; it arrives in the household through hidden wires and is consumed as part of daily life and routine, which makes it difficult to connect daily activities to energy consumption (Burgess & Nye, 2008; Hargreaves, Nye & Burgess, 2010). Residential consumers tend to overestimate their energy use in terms of visible, low-energy appliances such as lighting, whereas they underestimate consumption from less visible, high-energy items (Attari *et al.*, 2010).

Furthermore, most residential consumers pay a fixed rate for electricity. All consumed kilowatt hours (kWh) are charged at the same fixed price; the consumer does not differentiate between a kWh consumed at 7 pm or one that is consumed at 4 am. Yet these two kWh do not have the same production costs, as electricity consumed during peak hours costs significantly more to produce and distribute (Faruqui, 2012). This lack of transparent pricing gives electricity an unlimited quality; no matter how much is consumed, no matter when it is consumed, the price per kWh remains the same.

In reality, electricity is not invisible nor in unlimited supply. Electricity grids across the world are under pressure to supply enough to meet the demands of modern life. With the electrification of the home and domestication of technology, energy needs have changed and energy networks cannot keep up (Verbong, Beemsterboer & Sengers, 2013). This increased demand is putting great strain on electricity generators, with certain generators only used for a few hours a year to meet demand on high peak days. In the EU 5–8% of electricity network capacity is used only 1% of the time (Faruqui, Harris & Hledik, 2010).

Across the world, countries are setting objectives to facilitate the transition to a greener society with fewer CO_2 emissions, more renewable energy sources and increased energy savings. This transition to a cleaner, sustainable energy system requires residential consumers to take a more active role in energy systems. To aid consumers, smart meters (SMs) are being installed with associated in-home displays (IHDs) that better inform households of their real-time energy consumption and encourage reduced consumption through incentives such as dynamic pricing (DP).

SM implementation by consumers is considered central to the success of the electricity grid transition, and equally one of its greatest barriers (Verbong, Beemsterboer & Sengers, 2013). To lower energy consumption, consumers must not only accept the installation of SMs and the use of different incentives, but also engage with the information and incentives provided, and use them to modify their daily energy-consuming behaviour[1] (Buchanan, Russo & Anderson, 2015). This paper systematically reviews studies presenting interviews, focus groups and surveys with residential consumers to provide a qualitative analysis of the different barriers to acceptance and adoption of SMs and DP.

Method

Appropriate articles were located through searches of CrossRef, EconLit, EconPapers Repec, Google Scholar, NBER, ScienceDirect, SpringerLink, Web of Science and SSRN databases using the following keywords:

– Type of consumption: electricity consumption, electricity demand, electricity usage, energy consumption, energy demand, energy usage
– Type of incentive: smart meter, advanced met*, feedback, nudge, norm, dynamic pricing, tariff, time of use, critical peak pricing, real time pricing, peak time rebate
– Level of consumption: residential, household, consumer

This search produced a selection of 3153 references. After eliminating duplicate and irrelevant references based upon title and abstract, 47 articles written in English and carried out in a developed country since 2005[2] were kept for review. Table 1 provides details of the study selection methodology. The 47 articles were thoroughly read in order to identify the main barriers to SM and DP acceptance and adoption.

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1 See Buckley (2020) for a complementary meta-analysis of quantitative experimental results from using different information and incentives to encourage households to lower their energy consumption.

2 Only references from 2005 onwards were considered to reflect studies taking place during the "Smart Grid Era" (McKerracher & Torriti, 2013).

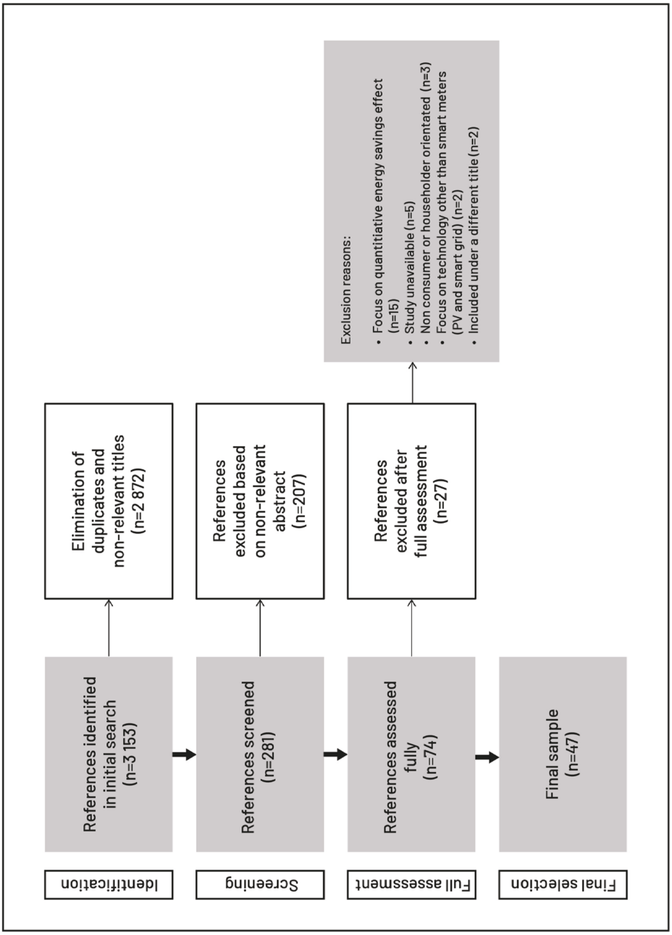

Table 1 – Study selection flowchart.

Source: P. Buckley.

Barriers to Acceptance

In today's society, much of an individual's life is tracked, monitored and analysed. SMs are another example of such monitoring, yet there is an increasing amount of opposition to their use. Equally, time-variant tariffs are not a new way of pricing goods and services. Consumers face DP in numerous areas; when buying a plane or train ticket, when reserving a hotel or hiring a car, and when using a toll bridge. However, such pricing programmes have low penetration in the electricity market (Dütschke & Paetz, 2013).

Mistrust of Energy Companies' Intentions

Consumers are wary of energy companies' motives for providing SM technology due to previous bad experience (Hall, Jeanneret & Rai, 2016). Energy companies may not offer an SM package that is in the interest of the household, but one that serves the energy companies' interest (Kaufmann, Künzel & Loock, 2013). Consumers who feel that energy companies benefit most from the use of SMs are less positive about SM installation in their homes (Krishnamurti *et al.*, 2012). Furthermore, householders doubt whether energy companies will pass on the monetary savings to customers. Instead, they believe energy companies will prioritise maintaining their profit margins, given profits increase as consumers use more energy (Goulden *et al.*, 2014; Spence *et al.*, 2014). Dutch stakeholders[3] express ambiguity as to whether SM installation is in the interest of end-users. They emphasise that while there are advantages for consumers, energy companies have their own motivations and it is unclear as to whose interests are better served (Verbong, Beemsterboer & Sengers, 2013).

Australian households' trust in their energy supplier greatly affects their willingness to participate in direct load control, with those who explicitly express mistrust being much less likely to participate. Even when this lack of mistrust is addressed, the proportion of households willing to participate only increases by a marginal amount (Stenner *et al.*, 2017). Even attempts to address issues of misinformation may backfire; when

[3] The stakeholders interviewed represented governmental organisations, electrical and gas utility companies, researchers of energy-related consumer behaviour, and residents.

American consumers are better informed about SM technology, they are more likely to react negatively to the technology (Horne *et al.*, 2015).

Trust remains an issue once the SM has been installed. Consumers are unsure of what energy companies will do with the substantial amount of data on their energy consumption behaviour and habits (Richter & Pollitt, 2018). Dutch households are concerned that energy companies will use data for commercial means (Naus *et al.*, 2014). Namely, that energy companies will be able to use the real-time data to market specific services and/or products to consumers. For this reason, consumers are willing to pay a significant amount to have an SM which has no effect on privacy (Pepermans, 2014). This lack of trust increases the psychological costs that consumers face, as they must spend time monitoring energy companies' use of their data (Gerpott & Paukert, 2013).

Though trust issues are mostly viewed as a barrier to adoption of SMs, American consumers suggest that the increased accuracy of energy bills due to real-time feedback from SMs provides energy companies with an opportunity to build trust with consumers (Krishnamurti *et al.*, 2012). However, households could face increased bills if their consumption was previously underestimated (Raimi & Carrico, 2016).

Uncertainty Regarding Technology

With new technologies of a particularly technical nature, consumers are not always sure of what the technology is and what it can do. Few surveyed American consumers have heard of SMs and smart grids, and those who have are not sure of their purpose (Raimi & Carrico, 2016). Both British and American consumers have a tendency to confuse SMs with the devices required to display energy consumption data, expecting an SM to come with an IHD so that they can verify the accuracy of their energy bill and see appliance-specific data describing their energy consumption in detail (Darby, 2010; Krishnamurti *et al.*, 2012).

German consumers are also unsure of what dynamic electricity pricing is and what it can do. Of 160 participants, 53% believed that DP may result in a reduction in their energy use (Dütschke & Paetz, 2013). Added to this uncertainty are difficulties in calculating peak and off-peak consumption, given consumers are generally unaware of the different energy demands of their various appliances (Goulden *et al.*, 2014).

This uncertainty is unsurprising given how the traditional electricity market is set up; households are accustomed to being passive users of energy. The implications of DP in the residential sector goes against years of policy aimed at reducing price volatility for residential consumers in the electricity market (Alexander, 2010). This uncertainty can lead to confusion in regard to the benefits and risks of SM and DP, leading to unrealistic expectations (potentially in favour of energy companies) and disappointed consumers (Krishnamurti *et al.*, 2012).

Complexity of Tariffs

In choice-based experiments, few Norwegian participants opt for the more complicated time of use (TOU) or critical peak pricing (CPP) tariffs, even when offered SM technology to automatically measure their hourly consumption (Ericson, 2011). German participants are more likely to select a simple TOU tariff with low price variation, as opposed to dynamic real-time pricing (RTP) with high price variation (Dütschke & Paetz, 2013; Schlereth, Skiera & Schulz, 2018). Time-variant tariffs are generally considered too complex, with consumers particularly confused if the tariff contains multiple components[4], odd-endings to price values or uses percentages (Layer, Feurer & Jochem, 2017).

However, greater knowledge of energy conservation increases the likelihood that consumers choose TOU and CPP tariffs (Yoshida, Tanaka & Managi, 2017). Indeed, consumers generally prefer dynamic tariffs to static tariffs, as Dütschke & Paetz (2013) experiment using different tariffs in a smart home laboratory over 8 weeks reveals; three of the four participants preferring dynamic tariffs to static tariffs, with the exception of the most dynamic tariff including both varying prices and load limits.

4 Price components refer to the number of differently priced periods. For example, a simple TOU tariff would have two price periods: peak and off-peak.

Reluctance Towards Automation and Third-party Control

A particular concern with SM installation is relinquishing control of one's environment to energy companies (Barnicoat & Danson, 2015). Krishnamurti *et al.* (2012) find that American consumers believe SMs will be used by energy companies to control household energy use; for example, to cut off supply to households that consume too much electricity.

Dutch households prefer manual control to automatic SM control in order to make their own decisions regarding when to turn off appliances. These households do not wish to lose control for the sake of convenience (Leijten *et al.*, 2014). When Swedish consumers are willing to allow third-party control of their appliances, they expect substantial monetary compensation to do so (Broberg & Persson, 2016). On the other hand, German consumers prefer a system in which smart appliances can react automatically to variations in prices rather than making the changes themselves (Dütschke & Paetz, 2013).

Belgian consumers are willing to accept a trade-off between no automation and total automation, preferring to monitor and self-program the SM and IHD to automatically turn off appliances that have been on stand-by for too long (Pepermans, 2014). British participants are willing to accept an electricity tariff with a limited amount of control of their heating by a third party over a more dynamic TOU tariff (Fell *et al.*, 2015).

For households unwilling to allow third-party intervention to control their energy consumption, it is unlikely that they would make the necessary behavioural changes in order to reduce energy consumption (Verbong, Beemsterboer & Sengers, 2013). Additionally, the extent to which consumers are willing to allow automatic control is limited by their willingness to compromise on their desired comfort level.

Barriers to Adoption

Assuming consumers have accepted SM installations in their homes, the next issue to consider is whether households will engage with the information and respond to the incentives provided in order to lower their consumption.

Limited Motivation from Monetary Savings

Consumers typically state that their main motivation for accepting SMs and DP is financial. British consumers expect to make financial savings that are double the price they pay for "smart services" (Richter & Pollitt, 2018). When choosing between tariffs, German consumers expect to save 50 €–150 € (Dütschke & Paetz, 2013). Actual savings are in the order of 20 €–60 €; the lower end of these expectations.

Although monetary savings are the main driving factor to accepting SM and DP, actual savings from smarter energy consumption in individual appliances are likely to be too small to induce behavioural changes (Goulden *et al.*, 2014); pennies rather than pounds (Hargreaves, Nye & Burgess, 2010). On the other hand, some participants in Murtagh, Gatersleben & Uzzell (2014) find that each little saving adds up; though others feel that they are comfortably well-off to not bother with trying to save energy to lower their bills.

To motivate engagement with energy consumption data, Bager & Mundaca (2017) frame consumption information as a salient loss compared to an amount spent on electricity. Framing information as a loss of money instead of a cost saving invokes greater motivation, as consumers do not wish to lose earnt money.

Understanding of Information on Display

To allow consumers to make the most out of the two-way communication capabilities of SMs, they require an IHD to visualise their energy consumption in real time. German households believe that such a device is a necessity for DP tariffs as without it, they do not feel adequately informed to be able to make the appropriate changes to their behaviour (Dütschke & Paetz, 2013).

IHDs can present consumption data in a variety of ways. In an investigation of the effectiveness of IHDs, British consumers respond quickest to changes in information when presented numerically, and find analogue displays[5] hardest to understand. Participants

[5] The study presents the consumption level on an analogue scale (a dial like a speedometer in a car) as opposed to a digit or in the form of a smiley or sad face.

prefer consumption data to be in colour, but this does not improve their understanding (Chiang, Natarajan & Walker, 2012). On the other hand, both Italian and British consumers quickly understand colour-based feedback, but prefer numerical information to be displayed as well (Bonino, Corno & De Russis, 2012).

Households express a preference for consumption data to be displayed in monetary terms, rather than in energy units or CO_2 emissions, as such information is more relatable and comparable (Hargreaves, Nye & Burgess, 2010; Karjalainen, 2011; Raw & Ross, 2011; Buchanan, Russo & Anderson, 2014). While it is understandable that monetary comparisons are more relatable for consumers, they may not be of much value if prices have changed across different time periods. In this case, energy unit comparisons would be of more use (Darby, 2010; Karjalainen, 2011). American consumers are particularly interested in an appliance-level breakdown of their energy consumption (Krishnamurti *et al.*, 2013).

Spence *et al.* (2014) find that participants who see their hypothetical consumption in monetary or energy units are more likely to state financial reasons as motivation for lowering their demand. Those who receive consumption information in terms of CO_2 emissions are more likely to cite environmental motivations. Participants' motivations are clearly primed by their IHD's data presentation; as different displays evoke different motivations. Interestingly, participants who see monetary units are more likely to say that lowering their energy consumption is not worth it. Australian households find that IHDs focus too much on the numbers, on quantifying what can be "saved and shaved" rather than on what households can do to change their behaviour and ultimately lower their consumption (Strengers, 2011).

Inflexibility of Daily Routines

The principal objective of DP is to lower consumption during peak periods when demand is higher and electricity costs more to produce (Faruqui, Harris & Hledik, 2010). Households feel that there is little that they can do to prevent their natural peaks of energy consumption (due to inflexible work routines or ingrained energy consumption habits) without drastically changing their lifestyle (Naus *et al.*, 2014; Hall, Jeanneret & Rai, 2016).

UK households are reluctant to lower consumption below their normal level and, when prompted to do so, become defensive. They feel that they have no control over certain aspects of their energy consumption; certain appliances are necessities no matter how much is consumed and they are not willing to sacrifice their quality of life to save a small amount on energy (Hargreaves, Nye & Burgess, 2010). Households with children are particularly inflexible during the evening peak, leading to difficulties in their ability to adjust consumption during potentially high-priced hours (Nicholls & Strengers, 2015).

German households are willing to change certain behaviours and use certain appliances at off-peak hours, such as dishwashers, washing machines and tumble dryers. However, they are unwilling, and potentially unable, to change their time of use of other activities related to comfort or entertainment (Dütschke & Paetz, 2013). Similarly, Goulden *et al.* (2014) finds that consumers are willing to adjust their habits in regard to appliances where energy consumption is not at the point of use, i.e. white goods, but unwilling to do so for items that consume energy at the point of use, i.e. showers and televisions.

Ericson (2011) hypothesises that consumers whose consumption patterns are favourable to DP (i.e. their consumption is low during peak periods) are more likely to accept such tariffs. However, this will not have the desired demand reduction effect for these consumers, as they have less demand to shift to begin with. These consumers will benefit from DP without demand responsiveness. This is true of both British and German participants in choice experiments who are more likely to choose a time-variant tariff if they consider that shifting consumption is an easy task (Buryk *et al.*, 2015; Schlereth, Skiera & Schulz, 2018).

Novelty Factor of Consumption Information

A common theme in field experiments and pilot studies using SMs, IHDs and DP is that behavioural changes made by households are short-lived. There is an initial novelty factor when households use IHDs frequently to identify a baseline or normal level of consumption (Oltra *et al.*, 2013). Any deviations from this level are then identified and acted upon (Strengers, 2011; Buchanan, Russo & Anderson, 2014; Westskog, Winther & Sæle, 2015).

This identification leads to reactive and proactive behavioural changes. When energy consumption is unusually high, households identify and turn off appliances as necessary (reactive). In the longer term, they monitor individual appliances to determine which are inefficient and need replacing (proactive; Hargreaves, Nye & Burgess, 2010). Essentially, this affects future consumption decisions, with households taking energy efficiency into greater consideration when purchasing new appliances.

However, IHDs are rarely used by households in the longer term; they become part of the background of daily life and are used to monitor abnormalities rather than elicit demand reduction (Hargreaves, Nye & Burgess, 2013). This finding is corroborated by Schleich *et al.* (2013) who report limited use of feedback via a web portal, and by Ueno *et al.* (2006) who find a decrease in the number interactions with an IHD a few weeks after installation.

Studies on DP are not without questions as to the durability of demand response. Faruqui & George (2005) find that under TOU pricing, the demand response across two summers greatly decreases; from 5.9% in summer 2003 to 0.6% in summer 2004. An Italian experiment finds that consumption increases under TOU pricing compared to flat-rate tariffs (Torriti, 2012). This could be considered a rebound effect, where households respond to the lower off-peak price by increasing their consumption off-peak by more than they lower their consumption in the peak period.

Effect on Household Dynamics

In Hargreaves, Nye & Burgess (2010) mostly male household members use IHDs, with female members reported as "uninterested". IHDs are seen to cause conflict within households; as some individuals feel their actions are being constantly monitored by another member of the household. However, though the male household members may be more likely to be the bill payer, it is often the female household members who are responsible for managing daily activities and thus energy consumption of the household (Murtagh, Gatersleben & Uzzell, 2014).

Households with children and older people are less likely to sacrifice comfort and convenience to lower their energy consumption (Murtagh, Gatersleben & Uzzell, 2014). These types of households are less flexible than others. Older generations, in particular, are more likely to spend more time at home, and they may have certain needs or health issues that require consuming energy (Barnicoat & Danson, 2015). In focus groups with both children and their parents, Fell & Chiu (2014) find that although parents are interested in discussing energy consumption for their children's educational benefit, implementing energy-saving behaviours is a low priority.

Conclusion and recommendations

SMs and DP correct two market failures in the residential electricity market: SMs make energy visible by providing consumption information, and DP limits how much energy can be consumed by charging residential consumers prices that reflect actual costs at a given time. This paper has reviewed the qualitative literature on how households and consumers perceive, interact with and use SMs, IHDs and DP as tools and incentives to lower their energy consumption. Four barriers to acceptance and five barriers to adoption of both SMs and DP have been highlighted. In order for SMs and their associated incentives to be effective at encouraging households to lower their consumption, the barriers to acceptance and adoption discussed above will need to be overcome. This paper concludes with recommendations for overcoming these barriers.

Energy companies should increase their efforts to rebuild consumer trust where it has been lost. Such efforts will need to be credible given that non-verifiable attempts at "trust building" are insufficient to increase consumer confidence in energy companies (Stenner *et al.*, 2017). Trust could be rebuilt by decreasing the uncertainty around the impact of SMs, IHDs and DP on household bills. In particular, as the introduction of SMs results in more reliable billing, some consumers whose consumption was previously underbilled will see an increase in their bill despite not changing their behaviour. To build trust with these consumers, energy companies could pledge to freeze consumer bills for a certain transition period after the installation of an SM to allow households to familiarise themselves with the technology. This would be a similar practice to that of designing DP tariffs to be revenue neutral (Faruqui, Hledik & Tsoukalis, 2009).

Given the increased complexity of DP tariffs relative to flat-rate tariffs, consumers need to be carefully informed of the detail and educated as to how such tariffs can be beneficial to them. In particular, energy companies should take care to limit the complexity of tariffs (Layer, Feurer & Jochem, 2017). After exposure to DP in experimental studies, households are more likely to opt for such tariffs in their daily life (Dütschke & Paetz, 2013; Yoshida, Tanaka & Managi, 2017). Energy companies should work on effective communication strategies to better inform households about both the technology and incentives, as doing so can build trust, and has been shown to increase consumers' willingness to accept SMs and DP.

Engaging consumers with the information provided by SMs and IHDs is paramount to effective energy consumption reduction. Simply stating how much money households are saving highlights that only small monetary amounts are saved with each energy-saving action, and may serve to discourage energy-saving efforts (Hargreaves, Nye & Burgess, 2010; Murtagh, Gatersleben & Uzzell, 2014). Different presentations of consumption information invoke different motivations to save energy, and different individuals respond differently to these presentations (Spence *et al.*, 2014). Given this, it is unlikely that a one-size-fits-all approach would be successful at encouraging reductions in consumption: a more individual approach may be appropriate.

With regard to smart service preferences, Kaufmann, Künzel & Loock (2013) identify four different segments of Swiss consumers: "technology minded", "safety minded", "risk-averse" and "price sensitive". Murtagh, Gatersleben & Uzzell (2014) categorise British participants into one of three groups: "monitor enthusiasts", "aspiring energy savers" and "energy non-active". Richter & Pollitt (2018) find three specific clusters of British consumer types: "private data", "risk averse", and "open data". Concerning the choice of dynamic tariffs, Schlereth, Skiera & Schulz (2018) separate German consumers into three different groups: "price sensitive", "flexible" and "risk averse".

Across these different consumer categorisations, four clear segments can be identified:

- Technophiles, who are enthusiastic about receiving data on their consumption and managing it, and who are open to sharing their data in order for energy companies to provide automated control of appliances
- The data usage conscious, who are concerned about how their data can be exploited and who prefer to retain control of their own energy consumption
- The risk-averse, who have strong preferences for a tariff with a low peak/off-peak price ratio or a flat-rate tariff. They do not value potential monetary savings as highly, and are more technology-averse
- And the price-sensitive, who prefer a tariff with a high peak/off-peak price ratio and are more likely to switch to DP contracts.

An additional category consists of pro-environmental consumers, who see the the positive environmental benefits of using of an SM and IHD to reduce their energy consumption. These consumers derive additional utility due to a "warm glow" effect of giving to others, or to the environment (Gerpott & Paukert, 2013).

If these different segments of consumers can be identified, then appropriate technology and incentives can be offered to them so that they have the tools most relevant to their characteristics, motivations and situation. These tools will be more effective at engaging with consumers to lower their energy consumption. Therefore, rather than a one-size-fits-all approach to energy saving, a consumer segment-specific approach is recommended.

That being said, a consumer segment that may not necessarily benefit from the use of SMs and IHDs to reduce energy use is the segment of consumers for whom energy consumption is already low, as they will have little scope to further reduce their demand (Darby, 2010). Such consumers may be pro-environmental consumers who have already reduced their consumption through other mechanisms, or low-income consumers who may not have the means to consume large quantities of energy, nor the scope to further reduce their consumption without becoming fuel-poor. Special consideration should be taken when targeting this particular consumer segment.

Finally, automation and third-party control was found to be a significant barrier to acceptance even though it has the potential to help overcome the barrier to adoption concerning the inflexibility of daily life. Given that households may find it difficult to shift some consumption, the recommendation here is to focus on demand that can be shifted, and to provide households with technology that will allow for automatic peak demand shifting of appliances for which consumption is not at the point of use. Introducing automation and third-party control may also help to increase consumer trust in energy companies if it helps consumers achieve energy savings with minimal effort. Such technology will not be readily accepted by all consumers, and so the focus here should be on technophiles and price-sensitive consumers.

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ÉNERGIES « NOUVELLES » ET SOCIÉTÉ
LA TRANSITION ÉNERGÉTIQUE ACTUELLE À LA CROISÉE DES CHEMINS ET DES SAVOIRS

Les mutations importantes imposées par l'urgence climatique, la digitalisation accélérée des activités économiques et la crise sanitaire interrogent la manière dont on comprend le monde et ses évolutions. À ce titre, l'énergie demeure au centre des débats sur l'avenir des sociétés. Les deux derniers siècles ont été marqués par des progrès considérables, qui ont reposé sur un usage intensif des ressources énergétiques à l'origine de problèmes d'ordres écologique et technologique. Les réponses actuelles proposées reposent à la fois sur la pleine maîtrise de la consommation d'énergie et la forte pénétration des sources renouvelables dans les mélanges énergétiques utilisés. Or, ces réponses sont sources de défis pour les acteurs des filières énergétiques, les usagers et les décideurs politiques. En effet, la transition énergétique actuelle doit promouvoir la sobriété énergétique requise pour préserver la stabilité du climat, tout en garantissant le droit d'accès à une énergie bon marché.

Comment pareille transition rencontre-t-elle le droit par référence à la protection des libertés individuelles et à la garantie de la sécurité de chacun ? Sous quelles conditions les innovations technologiques, telles que la solution hydrogène pour la mobilité et la batterie pour le stockage de l'énergie électrique, peuvent-elles être déployées à grande échelle ? Quels sont les obstacles à l'appropriation par les usagers des technologies contribuant à la maîtrise de leur consommation d'énergie ? Telles sont les questions traitées dans cet ouvrage qui rassemble des contributions présentées lors du workshop MOMENTOM *(MOlecules and Materials for the ENergy of TOMorrow)* du 21 novembre 2019 à la Maison des Sciences de l'Homme Paris-Saclay. S'inscrivant dans le cadre de l'Initiative de Recherche Stratégique du même nom, l'approche originale adoptée dans ces pages vise à croiser les regards de chimistes, économistes et juristes sur les modèles de référence et autres systèmes de représentation de la transition énergétique actuelle.

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