Proposal for PhD Workshop Energieinformatik 2013 "Customer Acceptance of Smart Grid: The role of psychological interventions and customer value"

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Abstract: Besides efficiently managing the energy supply – which has been the focus in the past – the efficient and effective management of the energy demand is nowadays considered to be of utmost importance in order to meet the energy challenges of the future. Politicians, managers, engineers and researchers alike agree on so-called smart grids being a promising solution in that regard. The smart grid provides various solutions, products and services – such as demand response programs, real-time feedback systems, smart metering solutions etc. –, which enable a better management of the demand for energy. However, these solutions must be employed at customer side and the customers need to accept and use them in their daily life. Only if customers actively accept and use these solutions and thus actively participate in the smart grid, one can fully exploit the opportunities regarding energy efficiency and demand control they offer. Thus, it is crucial to understand which factors increase customers' acceptance of smart grid technologies and services. In this PhD different interventions, including psychological interventions, will be tested in order to identify acceptance factors that increase customer participation in a smart grid. The results of this PhD should prove useful for managers as well as for policy makers when designing smart grid applications, developing products and service bundles, effective business models and incentive schemes.

1 Motivation

In order to achieve political and societal goals, such as the reduction of CO2 emission and the nuclear phase-out, the energy system needs to transform and an increasing share of energy supply needs to be provided by renewable energies, such as solar and wind. The increasing integration of fluctuating and decentralized generation of electric energy – typical for renewable energies – challenges the current electricity grid. Contrary to the

past in which the focus lied on adapting the energy supply – mainly coming from large-scale energy generation plants – to the energy demand, it now becomes important to not only manage supply of decentralized renewable energy resources but also to manage the demand to adapt to this fluctuating energy supply [Appelrath03]. Only by simultaneously managing demand and supply for energy, a higher integration of renewable energies into the grid can be achieved while still maintaining a high stability of the grid [Appelrath03]. It is widely agreed that the integration of intelligent information and communication infrastructure into the electricity grid helps to solve these issues [Appelrath03]. However, whereas using intelligent information and communication infrastructure to make the grid smarter is a necessary step to take, it is not sufficient to fully exploit the benefits of smart grids. Especially for being able to manage the demand the customer needs to accept and actively use smart grid technologies and applications, such as demand response programs or feedback systems. Only when customers accept and integrate these new applications and technologies in their daily lives they might ultimately provide flexibility to the grid by shifting demand either through automatically controlled devices or by reacting to a feedback they receive on e.g. a mobile app. This leads to the question what increases the usage and acceptance of smart grid devices, applications and services by private electricity consumers. Simply providing such services and products might not guarantee that a sufficient number of consumers will accept them and start using them in daily life. The implementation of smart grids will only be successful if we identify ways to increase customer acceptance of smart grid applications. This Ph.D. thesis focuses on two ways to increase customer acceptance of smart grid services and products, namely psychological intervention and customer value. On the one hand, understanding these potential influencers of customer acceptance is relevant for designing appropriate smart grid applications and services. On the other hand, it is important to identify whether and which additional steps need to be taken to increase acceptance, e.g. through accompanying marketing initiatives or incentives schemes. The results of this research should shed light on how to combine smart grid applications into service packages for end customers in order to most effectively increase the customer participation and thus to better exploit the potentials of a smart grid.

2 Goal of PhD

The goal of this PhD project is to better understand the factors influencing customer acceptance of smart grid applications in order to increase customer participation in a smart grid. To achieve this goal, this PhD has two main research objectives.

First, it aims at clarifying the construct of customer acceptance in the specific research context. Based on a clear definition of customer acceptance of smart grid, smart grid applications and means to increase their acceptance can be categorized and mapped. On the one hand, the different smart grid applications should be mapped according to what kind of acceptance is needed for them. On the other hand, different means of increasing customer acceptance of smart grid should be mapped according to which aspect of acceptance they influence most. This should prove useful for researchers to structure their own research and identify research gaps and for practitioners to identify the most

promising means to increase customer acceptance with respect to the specific smart grid application.

The second research objective of this PhD is to provide five concrete examples – derived from the map of the first research objective – for increasing customer acceptance of specific smart grid applications. As this PhD will be a cumulative thesis, these five examples will each correspond to one paper of the PhD thesis.

Paper one "Generic customer segments and business models for smart grids" and paper two "Customer value of smart metering: Explorative evidence from a choice-based conjoint study in Switzerland" elaborate on the topic of customer value and customer segmentation as factors influencing customer acceptance of smart metering and draw conclusions on the effective design of business models.

Paper three "Increasing customer acceptance of demand response programs: Under which conditions do punishments work better than rewards?" will focus on the effect of reward versus punishment on customers' willingness to participate in demand response programs. Demand response programs are considered to be one of the most important smart grid applications to manage energy demand [Appelrath03, Strbac17]. Such programs might be designed in different ways [Wolsink24], which has implications on what kind of acceptance level is needed. For example demand response programs can consist of an application device which automatically steers and controls all the devices of the customer. In this case customers only need to adopt this application device and no further action is needed. Thus, one can say that a "passive" acceptance – demonstrated by the adoption of the application device – would be sufficient. However, customers might be reluctant to let their devices (or some of them) be automatically controlled by someone else. Thus, this paper investigates whether this is the case and if so, whether promised rewards or punishment would enhance the "passive" customer acceptance. Demand response programs might also be designed in a way which requires the customers to be more actively involved, for example by sending a message to a mobile device which asks the customers to actively switch on or off their devices themselves. In this case a more active acceptance – demonstrated by an active customer reacting to the message – is needed. In such a context, punishment and rewards might have a different effect on customers' willingness to participate in the program. It is not decided yet, whether this paper will address both cases or only one of it, however the above mentioned example should highlight the importance of clarifying the concept of acceptance of smart grid in different contexts first before it can be decided which interventions should be tested experimentally.

Paper four "Walk the talk – The role of hypocrisy and construal level in influencing energy usage behavior" will analyze the effect of cognitive dissonance and construal level on customers' intention to change their energy consumption behavior. Thus, it strongly focuses on the psychological intervention in order to increase customer acceptance of smart grid. In a smart grid customers can be provided with instant energy consumption feedback through e.g. in-home displays. However, studies investigating the effectiveness of feedback demonstrated that feedback alone does not lead to a behavioral change [Abrahamse01]. Whereas other studies investigate for example the effect goal

setting and social feedback [Abrahamse01, Loock14] on the effectiveness of feedback on behavioral change, I intend to focus on the content of the feedback message. I believe that the right content, such as a message inducing hypocrisy and a high-construal mindset, might make real-time energy feedback system more effective. Further, I believe that if real-time feedback systems, which only are possible with smart grid applications, provide the right message, customers will be more inclined to use these feedback systems in their daily life and change their energy consumption behavior according to the feedback. The research of this paper is strongly related to the body of literature dealing with energy consumption behavior and energy savings in general. However, the main goal of this paper is to investigate whether reminding customers of the discrepancy between their attitude and behavior can foster customer acceptance of real-time energy feedback systems. The results of this research should shed light on how to design real-time energy consumption feedback systems, which are believed to play a major role for the future smart grid customer [Appelrath03, Loock 14].

Paper five "Preferences for energy efficiency portals – how to increase customer base and frequency?" will focus on energy efficiency portals. Energy efficiency portals might not be a smart grid application per se, because they can also exist without the integration of intelligent information and communication infrastructure into the grid. However, they might be important pathfinders to increase customer acceptance of smart grid. This might be due to their ability to increase awareness by educating customer. Thus, they might prepare the ground for a positive attitude towards smart grid technologies and applications. As will be explained later, a positive attitude constitutes one part of customer acceptance. This is the reason to expect that investigating what increases customer usage of such portals as well as the number of customers using such a portal is worthwhile and important when researching customer acceptance of smart grid products and services.

As already pointed out, my research does not analyze and develop smart grid technology or applications. The focus of this research rather lies in identifying the factors, which help in increasing the acceptance of the specific applications and technologies, by either bundling them in service packages of value to customers or by adding psychological intervention and incentives in order to increase customer acceptance of these applications.

3 Current state

I started my PhD in summer 2011 as an internal research associate at the Chair for Management of Renewable Energies at the University of St.Gallen. I intend to submit my thesis in autumn 2015. As my PhD is a cumulative dissertation the papers are in different research states.

Paper one and paper two of my PhD are already published (see section 7). For paper three I am currently conducting experiments and collecting data. I intend to submit the paper to a journal in winter 2013. Paper four is work in progress. The general idea and theory is outlined and the next step would be to conduct several laboratory experiments

as well as to find a setting for a field experiment. I intend to conduct the experiments and collect the data until summer 2014 and submit the paper in autumn 2014. Paper five still needs to be outlined.

The first three papers of my PhD are embedded in the joint research project IMPROSUME with project partners from Norway and Denmark. The project focuses on prosumers and their role in the future energy market. The Swiss part of the research project is funded by the Swiss Federal Office for Energy and investigates potential business models for prosumers in the future energy market. In this research project prosumers are defined as people who either produce (e.g. by distributed energy generation such as photovoltaic) and consume energy or as people who mainly consume energy but also provide flexibility by adapting their consumption to the supply. Paper one and paper two focus on perceived customer value in different customer segments as the main driver for customer acceptance of smart grid and proposes potential business models. Paper three addresses how business models relying on demand response can activate enough consumers to participate in a demand response program – that is transforming a consumer to a prosumer – through increasing consumers' acceptance by means of rewards or punishments.

Paper four will be embedded in a recently started four-year research project "HeatReserves" funded by nano-tera.ch. Together with partners from the ETH, Swissgrid and EMPA this research project focuses on electricity storage using thermal loads and appropriate demand response schemes. It investigates business models which feature solutions that are feasible from a technology and economic perspective and which provide value to customers. Our part of the research project consists in finding out what is needed to increase consumer involvement and willingness to take part in respective demand response schemes.

Paper five will be embedded in a research project funded by Repower, a Swiss energy provider based in Graubünden, Switzerland. This research project investigates smart grid acceptance factors of various market participants, such as small and medium energy providers, the grid operator and end consumers. The identified acceptance factors should provide input for designing effective and valuable platform-based business models.

4 Methodological approach

For the framework paper, which addresses the first research objective, an extensive literature review will be conducted, complemented with in-depth expert interviews. The five papers of my cumulative PhD thesis will each base on an appropriate methodology for the specific research and decision context.

Paper one is based on an explorative customer survey in Switzerland, Austria, Germany and Lichtenstein to get customer insights on smart grid related preferences and knowledge. Based on the results of the survey a cluster analysis was performed in order to group the customers into different segments. The development of a generic map for

business models was based on these customer segments and theory from business model literature.

Paper two strongly focused on customer preferences and different value perception of smart metering. In order to segment the customers according to their value perception of smart metering a conjoint study was conducted. The individual preferences of each participant in the conjoint study were then used in a cluster analysis for customer segmentation according to the different value perception of smart metering. Based on this we derived different service bundles providing the highest value for each customer segment.

The chosen methodology for paper three and paper four consists of experiments. Experiments are chosen because they are the most appropriate research methodology for measuring causal effects [Backhaus04]. For the paper three at least three experiments will be conducted. All of them will be conducted via either a paper based or online survey. One of the experiments investigate the intention to join a demand response program from customers participating in a smart meter pilot project. The other two experiments will most certainly be conducted with customers participating in an energy efficiency customer web portal. For paper four at least two experiments are envisioned. One will be a laboratory experiment to test the proposed effect of cognitive dissonance and construal level on intention to change the energy usage behavior. For the second experiment, I aim at conducting a long-term field experiment, in which the manipulation is provided through a energy consumption feedback system. This experiment is aimed at measuring the actual change in usage behavior and the long-term effect of the manipulation.

The methodology for paper five is not yet chosen, as the paper still needs to be outlined. Potential research methods for investigating preferences of end customers might be conjoint studies. However, additionally there might be a need of conducting experiments to test different manipulations with regard to their effect on increasing participation frequency.

5 Related work

Due to the nature of my PhD – a cumulative thesis – the related work needs to be separated into related work for the basic framework of the PhD thesis and related work for each paper.

As for the basic framework I am basing my own research on the acceptance model from Kollmann [Kollmann13] and on a variety of research related to energy efficiency. I refrain from mentioning and describing all relevant studies here because it is not my goal to write another meta-study on energy efficiency but rather to map existing works regarding how they contribute to customer acceptance of smart grid. Other reviews of models for decision-making in residential energy use [Wilson23] and of intervention studies aimed at household energy conservation [Abrahamse01] provide an overview about potential studies, which might be included in my own research. It is important to

note here that there are a lot of parallels between my research and the body of literature dealing with energy consumption behavior and energy savings in general. And, indeed, I will considerably draw on the findings of this literature body for my own research. This is mainly due to the fact that energy consumption behavior and energy savings are also highly important in the field of smart grid. Even though smart grids provide new technologies and tools, they still aim at changing consumption behavior as an ultimate goal. Thus, research on customer acceptance of smart grid products and services should build on previous findings on energy consumption behavior. However, in my research I will only focus on studies which are relevant for designing smart grid applications, services and products, such as real-time feedback systems or demand response programs.

Based on the acceptance model developed by Kollmann [Kollmann13] a definition of acceptance of smart grid will be derived for my own research. According to Kollmann [Kollmann13] the acceptance process can be separated into three distinct levels: attitude, adoption and acceptance (see figure 1).

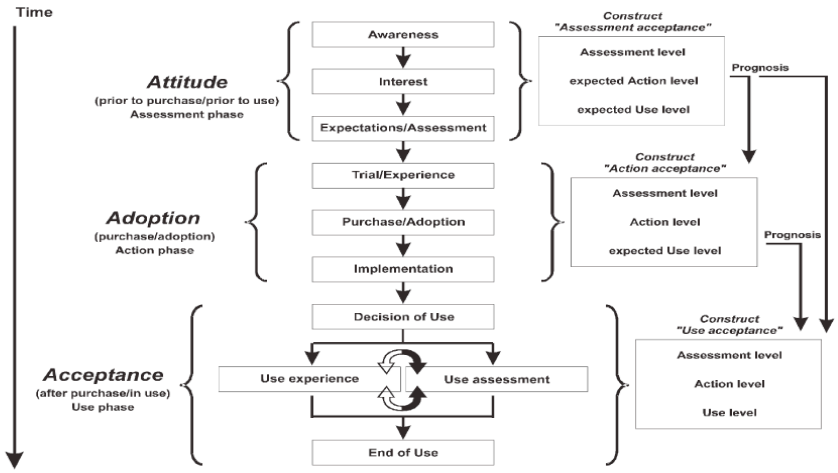


Figure 1: Scheme of phases in the acceptance process [Kollmann13, page 140]

Whereas a positive attitude (internal assessment of a product or service) is a necessary precondition for leading to an action (purchase or adoption of a technology) it does not guarantee this action [Kollmann13]. Thus, besides researching attitudes, factors influencing the adoption need to be investigated [Kollmann13]. For certain goods, such as food and other nondurable goods, the adoption and purchase is sufficient to draw conclusion on the acceptance of such goods. However, there exist a variety of goods and services which require a constant or repeated usage by the customer. For example, when market data says that the sales of mobile phones are high, but no call was ever made, one cannot conclude that telecommunication systems are accepted because apparently customers refrain from using the service (barriers to acceptance). Thus, taking the third level acceptance – the act of usage – into consideration is necessary for concluding on overall acceptance. In the case of smart grid the alternative construct of acceptance proposed by Kollmann is helpful to investigate and structure potential ways to increase customer acceptance of smart grid applications. Most importantly, this construct helps to

design effective means to increase customer acceptance by demonstrating the different phases of acceptance which need to be considered. For example, for certain smart grid applications such as for example in-home displays providing feedback, one cannot infer acceptance by simply increasing the overall adoption but also needs to consider how these applications can effectively be integrated into the daily life of the consumer. Only when the consumer uses the feedback system in the daily life on a repeated or even constant basis, and starts to adapt his or her behavior, one can assume that the application is successfully accepted in the market. However, for other smart grid applications, such as an automated control system for the electric boiler, where no further involvement of the customer is needed after his purchase or adoption of the technology or application, influencing the first two levels of the acceptance process might be sufficient.

Related work for paper one and paper two are mainly based on literature on customer value, customer segmentation and social acceptance. According to Zeithaml [Zeithaml26] and Sheth et al. [Sheth16] consumers purchase a product or service if they perceive some kind of positive value. Zeithaml [Zeithaml26] defines perceived value of a product or service as an overall assessment by the customer of what is given (drawbacks) and what is received (benefits). It is important to note that according to this definition value is not objective or simply given, but rather it is based on an individual perception. Regarding smart metering and smart grid services this means that the customer-perceived benefits of such services must exceed the perceived drawbacks. Only then will the customer accept – meaning purchase – such services. Only then will there be a market acceptance of smart metering and smart grid services by consumers, which is a part of social acceptance [Wolsink24, Wüstenhagen25]. Literature on customer value also suggests that different customers have different needs and therefore a market segmentation based on the heterogeneity of value perceptions in a market is needed [DeSarbo06, Wiedmann22]. DeSarbo et al. [DeSarbo06] state that "there are indeed heterogeneous interpretations of customer-perceived value, and multiple customer segments may assign differential importance weights to the value drivers" (p. 846). Thus, an assessment of customer value on an aggregate level might be misleading [DeSarbo06, Wiedmann22]. This presumably will hold in the case of smart metering and smart grid services and related applications, which may not be valued by all customers in the same manner. For instance, technology-oriented value propositions like coupling smart metering with mobile devices (e.g. iPhones) might be very valuable for customers who favor smart phones. However, this may not attract other customers with less technological exposure.

Relevant literature for paper three mainly consists of previous research on the effects of punishment versus rewards and incentive structures. For example in a study [Kalsher10] it was found out that punishment and reward both increased the usage of safety belts. Punishment only seemed superior when there was an enforcement official present [Kalsher10]. In their study on the effects of feedback, reinforcement and information to reduce energy consumption in households, Midden et al. [Midden15] found out that incentives in forms of payments pared with feedback can reduce energy consumption better than information and/or feedback alone. Another study [Bolderdijk05] found an effect on incentives pared with feedback on reducing risky driving behavior. Goldsmith

and Amir [Goldsmith08] investigate whether uncertain rewards are always inferior to certain rewards and found out that under certain conditions (e.g. intuitive and low-consideration decisions) uncertain rewards have the same effect as certain rewards. Kim and Smith [Kim12] investigate how customers respond to penalties and derive useful implication for the management and design of punishments.

For paper four the relevant literature body is based on the theories of cognitive dissonance and construal level. The effectiveness of hypocrisy in changing conservation behavior has been proved by various studies [Aitken02, Dickerson07, Kantola11]. Dickerson et al. [Dickerson07] demonstrated that when participants were reminded of their past failures after they committed publicly to conserve water, they reduced the length of the shower they took shortly after the intervention. Aitken et al. [Aitken02] showed that households, which were treated with dissonance in addition to feedback, conserved more water than household who only were treated with feedback. Kantola et al. [Kantola11] showed in their study about household electricity consumption, that households which were treated with dissonance showed more conservation behavior after the manipulation than other treatment groups. In both studies [Aitken02, Kantola11] hypocrisy was induced by sending a letter to the households stating that (a) they were high consumers of electricity (water) and that (b) they previously stated in a questionnaire that conservation was important to them, thus making them aware of their discrepancy between their behavior and pro-conservation attitude. The construal level mindset of an individual might be an important moderator of when induced hypocrisy will be most effectively in provoking changes in behavior. As high-level construals focus on "why" aspects, the idealistic self, central values and desirability [Trope18, 19, 20], one can assume that under a high-level construal mindset consumers react more to induced hypocrisy than under a low-level construal mindset: Under a high-level construal mindset, desirability and the idealistic self are more salient. Thus, the threat to the self-integrity of a person – provoked by inducing hypocrisy – should be more pronounced under a high-level construal mindset than under a low-level construal mindset, leading to an even greater motivation to reduce the cognitive dissonance through changing the behavior. Apart from the general theory of construal-level, the relevant literature body for my own research consists of studies concerning the effect of construal level and message framing on consumer efficacy and conservation behavior [White21].

As the fifth paper still needs to be outlined, the relevant literature still needs to be identified. Research on energy efficiency portals provides a good starting point [Graml09, Loock14].

6 First results

As three of my papers of my PhD are work in progress and thus do not yet provide results, only the results of my already published papers will be shortly outlined below. As these papers are already published, I concentrate on the main findings and highlights.

The results of the cluster analysis – based on the survey data of an explorative customer survey about perceived advantages of and concerns about smart metering among customers in Switzerland, Austria, Germany and Lichtenstein – provided three distinct customer segments: Supporters, Ambiguous and Skeptics.

Whereas "Supporters" expect great benefits from smart grid technologies and have only little concerns, customers of the second cluster "Ambiguous" – while expecting an equal amount of benefits – have higher concerns. Thus, it can be assumed that customers belonging to the first cluster might accept smart grid applications more than customers of the second cluster. In the third cluster "Skeptics", customers' concerns regarding smart grid technologies seem be higher than the by the customer perceived benefit of these technologies. Thus, customers of this segment might be least inclined to accept smart grid technologies.

Based on the identified customer segments an analytical framework for different business models for each segment could be conceptualized. These are represented in figure two.

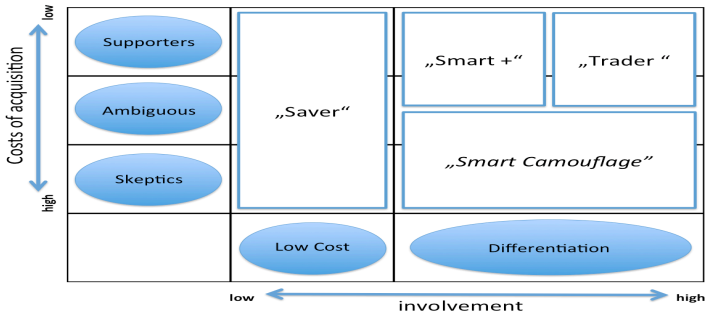


Figure 2: Generic clusters and generic business models for smart grids

Business models providing a value proposition regarding smart grid, such as the Smart+ and Trader business model, should favorably address the segments of the Supporter and maybe part of the Ambiguous as customers of those segments are more inclined to accept smart grid technologies and respective value propositions. However, in order to also integrate customers of other segments into the smart grid, business models for the segment of Skeptics also need to be developed. As customers of those segments are less inclined to accept smart grid technologies and applications, the value proposition of potential business models (Smart Camouflage) needs to be build around other aspects than smart grid per se, e.g. electronic gadgetry.

Based on a cluster analysis of the individual preference for smart metering services derived from a choiced-based conjoint study, four different customer segments were identified. Figure 3 illustrates the resulting clusters by highlighting the differences in the respective part-worth utilities among the clusters. The dotted line represents the total part-worth utilities for the whole sample to illustrate how the value perceptions of each cluster differ from those of an aggregate assessment of customer value. These explorative results clearly demonstrate that – in order to achieve an overall customer

acceptance of smart grid – different smart grid applications need to be bundled into valuable packages for each segment. For example, the second cluster consist of technology affine customers, thus service bundles should center around this value proposition.

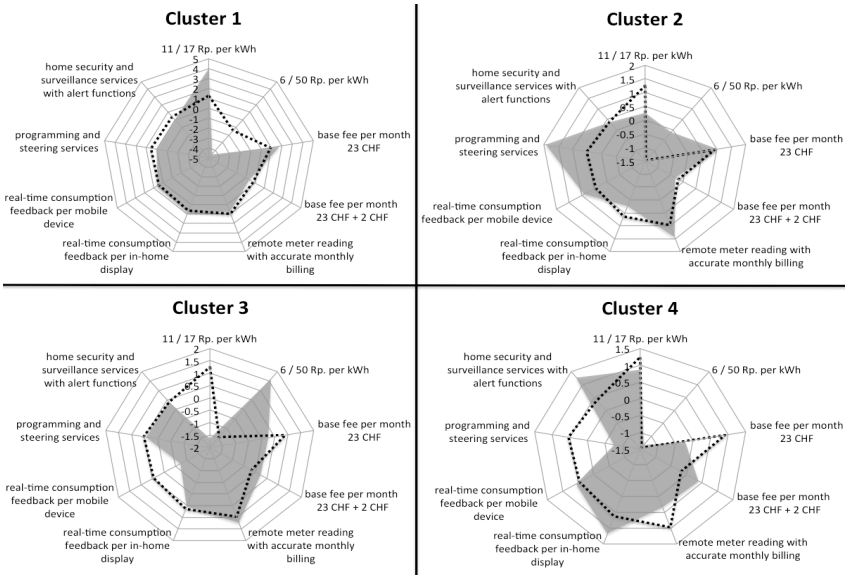


Figure 3: Generic clusters and generic business models for smart grids

7 Own publications

The following two papers of my PhD are already published:

Curtius, H. C.; Kuenzel, K. & Loock, M. (2012). "Generic customer segments and business models for smart grids." der markt, International Journal of Marketing, Volume 51, Issue 2-3, pp 63-74.

Kaufmann, S.; Künzel, K. & Loock, M. (2013). "Customer value of smart metering: Explorative evidence from a choice-based conjoint study in Switzerland". Energy Policy, Volume 53, Pages 229–239.

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