IMPROSUME

The Impact of Prosumers in a Smart Grid based Energy Market

Final report

Bernt A. Bremdal

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Overall project objectives

The overall project objectives defined for IMPROSUME at the outset of the project were both ambitious and highly future oriented. The basic aim was to define and study the role of prosumers in the future power market. In the context of IMPROSUME prosumers are not merely consumers that also produce energy, but active participants in the market. This also implies the capacity to sell their flexibility both as producers and consumers to different players in the energy market.

To determine the future impact of prosumers on the market a number of aspects need to be addressed. First of all it is important to determine the potential market contribution of the prosumer in the market. That hinges on the technical capacity that we foresee across a 10-20 year perspective. It depends on the willingness of regular people to take part in such a regime. It depends on viable business models that can leverage the contribution of prosumers in a smart grid oriented market. Consequently the project has been addressing what incentives and stimuli are likely to drive prosumers in the future. Also, what are the possible constraints? The project has been focusing on strategies for securing consumer acceptance and active participation in a smart grid oriented regime. A prime objective has been to determine what business strategies are required to ensure participation and growth. The ultimate objective has been to define models that can be used to analyze technical and commercial impacts from prosumers. This model together with a better insight of the prosumer role should provide the basis for analyzing the effect of different trading strategies covering inter- as well as intra-trading, to analyze the relation between the prosumer and technical and commercial aggregators (TVPP and CVPP), to analyze the value chain encompassing the axis prosumer-VPP-market and to extract constraints, rules and relationships that can help to design and optimize the smart grid of tomorrow.

Overall method of approach

The overall concept pursued can be illustrated as shown in Figure 1. It shows the different conceptual roles in a smart grid oriented market and their connections forming a new type of value chain. It has been shown in the course of the project that the classic consumer can alone and in company with others seize more than one role.
Despite many different dependencies between the goals defined, the project settled for a method of approach that was pinned on a logic that is shown in Figure 2. The project assumed that specifying the concept and potential roles of prosumers in a SG market should receive attention first. People’s acceptance of new technology and assignment of new roles should be explored. Next our notion of the future energy market should be elaborated. Similarly we assumed that a conceptualization of viable business models and strategies was necessary to define prior to modeling the market itself.

The work was organized in different work packages (see Figure 3 Work breakdown for the project). The Danish party headed by University of Aarhus focused on user acceptance and the prosumer role. The Swiss side, led by ST.Gallen University has primarily addressed the various business aspects, while the Norwegian team focused on the prosumer and market models. The project management was taken care of by the NCE SMART in Halden.
**Contributions of the Danish party (WP1)**

The contributions from the Danish party will be addressed in a separate report similar to this one and submitted to the Danish funding authorities according to their specific termination deadline. Here we will provide a summary of their findings. The Danish side included University of Aarhus, (Business and Social Sciences Department), the Danish electricity suppliers NOE and SEAS-NVE and the technology providers Grid Manager and Green Wave Technologies. The work has been essentially carried out by Professor John Thøgersen, Post Doc Geertje Schuitenma and PhD student Madeleine Broman Toft. Focus here was directed towards private consumer acceptance of smart grid technology. The first part of their investigation consisted of a cross-national survey related to user attitudes towards AMS and other smart-grid technologies. The other part was directed towards field work where user’s actual acceptance would be put to test in practice. The latter part was delayed due to latency caused by the industrial partners. This in turn led to a postponement of the overall project.

The online survey gave 1165 respondents in Denmark, 1251 in Norway and 1242 in Switzerland. People living with their parents were screened out. Also, those who did not pay their own electricity bill were ruled out. The data has been analyzed. As hypothesized initially the WP1 team found that the participation rate in the smart grid depends on the recruitment method and specifically what is the implicit or explicit default option. This offers significant insight to business developers and smart grid pioneers requiring the participation of prosumers.

If the standard recruitment procedure is used where electricity consumers are asked to sign up (opt-in model), the default option is to not have Smart Grid equipment installed in one’s household. It was found that under this condition, participation is much lower than under an alternative procedure where people were told that that everybody will get Smart Grid equipment installed in their household (the default option), unless they explicitly state that they do not want to (opt-out model). Being part of the Smart Grid is generally a difficult issue to make a decision on, because people may fear risks such as comfort loss or invasion on their privacy. The project team has argued that in the opt-in model, it is easy for people to avoid making a decision about these consequences, and they will easily procrastinate. In the opt-out model, there is more motivation to make a decision and less motivation to procrastinate: if no action is taken (i.e. people do not opt-out), the (potentially negative) consequences of participation for the individual household have to be dealt with, and if they want to avoid such consequences, they will have to take action (i.e. people do opt-out). We argue that because in the opt-out model people have more incentives to put sufficient effort into the decision making process and are more motivated to carefully and thoroughly consider the pros and cons of participation, consumers’ true preferences are more likely to be revealed when the opt-out model is used than when the opt-in model is used. To test this hypothesis, a ‘neutral’ model was introduced as a benchmark, where no default option was presented, but people are forced (by the experimental conditions) to make a decision and explicitly indicate whether or not they are willing to adopt Smart Grid technologies. Because people could not escape spending the effort to make a decision, we reason that their true preferences are revealed in the neutral option. The results show that the participation rate in the neutral model is not significantly different from the participation rate in the opt-out model; and in the opt-in model significantly less people participated compared to the opt-out and neutral. This confirms the expectations that the lower participation rate in the standard recruitment model (opt in) is due to procrastination and that people’s true preferences to participate in the Smart Grid are more likely to be revealed when the opt-out model rather than the opt-in model is applied.

In a second part targeted for separate publication WP1 focused on psychological factors that influence consumers’ intention to adopt Smart Grid technologies. Here a theoretical framework combining two
psychological theories, i.e., the Technology Acceptance Model (TAM) and the Values-Beliefs-Norm (VBN) model were applied (Figure 4). According to the TAM, individuals’ acceptance of a new technology is primarily determined by rational choice, implying that people focus on ease of use and their own benefits. Although it is highly likely that this influences the adoption of Smart Grid technologies, it is not likely that people actually expect large private benefits from Smart Grid technologies, at least not in the near term. The VBN model suggests that Smart Grid technologies are more likely to be accepted if its usefulness is assessed in terms of positive impacts for society and the environment (i.e., a better functioning grid and integration of more renewable electricity). Our data confirm that, as we expected, both personal and collective benefits are important for the acceptance of Smart Grid technologies in Denmark and Switzerland. However, in Norway collective benefits seem to play a less important role, and personal benefits are more important.

In Figure 5 we have specifically highlighted the responses for Norway processed according to the two models are shown. Generally the nation specific responses yield approximately the same amount of emphasis on usefulness and ease of use. Interestingly, moral aspects in attitude differ distinctly. In Switzerland user acceptance is strongly influenced by norms, while in Norway this aspect is significantly lower. This implies that acceptance of the technology in Norway is only faintly based on moral reasoning compared to the two other countries. Overall for the two other countries acceptance is more centered on a mix of usefulness and pro-social motives. When promoting smart grid, not only the technical usefulness should be communicated, but also the usefulness for the society and the environmental benefits from use of this technology. The latter being somewhat a weaker argument in Norway.

These results have profound implications for how to approach people with regard to specific technologies. This also yields valuable insight with respect to behavior modeling in simulation models and have been used in the project accordingly.
The field test was meant to investigate practical actions and compare it with attitudes harvested in the survey. More precisely it was meant to identify effective approaches to recruit electricity consumers as prosumers (i.e., opt-in vs. opt-out models) and to examine consumers’ experiences with also being a prosumer. The plan was to involve two different groups of participants: private households and small and medium sized companies (SMEs).

The recruitment of SMEs started in June 2011. This process proved to be more difficult than anticipated, because considerably fewer companies than anticipated by the partners are interested in buying Smart Grid equipment. The economic incentive seems to be insufficient for others than very large electricity consumers. As a result, GridManager, the Danish partner company that were responsible for delivering the smart grid equipment to the project changed their business plan. Sale of smart grid equipment was terminated. Instead they now provide companies with information and smart solutions on how to reduce their energy use. Consequently the equipment planned for testing SMEs’ responses was no longer available.

The recruitment of private households was delayed, but eventually executed. The reason for the delay was that the technology needed for remotely regulating household electricity consumption showed to be less mature than anticipated when the project was planned. After long negotiations and explorations we ended up identifying a few suppliers that could deliver functioning, tested, and future-proof equipment and we zoomed in on heat-pumps as one of the few types of electricity consuming equipment that can currently be regulated in practice. However, new difficulties arose as costs grew higher. The Danish side had to apply for more funding, which was granted to them. Eventually the necessary equipment was acquired. An extensive effort was initiated to recruit 400 households of SEAS NVE that had recently or were about to replace their former heaters with a new water-to-air heat pump. The idea was to invite this group to take part in the test, and offer them a control device which would make it possible to remotely regulate the heat pump and in that way carry out a demand side management program to shed or move loads. Recruitment was carried out for a long period. The actual devices were given for free to those who took part. The
However, several complications arose and only 17 became part of the actual field test. Among this group 6 suffered serious technical problems. The data harvest anticipated became very lean and faulty. The primary objective for the field test could never really be achieved within the extended project period. However, valuable experiences were harvested from this type of scientific field test. Immature technology, restrictions related to business concerns, poor customer service, poor technical support and lack of sufficient incentives for the industry partners to rectify this made the execution of this part of the work very difficult. Nevertheless, the unfortunate experiences gathered from the field test were openly highlighted in the final project workshop in Aarhus in June 2013 like a “lessons learned” type of entry. The idea is now to publish a more elaborate version of this as a scientific paper and for the benefit of others aiming to conduct similar field tests.

More details on WP1 can be found in reports provided to the Danish funding sources and which will be associated with this report.

Contributions of the Swiss party (WP2)

The Swiss party was involved in two work packages. The main effort was dedicated work package 2 (WP2), while the remaining was related to work package 3 lead by the Norwegian team. The former effort was headed by Assistant professor Moritz Loock and St.Gallen University, PhD student Karoline Künzel and MSc student Hans Curtius (also employed by Landis and Gyr). Bacher Energie was involved with WP3 and the market modeling effort. This part will be addressed in the next paragraph.

The first effort in WP2 was to carry out a conjoint experiment on professional prosumers (SME’s) where the objective was to explore preferential business models for professional electricity prosumers in Switzerland. Conjoint analysis is a statistical technique used in market research to determine how people value different features that make up an individual product or service.

An important bottleneck for the diffusion of smart metering is acceptance of this new technology by various stakeholders, such as customers on the one hand and firms that offer smart metering products and services on the other hand. Both perspectives are commonly addressed within the design of business models. Various studies report that private and commercial consumers often struggle to recognize the value smart metering could provide them. Companies offering smart metering products and services thus seek to develop additional services that are suitable to be bundled with a smart meter. Such services could relate to smart metering in a direct way, such as different ways of presenting energy consumption data, or have a wider scope, such as bundling smart metering with different products like smart home applications. Service innovation is an important topic for production economics and provides various challenges.

So there is a fair risk that smart metering and services, which are developed from a firm perspective, fail to attract consumers. As smart metering is often considered a principal stepping stone into a smart grid related development these issues must be addressed. This has been a major goal of Work Package 2 led by St. Gallen University.

A conjoint study with small and medium enterprises (SMEs) was conducted in Switzerland to investigate the standing of smart metering and associated technologies within the business community. In particular tests for the acceptance of different smart metering service bundles were conducted. The objective of conjoint analysis is to determine what combination of a limited number of attributes is most influential on respondent choice or decision making. A controlled set of potential products or services is shown to respondents and by analyzing how they make preferences between these products, the implicit valuation of the individual elements making up the product or service can be determined. These implicit valuations can be used to create market models that estimate market share, revenue and profitability of new product designs.
The conjoint methodology further allows measuring part-worth utilities of single services. It was further seen suitable to test the share of preference for different smart metering service bundles among SMEs in Switzerland.

For the conjoint experiment 250-350 people were contacted. Of this number 171 responded. 109 took part in the conjoint experiment. Results from the survey highlights what aspects professional players believe is most valued from the perspective of prosumers. This is shown in Figure 6. In Figure 7 some of the results of the conjoint experiment are shown. These clearly show what attributes, and to what extent these attributes are valued. As a case in point, information about own consumption is highly valued. The same is own investment and price of kWh.

The data gathered reveals a “more is less”-effect, as SMEs in Switzerland prefer service bundles that cover an optimal level of smart metering services. Those services provide more services than just the very basic offer, but less services than the maximum service offer.

Based on those results a hypothesis was put forward implying that for smart metering we see a phenomenon, which has recently been discovered for consumer psychology, namely “the presenter’s paradox”. The very basic assumption is that firms (presenters) and SMEs (consumers) have different and assumingly even opposite perceptions about costs and benefits of smart metering. Only an integrated view of those perspectives reveals how smart metering services are best designed: with an optimal level of service.

![Average Importance of Attributes](image)

Figure 6 Survey responses show emphasis with respect to business propositions
Beyond this WP2 defined a model for how the “presenter’s paradox” informs our data-interpretation and how an optimal level of services helps to solve the presenter’s paradox. The work of the Swiss group precipitated into a model that specifies a generic value proposition per segment that can be used for practical marketing as well as for business strategy development (Figure 8). This value – segmentation model has been used extensively in other IMPROSUME work. Combined with the work of the Danish side it provides a basis for a differentiated approach. Such approach implies that there is no such thing as “one size fits all”. This indicates a need for specialized energy products, each targeting a particular end-user segment. Moreover it demands an acute form of communication strictly focusing on the aspects valued by each segment. All this defines a distinct departure from regular energy business that is rooted in the traditions of commodity trading.
Obviously the customer group called “supporters” is important in a virgin market. They represent the group requiring potentially lower acquisition costs. They can serve an important role as champions in the form of traders, gadget driven or simply pioneer the field in order to save money. As such they are likely to be gadget interest driven or motivated by potential economic savings. St.Gallen has taken these findings further to determine how the group of supporters could be extended. This work is now injected into a separate PhD project and ongoing. Figure 9 shows the concept. Based on discussions among the work package members hypotheses on what conditions require punishment and/or rewards to increase customer acceptance of demand-response programs have been introduced. The issue is important for practical recruitment, but also for creating models of user behavior for simulation purposes. St.Gallen initiated work on this and conducted empirical work accordingly. This effort was spurred in IMPROSUME, but continuous for completion in a separate project. Work from WP1 is currently assimilated into this effort.

St.Gallen University has also leveraged results from the empirical work in IMPROSUME WP2 towards a concept termed “time-based business models”. This was a concept that came forward during the analysis of the results gathered in WP2 and the associated theoretical work. Further investigation of this will be
pursued in a new effort beyond IMPROSUME. The electric power sector represents a typical time-based concept where supply needs to cope with demand at any given moment in time. Temporal imbalances result in volatile prices which incentivize the provision of flexible demand and supply capacities. The traditional logic of electricity supply is more and more questioned through the increasing diffusion of fluctuating generations from renewable sources. That precondition paves the way for new demand side oriented business models. Two cases in point discussed in IMPROSUME have been addressed. One is the demand response aggregation. The other is a decentralized market platform. Both illustrate, that demand side oriented business model do not only require a profound knowledge of energy markets and its main price drivers, but additionally the skill to upscale and aggregate small consumers and create a marketable product. All of which have been captured in the models of WP3. Furthermore the automated synchronization and balancing of a large number of consumers and producers requires advanced information and communication systems; information exchange becomes a core competence of demand side oriented smart grid business models. The conceptualization of time-based business model contributes to different theories. First, it enhances our understanding of demand side management and showcases how joint temporal activities of demand and supply create value. Second, timing and time-based business models emerge as new contingency factors and can enhance our understanding of how configurations of timing activities effects firm performance. Third, we see implications for the practice turn in management science as practices of timing evolve as new source of value creation. Finally we see implications for a knowledge-based perspective as knowledge about timing appears to become an important factor in competition. University of St.Gallen will continue to investigate this concept in subsequent research.

More details on WP2 can be found in reports provided to the Swiss funding sources and which will be associated with this report.

**Contributions of the Norwegian partner (WP3)**

The basic aim of work package 3 managed by NCE Smart Energy Markets was to model the relationship between the prosumer and the market and to determine what the impact of this relationship could be in the future. Based on the behavioral patterns and the type of stimuli that was investigated by the Danish team in WP1 and the business aspects of WP2 we were determined to develop a regime of models that could support simulation of the prosumer’s universe. Prime focus would be placed on efficacy in terms of active energy management and impetus for market participation. Both individual and collective behavior was meant to be modeled and simulated. The simulations run based on the modeling work done should allow us to determine:

- The resulting price elasticity on demand and supply
- The role of prosumers in the future market
- Strategies for securing consumer acceptance and active participation
- Effect of micro-grid topology and the possibility of inter-trading as well as intra-trading
- The impact of micro-generation and storage on the market and the configuration of such
- Operational criteria for Virtual Power plants, DSO’s and TSO’s in the future

In accordance with this the following deliverables were planned:

- A report on state-of-the-art including existing mathematical models pertinent to central WP3 issues
- A methodology for building viable simulation models that can cope with the complexities identified.
- Simulator model(s) addressing the prosumer concept, the VPP and the overall market and a set of industry generated scenarios
- Report on simulation results and specifications for affordable micro-generation
In terms of dissemination we anticipated three papers targeted for channels such as IEEE PES, CIRED and Intelec. In addition we claimed that the work undertaken would be of great significance or the Nordic energy business.

Work done

Main tasks
In WP3 the work was centered on three main tasks:

1. Creating a state-of-the-art review of the energy market and address this in the context of current and anticipated smart grid developments.
2. Determining the effect of technologies, user behavior and business impacts on a micro level.
3. Adopt a scenario approach and create a suite of simulation models to cater for the analysis of the impact of prosumers on the future smart grid oriented market.

Over the project period the Norwegian IMPROSUME group has been manned by the following people, Iliana Shandurkova (PhD student), Andreas Nilsen (MSc), Stig Ottesen, Dr. Christian Künze, Hollie Orr (master student), Dr. Thomas Martinsen, Åsa Grytli Tveten (PhD student), Satya Ram Twanabasu (Master student), Professor Rainer Bacher (representing Switzerland), Professor Torjus Bølkesjø and Professor Bernt A. Bremdal who also managed the full project.

State-of-the-art review
The state-of-the-art perspective was documented in the publication “A Prosumer Oriented Energy Market - Developments and Future Outlooks for Smart Grid Oriented Energy Markets” (Shandurkova et al. 2011). The report provides an introduction to the basic concepts associated with a Smart Grid dominated energy market. These concepts are discussed to create an understanding of how they could possibly evolve as smart grid technologies enter the energy market in Europe and in the Nordic market in particular. Comparisons are made between existing markets and what seems to become the future. Special attention is paid to the energy prosumer. An energy prosumer resonates with the market in various forms. The report states that together with other prosumers he or she could constitute an important market power in the future as demand-response (DR) programs on the user side evolve, and as distributed energy production with micro-generators gains increased foothold among regular consumers. This was formulated as the principal hypothesis for the subsequent work done. The state-of-the-art review presents an overview of research activities that address concepts that we expected could relate to this hypothesis and the issues associated with it. The review discusses different methods for modeling the future energy market and to investigate the impact of prosumer groups on this. A number of research initiatives have employed an array of such methods to determine various aspects of the Smart Grid and the future energy market. The report points to the most relevant ones. The survey and investigations that resulted in this review report created a solid knowledge platform for further research into the market aspects that we were determined to pursue.

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Micro level investigations

Price elasticity
The most important micro level oriented research was performed in WP1 on user behavior and acceptance and in WP2 on business models. Indeed it was important for WP3 to assimilate the results from these work packages. However, given that the work packages needed to be performed in a highly non-linear manner, the foundation for modeling in WP3 required a wider set of input sources. Technology development demanded close attention. Also, with a degree of user acceptance what would the energy user be likely to do with the technology available? The micro level investigations were important to hypothesize further about the prosumer behavior. Consequently we also addressed the energy prosumer in a wider context comparing the situation in energy with prosumerism in other domains. To be able to capitalize on previous research on demand side management we had also had to address historical work. In “THINKING SMART ABOUT ELECTRICITY USAGE - How can advanced demand response programs affect consumption of electricity?” addresses core issues in IMPROSUME and bridge this to a previous study carried out by Grande, Sæhle and Graabak2 (2008) at Malvik in Norway. Shandurkova (2011)3 documents an analysis whereby demand-side management of water boilers and space heating could yield an impact on peak hours. For this purpose she used econometrics to estimate substitution elasticity and a price-elasticity equivalent measure. In her analysis she found that substitution elasticity does not provide any statistically significant proof of shift from peak to off-peak usage as a response to prices charged. These results indicate that load reduction should be attributed specifically to remote load control and not to price changes as prices and usage do not follow a particular correlation pattern during the hours neighboring the predefined peak periods. Price elasticity’s estimates prove to be highly significant and show that load during hours of remote load control in a demand curtailment regime has been reduced simultaneously with the customers being charged peak prices. The resulting elasticity, equal to -0.47 and -0.10, account for a much higher extent of price-responsive behavior as compared to previous studies that analyzed price elasticity. Shandurkova showed that user flexibility, managed through remote control holds a big potential.

Prosumerism
As opposed to a general view within the energy domain that prosumerism as a concept is something that has emerged with the advent of smart grid and micro-production technologies an investigation was conducted to determine the nature of prosumerism and prosumer oriented businesses. This is documented in “Prosumer Oriented Business in the Energy Market” (Bremdal 2011)4. Here it is established that prosumers are consumers that resonate with the market. In this context the market could be the unitary relationship between a seller and a customer or it could include an extensive group of different buyers and sellers. It was found that prosumerism as a business and market concept has extensive historical roots and

2 Grande Ove S, Sæle Hanne, Graabak Ingeborg (2008). “Market Based Demand Response Research Project summary”. (Teknisk rapport (SINTEF Energiforskning); TR A6775)


is represented in multiple domains; the most well-known during the last decade are prosumer activities in telecom and Internet. A selection of 60 businesses were studied and categorized according to four different models of prosumer based enterprises, each with a different degree of market transforming power. It was found that prosumers combined with the proper business model have the power to transfer entire business domains. To put it short, prosumerism has been and can again be a game changer. Bremdal (2011) emphasizes the importance of value networks as opposed to value chains and how both should be managed in a prosumer oriented setting. Different forms of communication models are also discussed. The choice of model, its implementation and management is crucial to the prosumer himself, the efficiency of the market and the enterprises operating in it. Based on this a set of archetype scenarios were specified for the future energy market. A market governed by SmartGrid technologies and distributed energy production, fully or partially controlled by prosumers. The degree to which of these scenarios will manifest themselves in the future will be dependent on some key aspects that will be discussed below.

**Future scenarios**

In our research we found that the most viable future scenario would be determined by the development of price, price volatility, technology development and how prosumerism would be encompassed by players in the market or the energy users themselves. A low price – low volatility future scenario, much like the market state that we have experienced in Norway over the past 20 years, will yield marginal business incentives for extensive investments in smart grid technologies unless new government requirements are put forward. During the course of the IMPROSUME project the Norwegian regulator, NVE, has introduced a new precept that requires that most households should be equipped with AMS based smart meters by January 2019. In [Figure 10](#) Energy prices and price/performance for technology will determine future development. Regular people may have sufficient impetus to organize their own micro-market and "energy cell". This is highly likely if energy prices remain at a level low to moderate. Low price levels may tend to slow down initiatives among professional players.

Norway and in other European countries AMS can be seen as a complementary infrastructure to broadband technologies and home automation systems (HAS) already installed. Seen from the perspectives of the users and non-energy players, AMS and smart meters are just additions to an existing infrastructure associated with the Internet and consumer electronics. The most important part of the new addition is that efforts to control heating, lighting and appliances can be reflected in the load and consumption profile that will be officially recorded on an hourly basis. Analyzing this, an impetus exists for user-initiated activities that could trigger a grass root movement that might develop into small energy communities. This is illustrated in [Figure 10](#). If inertia prevails among the classic players due to marginal economic incentives...
such communities might develop into a kind of semi-independent “Linux” communities of the energy world maintaining their own micro-market and consequently weaken the market powers of the regular utility. This scenario could be amplified due to decreasing prices for micro-production technologies, making it attractive to install and control own energy producing equipment. Another effect of a continued low price scenario combined with mature and affordable technologies would be the emergence of a non-commodity end user market whereby energy would be bundled with sales of other products and services. In order to boost earnings and draw the attention of new customers, sellers would add a number of services that would be rated not only for its price, but for its user value, quality and timeliness. For infrastructure owners this would set the focus on service development and not energy. Opening the infrastructure for third party service providers would define a more attractive business platform than pure energy sale. However, in the event that prices go up and price volatility will be more violent this development would cease (but hardly disappear). Either way, it was hypothesized that the prosumer will have an impact, albeit different, depending on the degree of control and involvement of the user side.

Models

Stochastic bottom-up analysis of demand curtailment and production capacity on the user side

Based on the introductory work the Norwegian group initially set forth to develop a micro-level simulator to create an instrument for bottom-up analysis of user flexibility. The idea was to use input from the Danish side to determine the degree of recruitment among different groups of energy users for smart grid technologies. This would yield a population density that would be willing to involve themselves actively or semi-actively in the market. Next task would be to determine the latent and actual capacity for load shedding/shifting and energy export. As data from WP1 was delayed the analytic group in WP3 got hold of data from the Skagerak in Norway. Skagerak had historic records from a previous AMI experiment in the early 20-hundreds. This was made available for the project. A Monte Carlo simulator was built that predicted recruitment percentage, load shifting flexibility and production capacity among a dedicated group of prosumers according to different policies. The concept is illustrated in Figure 11. However, the Skagerak data appeared to be irregular with a lot of missing records and infected with noise. It was only possible to create an average distribution for a full year. Aggregation took into effect the variance of the distribution and the randomness of the data picking. Still, the final result tended to be too coarse. Seasonal differences disappeared entirely. The data was used to make a preliminary qualification of the method applied and to produce “ball park” figures that served as a course reference for other data gathered later.
Figure 11 Stochastic bottom-up estimation of future prosumer contribution. Prosumer recruitment and degree of participation are modeled as probability density functions. Probability density functions also defines their own need for power at a given time.

Figure 12 Screen shot of the simulator built. Note the possibility to construct artificial probability densities.
Screen views from the system developed can be seen in Figure 12 and Figure 13. The system can be set up so as to simulate the behavior of users equipped with a smart meter and a display unit. It can also simulate the effect of a technology based demand-response regime driven by price or other type of signal. Finally it may simulate both general and tactical use of self-produced power. In lack of data we constructed a series of artificial distributions based on historic reports to test the system. This included a distribution of user responses based on a diverse set of records from tests with smart meters and display. It also included a response profile for remote control of heaters and other loads based on reports such as Shandurkova (2011). Finally it included a production profile synthesized from different sources and NordPool price data. Different groups of consumers can be defined in the system (with different profiles constructed) and allocated to different price zone across the Nordic market. Using the Monte Carlo engine it would be possible to construct an aggregated load profile for the full population of prosumers in the market. Here we used the preliminary results from the Danish side whereby the technology acceptance factors were applied to determine to which extent the entire population of energy users in Norway and in the rest of Nordic countries would take part. The intention was to use the results from this new simulation tool to feed a more sophisticated market simulation (see later paragraph). However, poor and insufficient data could not be made available to verify the model and to allow its use for further analyses. In the recent weeks, however, data has become available from a source in Sweden and from Hvaler in Norway through the DeVID project. This should make it possible to verify the stochastic aggregation model for user flexibility and apply the tool for its intended purpose. We anticipate that we will be able to do this in a student oriented project the fall of 2013.

Predicting consumption and aggregated flexibility
To compensate for the lack of good quality household data during 2011 we focused on commercial and public buildings to determine latent flexibility that could be used for our simulations. For that purpose we were able to get access to consumption and load data for Campus Remmen of Ostfold University College. A prerequisite for determining the latent user flexibility of prosumers is to establish a relationship between a
set of observable variables and the energy output. Assuming, a priori, that historic records under normal use represents a satisfactory (but not necessarily optimal) case with respect to the balance between a good indoor environment, the outside temperature and use of the building such records might provide a good reference for also determining what latitude is possible to obtain in order to shed or move loads during peak hours in the grid. From historic work we know that there is a strong relationship between outdoor temperature and consumption across a period of weeks and months, during the winter time. Indeed also the level of activity in such a building influences the consumption. For Campus Remmen we soon established that the linear correlation between outdoor temperature and the hourly energy loads across a winter season was approximately -0.75 depending on the duration of the period analyzed and -0.62 for the full year. Using different regression techniques we intended to determine the relationship:

\[ E_t = f(T_o, A, E_{t-1}, E_{t-2}, E_{t-3}...E_n) \]

where \( E_t \) is load at time \( i < t \), \( T_o \) is outdoor temperature at time \( i = t-1 \), and \( A \) is activity level.

Specifying this mathematical relationship can be seen as a prerequisite for prediction of energy use and to phantom the degree of user flexibility, \( \Delta E_t \). This tolerance is an expression of flexibility as a function of \( T_o, A, E_{t-1}, E_{t-2}, E_{t-3}...E_n \). When actual and historic states are comparable we may determine the latitude of operation control.

Different regression techniques were applied, including the moving average technique, ARIMA, the Neural Network and the Support Vector Machine. To simplify focused was fixed on the actual regression and prediction. Due to the significant negative correlation with the outdoor temperature reference to activity, \( A \) was excluded from the model. The table below specifies the results obtained.

<table>
<thead>
<tr>
<th>Model</th>
<th>MAPE</th>
<th>RMSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARIMA</td>
<td>5.678%</td>
<td>93.497</td>
</tr>
<tr>
<td>ANN</td>
<td>5.319%</td>
<td>85.803</td>
</tr>
<tr>
<td>SVM</td>
<td>7.682%</td>
<td>96.789</td>
</tr>
</tbody>
</table>

The ANN (neural network) yields the highest precision. However, due to its oblique properties we accommodated the ARIMA model as the best runner up. The work has been published and presented at CIRED 2013.

**Final energy market model**

In spite of the initial difficulties in establishing recruitment data unit flexibility for prosumers based on reliable empirical sources progress was secured through a combined strategy applying a top down strategy and calibrating this with the initial bottom-up approach. The top-down approach addresses flexibility at an aggregated level. The basic idea is that a percentage volume of the aggregated consumption can be reduced or moved from peak hours to off-peak hours. Assuming 50% demand flexibility means that 50% of the consumption above average is moved to hours with a lower consumption level than the day-average\(^5\). The unit flexibility can then be estimated by working backwards. In this way it is possible to determine a

---

\(^5\) A demand flexibility (of 25%) more precisely means that in hours with a higher consumption than the day-average consumption level, 25% of the difference between the consumption in that particular hour and the day-average is moved to hours with a lower consumption level than the day-average.
rationale for both the required recruitment and participation of households and public buildings. This is important to enable the shift at a cumulative level. Consequently the method of approach combines a top-down approach with available micro-level estimates. The macro potential is estimated by shifting the aggregated consumption from day-time to night-time in order to flatten the demand curve and a bottoms-up approach based on the diurnal consumption profile of electric household equipment. It is estimated that shifting 7.1 GWh and 3.6 GWh of household electricity consumption may flatten the demand curve in winter and summer respectively. This equals a little less than the electricity consumption for heating hot water in households. Consequently the results produced reflect a modest, more than an aggressive user involvement. The relatively large use of biomass in wood burning stoves in Norway suggests a kind of prosumer involvement already. The incentive from reduced electricity cost for an individual consumer is small. User involvement in Norway is thus likely to require additional incentives. This again suggests business models of the type called “Smart + or “Camouflage” proposed in work package 2.

Figure 14 2015 simulations using the top-down approach to determine the effect of load shifting. The various curves illustrate the impact of prosumers and their degree of involvement. The graph shows well how user flexibility reduces aggregate loads during the day, while loads naturally will increase during the night.

Based on reviews of current policies, costs and resource availabilities and overall trends in the energy market, we have developed scenarios for investments in new generation technologies, transmission lines, demand and power plant closures. These data are used as input in a detailed energy market model for the North European power system to analyze likely price developments towards 2025. The model has an hourly time resolution and can hence be used to analyze impacts of different scenarios for short term electricity demand flexibility (see Figure 14) The assumed changes in generation capacity and demand cause a rather healthy power balance in the Nordic countries. However, when assuming rather high fuel and CO₂ prices the modeled market clearing prices are in the area €50-60/MWh in the Nordic countries in 2025, according to the model simulations (see examples in Figure 15, Figure 16 and Figure 17). The price level is heavily dependent on fuel and carbon price assumptions, though. High investments in renewable generation and increased transmission capacity to continental Europe cause higher diurnal variation in Nordic electricity prices in 2025 than what is observed today. Increasing diurnal price variation may motivate for smarter energy consumption. The scenario analysis indicates that demand flexibility will have a considerable influence on the daily price variation for both Norway and Denmark. The modeled prices and price variations are shown in
Figure 15  Average hourly prices, Denmark and Norway, winter weeks (S01-S05), base case 2025. Note the relative distance to the SRMC line that represents the short term marginal energy generation cost for coal fired power plants.

Figure 16. High fuel price scenario. Average hourly prices, Norway, winter weeks (S01-S05), base case 2025. Comparing no flexibility with 3 GWh, 6 GWh and 9 GWh average daily flexibility (scenarios 5-8).
Figure 17. High fuel price scenario. Average hourly prices, Denmark, winter weeks (S01-S05), base case 2025. Comparing no flexibility with 3 GWh, 6 GWh and 9 GWh average daily flexibility (Scenarios 5-8).

### Winter (W01-W05)

<table>
<thead>
<tr>
<th>Demand flexibility</th>
<th>Region</th>
<th>Avg. price (€/MWh)</th>
<th>Avg. consumer price (€/MWh)</th>
<th>Change in cost (%)</th>
<th>Avg. price var. (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No flexibility</td>
<td>NO15</td>
<td>60.1</td>
<td>60.7</td>
<td>15.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>59.1</td>
<td>60.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>NO15</td>
<td>59.7</td>
<td>60.0</td>
<td>-1.1%</td>
<td>6.2</td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>58.7</td>
<td>59.6</td>
<td>-2.1%</td>
<td>49.4</td>
</tr>
<tr>
<td>50%</td>
<td>NO15</td>
<td>59.3</td>
<td>59.5</td>
<td>-1.9%</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>58.3</td>
<td>58.7</td>
<td>-3.5%</td>
<td>27.5</td>
</tr>
<tr>
<td>75%</td>
<td>NO15</td>
<td>59.5</td>
<td>59.7</td>
<td>-1.7%</td>
<td>0.3</td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>57.9</td>
<td>58.1</td>
<td>-4.6%</td>
<td>19.2</td>
</tr>
</tbody>
</table>

### Summer (W25-W29)

<table>
<thead>
<tr>
<th>Demand flexibility</th>
<th>Region</th>
<th>Avg. price (€/MWh)</th>
<th>Avg. consumer price (€/MWh)</th>
<th>Change in cost (%)</th>
<th>Avg. price var. (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No flexibility</td>
<td>NO15</td>
<td>50.3</td>
<td>51.0</td>
<td>49.3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>52.0</td>
<td>53.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25%</td>
<td>NO15</td>
<td>50.6</td>
<td>51.0</td>
<td>0.1%</td>
<td>36.4</td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>52.3</td>
<td>52.8</td>
<td>-0.4%</td>
<td>39.2</td>
</tr>
<tr>
<td>50%</td>
<td>NO15</td>
<td>51.5</td>
<td>51.7</td>
<td>1.5%</td>
<td>22.0</td>
</tr>
<tr>
<td></td>
<td>DK1</td>
<td>52.8</td>
<td>53.1</td>
<td>0.2%</td>
<td>26.0</td>
</tr>
</tbody>
</table>

Table 1 Modeled average price and daily price variation in 2025 with levels of consumer flexibility. (week 1-5 and week 25-30, 2025).
Our results show that consumer flexibility without doubt will contribute to significantly lower short-term price variations, and also in most cases increased power system stability. Having said that, the magnitudes of consumer savings is still rather limited according to our results, so the incentives to implement smarter energy usage from the pure market effects studied here, can be questioned.

The collaboration

**Work packages and interrelations**

![Figure 18 Work package interaction defined for IMPROSUME](image)

In Figure 18 Work package interaction defined for IMPROSUME the basic concept for work package interaction and collaboration in IMPROSUME is shown. This division of work and flow of information was largely maintained throughout the project. Each work package was managed and manned by one of the national teams. Thus WP1 was the responsibility of the Danish party. WP2 was managed throughout the project by the Swiss side and the other two were managed by the Norwegian team. Each team was responsible for output required by the others as shown in the figure. Beyond this there was also multi-national cooperation within the work packages (WP1 – WP3). One of the Swiss partners, Bacher Energie was actively involved in WP3 together with NCE SMART in Norway. The state-of-the-art report produced and published in the work package is a tangible result of this collaboration. In order to conduct the online survey in WP2 the Danish side had to involve local resources in both Switzerland and Norway. The results published by University of Aarhus reflect a substantial and balanced set of records from the three countries involved. The conduct of such a cross-national survey would have been more difficult and more time consuming without the collaborative environment offered by the IMPROSUME project. Similarly NCE SMART produced input on prosumer oriented business models for WP2 while St.Gallen University in WP2 came up with the basic segmentation model shown in Figure 8. This segmentation model was embraced by the other parties. It offers an explanatory model for different user behavior that conforms to the findings in WP1. It also provided a template for differentiation of prosumers in the simulation model built in WP3. WP3 embraced the findings from the online survey in WP1 in order to determine a probability density function for user acceptance in the micro-level simulation model. WP1 and WP2 enjoyed mutual
reinforcement of beliefs when analyzing user responses. The conjoint experiment in WP2 was of high relevance to the study of user responses and behavior in WP1, and had been even more so if the field experiment conducted for Danish household had been set forth earlier and been more successful. The Norwegian side in WP3, mainly UMB and NCE SMART, had prepared to use data from the Danish field tests to populate its simulation model. A real time data feed channel was established between NCE SMART and one of the Danish industry partners during winter 2012-2013. However, due to severe problems with the Danish field experiment only test data were captured by these means. As explained earlier the lack of data from WP1 required that WP3 had to look for other resources to populate its simulation models. Substitutes were found in Sweden and to some extent in Norway. The quality of the results in WP3 was thus largely unaffected, although hands-on, live data from the Danish field experiment could possibly have improved some aspects. First of all it would have been possible to ask the prosumers directly about issues related to their load profile and routines. This might, in an aggregated form, have helped to answer some issues related to the market projects created. Another element that was possibly lost in the collaboration was the chance to create specific stimuli directed toward the Danish field subjects to gauge their reaction. That could have added a dimension to the simulation in WP3, helping to better determine the sensitivity of certain means on the market, and in judging the correlation between the on-line survey conducted and the actual responses. That would have provided extra value.

The communication between the different parties was not tight, but sufficient. Partner budgets did not allow extensive travelling and meetings were generally substituted with on-line means. However, 5 physical full day meetings with all partners present were held:

Halden (kick-off): November 2010
St.Gallen: March 2011
Oslo: November 2011
Aarhus: June 2012
Aarhus: June 2013

As part of the planned dissemination effort specified for the project two major workshops were hosted. One was held in Oslo in November 2011 (mid-term) where app. 60 invited guests from 7 different countries took part, both scientists and experts from the industry. A second workshop was held in Aarhus at the end of the project (final). Most of the delegates (app. 40) here were from Danish research and industry communities. Both workshops were very successful and have helped to leverage the status of IMPROSUME in Europe.

In addition to the joint workshops each of the parties have run local events were members of the other groups have taken part.

Currently, no joint scientific papers have been produced. However, there are plans for such through the axis WP1-WP2 as well as WP2-WP3.


**Summing up**

The simulation models generated are viable and usable and will be applied for future work. The IMPROSUME project and the results obtained have given important insight into an energy future that is likely to be influenced by households and owners of larger properties that may involve themselves as prosumer and market participants both directly or indirectly. The impact of such will generate positive effects.

Given the time limits of the project and the scarcity of good data at the outset we finally concentrated a full analysis on user flexibility involving load shifting only. Even an involvement that results in only 25% of the beyond average loads being moved to off-peak hours during the night will yield positive effect on the market in the future. The average unit load moved may be perceived as conservative as we assume that there are much more to be gained by more intelligent control of households and buildings. This needs to be investigated further. We also think that tactical small scale production and load reduction may yield very significant results even if recruitment of prosumers is relatively low. The latter is important as the economic incentives for participation is doubtful. But WP1 shows that there might be other drivers that might spur recruitment. It seems that there are limits to how much the moral aspect related to energy use and environmental concern may be a driver for recruitment in Norway, but there are other drivers that might accelerate involvement. These may include ease of use and maturity of technology and the imminent price volatility and uncertainty that sellers and buyers of energy are likely to be exposed to if prosumer recruitment fails.

To organize that first, critical group of prosumers it is important to determine the right business model. In Norway a strategy based on Smart Camouflage is the most likely. This implies a form of product or service bundle. The energy part of this may not be very pronounced, but important. With low to moderate prices professional players such as utilities and ESCO’s are likely to stack different types of incentives on top of the energy part to make money. This will be essential to recapture basic investments in IKT infrastructure and AMS. If that happens the end-user market is likely to become more decoupled from the whole sale market as the cost of energy in that bundle will have little influence on the price of the bundle. The end-user market will be more like a service market and the energy ingredient thus part of a non-commodity. The capital costs for creating such bundles will be fairly low and can be compared to a number of Internet services. Consequently we are likely to see a number of combos specialized for target groups spanning an array of segments. That will create a market tail of specialized offers that is essentially infinite. The head of the end-user market will then consist of a few, large players selling energy in bulk like today, while the remaining tail will define a package of services and energy elements that might well be developed by the prosumers themselves. A reference for this could be the media market. Over the past 15 years digitalization and prosumerism has transferred the media world into a market where the long tail is still expanding. This is still happening even if some of the larger market players i.e..Apple, Spotify, Google have recaptured parts of the market and thereby consolidated the head.

The IMPROSUME project has through dissemination activities and through the tri-country cooperation created a number of favorable effects. According to Professor Loock the IMPROSUME project has defined a new direction for research at St.Gallen with smart grid as basic ingredient. At University of Aarhus the work done has supported the education of a PhD student and produced highly relevant experience in field work as well as relevant market analyses. All three parties have cross-pollinated ideas and knowledge. This has helped to establish a common basis that should cater for mutual benefits also in the future. The
collaboration has been substantial despite very distinct fields of expertise. All three parties have officially declared motivation for further cooperation within a similar scope for framework as IMPROSUME.

In Norway the IMPROSUME project has contributed to the growth of smart grid expertise in the NCE SMART network and within the Norwegian Smart Grid Centre. Two of the original team members are now pursuing a PhD within a field complementary to IMPROSUME (Stig Ottesen and Iliana Shandurkova) in cooperation with NCE SMART, NTNU and UMB (The Norwegian University of Life Sciences). The work published has attracted international attention and has been addressed in foreign media. WP3 in IMPROSUME also attracted the interest of Dutch, Chinese, American and Spanish interests. The latter leading to the inclusion of the NCE SMART research group in the Spanish led EU project “Smart Rural Grid”. Cooperation with Green Technology Center at Erasmus University has also been established.

Bernt Bremdal was recently invited to a panel on “energy markets” for the 2013 IEEE ISGT (Innovative Smart Grid Technologies) Europe Conference in Copenhagen and to BITs New Energy Forum in China. Invitations have also been received to join the International Journal of Management and Marketing. All invitations have been made with reference to the IMPROSUME project.

**Dissemination**

**Recent and forthcoming publications by the Norwegian partner**


The results documented in this report will also be targeted for an international journal the fall of 2013.


**Recent presentations by the Norwegian partner**

Bremdal, B: «Energiprosumenter i Østfold kan skape en bedre verden», Østfoldkonferansen, Sarpsborg, januar 2013


A presentation as invited panel speaker will be held at the 2013 IEEE ISGT (Innovative Smart Grid Technologies) Europe Conference in Copenhagen 2013.

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6 See the following links for pertinent references:


[http://www2.solar.dk/Nyheder/projektet_improsume_-_intelligent_styring_af_varmepumpe/](http://www2.solar.dk/Nyheder/projektet_improsume_-_intelligent_styring_af_varmepumpe/)
**Recent publications by the Danish partner**


Broman-Toft, M, Thøgersen, J., & Schuitema, G., When does choosing the default reflect people’s true preference? *Energy Policy, paper under review.*

**Recent presentations by the Danish partner**

Broman Toft, M., Schuitema, G., Thøgersen, J., & Groenhøj, A. (forthcoming). Exploring the prosumers role in the Smart Grid. Poster to be presented at the 10th Biennial Conference on Environmental Psychology, Magdeburg, Germany.


Broman-Toft, M., Schuitema, G., & Thøgersen, J., (2013), Vil du deltage I fremtidens elstystemet? (Do you want to participate in the electricity system of the future?). Poster presented at the Festival of Research, Aarhus University, Denmark


Recent publications by the Swiss partner


Attachments

1. IMPROSUME – a synthesized view from all work packages
2. Improsume Schlussbericht - St.Gallen University, Switzerland
3. Interim report IMPROSUME 10/2012 – University of Aarhus, Denmark
Improsume – The impact of prosumers in a smart grid based energy market

Closing report
July 2013

For the IMPROSUME project, the leaders of the work packages

Bernt Bremdal, NCE, Norway
John Thøgersen, Aarhus University, Denmark
Moritz Loock, University of St. Gallen, Switzerland

Note: This report complements the national final reports of each work package. It gives an overview of the project as a whole. However, for detailed information of each work package we refer to the distinct reports of each work packages and the published paper or working papers, which keep stock of research done within the project.
**The project**

“Prosumer” is an emerging concept in the power market that applies to consumers of energy that can also be producers. In a Smart Grid a prosumer can be a new and active participant in balancing the electricity system. A prosumer can be characterized by owning distributed generation technologies, energy storing equipment, smart meters and equipment to monitor, control and operate electric devices. The Smart Grid creates the basis for intelligent integration of user-actions in securing a continuing high supply security while integrating more fluctuating renewable energy into the electricity supply system. An important requirement is acceptance and active adoption of the new possibilities by the prosumer. This project focuses on prosumers and their role and influence on the future energy market, and the role’s impact on established structures will be highlighted.

The improsume project investigated the impact of prosumers in a smart grid based energy market. Researchers from Norway, Denmark and Switzerland worked together in four different work packages on topics like acceptance of the prosumer role (WP1, Aarhus School of Business), preferences for prosumer business models (WP2, University of St. Gallen) and prosumer impact simulations (WP3, NCE Halden). See figure 1 for an overview of the project set-up.

**Goals achieved and international cooperation**

The international setup of the project allowed to combining national managed research projects and international research coordination. During the course of the project, projects meeting were held in Denmark, Norway and Switzerland. In June 2013 a final workshop hold stock of the most important contributions of the project. See website of the project here:  [http://badm.au.dk/research/research-groups/marketing-sustainability/projects/](http://badm.au.dk/research/research-groups/marketing-sustainability/projects/)
Throughout the Improsume project the participating researchers worked on a dissemination their work within various speeches and workshops and especially by publications:

- Broman-Toft, M., Schuitema, G., & Thøgersen, J., (in prep): “Responsible technology acceptance: Model development and application to consumer acceptance of Smart Grid technology”
- Künzel, Loock, Cometta (in prep): Under which conditions can punishment and/or reward increase customer acceptance of demand response programs?

Summary WP1
The main objective of WP1 was to get a better insight into the motives and barriers that influences acceptance of the prosumer role in the context of the Smart Grid. In one part, mechanisms to increase consumers’ participation rate in the Smart Grid were examined. The study revealed that a significantly larger proportion of people accept to participate if participation is the default and people have to opt-out in order not to participate rather than opt-in in order to participate. In a second part it was examined how consumers evaluate the costs and benefits of being a prosumer in the Smart Grid, and how this affects their acceptance of Smart Grid technology. Results show that people are more likely to become a prosumer if they perceive Smart Grid technology to be easy to use and useful, but, interestingly, they are also more likely to become a prosumer if they feel morally obligated to contribute the interests of the society as a whole and the environmental by becoming a prosumer.

The work carried out in WP1 has been reported in a published book chapter (Ölander & Thøgersen, 2012) and in a journal paper that has been invited for resubmission, with fairly small changes requested (Energy Policy). In addition, two other journal papers are in preparation. A PhD-thesis will be based merely on the work done in WP1. Moreover, the work of WP1 has been presented at various international and national conferences and workshops.
Summary WP2

Questions of how to develop the market are crucial for the prosumer concept. An aspect of paramount importance in this regard is that business models for prosumers meet stakeholder expectations. Thus, an investigation of stakeholder preferences for different prosumer business model configurations is of interest. As a first step WP2 did case study work to categorize and take stock of different conceptualized and empirically validated prosumer business models. Within a second step WP2 measured preferences of different stakeholders to derive implications for managerial business model design and supportive energy policy. The work package as a whole builds on consistent body of theory (business models) and uses the same state-of-the-art methodology for data collection and analysis (interviews, online Adaptive Choice-based Conjoint experiments and paper-based experimental manipulation (between subject-designs)).

The work of the WP2 so far resulted in two published journal papers (Energy Policy, and der markt - International Journal of Marketing), one conference paper (SMS conference), a case study for teaching purposes and two working papers, which will be further developed towards publication. It also helped to build up a competence center on smart grids with significant impact on teaching (65 in-class business model innovations during the project) and further research.

Summary WP3 (taken from the Norwegian final report, see Folsland Bolkesjø et al. 2013):

The technical potential for demand response in Norway is substantial because electricity is the dominating energy carrier. In this study, the potential for demand response is estimated by two different approaches; A top-down approach where the potential is estimated by shifting consumption from day-time to night-time in order to flatten the demand curve and a bottom-up approach based on the diurnal consumption profile of electric household equipment. It is estimated that a daily average shifting of 7,1 GWh and 3,6 GWh of household electricity consumption may flatten the demand curve in winter and summer respectively. This equals a little less than the electricity consumption for heating hot water in households. The energy efficiency of state of the art hot water heaters are good and not expected to improve within the next decade. Electric appliances, e.g., washing machine, on the other hand, will most likely exhibit improved energy efficiency. It is difficult to shift such demands to night hours because it requires interaction with the user. The demand response potential from shifting these technologies is thus small. The relatively large use of biomass in wood burning stoves may already provide some prosumer response. The incentive from reduced electricity cost for an individual consumer is small. Demand response and prosumer response is thus likely to require additional incentives.

Further, the study analyses the development of the Nordic energy system in the long run and the possible impacts of different degrees of short term consumer flexibility in demand. Based on reviews of current policies, costs and resource availabilities and overall trends in the energy market, we develop scenarios for investments in new generation technologies, transmission lines, demand and power plant closures. These data are used as input in a detailed energy market model for the North European power system to analyze likely price developments towards 2025. The model has an hourly time resolution and can hence be used to analyze impacts of different scenarios for short term electricity demand flexibility. The assumed changes in generation capacity and
Improsume: Closing overview report as appendix to the national final reports

demand cause a rather healthy power balance (defined as total production minus total consumption) in the Nordic countries. However, when assuming increasing fuel and CO2 prices (based on IEA world energy outlook) the modeled market clearing prices are in the area €50-60/MWh in the Nordic countries in 2025, according to the model simulations. The price level is heavily dependent on fuel and carbon price assumptions, though. High investments in renewable electricity generation and increased transmission capacity to continental Europe cause higher diurnal variation in Nordic electricity prices in 2025 than what is observed today. Increasing diurnal price variation may motivate for smarter energy consumption.

Outlook
Although the Improsume project has been officially ended, some of the work will be followed further (e.g. the development of the working papers). Moreover, the prosumer role for the future energy grid has become even more important. As the project shows, one of the most valuable entities prosumer provide to the market is flexibility. We just have started to understand how flexibility impacts customer acceptance, business models and the energy grid. This impact needs to be investigated on the local, the national and international level. From this perspective we strongly recommend to further engage in interdisciplinary and international research projects like Improsume.
Abschlussbericht 2013. Juli 2013

IMPROSUME

The Impact of Prosumers in a Smart Grid based Energy Market
Auftraggeber:
Bundesamt für Energie BFE
Forschungsprogramm Netze
CH-3003 Bern
www.bfe.admin.ch

Auftragnehmer:
Good Energies Chair for Management of Renewable Energies
Institute for Economy and the Environment (IWÖ-HSG)
University of St. Gallen
Tigerbergstr. 2
CH-9000 St. Gallen
http://goodenergies.iwoe.unisg.ch

Autoren:
Karoline Künzel, Universität St. Gallen, karoline.kuenzel@unisg.ch
Dr. Moritz Loock, Universität St. Gallen, moritz.loock@unisg.ch

BFE-Bereichsleiter: Dr. Michael Moser
BFE-Programmliefer: Dr. Michael Moser
BFE-Vertragsnummer: SI/500546-01 / SI/500546

Für den Inhalt und die Schlussfolgerungen sind ausschliesslich die Autoren dieses Berichts verantwortlich.
Zusammenfassung


Untersuchungsgegenstand des Projekts war zusammen mit Partnern aus Norwegen (NCE Halden), Dänemark (u.a. Aarhus School of Business) und der Schweiz (Universität St. Gallen) die Rolle der Prosumen und deren Einfluss auf den zukünftigen Strommarkt. Der von der Universität St. Gallen bearbeitete Forschungsteil (work package 2; WP2) widmet sich der Untersuchung und Konzeption von Geschäftsmodellen für verschiedene Prosumen. In einem zweiten Schritt wurden die Präferenzen von verschiedenen Anspruchsgruppen für verschiedene Geschäftsmodelle der Prosumen erforscht.


Projektziele

Der von der Universität St.Gallen bearbeitete Forschungsteil (WP2) unterteilt sich in verschiedene Subprojekte, aus denen jeweils eigenständige Berichte hervorgehen. Gemeinsam ist allen Subprojekten die Förderung der Marktakzeptanz von Smart Grid, um dadurch einerseits Energiesparpotentiale und andererseits die Verbreitung von Erneuerbaren Energien zu ermöglichen.


Die **Einbettung in die Lehre** und Dissemination war ein Ziel des Improsume-Projektes. Status: Während der Projektlaufzeit wurden in verschiedenen Bachelor, Master und Executive Education Kursen weit über 50 Geschäftsmodelle für Smart Grids entwickelt (teilweise in Kooperation mit Schweizer Unternehmen). Ebenfalls wurde eine Case Study entwickelt, die zum weiteren Einsatz in der Lehre zur Verfügung gestellt werden soll. Auch wurden Bachelor und Masterarbeiten zum Thema durchgeführt (u.a. eine Untersuchung des Smart Grid Marktes in Singapur, um Kooperationsmöglichkeiten zu ergründen).
Durchgeführte Arbeiten und erreichte Ergebnisse

**Paper 1: Generic Customer Segments and Business Models for Smart Grids**


*Abstract:* The implementation of smart grids—one of the urgent goals to meet international policy expectations for energy efficiency and CO2 reduction targets—is not a technological issue alone, as it also requires social acceptance by various stakeholders (Wolsink, Renew Sustain Energy Rev, 2011). It is of particular interest that smart grid products and services provide value to the customer. On the one hand, customer value of smart grid technologies is crucial to customer acceptance. On the other hand, as customer value is a key driver for economic value creation and competitive advantage (DeSarbo et al., Strategic Manag J 22:845–857, 2001; Porter, Competitive advantage, 1985), it is also important for companies and investors and thus will affect market acceptance of smart grid technologies. In the literature, business models address the bridge between customers and company needs and serve as mediators between technology and economic success by providing a value proposition to customers and a revenue model for companies (Chesbrough and Rosenbloom, Ind Corp Chang 11:529–555, 2002). However, we know from the literature that a one-size-fits-all business model may not lead to the best results as it might fail to address heterogeneous customer value perceptions (DeSarbo et al., Strategic Manag J 22:845–857, 2001; Morris et al., J Bus Res 58:726–735, 2005; Ruiz et al., Serv Ind J 27:1087–1110, 2007; Wiedmann et al., Psychol Mark 26:625–651, 2009). Thus, different business models providing different customer value propositions need to be developed to fit the different market segments in an optimal way. On the basis of a cross-European country study, we explore three generic B2C customer segments for smart grid products and services based on different value perceptions (Supporters, Ambiguous and Skeptics). Based on the segmentation we conceptually derive four generic business model designs with different customer value propositions best suited for approaching those segments (Saver, Smart+, Trader, Smart Camouflage). Implications for energy policy, research and smart grid management are derived from the findings.

**Paper 2: Customer value of smart metering: Explorative evidence from a choice-based conjoint study in Switzerland**


*Abstract:* Implementing smart metering is an important field for energy policy to successfully meet energy efficiency targets. From an integrated social acceptance and customer perceived value perspective we model the importance of customer value of smart metering in this regard. We further shape the model on a choice-based conjoint experiment with Swiss private electricity customers. The study finds that overall customers perceive a positive value from smart metering and are willing to pay for it. Further, based on a cluster analysis of customers’ value perceptions, we identify four customer segments, each with a distinct value perception profile for smart metering. We find that energy policy and management should integrate a solid understanding of customer value for smart metering in their initiatives and consider different smart metering market segments within their measures.
Paper 3: Too smart to fly? Towards an optimal level of smart metering services for commercial electricity consumers


Abstract: The preferences of small and medium-sized enterprises (SMEs) towards smart metering are unclear. Within conjoint experiments among 54 commercial electricity consumers in Switzerland we measure that more Smart Metering services do not always result in a higher utility: the highest share of preference has been achieved with an optimal level of service, which is not identical to the maximum level of the respective service. Moreover the share of preference for a smart metering service-bundle with an optimal level of each service achieves 74.28 % compared to only 25.72 % achieved by an offer with the maximum level of each service. Similar to the presenter’s paradox in b-to-c consumer psychology it appears that smart metering service providers face the risk of offering too much service and fail to attract commercial consumers. We discuss implications for theory and practice.

Paper 4 (new): Sustainable advantage through time based-business models: Theoretic foundations and the case of smart grids


Abstract: The call for sustainable and innovative business models can be answered either deductive from a theory perspective, or inductive from an empirical perspective. The paper at hand, combines both perspectives and first discusses a new type, time-based business models. We integrate research on business models, as activity systems, and research on the role of time, temporal activities, in organization science. In that sense time-based business models create value by activities of temporal structuring. Drawing from recent innovations in the utility industry, cases of time-based business models will be presented along the issue of demand side management within smart grids. The cases further validate the concept of time-based business models. Implications especially for a demand side-perspective in management apply.

Paper 5 (new): Under which conditions can punishment and/or reward increase customer acceptance of demand response programs?

In Zusammenarbeit mit der ZHAW und aufbauend auf umfangreichen explorativen Studien mit mehreren hundert Probanden, wurde ein Konzeptpapier erarbeitet, welches wichtige Aspekte zur effizienten Ausgestaltung von Demand Response Programmen aufzeigt, um eine möglichst hohe Akzeptanz bei Kunden zu erzielen (Ergebnisse der explorativen Studien und Fragebögen erhältlich bei Bedarf). Die in dem Paper entwickelten Hypothesen werden in folgenden Projekten empirisch überprüft.

Abstract: The paper addresses the question of how to increase customer acceptance of demand response programs. To reach the goals of the Energy Strategy 2050 – such as increasing energy efficiency and a higher and better integration of renewable energies into the energy system – the Swiss Federal Government proposes a set of tasks which different market players need to fulfill (SFOE, 2012a; 2012b). For electricity providers the Swiss government aims at introducing a mandatory energy efficiency goal that forces utilities to reach electricity savings of their end consumers in the amount of 1.5 percent of the overall electricity sales in the respective service area (SFOE, 2012b). Introducing demand response programs which help consumers to conserve energy and shift loads, can help electricity providers to fulfill this mandatory task (SEDC, 2011; DOE, 2006). However, the question how to make customers participate in such programs in the most effective way, poses a lot of challenges for practitioners and researchers alike. Incentives (rewards) and disincentives (punishments) could be a potential influencer of customer acceptance. Thus, this paper aims at investigating whether and under which conditions rewards and punish-
ment can increase customer acceptance of (participation in and positive attitude towards joining) demand response programs. It aims at answering the following specific research questions: (1) Are rewards and/or punishments an effective market instrument to increase customer acceptance of demand response programs? (2) Are rewards or punishments better for increasing customer acceptance of demand response programs? (3) How does one have to design and frame punishments in order to mitigate their potential negative side effects?

Smart Grid Fallstudie (neu)
Aufbauend auf insgesamt sieben Fallstudien, die in der Anfangsphase des Improsume-Projektes als Datengrundlage analysiert wurden, wurde ein Teaching Case entwickelt, der bereits mehrfach im Unterricht Anwendung fand. Durch zusätzliche Unterstützung der HSG wurde der Case aufbereitet und befindet sich in Vorbereitung zur Publikation auf http://www.thecasecentre.org/educators/ und steht dann zur weiteren Verwendung zur Verfügung und ermöglicht das Thema Geschäftsmodelle für Smart Grids in Schweizer Universitäten zu behandeln.

Für die Workshop-Beschreibung siehe Improsume Jahresreport Report 2012

Nationale Zusammenarbeit
In Zusammenarbeit mit der ZHAW findet ein Gemeinschaftsprojekt zur Erforschung der Gestaltung von Demand Response Programmen statt.
Die Zusammenarbeit mit Landis+Gyr, Herr Andreas Wirtz, für die Datenerhebung und Konzeption der Studie „Präferenzen von Grosskunden bezüglich Smart Grid“ sowie des daraus resultierenden Papers war äusserst erfolgreich.

Internationale Zusammenarbeit
Die internationale Zusammenarbeit von Improsume im Rahmen der ERA-Net Ausschreibung verlief sehr erfolgreich. Ein gemeinsamer Abschlussbericht findet sich im Anhang.

Bewertung 2013 und Ausblick nach Improsume
Der Projektverlauf war erfolgreich und die Ziele konnten erreicht werden. Ausserdem konnte das Thema Smart Grids weiter erfolgreich in die Lehre an der Universität St.Gallen integriert werden.
In 2013 wurden folgende Projekte durchgeführt und realisiert:
- Durchführung Folgeexperimente Demand Response Programme in Zusammenarbeit mit der ZHAW
- Paper: Under which conditions can punishment and/or reward increase customer acceptance of demand response programs?
- Paper: Sustainable advantage through time based-business models: Theoretic foundations and the case of smart grids
- Case Study: The dawn of a big thing: New business models for Smart Grids
- Projekttendmeeting Juni 2013 und Gesamtprojektendbericht
- Projekttendbericht WP2
Anhang

Paper 3: Too smart to fly? Towards an optimal level of smart metering services for commercial electricity consumers

Paper 4: Sustainable advantage through time based-business models: Theoretic foundations and the case of smart grids (new)

Paper 5: Under which conditions can punishment and/or reward increase customer acceptance of demand response programs?

Overall final report for all WPs
TOO SMART TO FLY? TOWARDS AN OPTIMAL LEVEL OF SMART METERING SERVICES FOR COMMERCIAL ELECTRICITY CONSUMERS

ABSTRACT

The preferences of small and medium-sized enterprises (SMEs) towards smart metering are unclear. Within conjoint experiments among 54 commercial electricity consumers in Switzerland we measure that more Smart Metering services do not always result in a higher utility: the highest share of preference has been achieved with an optimal level of service, which is not identical to the maximum level of the respective service. Moreover the share of preference for a smart metering service-bundle with an optimal level of each service achieves 74.28 % compared to only 25.72 % achieved by an offer with the maximum level of each service. Similar to the presenter’s paradox in b-to-c consumer psychology it appears that smart metering service providers face the risk of offering too much service and fail to attract commercial consumers. We discuss implications for theory and practice.

Keywords: Smart metering, small and medium-sized enterprises, optimal level of service, conjoint experiment
INTRODUCTION

Energy efficiency is important for production economics (Ashok & Banerjee, 2000; Ngai, To et al., 2012; Smith & Ball, 2012) and it is widely agreed upon that smart metering is a central enabler of energy efficiency within production and operations. Smart metering allows to measure and to control energy consumption. Based on smart metering data measures for reducing energy consumption and load shifting can be identified and developed (ESMA, 2012). The importance of smart metering for efficient energy systems is mirrored in international policy making, as energy policies on national and international levels establish programmes for large scale roll-out of smart metering (Wolsink, 2012; Curtius, Kuenzel & Loock, 2012). However an important bottleneck for the diffusion of smart metering is acceptance of this new technology by various stakeholders, such as customers on the one hand and firms that offer smart metering products and services on the other hand (ibid.). Both perspectives commonly are addressed within the design of business models (Martinez-Olvera 2009; Curtius et al., 2012).

Various studies report that private and commercial consumers often struggle to recognize the value smart metering could provide them (Cometta, Hannich & Rauh, 2010; Curtius et al., 2012). Companies offering smart metering products and services thus seek to develop additional services that are suitable to be bundled with a smart meter. Such services could relate to smart metering in a direct way, such as different ways of presenting energy consumption data, or have a wider scope, such as bundling smart metering with different products like smart home applications (Curtius et al., 2012). Service innovation is an important topic for production economics (Chae 2012) and provides various challenges. For instance not within every firm is energy at top of managers’ mind and the knowledge of costs and benefits of smart metering varies across firms. So there is a fair risk that smart metering and services, which are developed from a firm perspective, fail to attract consumers.

Based on this, we conduct a conjoint study with small and medium enterprises (SMEs) in Switzerland. We test for the acceptance of different smart metering service bundles. The conjoint methodology allows measuring part-worth utilities of single services and further is suitable to test the share of preference for different smart metering service bundles among SMEs in Switzerland. Our data reveals a “more is less”-effect, as SMEs in Switzerland prefer service bundles, that cover an optimal level of smart metering services. Those services provide more services than just the very basic offer but less services than the maximum service offer. Based on those results we hypothesize that for smart metering we see a phenomenon, which has recently discovered for consumer psychology: the presenter’s paradox (Weaver, Garcia & Schwarz, 2012). The very basic assumption is that firms (presenters) and SMEs (consumers) have different and assumingly even opposite perceptions about costs and benefits of smart metering. Only an integrated view of those perspectives reveals how smart metering services are best designed: with an optimal level of service. Within the paper, we first present our explorative conjoint study and the results. Second we model how the presenter’s paradox informs our data-interpretation and how an optimal level of services helps to solve the presenter’s paradox. We conclude with implications for theory and practice.
METHODOLOGY

We report from an Adaptive Choice-based Conjoint Experiment (ACBC), which has been conducted from September till October 2011 among industrial consumers in Switzerland. Conjoint analysis is a methodology that explores the utility, the importance and partial utility of characteristic values based on the holistic judgment of a product or a service and has been occasionally used in production economics (Yoo and Ohta 1995). To calculate the utility of a product or service, the sum of the partial utility is used and evaluated simultaneously (Backhaus et al., 2008). Conjoint analysis has been successfully used in answering energy related research questions such as preferences for electricity products or preferences for business models (Burkhalter, Kaenzig et al. 2009; Loock 2012). We used Sawtooth to capture and manipulate the data. It is beyond the scope of this paper to present the details of conjoint analysis, thus, we refer to available literature (ibid.). For the specifics of ACBC we refer to (Johnson & Orme, 2009; Chapman et al., 2009; Sawtooth, 2009).

Within ACBC the first step “build your own” aims at identifying the ideal offering combination by requesting the participant to pick the most preferred level of each attribute. This step allows introducing the experiment set up as well as for the participant to familiarize oneself with the meaning of some of the terms. Based on the first step the software generates a pool of alternative offerings containing all attributes, which are shown to the participant in groups of four (screening section). These alternatives vary by a predefined number of attributes when compared to the ideal offering of the first step. For each alternative the respondents have to indicate whether they would consider to buy this offering or not. This results in a consideration set for the final buying decision (Sawtooth Software, 2009). Additionally an interactive option of the Sawtooth software tool is used: based on the answer patterns, the tool pro-actively suggests attribute levels as “must have” or “unacceptable”. The user can then either decline the proposal or confirm it, resulting in a neutralization of this attribute value. In case of “must have” the software sets the value to the chosen level for all following steps, allowing the user to focus on the other attributes and their levels. In case of an attribute level being confirmed as “unacceptable”, this level will be suppressed in all following experiment steps (Sawtooth Software, 2009). Those alternatives, which passed the screening section and thus were identified as offerings the respondent would consider to buy, are taken into the third step, the choice tournament. In this step the respondents are typically shown three to four alternatives in each choice task from which they have to select the most preferred option (Johnson & Orme, 2007). The winning offering then is taken further into the subsequent choice task until the most favored option is identified (Johnson & Orme, 2007).

In a first step we collected a wide range of attributes by using brainstorming techniques among the three authors and one external expert. Then all attributes that did not match following criteria were eliminated: Relevance, Feasibility, Independence, Compensatory relationship, Non exclusion criteria (Backhaus et al. 2008). In a third step the corresponding levels to the remaining attributes were developed. All attributes and corresponding levels were reviewed and tested by the individuals of the brainstorming exercise. After the selection of six final attributes and final adjustments the conjoint analysis was programmed. A pre-launch test of the experiment was conducted with six independent participants. The following attributes with four levels have been selected for the experiment.
Table 1: Smart metering service levels and attributes for SMEs in Switzerland

<table>
<thead>
<tr>
<th>Service attributes</th>
<th>Service Levels</th>
</tr>
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</table>
| (1) Consumption data | (a) None any access to consumption data, only a regular invoice.  
(b) Web portal with historical data access to historical consumption data  
(c) Meter with data interface access to instantaneous consumption data via an electricity meter with an interface.  
(d) Web portal with actual and historical data access to historical and actual consumption data (now till last year) via an internet portal |
| (2) Allocation of electricity cost | (a) None any service supporting cost allocation  
(b) Allocation per cost center by distribution key service enabling the allocation of electricity cost per cost center by usage of distribution keys  
(c) Partial measurement/partial distribution key per cost center service enabling partially measurement of electricity consumed per cost center and partially the allocation of electricity cost per cost center by usage of distribution keys  
(d) Measurement per cost center service enabling the measurement of electricity consumed per cost center, hence pay per kWh consumed |
| (3) Energy efficiency | (a) None no services supporting energy efficiency  
(b) Minimum service with little equipment minimum service providing for example reduction of standby or targeted remote load regulation.  
(c) Equipment for local generation/consumption management service enabling the maximization of consumption to utilize local generation or minimization of consumption at peak times  
(d) Micro grid management service providing a self-regulating low voltage network including local generators, storage, normal loads and switchable loads with the possibility to react to external or internal price signals |
| (4) Flexible electricity origin | (a) No flexibility no flexibility in the choice of the origin of electricity exists as for example a long term supplier contract may exist  
(b) Minimum flexibility possibility to change the origin and mix on an annual basis  
(c) Increased flexibility possibility to change the origin and mix on a monthly basis  
(d) Maximum flexibility possibility to change the origin and mix on a daily basis |
| (5) Payment Modality | (a) Own investment & Price per kWh the company invests once in the necessary services and equipment. The company pays regularly only for the electricity per kWh consumed.  
(b) Monthly rate & Price per kWh the company pays a rate for remuneration of services and the pro rata share of the occurred investment costs, which are paid back over 5-10 years. As an additional line item the company pays for the electricity per kWh consumed  
(c) Monthly leasing fee & Price per kWh the company pays a fee for remuneration of services and usage of any equipment, which is owned and regularly kept up to date by the service provider. As an additional line item the company pays for the electricity per kWh consumed  
(d) No investment cost but included in price per kWh the remuneration of the services and the equipment cost are included in the price per kWh (one price) |
| (6) Price per kWh | (a) 5 Rappen per kWh per average metering point  
(b) 8 Rappen per kWh per average metering point  
(c) 10 Rappen per kWh per average metering point  
(d) 14 Rappen per kWh per average metering point |
The descriptions of attributes and levels were made available to the respondent via hoover text (mouse over text) and were written to address the respondent directly (you) in order to stimulate involvement and support the imaginary offering.

**SAMPLE**

Over 300 decision makers for energy related questions in their company were invited to participate in the survey. In total 171 individuals reacted to the request and started the online survey. Of those participants 62 (36.2%) stopped before the conjoint experiment and 55 (32.2%) dropped out during the conjoint experiment. 54 (31.6%) participants completed the entire questionnaire. The graph maps the proportion of responses received by segment against the proportions of actual consumption data per segment in Switzerland. This representation was chosen as a reference to assess the diversity of the sample in the framework of the actual consumption.

![Sample vs Consumption 2010 Graph](image)

**Figure 1: Industry Segment**

The study misses to fully represent the service sector as the segment of hotel and restaurants (7% of consumption) and the segment of education (4%) are missing in the sample size. Also worth noting is the 10% share of the energy sector in the sample size, which is included in others in the Consumption 2010 column. The survey sample provides a balanced mix of respondents between general management and energy affine employees, consisting of energy experts (specialist knowledge) and energy responsibles (specialists with decision making power). General employees and others represent just above 15%. For the following analysis energy specialists and energy responsibles are treated as energy experts with a weight of 39%.
The graph provides an overview of the sample annual consumption classes. Seven respondents with an annual consumption below 100'000 kWh belong to the non-liberalized part of the market. A clear majority of respondents ranges in the classes 100’000 kWh to 5 GWh per annum, 6-10 GWh and 11-50 GWh. As expected the number of heavy consumer 501-1’000 GWh per annum and above 1’000 GWh is rather small proportion of the sample (7.4%).

In regard to the proportion of the electricity cost compared to the total product or service cost, the majority of the respondents fall into a proportion of up to 5% of product or service cost. Only 6 participants estimated the electricity cost being larger than 10% of the total product or service costs. 20% of all respondents did not know how much the electricity cost contributes to the overall product or service cost. Over 40% of the participants state that they have access to their monthly electricity consumption data. Over 25% of the respondents have daily or more frequent access to their consumption data, whilst only 11% receive their consumption data quarterly. The only link between “annual electricity consumption” and “frequency of consumption data access” seems to be in the <100’000 kWh segment receiving maximum quarterly consumption data, all other consumption segments seem to get access to their data independent of how much electricity they consume.

**RESULTS OF THE CONJOINT ANALYSIS**

As an output of the conjoint analysis we calculated the individual utilities of the levels, which are used to calculate the average part-worth utilities (Orme, 2000; 2010). The average part-worth utilities are to be seen as an indicator of the utility of the corresponding attribute level. Due to the zero centered design of the method, the sum of all part-worth utilities corresponding to the levels of an attribute is equal to zero. Therefore a negative part-worth utility for a level does not indicate that the respective level is unattractive. It rather indicates that the other levels provide a higher utility. Another effect is that the average utilities of an attribute cannot be compared to the average utilities of another attribute due to the arbitrary starting point of the average utilities (ibid.). We were able to measure that more services do not always result in a higher utility: Only for one out of four service features we were able to measure “a-more-is-better” effect. For the majority of the attributes the highest utility has been achieved with an optimal level of service, which is not identical to the maximal level of the respective service. This is demonstrated by the inverted u-shape utility curves in figure 1. Moreover the share of preference for a smart metering service-bundle with an optimal level of each service achieves 74.28 % (std. err. 4.10) share of preferences compared to only 25.72 % (std. err. 4.10) achieved by an offer with the maximum level of each service.

If we calculate the willingness-to-pay as indicated by Orme (2010) – WTP! [Rappen per kWh]= (U1 x Δ Price (PriceMax - PriceMin)) / Max UPrice – for those two bundles, we find that an “over-service” offering requires a discount of 2.87 Rappen p/kWh compared to an offering, which is providing the highest utility to the customer.
SOLVING THE PRESENTER’S PARADOX WITH AN OPTIMAL LEVEL OF SERVICE

Getting consumers involved in a smart grid and energy efficiency is a prerequisite for the diffusion of smart technologies, such as smart metering. However, smart metering products and services often fail to attract consumers (Cometta et al., 2010). Zooming into that puzzle it appears that managers for smart technologies develop packages, which seem to be valuable from their perspective. However, from a customer’s perspective these products and services seem to be of limited value and customers show only a limited willingness-to-pay for smart metering services. Consumer psychology has recently revealed a similar effect, the presenter’s paradox (Weaver et al., 2012).

“Robust findings in impression formation demonstrate that perceivers’ judgments show a weighted averaging pattern, which results in less favorable evaluations when mildly favorable information is added to highly favorable information. (...) we show that presenters do not anticipate this averaging pattern on the part of evaluators and instead design presentations that include all of the favorable information available. This additive strategy (“more is better”) hurts presenters in their perceivers’ eyes because mildly favorable information dilutes the impact of highly favorable information” (Weaver et al., 2012, p.1).

The theoretical solution to escape the presenter’s paradox is to develop a deep understanding of the optimal level of service by investigating currently existing customer preferences and by avoiding over engineering of the offerings for the target market. Our data shows that this holds true for smart metering services as well: an optimal level of smart metering services – not necessarily identical to the maximum level of smart metering services – increases the share of preference and thus the likelihood of Swiss commercial electricity consumers to engage in smart metering. Figure 4 illustrates our conceptual model of escaping the presenter’s paradox with an optimal level of smart metering services.
Our data reveals that Swiss commercial electricity consumers regard more not always to be better when it comes to smart metering services. In particular there seem to be an optimal level of each service for smart metering which is providing a higher customer value than the maximum level of each service. In order to achieve the highest market acceptance smart metering services, which foster the market diffusion of smart grid technologies, a bounded R&D is required and customer preferences should be thoroughly investigated and incorporated in the decisions about the design of service offerings. Our data shows that an optimal level of smart metering services – not necessarily identical to a maximum level of smart metering services – increases the share of preference of Swiss commercial electricity consumers. Thus, it is more likely to engage customers in smart grid and smart metering by providing this optimal level and avoiding over engineering of the offerings for the target market. For technology managers our results point to the necessity of more market orientation, e.g. by working more closely with marketing people in the company or by conducting lead-user workshops. Service providers are also encouraged to integrate a deeper market orientation when designing their offerings. Finally, energy policy should integrate the need of a customer perspective next to the technology perspective in their measures and regulations.

5.3. References


UNDER WHICH CONDITIONS CAN PUNISHMENT AND/OR REWARDS INCREASE CUSTOMER ACCEPTANCE OF DEMAND RESPONSE PROGRAMS?

Karoline Künzel, Moritz Loock, Claudio Cometta
University of St. Gallen

Introduction

The Swiss Federal Government recently developed an energy strategy for the year 2050 "Energy Strategy 2050" which outlines various political goals, such as increasing energy efficiency and a higher and better integration of renewable energies into the energy system (SFOE, 2012a; 2012b). To reach these goals the Swiss Federal Government proposes a set of tasks to be fulfilled by different market players (SFOE, 2012a; 2012b). For electricity providers the Swiss government e.g. plans to introduce a mandatory energy efficiency goal that forces utilities to reach electricity savings of their end consumers in the amount of 1.5 percent of the overall electricity sales in the respective service area (SFOE, 2012b). If these goals are not met the energy provider is likely to face a punishment, e.g. having to pay a penalty fee (SFOE, 2012b). Introducing demand response programs which help consumers to conserve energy and shift loads, could enable electricity providers to fulfill the mandatory task and to avoid a punishment (SEDC, 2011; DOE, 2006). Whereas the technical feasibility of such programs poses no problems (Appelrath et al., 2012), customer acceptance of such programs – expressed not only in high participation rate in demand response programs but also in a positive attitude towards joining such programs – remains an issue for practitioners and researchers alike (Hancher, 2013; Steg & Vlek, 2009). Both, practice (Hancher, 2013; DOE, 2006) and theory (Steg & Vlek, 2009), wonder whether customers voluntary join demand response programs, whether they need to be incentivized in order to join or whether they should and could be punished if they do provide flexibility (load shifting). To answer these questions we consulted theory and literature to understand whether and under which conditions rewards (incentives) and punishments (disincentives) can be effective to increase customer acceptance of – participation in and positive attitude towards joining – demand response programs. In the rich literature body regarding environmental behavior we found a lot of studies stating that rewards can indeed have a positive effect on individual behavior (Osbaldiston & Schott, 2012; Kazdin, 2009; Steg & Vlek, 2009; Iyer & Kashyap, 2007; Abrahamse et al. 2005; Dwyer et al., 1993; Cook & Berrenberg, 1981). However, when it came to the question of the effectiveness of punishment compared to rewards our review on environmental behavior studies proved in vain. However, we cam across a call for research investigating "under which conditions rewards and/or penalties are effective, or when a combination of rewards and penalties is warranted" (Steg & Vlek, 2009, p.314; see also Kazdin, 2009). Although we reinforced our efforts, we were unable to find a single theory allowing us to answer all the aspects of this call for research. Thus, we embarked on a cross-disciplinary literature review to better understand the effectiveness of rewards and punishment.

In the light of the practical need to find effective ways to increase customer acceptance of demand response programs and the need for research investigating the effectiveness of rewards and punishments this paper aims at answering the following research questions:

(1) Are rewards and/or punishments an effective market instrument to increase customer acceptance of demand response programs?¹

¹ Rewards are considered to be market instruments which may be employed by politicians (e.g. subsidies) but which are more often employed by marketers (e.g. reward programs of various companies) (Gärling & Schuitema, 2007; Braithwaite, 2002; Frey, 1999). As for punishments, environmentalists usually consider them to take the
(2) Are rewards or punishments better for increasing customer acceptance of demand response programs?
(3) How does one have to design and frame punishments in order to mitigate their potential negative side effects?

To answer these questions the remainder of this paper is organized as follows. In the theoretical background we will review literature across disciplines on the effects, benefits and pitfalls of rewards and punishments and derive hypotheses for the empirical studies. These hypotheses will then be tested in several experiments and the empirical results of each experiment will be analyzed and discussed. After a general discussion of the findings from the empirical part of this paper, we will conclude our research with highlighting important managerial and theoretical implications and with pointing out ideas for further research.

Across discipline literature review on the effects, benefits and pitfalls of rewards and punishments

Cooperation in a social dilemma

There is a rich literature body investigating the effect of punishment versus rewards in social dilemmas (see Balliet et al., 2011). According to Balliet et al. (2011) interdependence theory explains why incentives, such as punishments for noncooperation and rewards for cooperation, are an effective tool to foster cooperation. They state, “when incentives are present, there is less discrepancy between the self-interest and collective interests compared to when incentives are absent” (Balliet et al., 2011, p. 595f.). The results of their meta-analysis confirm this assumption (Balliet et al., 2011). We believe that the same argumentation holds true for increasing customer participation in demand response programs. When people collectively engage in demand response programs they can contribute to a cleaner and more sustainable energy future – collective interest (SEDC, 2011; DOE, 2006). Demand response programs might provide personal benefits through – e.g. reduction in energy related costs when coupled with a pricing system or convenience through automated steering of appliances (Hancher, 2013). However, as they also entail some costs – e.g. effort, price risk, loss of privacy (Hancher, 2013) there might not be a net personal benefit for all customers. Thus, joining a demand response program might not be of self-interest per se. Introducing incentives, such as rewards or punishments, might therefore reduce the conflict between self-interest and collective interest (Balliet et al., 2011) and thus increase customer participation in demand response programs.

H1: Adding a reward or a punishment to a demand response program will have a positive effect on participation in the demand response program.

In their meta-analysis Balliet et al. (2011) demonstrate that, although the effect of punishments is a little stronger, punishment and rewards are equally effective to foster cooperation in one-shot and iterated dilemmas. However, in one-shot interactions the effect of punishment on cooperation was significant whereas the one of rewards was not (Balliet et al., 2011). As people normally decide only once whether to participate in a demand response program or not, this situation is more likely to be a one-shot dilemma than an iterated dilemma. Thus, we assume that punishments could be more effective in increasing customers’ participation in demand response programs than rewards. Studies on safety-belt form of taxes and other political coercive measures (Gärling & Schuitema, 2007; Geller, 1995). However, we do not want to compare political measures to private market instruments, but rather compare the effectiveness of rewards and punishments when both take the form of private market instruments being employed by private marketers.
usage investigating the effect of punishments versus rewards provide evidence for this assumption (Hagenzieker, 1991; Kalsher et al., 1989).

H2: Participation in a demand response program is higher when the program is accompanied with a punishment for non-participation than when it is accompanied with a reward for participation.

In the discussion of their findings of the meta-analysis Balliet et al. (2011) point out that rewards and punishment might differently impact expectations of the cooperation of others, intrinsic motivation, emotions, attitudes, the development of social norms and various other aspect (see also Kazdin, 2009). Our aim of this paper is to investigate the effectiveness of rewards and punishment to increase overall customer acceptance of demand response programs which consists not only of a high participation rate in demand response programs but also of a positive attitude towards joining such programs. Further, we want to investigate whether rewards and punishments have an effect on other consumer behaviors, such as patronage or word of mouth, and how to mitigate potential negative side effects. Thus, we will now have a closer look at what different theories state about the effect of punishments and rewards on attitude, compliance with the desired behavior, other customer behaviors (e.g. word of mouth), emotions and on social norms.

**Theory of motivation and the crowding-out effect**

Social psychologists argue that when people have an intrinsic motivation to do something, introducing a reward, especially a monetary reward, crowds-out this intrinsic motivation (Frey & Jegen, 2001; Frey, 1999; Deci 1976). Individuals could even engage less in the desired behavior when it is reinforced by a reward than when no reward is offered (Deci, 1976). The same holds true for negative reinforcements such as punishments (Frey & Jegen, 2001; Frey, 1999; Deci 1976). Intrinsic motivation, the interest in the task or behavior for its own sake (Deci, 1976), is necessary for the crowding-out effect to take place (Frey, 1999). The reason why an extrinsic motivator – such as a reward or a punishment – can crowd-out intrinsic motivation is due to the fact that individuals might perceive the extrinsic motivator as being controlling (Frey & Jegen, 2001; Frey, 1999; Deci 1976). When an extrinsic motivator is perceived as being controlling, two psychological processes might follow. First, an individual might perceive that his or her motivation is not acknowledged and thus his or her involvement and competence is not appreciated (Frey & Jegen, 2001). This might result in an impaired self-esteem leading the individual to reduce his or her effort (Frey & Jegen, 2001). Second, an individual’s perception of self-determination can be decreased (Deci & Ryan, 1985). A decrease in self-determination results from individuals attributing their behavior to the external justification instead of to some internal justification, such as environmental moral or the joy of performing a task etc. (Aronson et al., 2013; Steg & Vlek, 2009; Frey & Jegen, 2001; Eisenberger & Cameron, 1996; Deci & Ryan, 1985; Lepper et al., 1973). A decrease of self-determination is also the reason why the behavior can drop to an even lower basis when the reward or punishment is withdrawn – even if the external motivator increased the desired behavior in a first stage (Deci et al., 1999; Schwartz, 1990).

Studies on environmental behavior have demonstrated that a drop in behavior to base line levels normally follows the removal of a reward (Steg & Vlek, 2009; Abrahamse et al., 2005; Dwyer et al., 1993; Geller et al., 1982). However, studies on safety belt usage revealed that after termination of the external intervention no or only a small drop in behavior followed (Hagenzieker et al., 1997; Hagenzieker, 1991; Geller et al., 1990). This might either be due to the fact, that there might not be a crowding-out effect at all (Eisenberger & Cameron, 1996) or that the external intervention crowded in the intrinsic motivation. Crowding in of intrinsic motivation is possible when the external motivator is perceived as being acknowledging, supportive and/or expressive rather than controlling (Frey & Jegen, 2001; Frey, 1999; Deci 1976).

Let us now consider the potential effect of a reward or a punishment on acceptance of demand response programs in the light of motivation theory. The question one needs to
answer is whether there is a substantial amount of intrinsic motivation, which would prompt customers to participate in such a program. As demand response programs help to provide a cleaner and more sustainable energy future (Appelrath et al., 2012; SEDC, 2011; DOE, 2006), one could suggest that people with a high environmental moral would have a high intrinsic motivation to join such programs. Thus, a crowding-out effect might occur (Frey, 1999).

**H3: Adding a reward or a punishment to a demand response program will have a negative effect on participation in the demand response program. (crowding-out effect)**

However, we suppose that the crowding-out effect is not likely to occur because demand response programs are relatively new and customers may perceive some risks associated with joining a demand response, e.g. the fear of losing comfort, of being in the mercy of the utility or a high effort related to joining the program (Forsa, 2010). These perceived risks might translate into a perception of high costs associated with joining the demand response program. According to Frey (1999) and Diekmann and Preisendörfer (1998) intrinsic motivation will only guide behavior if the costs of performing the behavior are not too high. Following this argumentation, we assume that a crowding-out effect will not occur when a demand response program is accompanied with a reward for participation or a punishment for nonparticipation. Instead, we believe that a reward or a punishment might be able to crowd in intrinsic motivation, such as environmental moral, if the reinforcement has an expressive function (Frey & Jegen, 2001; Frey, 1999; Deci 1976). Thus, when the demand response program clearly demonstrates its potential for providing a cleaner and more sustainable energy future and the reinforcement has an expressive function, customers might be more inclined to participate in the program and also have a stronger positive attitude towards joining the program. We believe that this effect might be more pronounced for customers with a high environmental moral than for customers with a low environmental moral because for the later there is little or no intrinsic motivation to crowd in.

**H4a: Participation in and positive attitude towards joining a demand response program will be higher when rewards and punishments have an expressive function compared to when they do not have an expressive function.**

**H4b: This effect will be stronger for customers with high environmental moral than for customers with low environmental moral.**

**Psychological reactance**

According to the theory of psychological reactance, individuals dislike attempts to control their behavior because they perceive it as a threat to their personal freedom (Brehm, 1972). In order to restore their sense of personal freedom they react to the requested behavior, e.g. by engaging in a behavior opposite to the one requested or by simply not performing the requested behavior (Brehm, 1972). Punishments and rewards are attempts to control behavior of individuals because they are external motivators (De Young, 2000; Frey & Jegen, 2001; Frey, 1999; Deci 1976). Thus, both are likely to elicit psychological reactance (Brehm, 1972). Psychological reactance resulting from a reward can be explained by the decrease in perceived self-determination (Kivetz, 2005). Following our argumentation from the preceding section (motivation theory), we suggest that there will be no psychological reactance following an introduction of a reward for participation in a demand response program if the reward has an expressive function (Frey & Jegen, 2001; Frey, 1999; Deci 1976). However, if the reward does not have an expressive function, psychological reactance might result (support for H4a). The same argumentation may hold true for the psychological reactance resulting from a punishment. However, Geller (1995; 1989) states that punishments might provoke a stronger psychological reactance than rewards because they are perceived as being more controlling and thus pose a higher threat to perceived personal freedom (see
also De Young, 2000). Zipf (1960) provides evidence for this assumption in his study by showing that resistance forces are higher in the fine that in the reward group. Thus, punishments without an expressive function are more likely than rewards without an expressive function to elicit psychological reactance. Following this argumentation we believe that providing an expressive function will have a stronger effect for punishments than for rewards.

**H5**: The expressive function of a punishment will have a stronger effect on participation in a demand response program than the expressive function of the reward.

**Reciprocity**

Another theory addressing the effects of rewards and punishment is the theory of reciprocal actions. According to Aronson et al. (2004) and Stegbauer (2002) people feel obligated to return something when they receive something due to the norm of reciprocity. Cognitive dissonance and the desire to restore equity between the partners involved explain this mechanism (Adams, 1965; Dahl et al., 2005). For example, if someone does not return a favor, he or she will most certainly feel cognitive dissonance, which will induce a feeling of guilt. This will most certainly provoke him or her to return the favor and restore equity among the partners involved. Contrary to the two aforementioned theories, the theory of reciprocity predicts different or even opposite effects of rewards and punishments. When provided with a reward, a customer receives a benefit and thus should be more inclined to join the demand response program in order to reciprocate the reward (Choi & Ahn, 2013; Michener et al., 1986). Compared to rewards, an introduction of a punishment for nonparticipation in demand response programs should not result in feelings of being obligated to reciprocate because the customer does not receive any benefits. Thus, customers should not feel obligated to join the program (contradiction to H2).

**H6**: Customer participation in a demand response program will be higher when customers are provided with a reward than when threatened with a punishment.

Even worse, if the threat of a punishment is considered to be an aggressive provocation, an individual might feel the need to retaliate due to strong reciprocation (Aronson et al., 2013; Choi & Ahn, 2013; Fehr & Schmidt, 2007). If the punishment for nonparticipation is perceived to be an aggressive provocation, customers might feel inclined to use e.g. negative word of mouth about the utility offering that program. However, we assume that this negative effect can be mitigated if the punishment is accompanied with a reason for it (Aronson et al., 2013; Michener et al., 1986).

**H7**: A demand response program with a threat of punishment will have a positive effect on negative word of mouth.

**H8**: Providing a reason for the punishment will reduce the positive effect of punishments on negative word of mouth.

**Signaling effect, social norms, attitude and perceived equity**

Although both, rewards and punishments, can have a signaling effect by communicating norms of desired behaviors (in the case of rewards) or communicating that environmental friendly behavior is expected (in the case of punishment) (Balliet et al., 2011; Coad et al., 2009; Johnson & Bering, 2006; Frey, 1999), behaviorist favor rewards over punishments. This is due to the assumption that the former are more likely to result in a positive attitude, which increases the likelihood that the behavior in question becomes a social norm (Geller, 1995; 1989). Punishments on the other hand might result in negative attitudes (Lehman &
Geller, 2004; Geller, 1995). Similarly, Festinger (1953) and Allen (1965) believe that rewards are superior to punishments, because the former increase both public compliance and private acceptance whereas the later is only affective for public compliance.

**H9: Rewards (Punishments) will have a positive (negative) effect on customers’ attitude towards joining a demand response program.**

However, there are two important aspects of punishments, which suggest that punishments might be equally or even more effective in inducing social norms. First, whereas rewards can encourage some people to comply by signaling a desired behavior, punishments can prevent “cheating” by signaling a behavior that is expected (e.g. complying to the speed limit) while simultaneously communicating behavior, which is not accepted and thus punished (driving too fast) (Bolderdijk et al., 2011; Shin et al., 2009; Gärling & Schuitema, 2007; Johnson & Bering, 2006; Goldenbeld & van Schagen, 2005). Thus, punishments for nonparticipation might increase the expected participation rate of other customers better than rewards for participation (Choi & Ahn, 2013; Gächter, 2012; Balliet et al., 2011; Gächter et al., 2008; Andreoni et al., 2003).

**H10: Expected participation of others is lower when a demand response program provides a reward than when it threatens a punishment.**

As a punishment might result in a higher expectation of cooperation of others (Balliet et al., 2011) this might lead to a higher willingness of the individual to participate in the demand response program. An explanation for this could be, that a high expectation of the participation of others reduces the fear of being exploited by free riders (Litvine & Wüstenhagen, 2011) and thus reduces the “sucker effect” – a drop in environmental moral due to realization that others are exploiting one’s responsible behavior – (Frey, 1999). Following this argumentation, we believe that punishment is likely to bring about a higher compliance rate than rewards (support for H2). As people tend to conform with the behavior they observe others doing (Aronson et al., 2013) and over time more people might participate in a demand response program when it threatens a punishment for nonparticipation than when it provides a reward, a punishment might be equally likely to induce a social norm.

The second important aspect of punishments consists of an equity consideration in a social context. O’Reillys and Puffer (1989) show that not punishing people for a bad behavior has a stronger effect than rewarding people for good behavior. They interpreted their results in the light of social learning theory, where “sanctions are important determinants of group norm” (O’Reillys & Puffer, 1989). Indeed, in social context, if a behavior is endorsed, “it will have an impact on the attitudes and behavior of many people” (Aronson et al., 2013, p. 341). Thus, a positive attitude and a social norm are also likely to follow a punishment because the punishment can signal socially not accepted behavior. However, one has to keep in mind, that this will only be the case when people perceive a clear reason for the punishment\(^2\) (Podsakoff et al., 2006). Literature on customer perception and evaluation of imposed penalties supports the statement that providing a reason for the penalty (punishment) is of crucial importance to increase acceptance of the penalty (Tax et al., 2013; Kim, 2010; 2007; 2006; Kim & Smith, 2005; Fram & Callahan, 2001; McCarthy & Fram, 2000; Fram & McCarthy, 1999; Fram, 1997). Following this argumentation, we assume that – when a reason for a punishment is provided – punishments might not only increase perceived equity more than rewards do (O’Reillys & Puffer, 1989) but also that punishments with a believable reason might reduce their negative effect on attitude towards joining the program.

**H11: Providing a reason for the punishment will reduce the negative effect of punishments on attitude towards joining a demand response program.**

**H12: Punishments with a reason will influence perceived equity more than rewards with and without a reason.**

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\(^2\) In the study of O’Reilly and Puffer (1989) the bad behavior of the employee can be considered as being the clear reason.
Emotions

Whereas punishments induce negative feelings and emotions (Kim, 2010; 2007; 2006; Kim & Smith, 2005; Geller, 1995; 1989) rewards lead to positive feelings and emotions (Foxall, 2008; Rolls, 2000; Carver & White, 1994). According to Baumeister et al. (2001) negative emotions following a negative event are stronger than positive emotions following a positive event. Thus, punishments (negative event) should have a stronger effect on negative emotions than rewards (positive event) have on positive emotions.

\[H13a: \text{A demand response program with a punishment (reward) has a positive effect on negative (positive) emotions.}\]
\[H13b: \text{The effect of punishments on negative emotions is stronger than the effect of rewards on positive emotions.}\]

Emotions can have a strong effect on consumer behavior (McColl-Kennedy & Sparks, 2003; Zeithaml et al., 1996). Whereas positive emotions following a reward could positively influence consumer behavior, e.g. patronage and positive word of mouth (Babin & Babin, 2001; Machleit & Mantel, 2001), negative emotions following a punishment may lead to the opposite (Bougie et al, 2003; Bagozzi et al., 1999). Further, as emotion can influence attitude (Geller, 1995; 1989) we believe that the effect of punishment and reward on customers’ attitude towards joining the demand response program might result from the affective response of the customer (emotions).

\[H14: \text{A demand response program offering a reward (threatening a punishment) will positively (negatively) influence customers' intention to patronage the utility.}\]
\[H15: \text{A demand response program offering a reward will have a positive effect on positive word of mouth.}\]
\[H16: \text{Emotions mediate the effect of a reward (punishment) on}\]
- customers' intention to patronage
- positive (negative) word of mouth
- attitude towards joining the program

So far we have repeatedly pointed out that providing a reason for punishments can mitigate their negative effects on e.g. attitude and intention to retaliate (H8, H11). We further pointed out that providing a reason for punishment might be more effective than providing a reason for a reward (H12). This can be explained by the stronger effect of negative emotions (compared to positive emotions) on thoughtful and careful information processing (Baumeister et al., 2001; Bless et al., 1990; Peeters & Czapinski, 1990; Witte & Grossmann, 1971). Thus, we believe that when customers are threatened with a punishment, they will first experience a greater need for meaning and then engage more in cognitive evaluation.

\[H17: \text{A demand response program with a threat of punishment provokes a higher cognitive evaluation than a demand response program with a reward.}\]

When the punishment provides a reasonable reason, the potential negative effect could be mitigated because individuals might carefully evaluate this reason and thus might adapt their attitude and behavior (Tax et al., 2013; Kim, 2010; 2007; 2006; Kim & Smith, 2005; Fram & Callahan, 2001; McCarthy & Fram, 2000; Fram & McCarthy, 1999; Fram, 1997). As rewards do not result in negative emotions, customers might not engage in thoughtful and careful information processing (Baumeister et al., 2001; Bless et al., 1990; Peeters & Czapinski, 1990; Witte & Grossmann, 1971). Thus, providing a reason for a reward should not be as important as providing a reason for a punishment.

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3 In H8 we already stated that punishments lead to negative word of mouth. Thus, this hypothesis will not be repeated.
H18: Providing a reason for punishment will have a stronger effect on participation in and attitude towards joining a demand response program than providing a reason for a reward.

Prospect theory

Prospect theory (Kahneman & Tversky, 1979) further helps to understand some of the previously mentioned effects of rewards and punishments. Whereas individuals are likely to perceive rewards as a gain, punishments are likely to be considered a loss (Puto, 1987; Kahneman & Tversky, 1984). Losses affect individuals more than gains due to the steeper value function for losses (Kahneman & Tversky, 1984). For example, losing an amount of money provokes more negative feelings than gaining an equivalent amount of money (Baumeister et al., 2001; Kahneman & Tversky, 1984). This is an additional explanation why punishments induce more negative emotions than rewards induce positive emotions (H13b). Further, the steeper value function for losses and loss aversion suggest that customers should be more likely to comply with a request when they can avoid a loss compared to when they can attain an equivalent gain (Kahneman & Tversky, 1979). This supports our prediction (H2) that customers are more likely to join a demand response program when doing so results in avoiding a loss (punishment) compared to attaining a gain (reward).

Regulatory focus

The theory of regulatory focus states that an individual’s regulatory focus influences whether the individual is more prone to pursue activities with the opportunity of attaining a gain or activities with the opportunity to avoid a loss (Aaker & Lee, 2006; Wang & Lee, 2006; Lee & Aaker, 2004; Van-Dijk & Kluger, 2004; Higgins, 1997). Individuals with a promotion focus react more to the opportunity of attaining a gain than to the opportunity to avoid a loss (Aaker & Lee, 2006; Wang & Lee, 2006; Lee & Aaker, 2004; Van-Dijk & Kluger, 2004; Higgins, 1997;). Individuals with a prevention focus, however, react more to the opportunity to avoid a loss than to the opportunity of attaining a gain (Aaker & Lee, 2006; Wang & Lee, 2006; Lee & Aaker, 2004; Van-Dijk & Kluger, 2004; Higgins, 1997;). As punishments can be perceived as being a loss and rewards as being a gain, we assume that the regulatory focus of a customer effects customers’ participation in the proposed demand response program.

H19a: For customers with a promotion focus, participation in a demand response program providing the opportunity to attain a reward will be higher than in a demand response program providing the opportunity to avoid a punishment.

H19b: For customers with a prevention focus, participation in a demand response program providing the opportunity to attain a reward will be lower than in a demand response program providing the opportunity to avoid a punishment.

Theoretical conclusion and overview about present research

The literature and theory review across disciplines partially provided contradicting expectations (hypotheses) regarding the effects of rewards and punishments. For example, according to cooperation in social dilemmas and interdependence theory, rewards and punishments should increase participation in a demand response program (H1). However, according to motivation theory one would suggest that the opposite is true (H3), because extrinsic motivators, such as rewards and punishments, crowd out intrinsic motivation. Another example are the contradicting predictions according to the reciprocity norm and the predictions yielding from previous studies on safety belt usage and cooperation in social dilemmas. Whereas the former predicts that rewards work better than punishments (H6), the later predicts the opposite (H2). In order to find out, which predictions hold true, we will
conduct at least two laboratory experiments to test the developed hypotheses. Further, we aim at conducting one additional experiment with customers of a utility to increase external validity of our findings. Due to the high number of hypotheses and resulting high number of dependent variables, the questionnaire might become too complex for respondents to thoughtful answer it. Thus, we might decide to conduct more experiments, each testing a limited number of hypotheses in order to reduce complexity. Table 1 provides an overview about the hypotheses, their respective theoretical background and the study, in which they will be tested.
**Table 1: Hypotheses, respective theoretical background and experimental study, first paper**

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<th>Theoretical Background</th>
<th>Hypothesis</th>
<th>Experimental Study</th>
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<td><strong>Interdependence theory</strong></td>
<td><strong>H1</strong>: Adding a reward or a punishment to a demand response program will have a positive effect on participation in the demand response program.</td>
<td>Study 1</td>
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<td><strong>H2</strong>: Participation in a demand response program is higher when the program is accompanied with a punishment for non-participation than when it is accompanied with a reward for participation.</td>
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<td>Study 2</td>
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<td><strong>H10</strong>: Expected participation of others is lower when a demand response program provides a reward than when it threatens a punishment.</td>
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| Emotions & Prospect Theory | H13a: A demand response program with a punishment (reward) has a positive effect on negative (positive) emotions.  
H13b: The effect of punishments on negative emotions is stronger than the effect of rewards on positive emotions.  
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H15: A demand response program offering a reward will have a positive effect on positive word of mouth.  
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a) customers’ intention to patronage.  
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c) attitude towards joining the program  
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H19b: For customers with a prevention focus, participation in a demand response program providing the opportunity to attain a reward will be lower than in a demand response program providing the opportunity to avoid a punishment. | Study 1 |
Study 1

Hypotheses H1, H2 and H6 through H19 will be tested in a laboratory experiment with around 180 undergraduate or graduated university students from the University of St.Gallen and the ZHAW. Participants will be recruited during major lectures and a price will be raffled among them. As mentioned before, it might be necessary to divide this study into two or more studies, which will each test a subset of hypotheses, in order to reduce complexity for respondents. We will conduct a pretest with around 10 students to test whether the survey is too complex to allow for a thoughtful and realistic answering. After completion of the survey, the participants of the pretest will be asked to judge the survey regarding its length and complexity. Additionally they will be asked how much effort they put in thoughtfully answering the questions at the beginning and at the end of the survey. Whether or not the study is divided into several sub-studies, the study (or sub-studies) will consist of a 2 (incentive: reward versus punishment) x 2 (reason provided: yes versus no) between-subjects design, which will be added with a control group to test H1. The experiment will most certainly take place in a classroom at the University of St.Gallen resp. ZHAW or another neutral office space and will most certainly be paper-based. We refrain from using the office space provided from the Institute for Economy and the Environment in order to prevent suspicion about the goal of the study (and thus social desirability in the answers to the questions).

Method

Stimuli development: Before the manipulation can be introduced, participants need to be informed about demand response programs, how they work and about their importance for the energy future. Therefore, we developed a description of a demand response program, which is supported by a graphic showing the process of controlling devices (figure 1). To make sure that this description is understandable we will pretest it. After the introduction of the demand response program, participants will either receive a punishment for nonparticipation or a reward for participation. As our goal is to encourage a behavior (participation in a demand response program) we frame the punishment condition as being a negative reinforcement (avoid a loss) rather than a positive punishment because the former strengthens a connection with a behavior rather than to weaken it (Solomon, 2004). A negative reinforcement consists of removing something bad to strengthen behavioral responses, which allow avoiding a negative outcome (punishment) (Solomon, 2004). Thus, consumers will learn to perform an action (participate in the demand response program), which allows them to avoid a punishment (negative outcome) (Solomon, 2004). The reward is framed as a positive reinforcement (providing a gain). We decided to use a monetary reward (punishment) for our stimuli. Further, we decided to use a substantial size for the manipulation of the reinforcement because small rewards or punishments might signal that the behavior in question (participating in the demand response program) is not valuable (Gneezy, 2003; Gneezy & Rustichini 2000a; 2000b). We are aware that this might result in a stronger crowding out effect of intrinsic motivation than a smaller size (Aronson et al., 2013). The respective reinforcement will either be accompanied by a reason or not. Again, both manipulations will be pretested for being comprehensible and realistic. Above all, with the pretest, we want to make sure that respondents perceive the reasons we provide for punishments and rewards as being strong and believable reasons. Table 2 shows the so far developed stimuli for each experimental condition.

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4 We have not yet decided whether to conduct the experiment through an online survey or paper based. Both ways are possible, however they have different advantages. An online survey demands fewer resources and has the potential to reach more participants than a paper-based survey. However, a paper-based survey with a researcher supervising the participants might prompt the respondents to invest more effort in thoughtfully answering the questionnaire. The remaining part of the paper (especially the procedure) will relate to a paper-based survey.
Politicians and energy providers increasingly think about which measures to take in order to ensure a sustainable energy provision in the future and to bring about the “Energiewende”. One potential step is the introduction of programs to balance the demand and supply of energy. Such programs rely on flexibility in energy consumption of consumers (Demand-Response). For example, such programs would allow to use excess solar energy of the grid or to prevent energy shortage at different times of the day (e.g. running the dishwasher in the afternoon or over night instead of during lunch time). In order for such programs to work, consumers need to allow the energy provider to steer their appliances.

Below, a scenario for such an energy consumption flexibility program will be described: Please imagine, that your current energy provider wants to introduce this program and think about how you would react as a customer in a liberalized energy market (meaning that you can easily change your energy provider, e.g. by making a phone call).

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Your energy provider will introduce a program for flexibility of energy consumption next year: the FLEX-program. This program will allow a more efficient energy provision.

What does this mean for you?
An electronic meter (Smart Meter) will be installed in your home. Depending on the amount of energy available at a certain time, your energy provider will send a signal to the smart meter in order to automatically switch on or off your devices (e.g. dishwasher, washing machine or dryer). Your devices will not be harmed and will work proper if turned on again. This will be made sure by a technical check of your devices prior to launching the program. You will have the possibility to prevent the automatic switch-on or switch-off by pushing a button on a mobile app or on a website.

The following picture illustrates the process:

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**Figure 1: Description of Demand Response Program**

CASE 1

Dishwasher

Smart Meter

Dishwasher

supply

demand
Table 2: Stimuli study 1, first paper

<table>
<thead>
<tr>
<th>Reward / no reason</th>
<th>If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will be rewarded with a discount of 50 CHF per month on your electricity bill.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punishment / no reason</td>
<td>If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will not be charged with an additional fee of 50 CHF per month on your electricity bill.</td>
</tr>
</tbody>
</table>

Reward / reason

If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will be rewarded with a discount of 50 CHF per month on your electricity bill.

Your utility provides this reward for customers joining the FLEX program due to the following reasons:

While bringing about the Energiewende, your utility also wants to guarantee that energy prizes do not rise, so that energy is affordable for all, even poor, households. Customers’ participation in the FLEX program can achieve this. Customers participating will be rewarded because they help to guarantee stable and low energy prizes.

Further, due to customers’ participation in the FLEX program, there will be fewer costs related to grid enforcement and provision of storage capacity. Both of which are necessary for a better integration of renewable energies. Additionally, the energy provided in the region can be used efficiently and thus your utility will not be forced to buy additional energy for high prizes in the energy market. Your utility wants to make sure that the resulting savings are fairly distributed among their customers. Thus, receiving a share of the savings through the discount on their bill will reward customers who participate in the FLEX program. Customers who do not participate will not receive this reward because they do not contribute to achieve this savings.

Punishment / reason

If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will not be charged with an additional fee of 50 CHF per month on your electricity bill.

Your utility imposes this fee to customers who do not join the FLEX program due to the following reasons:

While bringing about the Energiewende, your utility also wants to guarantee that energy prizes do not rise, so that energy is affordable for all, even poor, households. Customers’ participation in the FLEX program can achieve this. Customers not participating will be charged an extra fine because otherwise stable and low energy prizes cannot be guaranteed.

Further, due to customers’ refusal of participation in the FLEX program there will be higher costs related to grid enforcement and provision of storage capacity. Both of which are necessary for a better integration of renewable energies. Additionally, it might not be possible to use the energy provided in the region in an efficient manner and thus your utility will be forced to buy additional energy for high prizes in the energy market. Your utility wants to make sure that the resulting higher costs will be distributed fairly among their customers. Thus, customers who do not participate in the FLEX program will be charged the extra fee on their bill. Customers who do participate will not be charged because they do not contribute to these higher costs.

Procedure: Upon arrival, a researcher will introduce the participants to the experiment. Each participant will be instructed to carefully read the description of the demand response program. Participants will then be given the opportunity to ask questions if they did not understand how the demand response program worked. In a second step, participants will be randomly assigned to one of the four experimental groups or the control group. Participants in the control group will go straight to answer the questions of the dependent variables, the confound check and the demographic variables. Participants in the experimental groups will either receive the information that they will be rewarded if they participate in the demand response program or that they can avoid a loss (punishment) if they do so. Half of the
participants in each group will additionally be provided with a reason for the reward respective punishment. Participants will then move on to answer the questions of the dependent variables, the manipulation checks, the confound check and the demographic variables. Before being dismissed, all respondents will have the opportunity to put their name and email in a cube for taking part in the lottery drawing for the prize.

**Measurements**

*Dependent variables*: The dependent variables attitude towards joining the program, word of mouth (used to measure intention to retaliate) and patronage are adapted from the scales provided in the handbook of marketing scales (Bruner, 2009). To measure the dependent variable of participation in the demand response program, we adapted the items from White and Peloza (2009), which have been proven to have a high validity and reliability. Additionally – in order to increase the validity of the intention measures – a “cheap talk” presentation will be used (Litvine & Wüstenhagen, 2011). To measure expected participation of others we use the same items as for intention to participate, only framing them differently. To measure cognitive evaluation we use the scale of message involvement (Bruner, 2009). In order to measure perceived equity we adapted the items used by O’Reilly and Puffer (1989). As emotions are an affective response (Kim, 2010; 2007; 2006) we use the affective response scales provided in the handbook of marketing scales (Bruner, 2009) to measure positive and negative emotions.

*Moderators and other variables*: To measure whether people have a prevention or promotion focus (regulatory focus) we use the items for self-regulatory focus for promotion and prevention provided by Bruner (2009). We also measure perceived obligation to join the demand response program to find out whether reciprocity theory explains our results. Further, we will asked respondents to indicate to what extent joining the demand response program will be beneficial for themselves (self-interest) and the environment and society as a whole (collective interest) to find out whether interdependence theory could explain our results. Moreover, we will measure whether respondents perceive the intervention (reward, punishment) to have a signaling effect in order to find out whether the signaling function of a reward and a punishment could account for our findings. Finally, we will measure perceived drawbacks of joining a demand response program.

*Manipulation check, confound check and demographic variables*: We will conduct a manipulation check to find out whether participants realized that they receive a reward (could avoid a punishment) when they join the program. As reasons will either be provided or not, no manipulation check will be necessary. However, we will test whether the respondents perceived the reasons to be believable. We will use the scale of believability of the information for this purpose (Bruner, 2009). Furthermore, participants will be asked whether the tasks were understandable (yes, no) (confound check). Finally participants will be asked some demographic questions, such as age and gender, to rule out demographics as explanation for the findings.

Table 3 provides an overview about our measurements, the respected wording (adapted from the original source) and the original source of the scale, if one exists. All measurements will be on a 7-point likert respective semantic differential scale – if otherwise it will be indicated.

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5 For most dependent variables we will use intention rather than real behavior. Intention is a strong predictor of actual behavior and thus allows us to test our hypotheses in a laboratory setting (Litvine & Wüstenhagen, 2011).
Table 3: Measurements, sources and wordings study 1, first paper

<table>
<thead>
<tr>
<th>Variable</th>
<th>Source</th>
<th>Wording</th>
</tr>
</thead>
</table>
| DV: Intention to participate     | White & Peloza, 2009            | We frequently overestimate our intention to undertake a certain behavior. Considering that,  
- How likely are you to join the FLEX-program? (highly unlikely/highly likely)  
- How inclined are you to join the FLEX-program? (not very inclined/very inclined)  
- How willing are you to join the FLEX-program? (very unwilling/very willing) |
| DV: Attitude towards joining    | Bruner, 2009, p. 67-69          | Joining the FLEX-program would be…  
(a) a bad/good idea; (b) foolish/wise; (c) harmful/beneficial |
| DV: Intention to WOM            | Bruner, 2009, p. 1018           | To what extent do you agree with the following statements when thinking about the launch of the FLEX-program by your electricity supplier? (not at all/very much)  
I would speak positively of the utility offering the FLEX program. / I would speak negatively of the utility offering the FLEX program. / If private consumers could freely chose their utility I would recommend the utility offering the FLEX program to others. / If private consumers could freely choose their utility I would discourage them to join the utility offering the FLEX program. |
| DV: Intention to Patronage      | Bruner, 2009, p. 756            | To what extent do you agree with the following statements when thinking about the launch of the FLEX-program by your energy provider? (not at all/very much)  
I expect to be a customer of my energy provider for a long time. / If I could freely switch my energy provider, I would not expect to be a customer of my current energy provider in the future. / I expect my relationship with my energy provider to be enduring. |
| DV: Expected participation of others | White & Peloza, 2009 | - How likely do you think it is that other customers will join the FLEX-program? (highly unlikely/highly likely)  
- How inclined do you think other customers are to join the FLEX-program? (not very inclined/very inclined)  
- How willing do you think other customers are to join the FLEX-program? (very unwilling/very willing) |
| DV: cognitive evaluation (message involvement) | Bruner, 2009, p. 532 | To what degree did you pay attention to the reasons your read about for the reward (punishment)? / How deeply did you think about the reasons provided? / How much effort did you put into understanding the reasons? / How personally involved did you feel with the reasons provided?, Response scale: very little / a lot |
| DV: perceived equity           | O’Reilly & Puffer, 1989         | Do you believe that through the introduction of the FLEX program all customers will be treated equitably?  
Do you believe that your energy provider will treat all customers equitably?, Response scale: not at all/ very much |
| DV: Emotions (positive and negative affective response) | Bruner, 2009, p.18 & 25 | Please indicate on the scales below to what extent you feel the different emotions at the moment:  
Negative Emotions: Upset / distressed / irritable / angry  
/// Positive Emotions: good / happy / optimistic / friendly  
Response scale: not at all / strongly |
<p>| Moderator: self-regulatory focus (promotion) | Bruner, 2009, p.831-832 | Compared to most people, are you typically unable to get what you want out of life? (r) / How often have you accomplished things that got you “psyched” to work even harder? / Do you often do well at different things that you try? / When it comes to achieving things that are important to me, I find that I don’t perform as well as I ideally |</p>
<table>
<thead>
<tr>
<th>Moderator: self-regulatory focus (prevention)</th>
<th>Bruner, 2009, p.829-830</th>
<th>Growing up, would you ever “cross the line” by doing things that your parents would not tolerate? (r) / Did you get your parents’ nerves often when you were growing up? (r) / How often did you obey rules and regulations that were established by your parents? / Growing up, did you ever act in ways your parents thought were objectionable? (r) / Not being careful enough has gotten me into trouble at times. (r) Response scale: never or seldom / very often, 5-point scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other variable: Perceived obligation to join (reciprocity norm)</td>
<td>To what extent do you agree with the following statement when thinking about the launch of the FLEX-program by your electricity supplier? I have a feeling of being obliged to join the FLEX program. (not at all/very much)</td>
<td></td>
</tr>
<tr>
<td>Other variable: collective interest</td>
<td>To what extent do you agree with the following statement when thinking about the launch of the FLEX-program by your electricity supplier? (not at all/very much) If a lot of customers join the FLEX program, this will be beneficial for the environment and the society.</td>
<td></td>
</tr>
<tr>
<td>Other variable: self-interest</td>
<td>Litvine &amp; Wüstehagen, 2011</td>
<td>My interest or personal benefit in joining the FLEX program is [very weak/very strong]</td>
</tr>
<tr>
<td>Other variable: signaling effect</td>
<td>To what extent do you agree with the following statements when thinking about the launch of the FLEX-program by your electricity supplier? (not at all/very much) I believe that joining the FLEX program is a desired behavior. / I believe that joining the FLEX program is expected from me. / I believe that not joining the FLEX program is not socially accepted.</td>
<td></td>
</tr>
<tr>
<td>Perceived drawbacks of joining a demand response program</td>
<td>To what extent do you fear the following when thinking about joining the FLEX program (not at all/very much): I have to adapt my habits. / I cannot control my household appliances. / My consumption data will be mistreated. / I will lose a lot of comfort. / I am at the mercy of my energy provider.</td>
<td></td>
</tr>
<tr>
<td>Manipulation test: Reward versus Punishment</td>
<td>To what extent do you agree with the following statement when thinking about the launch of the FLEX-program by your electricity supplier? (not at all/very much) If I join the FLEX program I can gain a reward (I can avoid a punishment).</td>
<td></td>
</tr>
<tr>
<td>Believability of the reasons</td>
<td>Bruner, 2009</td>
<td>In your opinion the reasons for the reward (punishment) provided were: (a) not at all believable / highly believable; (b) not at all true / absolutely true; (c) not at all acceptable / totally acceptable; (d) not at all credible / very credible; (e) not at all trustworthy / completely trustworthy</td>
</tr>
<tr>
<td>Confound test</td>
<td>Was the scenario comprehensible? (yes/no)</td>
<td></td>
</tr>
<tr>
<td>demographics</td>
<td>Age, Gender, Educational Degree, Nationality</td>
<td></td>
</tr>
</tbody>
</table>
Data analysis plan: Depending on the hypothesis the results of the experiment will be analyzed using either a simple t-test to compare two groups, a two-factorial ANOVA or a two-factorial MANOVA. Additionally a mediation analysis will be necessary to test the mediating role of emotions. The independent variables are coded with effect coding, as demonstrated in table 4.

Table 4: Effect coding study 1, first paper

<table>
<thead>
<tr>
<th>Experimental condition number</th>
<th>Experimental condition</th>
<th>Incentive (reward=1, punishment=-1)</th>
<th>Reason provided (yes=1, no=-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>/</td>
<td>/</td>
<td>/</td>
</tr>
<tr>
<td>1</td>
<td>+ +</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>+ -</td>
<td>1</td>
<td>-1</td>
</tr>
<tr>
<td>3</td>
<td>- +</td>
<td>-1</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>- -</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Analysis and discussion of results
The study has not yet been conducted, so no results can be reported and discussed in this research proposal.

Study 2
Hypotheses H3 through H6 will be tested in a laboratory experiment with around 180 undergraduate or graduated university students from the University of St.Gallen and ZHAW. Additionally, hypotheses H1 and H2 will be tested again. Participants of the experiment will be recruited during major lectures and a price will be raffled among them. The study will consist of a 2 (incentive: reward versus punishment) x 2 (expressive function: yes versus no) between-subjects design, which will be added with a control group to test H1 and H3. The experiment will most certainly take place in a classroom at the University of St.Gallen resp. ZHAW or another neutral office space and will most certainly be paper-based. We refrain from using the office space provided from the Institute for Economy and the Environment in order to prevent suspicion about the goal of the study (and thus social desirability in the answers to the questions).

Method
Stimuli: For the description of the demand response program and the manipulation of reward and punishment the same stimuli as in study 1 will be used. The second manipulation (expressive function) will be different to the one used in study 1 in order to better highlight the expressive function. Table 5 gives an overview about the stimuli used for manipulating the independent variables in study 2. Again, we will pretest these stimuli in order to guarantee that our manipulations work as intended.

Table 5: Stimuli study 2, first paper

<table>
<thead>
<tr>
<th>Reward / no expressive function</th>
<th>If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will be rewarded with a discount of 50 CHF per month on your electricity bill.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Punishment / no expressive function</td>
<td>If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you <strong>will not</strong> be charged with an additional fee of 50 CHF per month on your electricity bill.</td>
</tr>
</tbody>
</table>
If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will be rewarded with a discount of 50 CHF per month on your electricity bill. You will be rewarded because through your participation in the FLEX program you demonstrate a lot of engagement for a clean and sustainable energy future and are willing to put some effort in it. Thank you for helping to achieve the Energiewende!

If you join the FLEX program and let your devices automatically be controlled by the signal of your energy provider, you will not be charged with an additional fee of 50 CHF per month on your electricity bill. You will be relieved of the extra fee because through your participation in the FLEX program you demonstrate a lot of engagement for a clean and sustainable energy future and are willing to put some effort in it. Thank you for helping to achieve the Energiewende!

**Procedure:** Upon arrival, a researcher will inform the participant that – next to the experiment they signed up for – he or she would like the participant to fill out a supposedly unrelated survey of a master thesis from a master student who investigates the different goals of young adults in a multi-option society. This will be done to assess respondents’ environmental moral. The respondent will be asked to fill out a measure (7 point scale: not at all important / very important) about their attitude towards energy conservation “How important is it to you to be a good citizen by e.g. conserving energy and collecting recycle material?” This measurement will be hidden among several other filler items (e.g. “How important is it to you to have a family and be a good parent?” / “How important is it to study hard for an exam in order to be qualified for a good job?” etc.). After completing this short questionnaire the respondent will be told that he or she can now proceed into the next room for the real experiment they signed up for. The same procedure as for study 1 will be employed, only that this time the second independent variable is expressive function of the reward (punishment) rather than providing a reason for it. Before being dismissed, respondents will have the opportunity to put their name and email in a cube for taking part in the lottery drawing for the prize.

**Measurements**

**Dependent variables:** We will use the same measures as in study 1 for the dependent variables: attitude towards joining the program, word of mouth (used to measure intention to retaliate), patronage, participation in the demand response program and emotion. To shorten the questionnaire we will not measure expected participation of others, perceived equity and cognitive evaluation.

**Other variables:** We will measure self-interest, collective-interest, and perceived drawbacks of joining a demand response program. The same items as in study 1 will be used. In addition to that we will measure reactance as an additional variable in study 2. The scale will be adapted from the reactance scale provided by Bruner (2012, p.528):

- To what extent did you perceived being forced to join the FLEX program?
- To what extent did you feel restricted in your ability to make a free and independent decision?
- To what extent did you sense of resistance in you? (9-point scale, anchor points: not at all / very much)

**Manipulation check, confound check and demographic variables:** We will conduct a manipulation check to find out whether participants realized that they receive a reward (could avoid a punishment) when they join the program. Further, we will test whether the reward (punishment) was perceived to have an expressive function or not. Thus, we will ask

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6 Further items will be developed to make sure that participants do not become suspicious about the purpose of the later experiment.
respondents to rate on a 7-point scale to what extent they believe that customers with a high environmental moral will perceive the possibility to attain a gain (reward) or avoid a loss (punishment) by joining the FLEX program as an acknowledgement of their pro-environmental behavior and related effort. Furthermore, participants will be asked whether the tasks were understandable (yes, no) (confound check). Finally, participants will be asked some demographic questions, such as age and gender, to rule out demographics as explanation for the findings.

**Data analysis plan:** Depending on the hypothesis the results of the experiment will be analyzed using either a simple t-test to compare two groups, a two-factorial ANOVA or a two-factorial MANOVA. The independent variables are coded with effect coding, as demonstrated in table 6.

**Table 6: Effect coding study 2, first paper**

<table>
<thead>
<tr>
<th>Experimental condition number</th>
<th>Experimental condition</th>
<th>Incentive (reward=1, punishment=-1)</th>
<th>Expressive function (yes=1, no=-1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 (control group)</td>
<td>1</td>
<td>+ +</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>+ -</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>- +</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>- -</td>
<td>-1</td>
</tr>
</tbody>
</table>

**Analysis and discussion of results**

The study has not yet been conducted, so no results can be reported and discussed in this research proposal.

**Outlook**

Provided that the laboratory experiments will yield to interesting results and provided that we can find partner companies, we aim at conducting a field test to measure actual behavior and to foster external validity of our findings.

**Conclusion**

This paper investigates means to increase customer acceptance of demand response programs. If customers accept – have a positive attitude towards joining and participate in – demand response programs this will enable energy providers to reach mandatory energy efficiency goals potentially imposed in future by the government (SFOE, 2012b). Further, a higher integration of renewable energy resources can be achieved if energy demand can be managed. Thus, customer acceptance of demand programs is crucial to provide a more sustainable and cleaner energy future.

More specifically, this paper aims at answering a call for research investigating the effectiveness of rewards and punishment with regard to encouraging pro-environmental behavior. Joining a demand response program can be considered to be pro-environmental behavior because doing so contributes to the provision of a more sustainable and cleaner energy future. We will investigate whether rewards and punishments are an effective market instrument for increasing customer acceptance of demand response program. Further, we

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7 We are currently discussing this with two different utilities, however so far we have not reached an agreement.
will investigate whether rewards or punishments are the better influencers and how to overcome potential negative side effects of punishments.

From a theoretical point of view, the results of this research are intended to shed light upon the effectiveness of rewards and punishments with regard to improving pro-environmental behavior. Further, we aim at improving our knowledge about the underlying mechanisms for the effectiveness of rewards and punishments by testing several hypotheses derived from a cross-discipline literature review on psychological and non-psychological theories and intervention studies. Finally, we intend to enhance our understanding of the prevalent psychological effects in the context of customer acceptance of demand response programs by testing theoretically derived hypotheses which predict opposite effects (H1 versus H3, H2 versus H6).

From a practical perspective, the results of this research are intended to help energy providers deciding whether and under which conditions to combine incentives programs with their demand response programs in order to reach a high customer participation rate without negative side effects, such as negative attitude or negative word of mouth. From an economic point of view, punishments are more efficient because they result in lower costs (Balliet et al., 2011; Gächter, 2012) – there will be no additional costs besides the ones of building the incentive system, which will also occur for reward-based incentive systems. Thus, punishments might be easier to withhold. Further, punishments provide an opportunity for the energy provider to pass on a part of the costs – arising from to need to enforce or rebuild the electricity grid for securing a reliable energy provision in future – in a fair and transparent manner (see Tax et al., 2013) instead of in a non-transparent manner, e.g. through higher energy prices in general. The results of this research aim at revealing whether and under which conditions potential negative effects of punishments can be mitigated so that an energy provider can realize the above stated positive economic aspects of punishments. However, even if the potential negative side effects of punishments can be mitigated, an energy provider might still be reluctant to introduce a punishment system in the first place because negative media attention (Fram & McCarthy, 1999; Fram, 1997) as well as political opposition (Coad et al., 2009) might follow. To overcome this dilemma we suggest a combination of coercive and non-coercive tactics as proposed by Coad et al. (2009) and Frey (1999). For example, an energy provider could first introduce the demand response program without any incentives and hope for voluntary customer participation. In a second step, a small one-time reward for participation could be provided if it is economically feasible. This might encourage customers who did not join the program yet to join it. Further, customers who already joined the program and receive this unexpected reward might engage in positive word of mouth (due to the reciprocity norm) which could convince other customers to join. As time goes by and more people participate in the demand response program, such behavior could become more accepted and even expected in society. Introducing a punishment at that time might thus no longer result in negative public perceptions (Coad et al., 2009). Further, introducing a punishment at that time might also prevent the emergence of negative emotions of existing participants (“sucker effect”) (Frey, 1999).

Further research: To improve generalizability of our findings, further research should investigate whether our findings hold true in other consumer behavior context, e.g. in health behavior. In addition to that, further research could investigate whether the provider of rewards or punishments (e.g. private company versus government) impacts their effectiveness, e.g. whether policy aversion exists and thus influences the effectiveness of rewards and punishments (Bürer & Wüsthenhagen, 2009). Finally, we will only investigate the effectiveness of monetary rewards and punishment and do not manipulate their size. Further research could investigate whether our findings hold true for different kinds of punishments and rewards and whether and under which conditions the kind of the incentive or disincentive (monetary versus non-monetary) and the size of rewards and punishments influence their effectiveness and impacts the potential side effects.
Sustainable advantage through time based-business models

Sustainable advantage through time based-business models: Theoretic foundations and the case of smart grids

moritz.loock@unisg.ch
thorsten.helms@unisg.ch
karoline.kuenzel@unisg.ch

ABSTRACT

The call for sustainable and innovative business models can be answered either deductive from a theory perspective, or inductive from an empirical perspective. The paper at hand, combines both perspectives and first discusses a new type, time-based business models. We integrate research on business models, as activity systems, and research on the role of time, temporal activities, in organization science. In that sense time-based business models create value by activities of temporal structuring. Drawing from recent innovations in the utility industry, cases of time-based business models will be presented along the issue of demand side management within smart grids. The cases further validate the concept of time-based business models. Implications especially for a demand side-perspective in management apply.

Key words: time-based business models, activity-systems, smart grids

INTRODUCTION

Every hands-on merchant knows it is wise to sell umbrellas when it rains. There is an important temporal component within that business model: it only flies when it rains, hence if certain conditions are in place, which are contingent with the business model. The managerial world knows such situations well not only in retailing. For instance airlines adjust their ticket prices over time and depending on when customers buy the ticket the price differs, also stock-market returns highly depend on buying and selling at the right time. In time lies money, it is one of the most famous heuristics in business but it is surprisingly under-researched. This paper theorizes on how companies can exploit the value of timing by time-based business models. Integrating research on business models as “a system of interdependent activities that transcends the focal firm and spans its boundaries” (Zott & Amit, 2010) and research on time in organization science (e.g. Ancona, Goodman, Lawrence, & Tushman, 2001; Ancona, Okhuysen, & Perlow, 2001; Bluedorn & Denhardt, 1988; Butler, 1995; Das, 1993; George & Jones, 2000; Gherardi & Strati, 1988; Lee & Liebenau, 1999; McGrath & Rotchford, 1983; Mitchell & James, 2001; Orlikowski & Yates, 2002; Roe, Waller, & Clegg, 2012), time–based business models are defined as activity-systems which create value by activities of timing. Orlikowski and Yates find that “actors produce and reproduce a variety of temporal structures which in turn shape the temporal rhythm and form of their ongoing practices” (Orlikowski and Yates, 2002: 684). This link to practices, hence activities, makes it suitable to integrate both streams of research. However, that value creating activity of time-based activities has yet to be described.
Sustainable advantage through time based-business models

FOUNDATIONS OF TIME-BASED BUSINESS MODELS

This paper draws on recent literature on business models (Baden-Fuller & Morgan, 2010; Casadesus-Masanell & Ricart, 2010; Casadesus-Masanell & Zhu, 2012; Chesbrough & Rosenbloom, 2002; Demil & Lecocq, 2010; Zott & Amit, 2007, 2008, 2010) and conceptualizes time-based business models along contingencies of time-based business models, activities within time-based business models and performance implications.

Contingencies of time-based business models

Research shows how the value creating effects of business models evolve from the fit of business models with their context (Zott & Amit, 2007, 2008). Business models in that sense are contingency factors that interact with other contingency factors and thus create economic value (Donaldson, 2001; Drazin & Van de Ven, 1985; Pennings, 1992; Zott & Amit, 2008).

For time-based business models we propose foremost the following external and internal contingencies that are important to consider. First, there needs to be an external incentive of pursuing the right timing. Precondition for that are variances of costs over time, which makes activities at a certain point of time more attractive for firms and their customers than on another point of time. This is the case when demand and supply are subject to temporal imbalances, and the flexibility of both elements for adaptation is limited. Assumingly this flexibility can be enhanced when some kind of storing functions are in place. Storing of products will be for most physical products related with a cost. In the case of financial products, interests can be seen as costs for storing. If an inventory could be held without costs, then demand or supply could be transferred from one point of time to another for free, and timing would lose its value. Additionally there needs to be inter firm variance in regard of timing activities, so that timing activities become meaningful in competition.

Second, firms or agents operating a time based business model, need to be able to offer flexibility in time, such as the capability of bringing forward or delaying production and supply. Customers need to pre- or postpone their activities of demand, the same applies for producers and their supply. The operation of a stock can also provide additional flexibility to the market.

The external contingencies will incentivize and determine the timing activities of the focal agent or firm operating the time based business model. This relationship is named first order relationship in our framework. But the effects of the timing activities will also be reflected back on the market: bringing forward or postponing supply or demand will have an effect on prices in the market, and consequently on supply and demand plans of other agents or firms in the market. This relationship is named second order relationship in our framework.

![Figure 1: time-based business models](image-url)
Sustainable advantage through time based-business models

Time-based activities within the focal firm

The notion of business models as activity systems (Zott & Amit, 2010) refers to the necessity to define relevant activities. For time-based business models cognition of timing, the capability of organizing internal micro temporal flexibility and the capability of organizing external temporal flexibility seem to be crucial.

Cognition of timing. The interpretative school explores the process of how companies make sense from contextual aspects (Daft & Weick, 1984). From attention-based perspective organizational capabilities moderate the effect how events are transferred into managerial outcome (Ocasio, 1997). Cognition of temporal activities have not yet been discussed though. However, timing could be considered as the central outcome of managerial, time-based decision-making. Managers need to recognize the value potential of timing and need to apply processes that monitor and capture timing-based activities within their processes.

Capability of organizing internal micro temporal flexibility. Dealing with change has lead to the emergence of concepts of dynamic capabilities (Teece & Pisano, 1994). Whereas dynamic capabilities have been the logical next step from a somewhat static resource-based view towards a better accounting of environmental dynamics, the concept is only of limited use to understand micro flexibility of organizations. From a fit theory perspective we know that companies adopt differently to different degree of velocity of environments (McCarthy, Lawrence, Wixted, & Gordon, 2010). However, time-based business models require a capability that is not yet well described. They need to be able to provide temporal flexibility, particular the need to be able to pre- or postpone their activities to match fluctuating demand. Time-based business models require such temporal flexibility on a micro level with capabilities of pre- and postponing activities down to seconds and milliseconds. In particular firms targeting to compete by time-based business need to be capable of real-time monitoring of supply and demand, flexible for temporal shifts of organizations and opportunities for storage.

Capability of organizing external temporal flexibility. Advances in understanding dynamic capabilities showed the importance of demand-side aspects of firms when dealing with change and uncertainty. The demand side approach of management appreciates customer activities as being core for firm performance (Adner & Zemsky, 2006; Priem, 2007; Priem, Li, & Carr, 2012). Such a view mirrors well with the concept of business models, as business models target to analyze the activity system of a firm with its silent stakeholders. In terms of time-based business models three important activities have to be considered when discussing the organizing of external temporal flexibility. First, firms need to be able to communicate and with that steer the activities of their customers. Basically that is to making them constantly aware of the customer value of temporal flexibility (e.g. the opportunity to safe or earn money when customers perform their activities at a later point in time). Second, behavioral research showed that consumers are often reluctant to change their behavior. In that sense companies striving for a time-based business model need to be able to nudge their customers towards flexible behavior. This can be achieved either by activities of punishment or reward or by other nudges. For instance following a camouflage approach firms would provide a different service which covers the primary goal to achieve customer temporal flexibility (Curtius, Künzel, & Loock, 2012). Finally, firms need to be capable of providing automatization to process of organizing external temporal flexibility.

Business Logic

Chesbroughs definition of business models as “mediators” between a technology and economic value creation (Chesbrough & Rosenbloom, 2002) shows how important the business logic, hence the mechanism of how to make money, is for business models. Zott and Amit ground their innovation- and efficiency-driven business models on the concepts of entrepreneurial rents and transaction cost theory (Zott & Amit, 2007, 2008). For time-based business models economic value is created in two steps. First, firms realize micro arbitrage and earn small rents based on their timing activities. Second, firms scale up their micro rents and aggregate them to significant returns.
Sustainable advantage through time based-business models

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<td>Capabilities</td>
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Table 1: New time-based business model in comparison with traditional business models as investigated by (Zott & Amit, 2007, 2008)

CASE STUDIES: TIME BASED BUSINESS MODELS IN THE POWER SECTOR

Electricity is only storable to a very limited extent. The only existing technologies applied on a large scale are hydro storages and pump storages. On the other hand, the demand side in electricity generation is still relatively inflexible; the final consumption does not significantly react on short term price fluctuations on the wholesale markets. One reason is that volatile wholesale market prices are in most cases not yet passed on to end customers. Both mentioned aspects result in the fact, that the supply side, namely the power plants, need to ensure, that the adequate amount of power is generated and provided at any given moment. Under- or oversupply can lead to large-area power outages and enormous economic costs (e.g. Bundesnetzagentur, 2006). For the mentioned reasons –limited storability of power, inflexible demand and limited production capacities and the constraint to cover the demand exactly at any given point of time, prices in the power sector are volatile. Such price volatility over time is an essential contingency for time-based business models.

The traditional logic in the electricity sector is that supply-follows-demand. That logic is represented in our case study through the first example, the speculative power trader. However, the traditional paradigm of electricity supply is eroding, due to the increasing diffusion of fluctuating generation from Renewables. In the new energy reality, more and more energy is produced unpredictably (at least in the medium to long term) from fluctuating Renewables. Demand becomes a more and more important element of balancing activities. That leads to two implications: the importance of timing will increase, as both supply and demand will be part of timing activities. Furthermore, the mentioned preconditions pave the way for new demand side oriented business models. The cases 2 and 3, demand response aggregation (entelios) and decentralized market platform (etelligence), illustrate, that demand side oriented firms require different capabilities compared to firms that operate with traditional business models.

Case study 1: Speculative Commodity/Power Trading

Contingencies. Commodity trading represents a typical example where the previously described contingencies are given. A commodity can be defined as “intermediate good, with standard quality, which can be traded on organized international on competitive and liquid international markets”
Sustainable advantage through time based-business models

(Clark et al. 2001, p. 3). The liquidity premise requires that the markets can be cleared at all times (Clark et al. 2001, p.4) In other words; supply must cope with demand at every moment. In a global market with many different agents, this objective is obviously difficult to achieve. Therefore traders have an important role as intermediaries on the market, by buying, goods, eventually holding of speculative stocks, and thereby taking significant risks and ensuring liquidity on the markets (Clark et al. 2001, p.4). Discrepancies between supply and demand will appear from time to time, as commodities are subject to continuous fluctuations, e.g. due to seasonal imbalances and changing circumstances or unforeseeable events (Clark et al. 2001, p.4). When stocking is related with a cost, these imbalances will result in volatile or flexible prices over time (Clark et al. 2001, p.4, p.10-11). These general conditions promote speculative activities and the holding of speculative stocks. Physical markets can be spot or forward markets (with a delivery and payment date in the future). Deals are related with a physical delivery and payment of the according product (Clark et al. 2001, p.13). Although speculation on physical products is possible, it is subject to technical constraints and significant variable and fixed costs, e.g. for shipping and for storing the goods (Clark et al. 2001, p.15). The cost of storing is also an opportunity cost, as the invested capital in the inventory does not yield any income (Clark et al. 2001, p.11). These technical constraints, the volatile price movements and the need of market participants to hedge their positions against those price movements, has provided the grounds for financial or derivative markets, which facilitate hedging activities significantly (Clark et al. 2001, p.4, p.15). On these derivative markets, purely financial products representing an underlying physical commodity, available for delivery at a future delivery date, are traded (Clark et al. 2001, p.14). These markets are very liquid, that means that there exists a demand, a supply, and a corresponding price for a certain product at any time. These markets therefore simplify hedging activities. Two typical derivatives are forwards (“an agreement where one party promised to buy a certain product to by an asset from another party at some specified time in the future a some specified price. No money changes sides until delivery date of the contract “- Wilmot, 1998) and futures (“a very similar contract, but usually traded on an exchange, have standardized contract term, and profits are calculated every day and the change of value is transferred from party to another” - Wilmot, 1998).

Derivative markets represent the stage for speculative activities, e.g. speculation on price increases and declines, as it can be executed without technical constraints, fixed and variable costs. The holding of physical inventories is not necessary (Clark et al. 2001, p.15). The initial investment is only very limited, as the trade with a future contract often requires only a deposit of cash or securities of around 10% of the initial value of the position (Clark et al. 2001, p.15). The maturity of the derivates or the delivery date can vary between a few days or several years (Clark et al. 2001, p.15). Physical delivery of the underlying assets is usually not executed; derivative contracts are usually settled financially by taking an equal and opposite position, by paying the difference in cash, and thereby offsetting the position. (Clark et al. 2001, p.15). The mentioned contingencies obviously vary among different commodities.

Figure 2: Price development for a Future Phelix Base Cal-15 (delivery of 1MW baseload in Germany in 2015, in EUR/MWh); Source: eex.com, 20.2.2013)
Sustainable advantage through time based-business models

Activities. Let’s take the example of a trader speculating with a future on power (in this case a future on the delivery of 1 MW baseload in 2015, traded on the EEX power exchange in Germany). He might have certain expectations of the development of the future price developments, reflected by his threshold for buying and selling (in this case 55 Euro and 62 Euro – more complex trading strategies shall not be in the scope of this paper). Whenever prices cope with his specific thresholds, he will buy or sell the future, realizing a certain small margin until the delivery time of that contract. In our case he would realize this margin of 7 Euros three times within the illustrated period, namely at the dates (2), (4) and (6) (…if prices will not recover after his last purchase in (7) until the maturity date 2015, he will obviously realize a significant loss). So his main activity consists of constantly observing the markets and gathering information, taking buy and sell decisions at the right point of time and realizing his decisions on the markets. On highly liquid and organized markets his main efforts will be in the field of data gathering and decision making, the buy and selling process itself are standardized processes on the exchange. The trader in this case is obviously not able to provide physical flexibility on the demand or supply side himself. He is providing financial stock for the market and thereby taking over risk, ensuring liquidity on the market, and providing information for the market (see ch.1.1.4 Value Creation).

Capabilities. The main capabilities the trader needed are above-average market analysis capabilities: he needs to be able to predict future price movements better than the rest of the market, to take his buy or sell decisions at the right price levels at the right point of time. Therefore the trader needs to possess superior knowledge of the relations and interactions of power (derivative) prices and its main drivers and influencing factors. The information that needs to be analyzed depends obviously on the kind of product and on the time horizon the trader is executing speculative activities. In the short term it is rather meteorological developments and possible outages of power plants, that will influence power prices, whereas in the long term – as in the illustrated case - economic factors like gdp-growth and electricity demand developments, regulatory aspects or development of installed generation capacities will influence power prices and related derivatives assets (source: discussion with energy experts ).

Business logic. (1) As mentioned the trader has an important role as intermediary and ensures liquidity in the market by offering producers the opportunity to hedge their future generation at any time against price movements. (2) By buying a future or another derivative contract, he is taking over risk from producers and offering his capacity to take risk (limited by his quantity of available risk capital) to the market. (3) His actions will also represent a signal to the market. By buying a derivative related to an underlying commodity for a certain point of time (e.g. power production) he will rise prices for that point of time (as he increases demand for that derivative) and will implicitly send the information to the markets, that he expects rising prices. That will indirectly incentivize producers to increase production capacity for that point of time. This relationship is described as second-order-relationship in our framework. As reward the trader expects to earn a margin for his activities, realized through the spread of his buy-cheap-and-sell-expensive activities.

Case study 2: Demand Response Aggregator - Entelios

Contingencies. Through the increasing share of fluctuating renewable energies in the energy system there is an increasing demand for flexibility, on the supply side as well as on the demand side, to ensure stability of the grid at all times. Demand Response is “a process to manage consumption (demand) of electricity in response to supply conditions”. For many small consumers, it is economically unfeasible to manage demand response activities themselves and they cannot directly participate on wholesale markets. Entelios, a firm founded in 2010, is a response to the increasing demand of demand side flexibility and acts as a demand response aggregator: by aggregating small loads and small generation capacities, Entelios provides access for these flexibilities to the wholesale markets. The aggregated demand elements can then act as a “virtual peaker” (similar to a peaking gas power plant) on the markets, by offering dispatchable loads as ancillary services to the grid operator, or by optimizing the dispatchable loads on the daily spot market. (Entelios, 2013)
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Figure 3: Functions of a demand side aggregator (Source: Entelios, 2013, adapted)

So the main activity can be summarized as up-scaling small scale flexibility from different suppliers on the demand side, and transforming it into a marketable product. The core of the Entelios-approach is the NOC (Networks operations center). The NOC represents the gateway between controllable load elements on the one side, and the energy suppliers, grid operators, wholesale markets and energy exchanges on the others side. The different load elements on the demand side can be controlled remotely from the system. The NOC continuously processes incoming information, and supply and demand are modeled and forecasted. The NOC then performs an intelligent load management, optimized according to price incentives from the markets, and within the particular constraints and boundary conditions of the different demand side elements (Entelios, 2013).

Capabilities. Entelios as a demand response aggregator represents an interface between small scale demand elements and energy markets, where the value of flexibility can be monetized. The required capabilities can be described in three categories: First, a demand side aggregator needs to have the technical knowledge to build-up a portfolio of remotely controllable demand elements on the demand side. This includes also a profound understanding of the related industrial processes and consequent constraints of flexibility. Second, the demand response aggregator needs to be familiar with the regulatory and market environment. Only then he will be able to create a marketable product of flexibility. Thirdly, he needs to possess the ability to forecast load requirements on a daily basis, and dispatch and steer the controllable loads accordingly, which can be summarized as analysis, forecasting and information management capability (Entelios, 2013).

Business logic. Demand response aggregation and the marketing of flexibility create value in different ways for the involved stakeholders. It allows smaller consumers to participate on energy markets and gaining an extra margin by offering flexibility of their consumption to the demand response aggregator. Furthermore, participants on the demand side might benefit through increased transparency on their energy consumption, which might enhance further energy efficiency actions. The local distribution grid operator also benefits, as improved balancing of the grid avoids excessive loads and limit the needs for grid extension due to increasing diffusion of renewable energies. The energy markets and TSOs benefit due to the increased availability of flexible loads on the market, which improves balancing of energy supply and grid loads. The demand response aggregator monetizes his value creation through a fee on his services (Entelios, 2013).

Case study 3: Trading flexibility over time: decentralized market platform eTelligence

Contingencies. eTelligence is one of the German six energy regions that take part in the e-energy project. The „E-Energy – Smart Grids made in Germany” project is an initiative of the Department for
Economy and Technology, aiming at developing and testing the main elements of smart grid (e-energy, 2013). The idea behind eTelligence is the intelligent integration of energy producers and consumers through a regional market place on the lowest grid layer, namely the distribution grid. The objective is to enable and incentivize a large number of consumers to participate in that regional energy market place, and to consume energy when it is available through renewable energy sources. The market platform offers prices for the connected customers in a way, that customers have an incentive to change their typical behavior. Through the intelligent synchronization of fluctuating suppliers (like wind & solar plants), controllable decentralized producers (like CHP-plants) and controllable flexible consumers (such as a cooling house), the loads on the distribution network can be limited (e-energy, 2013).

There are three main layers of the project. The market place enables the different actors to get involved into trade. The information and communication technology layer connect the different stakeholders. At the technical layer, various mechanisms for operational management are developed to integrate the actors and their needs (BMWI). One of the essential building blocks within eTelligence is the participation of cold stores of the fishery industry. The energy intensive cool down of the stores can be mostly shifted to times of high wind power generation. Those stores therefore represent a great shiftable demand element (e-energy, 2013).

Activities. The regional market place serves as platform for trading electricity and energy services, and allows small and medium consumers as well as producers (e.g. homeowners with solar panels) to trade energy in a fully automated way. Hourly and quarter-hourly contracts for active power are traded on the eTelligence marketplace. Trading occurs on the day before actual fulfillment, i.e. on a day-ahead basis. A so called market maker increases liquidity on the marketplace with its limited number of participants. He sells surplus electricity and buys up balancing energy for the eTelligence marketplace on wholesale energy market. The market maker creates bids for active power on a daily basis reflecting current EEX (German energy exchange) spot prices (e-energy, 2013).

Business logic. The general value proposition of the eTelligence market place is to enable small and medium consumers to market their flexibility. Through aggregation of numerous consumers, as well as small power producers, this flexibility can be marketed on a wholesale market or exchange. For consumers the value proposition consists of additional revenue potential, when they provide flexibility through shifting of loads (e.g. cold stores for industrial consumers and electrical vehicles for...
residential consumers), which can be traded on the market place. Additionally the increase of secure energy supply could be seen as an additional value, especially to industrial consumers for whom an outage often goes along with production downtimes and therefore costs respective lost profit. The grid operator can better balance the distribution grid through an adjustment of supply and demand, and thereby limit the need for further grid extensions through the diffusion of Renewables. The value proposition to the electricity supplier is based on cost savings potential and a more efficient use of electricity as the adjustment of demand to supply instead of supply to demand could prevent energy suppliers from buying additional electricity in order to satisfy demand or it could decrease the need of additional, controllable but expensive power plants (such as fossil power plants). The revenue model for the market place provider could be a service charge for each market player (e-energy, 2013).

**CONCLUSION AND OUTLOOK**

We have introduced time-based business models as a framework to systematically describe and analyze business models created around activities of timing. The electricity or power sector represents a typical example: supply needs to cope with demand at any given moment. Temporal imbalances result in volatile prices, which incentivize the provision of flexible demand and supply capacities. The traditional logic in the electricity sector is that supply-folows-demand. That logic is represented in our case study through the first example, the speculative power trader. The traditional logic of electricity supply is more and more questioned through the increasing diffusion of fluctuating generations from Renewables. That precondition paves the way for new demand side oriented business models. Our two selected examples, namely demand response aggregation (entelios) and a decentralized market platform (etelligence) illustrate, that demand side oriented business model do not only require a profound knowledge of energy markets and its main price drivers, but additionally the skill to upscale and aggregate small consumers and create a marketable product. Furthermore the automated synchronization and balancing of a large number of consumers and producers requires advanced information and communication systems; information exchange becomes a core competence of demand side oriented smart grid business models.

The conceptualization of time-based business model contributes to different theories. First, it enhances our understanding of demand side management (Adner & Zemsky, 2006; Priem, 2007; Priem et al., 2012) and showcases how joint temporal activities of demand and supply create value. Second timing and time-based business models emerge as new contingency factors and enhance our understanding of how configurations of timing activities effects firm performance (Donaldson, 2001; Drazin & Van de Ven, 1985; Pennings, 1992). Third, we see implications for the practice turn in management science as practices of timing evolve as new source of value creation (Chia, 2004; Jarzabkowski, 2004; Whittington, 2003; Whittington, 2006). Finally we see implications for a knowledge-based perspective (Grant, 1996) as knowledge about timing appears to become an important factor in competition.
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Sustainable advantage through time based-business models


Improsume – The impact of prosumers in a smart grid based energy market

Closing report
July 2013

For the IMPROSUME project, the leaders of the work packages

Bernt Bremdal, NCE, Norway
John Thøgersen, Aarhus University, Denmark
Moritz Loock, University of St. Gallen, Switzerland

Note: This report complements the national final reports of each work package. It gives an overview of the project as a whole. However, for detailed information of each work package we refer to the distinct reports of each work packages and the published paper or working papers, which keep stock of research done within the project.
The project

“Prosumer” is an emerging concept in the power market that applies to consumers of energy that can also be producers. In a Smart Grid a prosumer can be a new and active participant in balancing the electricity system. A prosumer can be characterized by owning distributed generation technologies, energy storing equipment, smart meters and equipment to monitor, control and operate electric devices. The Smart Grid creates the basis for intelligent integration of user-actions in securing a continuing high supply security while integrating more fluctuating renewable energy into the electricity supply system. An important requirement is acceptance and active adoption of the new possibilities by the prosumer. This project focuses on prosumers and their role and influence on the future energy market, and the role’s impact on established structures will be highlighted.

The improsume project investigated the impact of prosumers in a smart grid based energy market. Researchers from Norway, Denmark and Switzerland worked together in four different work packages on topics like acceptance of the prosumer role (WP1, Aarhus School of Business), preferences for prosumer business models (WP2, University of St. Gallen) and prosumer impact simulations (WP3, NCE Halden). See figure 1 for an overview of the project set-up.

Goals achieved and international cooperation
The international setup of the project allowed to combining national managed research projects and international research coordination. During the course of the project, projects meeting were held in Denmark, Norway and Switzerland. In June 2013 a final workshop hold stock of the most important contributions of the project. See website of the project here:  http://badm.au.dk/research/research-groups/marketing-sustainability/projects/
Improsume: Closing overview report as appendix to the national final reports

Throughout the Improsume project the participating researchers worked on a dissemination their work within various speeches and workshops and especially by publications:

- Broman-Toft, M., Schuitema, G., & Thøgersen, J., (in prep): “Responsible technology acceptance: Model development and application to consumer acceptance of Smart Grid technology”
- Künzel, Loock, Cometta (in prep): Under which conditions can punishment and/or reward increase customer acceptance of demand response programs?

Summary WP1
The main objective of WP1 was to get a better insight into the motives and barriers that influences acceptance of the prosumer role in the context of the Smart Grid. In one part, mechanisms to increase consumers’ participation rate in the Smart Grid were examined. The study revealed that a significantly larger proportion of people accept to participate if participation is the default and people have to opt-out in order not to participate rather than opt-in in order to participate. In a second part it was examined how consumers evaluate the costs and benefits of being a prosumer in the Smart Grid, and how this affects their acceptance of Smart Grid technology. Results show that people are more likely to become a prosumer if they perceive Smart Grid technology to be easy to use and useful, but, interestingly, they are also more likely to become a prosumer if they feel morally obligated to contribute the interests of the society as a whole and the environmental by becoming a prosumer.

The work carried out in WP1 has been reported in a published book chapter (Ölander & Thøgersen, 2012) and in a journal paper that has been invited for resubmission, with fairly small changes requested (Energy Policy). In addition, two other journal papers are in preparation. A PhD-thesis will be based merely on the work done in WP1. Moreover, the work of WP1 has been presented at various international and national conferences and workshops.
Summary WP2

Questions of how to develop the market are crucial for the prosumer concept. An aspect of paramount importance in this regard is that business models for prosumers meet stakeholder expectations. Thus, an investigation of stakeholder preferences for different prosumer business model configurations is of interest. As a first step WP2 did case study work to categorize and take stock of different conceptualized and empirically validated prosumer business models. Within a second step WP2 measured preferences of different stakeholders to derive implications for managerial business model design and supportive energy policy. The work package as a whole builds on consistent body of theory (business models) and uses the same state-of-the-art methodology for data collection and analysis (interviews, online Adaptive Choice-based Conjoint experiments and paper-based experimental manipulation (between subject-designs)).

The work of the WP2 so far resulted in two published journal papers (Energy Policy, and der markt - International Journal of Marketing), one conference paper (SMS conference), a case study for teaching purposes and two working papers, which will be further developed towards publication. It also helped to build up a competence center on smart grids with significant impact on teaching (65 in-class business model innovations during the project) and further research.

Summary WP3 (taken from the Norwegian final report, see Folsland Bølkesjø et al. 2013):

The technical potential for demand response in Norway is substantial because electricity is the dominating energy carrier. In this study, the potential for demand response is estimated by two different approaches; A top-down approach where the potential is estimated by shifting consumption from day-time to night-time in order to flatten the demand curve and a bottom-up approach based on the diurnal consumption profile of electric household equipment. It is estimated that a daily average shifting of 7,1 GWh and 3,6 GWh of household electricity consumption may flatten the demand curve in winter and summer respectively. This equals a little less than the electricity consumption for heating hot water in households. The energy efficiency of state of the art hot water heaters are good and not expected to improve within the next decade. Electric appliances, e.g., washing machine, on the other hand, will most likely exhibit improved energy efficiency. It is difficult to shift such demands to night hours because it requires interaction with the user. The demand response potential from shifting these technologies is thus small. The relatively large use of biomass in wood burning stoves may already provide some prosumer response. The incentive from reduced electricity cost for an individual consumer is small. Demand response and prosumer response is thus likely to require additional incentives.

Further, the study analyses the development of the Nordic energy system in the long run and the possible impacts of different degrees of short term consumer flexibility in demand. Based on reviews of current policies, costs and resource availabilities and overall trends in the energy market, we develop scenarios for investments in new generation technologies, transmission lines, demand and power plant closures. These data are used as input in a detailed energy market model for the North European power system to analyze likely price developments towards 2025. The model has an hourly time resolution and can hence be used to analyze impacts of different scenarios for short term electricity demand flexibility. The assumed changes in generation capacity and
demand cause a rather healthy power balance (defined as total production minus total consumption) in the Nordic countries. However, when assuming increasing fuel and CO2 prices (based on IEA world energy outlook) the modeled market clearing prices are in the area €50-60/MWh in the Nordic countries in 2025, according to the model simulations. The price level is heavily dependent on fuel and carbon price assumptions, though. High investments in renewable electricity generation and increased transmission capacity to continental Europe cause higher diurnal variation in Nordic electricity prices in 2025 than what is observed today. Increasing diurnal price variation may motivate for smarter energy consumption.

**Outlook**
Although the Improsume project has been officially ended, some of the work will be followed further (e.g. the development of the working papers). Moreover, the prosumer role for the future energy grid has become even more important. As the project shows, one of the most valuable entities prosumer provide to the market is flexibility. We just have started to understand how flexibility impacts customer acceptance, business models and the energy grid. This impact needs to be investigated on the local, the national and international level. From this perspective we strongly recommend to further engage in interdisciplinary and international research projects like Improsume.
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Interim Report

1. Project details

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<td>Entity responsible for the project</td>
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2. Project status

3.1 Overall project status

On 20 June 2012, the Danish, Norwegian and Swiss project partners met in Aarhus to discuss the project’s progress, state-of-affairs, results and plans for the future. The Danish partners of the project meet at least twice a year (steering group meetings). If project issues require this, additional phone meetings and discussions via e-mail are held. Within the third interim period, a steering group meeting was held on 12 June 2012. (The next meeting was held on 5 December, 2012. In addition, the project management group meets whenever there are issues that need to be discussed, which depends on the phase of the project.

The Swiss and Norwegian partners generally follow the time schedule that was put forward in the project proposal. However, the Danish partners have encountered severe obstacles with regard to implementing the planned field tests, which has led to delays in comparison to the original plan. The delay has implications for the Norwegian partner, who needs input from the Danish field tests for its simulation studies. Because of the delay, the Danish team has asked Energinet.dk to extent the project till 30 June 2013, which was approved. The Norwegians have also requested an extension of the deadline from the Norwegian Research Council, which was granted in September this year. In section 3.4 we elaborate on the reasons of the delay.

3.2 Status of the project phases and milestones

Aarhus University is responsible for 6 deliverables

**bility and adoption of Smart Grid technologies.** Aarhus, Denmark: Department of Business Administration, Aarhus University, Business and Social Sciences.

2. **Questionnaire development and online survey.** The online survey has been collected in three countries: Denmark, Norway and Switzerland. Results of the online survey have been presented at international and national conferences and workshops, and one journal paper has been submitted and a second one is being prepared for publication in international journals.

3. **Recruitment of participant pool for the field test.** The field test consists of two different groups of participants: private households and small and medium sized companies (SMCs). We started in June 2011 the recruitment of SMCs. The recruitment SMCs has been more difficult than anticipated, because considerably fewer companies than anticipated by the partners are interested in buying Smart Grid equipment. The economic incentive seems to be insufficient for others than very large electricity consumers. The recruitment of private households is delayed compared to the original time plan, but has started at the end of October.

4. **Stimulus material etc for the field test.** The survey material and recruitment method for the study amongst households have been developed. Recruitment of households is carried out in collaboration with Bosch’s heat-pump division in Denmark and SEAS-NVE. Both existing and new heat pump owners are recruited. Bosch installers have delivered addresses of potential participants to the project. A website for recruitment has been developed, hosted by SEAS-NVE, and a web portal for the participants, developed by GWR, is in place.

5. **Purchase and installation of equipment used in the field test.** Equipment from GWR has been purchased and delivered at Bosch’s heat-pump division in Denmark. However, it appeared that Bosch installers were not able to set up the equipment so that it would work when installed, so Bosch sent it back to GWR to set it up. Bosch’s installers have been instructed in how to install the equipment and a helpdesk is in place at SEAS-NVE in case of problems.

6. **Field test.** As mentioned above, the field test consists of two samples, households and SMCs. As mentioned above, the recruitment for the field test for SMCs has been more difficult than anticipated. So far, 1 SMC has been interviewed, and it seems unlikely that we will find more SMCs that are willing to participate in this project. The recruitment of the field test amongst households is delayed compared to the original time schedule, but has now started. We elaborate on the status of the field test involving SMCs and households in 3.4.

### 3.3 Technical results achieved

An online survey has been conducted in three European countries. Respondents were private electricity consumers in Denmark (N = 1165), Norway (N=1251) and Switzerland (N = 1242). The data has been analysed. One journal paper has been submitted for review for publication in an international journal and a second one is in preparation. A book chapter is under publication in which some IMPROSUME data are being presented as well.
In one journal paper the role of different approaches that can be used to recruit households to adopt Smart Grid technologies is examined. This is an important topic, as Smart Grid technologies have not yet been implemented in private households on a wide scale, but that needs to happen very soon. Hence, it is important to understand how different approaches affect the adoption rates of Smart Grid technologies and what the public’s attitude towards them is.

As reported in the interim report of January 2012, we found that the participation rate in the smart grid depends on the recruitment method and specifically what is the implicit or explicit default option. If the standard recruitment procedure is used where electricity consumers are asked to sign up (opt-in model), the default option is to not have Smart Grid equipment installed in one’s household. We found that under this condition, participation is much lower than under an alternative procedure where people were told that that everybody will get Smart Grid equipment installed in their household (the default option), unless they explicitly state that they do not want to (opt-out model).

Being part of the Smart Grid is generally a difficult issue to make a decision on, because people may fear risks such as comfort loss or invasion on their privacy. We argue that in the-opt-in model, it is easy for people to avoid making a decision about these consequences, and they will easily procrastinate. In the opt-out model, there is more motivation to make a decision and less motivation to procrastinate: if no action is taken (i.e. people do not opt-out), the (potentially negative) consequences of participation for the individual household have to be dealt with, and if they want to avoid such consequences, they will have to take action (i.e. people do opt-out). We argue that because in the opt-out model people have more incentives to put sufficient effort into the decision making process and are more motivated to carefully and thoroughly consider the pros and cons of participation, consumers’ true preferences are more likely to be revealed when the opt-out model is used than when the opt-in model is used.

To test this hypothesis, a ‘neutral’ model was introduced as a benchmark, where no default option was presented, but people are forced (by the experimental conditions) to make a decision and explicitly indicate whether or not they are willing to adopt Smart Grid technologies. Because people could not escape spending the effort to make a decision, we reason that their true preferences are revealed in the neutral option. The results show that the participation rate in the neutral model is not significantly different from the participation rate in the opt-out model; and in the opt-in model significantly less people participated compared to the opt-out and neutral. This confirms our expectations that the lower participation rate in the standard recruitment model (opt in) is due to procrastination and that people’s true preferences to participate in the Smart Grid are more likely to be revealed when the opt-out model rather than the opt-in model is applied.

In the second paper we focus on psychological factors that influence consumers’ intention to adopt Smart Grid technologies. We apply a theoretical framework combining two psychological theories, i.e., the Technology Acceptance Model (TAM) and the Values-Beliefs-Norm (VBN) model. According to the TAM, individuals’ acceptance of a
new technology is primarily determined by rational choice, implying that people focus on ease of use and their own benefits. Although it is highly likely that this influences the adoption of Smart Grid technologies, it is not likely that people actually expect large private benefits from Smart Grid technologies, at least not in the near term. The VBN model suggests that Smart Grid technologies are more likely to be accepted if its usefulness is assessed in terms of positive impacts for society and the environment (i.e., a better functioning grid and integration of more renewable electricity). Our data confirm that, as we expected, both personal and collective benefits are important for the acceptance of Smart Grid technologies in Denmark and Switzerland. However, in Norway collective benefits seem to play a less important role, and personal benefits are more important.

3.4 Status on the time schedule

The online survey has been collected according to the time schedule, the data has been analysed and papers are in preparation for publication. This data has given us valuable input to develop the stimuli (surveys/ interview schemes) needed for the field experiment amongst households. We are currently developing the stimuli for the field test and pilots will be held soon.

The recruitment for the field test for SMCs has been more difficult than anticipated. Apparently, the economic incentive is insufficient for others than very large electricity consumers. As a result, GridManager, the company who is responsible for delivering the Smart Grid equipment to the project, has changed their business plan. They do not sell Smart Grid equipment any longer, but instead provide companies with information and smart solutions on how to reduce their energy use. This means that the equipment we planned on testing SMCs’ responses to is not available anymore. Hence it is unlikely that we will succeed in finding more responses from SMCs that we have now (i.e. 1 SMC).

The preparation of the field test amongst households has taken more time than planned. The reason for the delay is that the technology needed for remotely regulating household electricity consumption showed to be less mature than anticipated when the project was planned. After long negotiations and explorations we ended up identifying few suppliers that could deliver functioning, tested, and future-proof equipment and we zoomed in on heat-pumps as one of the few types of electricity consuming equipment that can currently be regulated in practice. The equipment offers we received were unfortunately substantially higher than our budget. Hence, in early May 2011, we applied for additional funding, which was approved by the board of Energinet.dk late August 2011.

Between May and August 2012, we made an agreement with Bosch’s heat-pump division about collaboration in terms of recruitment, installation and regulation and we anticipated that we could start recruiting participants right away. However, fine-tuning and testing of the interplay between Bosch heat pumps and GWR’s system took longer time than anticipated as did the various negotiations about the details of the data catch, the hosting and designing of the webpage. Moreover, since the final configuration of the system implied a different use of various GWR components than
anticipated in their first offer, a tough and lengthy negotiation took place until a final contract with GWR could be signed. The final contract between GWR and the project was signed by GWR 18 April 2012 with a promise to deliver hardware in June 2012.

Because of the delay, the Danish team has asked Energinet.dk to extend the project till 30 June 2013, which was approved in July 2012.

The recruitment of heat pump owners for the project is done in collaboration with Bosch and IVT installers, who have agreed to provide us with addresses of existing customers (those who already have a Bosch or IVT heat pump) and new customers (those who purchase a new Bosch or IVT heat pump). Unfortunately, the recruitment is progressing at a rather slow pace. This has several reasons. First, there are considerably fewer customers with a relevant Bosch or IVT heat pump that we can recruit than initially was indicated by Bosch. Secondly, for contractual reasons between GWR and SEAS-NVE participants need to be customers of SEAS-NVE. This means that potential respondents have to change electricity supplier if they are not SEAS-NVE’s customers yet, which is a large barrier to participate. The slow recruitment of participants means that further delays of the project should be anticipated.

### 3.5 Status on the project organisation

The project organisation consists of a steering board and a management group. The steering boards meets at least twice a year and is responsible for the overall organisation and quality of the project. The management group is in charge of the daily organisation of the project. Both the steering board and the management group have representatives from all Danish partners, that is, Aarhus University, SEAS-NVE, NOE Net and GridManager.

### 3.6 Status on the budget

The budget is spent according to plans. The extra funding that Energinet.dk’s board (685,000 DKK) granted to us in August 2011 for the equipment from GreenWave Reality that is needed for the field test has been spent as planned. In agreement with the contract with GreenWave Reality, we are holding part of their payment back until the problem-free functioning of their delivery has been proven in a trial installation.

### 4. Presentation of the coming phase

The main focus of the next six months will be the field tests amongst households. Recruitment is done in several phases, with the main focus in the first phase on the recruitment of existing heat pump owners, while recruiting consumers who purchase a new heat pump as they come in.

1. The recruitment has started, but progresses, as mentioned, in a slower pace than anticipated. The equipment and GWR portal has been tested in the last quarter of 2012, and some minor issues are still remaining, but it is expected
that they will soon be solved and the installation of equipment will start in January 2013 in those household who signed up for the project.

2. The dissemination of the finding of the online survey will be finalised; the first journal paper is under review by Journal of Economic Psychology and a second journal paper has been drafted and will be submitted to an international academic journals after internal commenting and revision. A book chapter reporting some results will be published in January.

5. Publication and dissemination

Publications


Report
Schuitema, G., Broman Toft, M. & Thøgersen, J (2011). State-of-the-art in the field of prosumer’s acceptability and adoption of Smart Grid technologies. Aarhus, Denmark: Department of Business Administration, Aarhus University, Business and Social Sciences.

Conferences and workshops


Broman Toft, M., Schuitema, G., Thøgersen, J. (2012). Drivers and barriers among private consumers for accepting an active role in the Smart Grid. Project presentation at the 4th Danish Smart Grid Research Network, Aarhus, Denmark.


Thøgersen, J., Schuitema, G., Broman Toft, M. (2011). How to persuade the consumers to accept the role as "prosumers", that is to actively cooperate in the smart grid. Presentation at AU energy: Energy systems and smart grids, Aarhus University, Denmark.

**Organised events**
We organized the 4th Danish Smart Grid Research Network meeting at Aarhus University in March 2012. This is a network of researchers in Denmark that work on the Smart Grid. The network meets twice a year, organised by different universities in Denmark. At this event, results of the IMPROSUME project were presented as well.

### 6. Appendix P (financial statement)

<table>
<thead>
<tr>
<th>Project costs for this phase</th>
<th>Total costs (x1000 kr)</th>
<th>Of which PSO funding (x1000 kr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs realised for the period</td>
<td>1.298,6</td>
<td>1.201,3</td>
</tr>
<tr>
<td>Wages (incl overheads)</td>
<td>537,0</td>
<td>439,7</td>
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<tr>
<td>Travel &amp; accommodation</td>
<td>12,5</td>
<td>-</td>
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<tr>
<td>External services</td>
<td>749,1</td>
<td>761,6</td>
</tr>
<tr>
<td>Others, various</td>
<td>0,1</td>
<td>-</td>
</tr>
<tr>
<td>Total costs realised for the period</td>
<td>1.298,6</td>
<td>1.201,3</td>
</tr>
</tbody>
</table>