THE INFLUENCE OF REFERENCE FRAME AND POPULATION DENSITY ON THE EFFECTIVENESS OF SOCIAL NORMATIVE FEEDBACK ON ELECTRICITY CONSUMPTION

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Abstract

The strong effects of descriptive normative feedback ("how you compare to others") on an individual's electricity consumption have been documented in the IS literature. Here, we extend prior research on reference group effects ("whom to compare with") by defining the relevance of the reference group in terms of similarity in contextual factors as opposed to personal characteristics. Specifically, we manipulate the spatial proximity of reference groups and test whether population density moderates the effects of feedback. In a field study with 560 energy customers, we find that reference groups that are close in terms of geographical proximity are more effective than more distant groups. However, population density does not moderate this effect. Designers of green information systems should therefore use reference groups that are close to the energy consumer with regard to geographical proximity, but they do not need to tailor the intervention to the energy consumer's location.

Keywords: Green IT/IS, social norms, feedback, field experiment, design science

Introduction

Energy supply is a key challenge of our society. Due to growing populations, increasing incomes and the industrialization of developing countries, the world primary energy consumption is expected to increase annually by 1.6% (BP 2011). One of the most promising and cost-efficient means to counter this upward trend is to improve energy efficiency. The European Commission regards energy efficiency as "Europe's biggest resource". Similarly, the U.S. secretary of Energy, Steven Chu, states that "energy efficiency isn't just a low hanging fruit; it's just fruit lying around" (Charles 2009). A recent report found that households and businesses could reduce energy consumption by 23% from baseline and thus earn $1.2 trillion at an upfront cost of $520 billion if they would make use of their end-use efficiency potentials by insulating their house or by replacing old appliances through energy-efficient appliances, for example (Granade et al. 2009). In order to realize the efficiency potential, several policies have been introduced throughout the US and Europe. The European Union, for example, is committed to save 20% of annual primary energy consumption compared to projections (EC 2011). This saving target translates into obligations for public sector, industry, utility companies, and residential energy consumers. In this context, green information systems (Green IS) could contribute as powerful enablers to achieve the saving targets across stakeholders because they allow for cost efficiently delivering large-scale and at the same time tailored energy efficiency interventions. In this paper, we present an IT artifact that allows for motivating households to reduce their energy consumption.

Related to corporate responsibility, technology is both a cause of the environmental burden (due to the resources that need to be invested) and a potential solution (due to efficiency gains) (Watson 2010). Under the concept of 'Green IT,' firms and researchers traditionally place a focus on information and communication technologies as a cause of environmental concerns (Murugesan 2008). Research in this area concentrates on hardware design and implementation issues, with the aim of improving energy efficiency of data centers, minimizing the ecological footprint of IT, and reducing the impact of electronic waste (Bengtsson & Ägerfalk 2011; Dedrick 2010; Jenkin et al. 2011; Mithas et al. 2010). Recent developments in Green IS research acknowledge that IT is not only part of the problem, but could also be a potential solution to the problem of steadily increasing worldwide energy consumption. For example, the efficiency of business processes can be improved by automation and by developing more sustainable strategies by using decision support systems (Thambusamy & Salam 2010). We argue that Green IS can also be used to motivate residential energy consumers to increase their energy efficiency.

While the improvement of energy efficiency at the organizational level has been the objective of numerous studies in the realm of IS Research, the individual level has been largely overlooked. Only a few studies address the application of Green IS for motivating energy consumers to be more energy efficient, although it has been widely acknowledged that IT can have a positive influence on individual behavior and attitudes (Froehlich et al. 2009; Grevet & Mankoff 2009; Holmes 2007). Very recently, some IS researchers have employed the idea that individuals play an important role in realizing environmental sustainability (Melville 2010). Addressing the individual level (i.e. households) to achieve the saving targets is extremely important as households contribute to 20 to 30% of final energy use (EIA 2009). And due to growing populations and incomes, residential energy consumption is expected to increase even further (OECD 2008). Increasing the energy efficiency of appliances alone will not be sufficient to stop this undesirable trend. Energy consumers also need to change their behavior since they ultimately determine the energy efficiency of technology in the way they operate it (Lutzenhiser 1993). Therefore, it is inevitable to address human behavior with behavioral interventions.

Behavioral interventions can either change the context in which consumption decisions are made by, for example, offering rewards that render pro-environmental choices more attractive (Steg & Vlek 2009; Osterhus 1997) or by targeting an individual's perceptions, preferences, and abilities to induce eco-friendly behavior (Allen 1982; Poortinga 2003; Steg 2008; Steg & Vlek 2009).There is mixed evidence about the role of behavioral interventions in promoting energy conservation. While some studies showed that behavioral interventions are effective in motivating energy conservation, other studies found no effects, negative effects for certain energy consumers, or unsustainable effects (see Table 1). Research on social norm interventions, for example, demonstrate clearly that a behavioral intervention can be very

powerful if designed in the right way, but can also backfire if people are told that they perform better than others (Fischer 2008). To avoid negative effects, interventions need to be tailored to the specific characteristics of the energy consumer and the situational conditions. For example, by considering the a priori consumption levels of the energy consumers and thus providing them with different types of social normative feedback, Schultz and colleagues were able to eliminate the boomerang effects of descriptive normative feedback with regard to consumers with low consumption levels (Schultz et al. 2007). Similarly, by considering the political views of energy consumers, energy efficiency campaigns increase more strongly problem awareness of climate change (Schuldt et al. 2011) or engage more people in participation (Costa & Kahn 2010). Hence, social norm interventions should be tailored to the targeted individual to fully unfold their effects.

Table 1. Selective overview of energy feedback studies				
Author(s)	**Intervention**	**Resource**	**Sample**	**Results**
McClelland & Cook (1980)	Feedback	Electricity	101 families	Feedback group saves 12%
Graham et al. (2011)	Feedback	Fuel	128 students	All conditions (monetary feedback, environmental feedback, both types) reduce car use
Abrahamse et al. (2007)	Feedback, goal setting, information	Energy	189 customers	Feedback + goal setting + tailored information leads to 5.1% savings
Schultz et al. (2007)	Social normative feedback	Electricity	290 households	Descriptive feedback leads to increased consumption for low users of electricity
Van Houwelingen & van Raij (1989)	Feedback, goal setting	Gas	325 families	Low users of gas increased their consumption during the intervention
Van Dam et al. (2010)	Social normative feedback	Electricity	304 participants	Initial savings cannot be sustained over the medium-term
Haakana et al. (1997)	Feedback, information	Electricity	105 households	After 20 months, treatment effects have diminished for all groups

However, to offer such tailored interventions, one must gather and process information. These processes often do not scale well if they are being deployed over a large number of customers, as in the case of personal energy audits, for example. Traditional intervention strategies suffer from the classical trade-off between reach (i.e., "the ability to connect with a large number of actors" (Evans & Wurster 1999)) and richness (i.e., "the ability of information to change understanding within a time interval" (Daft & Lengel 1986)). IS could provide a powerful solution to the problem as it enables large scale interventions and personalization at the same time. A far-reaching development toward promoting tailored and large energy conservation practices by means of Green IS is currently underway in the utility sectors where smart electricity meters (smart meters) are gradually replacing the old electromechanical induction watt-hour meters. Smart meters resemble sensor nodes and measure consumption data and feed it to a network at high frequency (at intervals from seconds to months). By 2020, due to regulatory duties, 80% of all households in Europe will be equipped with smart meters (Renner & Heinemann 2011). Information

systems such as web portals or in-home displays that provide energy consumers with timely feedback on their consumption will accompany the smart meter infrastructure to allow energy consumers to act upon it and to change their behavior. However, the potential benefits of smart meters on energy efficiency can only be achieved if the design of feedback systems is driven by empirically proven design guidelines.

Against the background that IS can deliver tailored energy efficiency interventions and will soon be available to a large number of households, the goal of this paper is to develop a theory-informed IT artifact to empirically test different reference frames for social normative feedback with regard to the effects on electricity conservation. According to the framework of Zhang et al., the IT artifact under consideration can be categorized as application content (Zhang et al. 2011). Our approach corresponds closely with Baskerville's specification of "design as research methodology" (Baskerville et al. 2011). Specifically, we developed a web portal that was available to all customers of an Austrian utility company and conducted an experiment with 560 participants and tracked their electricity consumption over six weeks. We tested the effect of descriptive normative feedback with three different reference frames for social comparison. Reference groups varied in geographical proximity to the energy consumer and in size since these two variables are naturally linked to each other. Specifically, the consumer's consumption was either compared to his neighborhood's average consumption, his region's average consumption, or his country's average consumption. Furthermore, we tested the moderating effect of population density on the intervention's effects to be able to tailor the social norm intervention and ultimately achieve higher savings. The results of this study have implications for policy makers, feedback systems designer, and utility companies.

Theoretical Background

This section first presents prior research on IT artifacts that were built to influence energy consumption at the individual level to highlight the state of art in this domain as well as research gaps. Thereafter, we present theory on social norms and provide theoretical background on norm salience and the relevance of reference groups in social normative feedback since these two factors determine the success of social norm interventions and descriptive normative feedback in particular. Based on the theoretical background and the outlined research gaps, the hypotheses that will be tested in this study are defined.

Information Systems as Enablers of Large Scale Social Norm Interventions

IS hold the potential to enable cost-efficient energy efficiency interventions with the aid of modern technologies in data processing, personalization, and immediate feedback (Oinas-Kukkonen & Harjumaa 2009). They allow to address a large group of individuals with personalized interventions and thus help to overcome the trade-off between reach and richness (Evans & Wurster 1999; Daft & Lengel 1986) that many traditional energy efficiency interventions like energy audits suffer from. Despite its obvious potential, there are only a few examples for IT artifacts that aim at influencing individual consumption behavior. These artifacts are often developed based on social psychological theory, but do not formulate testable hypotheses. Besides, evaluations are often restricted to small scale usability studies over a short period of time. For example, Mankoff et al. (2010) developed an applet that sits on top of social networks like facebook or MySpace and that tries to motivate people to taking green actions. The applet further tracks progress and suggests new actions. For each action the CO_2 and dollar impact are indicated. In a study with 32 users over 3 weeks, the authors found that the applet actually motivated users to take more green actions. Another IT artifact is Ubigreen (Froehlich et al. 2009), a tool that uses information from various sensors and self-reported behavior to track and support green transportation habits. Feedback is provided on the mobile phone with two different visualizations: One includes a polar bear sitting on a sheet of ice which grows in size when green transportation behavior increases, and the other one contains a tree that gets more green leaves and flowers when the user shows the desirable behavior. In a usability study with 14 participants over 18 days the authors tested the preferences of the users regarding the visualization but they did not assess the effect of the two different visualizations on behavior. An IT artifact that was tested more rigorously is a web based tool presented by Benders et al. (2006). After filling out a questionnaire on energy requirements in the household, the web tool provided users with personalized saving tips and feedback on estimated energy savings. In an experiment with 190 users over five months, the savings of the experiment group were compared to the savings of a control group that did

not receive savings tips and feedback showing that the web tool achieved savings of 8.7%.

Recently, researchers have acknowledged that IS are not only capable of measuring energy consumption and providing historical feedback, but also enable interventions that use social influence to change people's behavior. Based on the insight that individuals respond socially to computers (Reeves & Nass 1996; Fogg 2003) and that certain website features may establish a feeling or social presence (Short et al. 1976) several IT artifacts have been developed to provide people with the opportunity to compare or compete with different social actors. For example, EcoIsland is an in-home display that aims at motivating families to reduce their daily CO_2 emissions by comparing each user with other family members or other families (Shiraishi et al. 2009). Petersen et al. (2007) developed a data monitoring system to provide dormitory residents with real-time feedback on their consumption and the performance of other competing dorms. While these studies hint to the effectiveness of IS to support social norm interventions, other researchers have used IT artifacts to systematically assess the effectiveness of different kinds of social norm interventions. Petkov et al. (2011) stress the importance of choosing a relevant reference subject for social normative feedback and states that normative feedback is only effective if contextualized. Based on these assumptions, the authors developed an application called EnergyWiz that compares a user's energy consumption with the average performance of both efficient and inefficient neighbors and adds a message of social approval based on their performance. The application further allows one-on-one comparisons with friends and a ranking with similar users. Unfortunately, the authors haven't tested the effects of the different social comparisons on energy consumption yet. Foster et al. (2010) have developed a similar application, but tested it with regard to energy savings. They developed a facebook application called Wattsup that visualizes the consumption data from the Watson home energy monitor. The application included comparisons with friends as well as a ranking. In a within-subjects experiment with eight households over 18 days it was tested whether households would save more energy when they were provided with social features. The authors found that households saved significantly more energy when the social features were enabled. Based on a taxonomy of dimensions of social comparisons Grevet et al. (2010) developed a system called stepgreen.org which includes comparisons with other individuals and with groups based on geographic location. The system was tested in a competition with 24 participants over one month but the authors were not able to find significant effects of the social features on environmental concern and actions taken to save energy.

The studies described above hint to the opportunity for IS research that traditionally combines technological expertise with psychological theories (Lim et al. 2009). The authors developed the IT artifacts and the different social comparison features based on theories from social psychology. However, the studies were rather exploratory in nature and did not formulate testable hypotheses. Besides, the IT artifacts were tested only with small groups and over a short period of time. To overcome these research gaps, this paper presents an IT based artifact that is used by 10,700 real energy customers and that aims at motivating energy conservation. We developed a web portal and conducted a randomized field-experiment with 560 participants. Electricity consumption was tracked over six weeks. The hypotheses on the effects of different reference frames in social normative feedback were derived from theory and previous research on social norms and social ties.

Social Normative Influence on Energy Consumption

When choosing an adequate action in a given situation people's cognitive capabilities of taking all relevant information into account is limited. People are bounded in their rationality (Simon 1955). To deal with the complexity and ambiguity of situations they have developed mental short-cuts or heuristics, that help them to make not optimal, but satisficing decisions. One of those heuristics includes the authority of others. That is, individuals often look to social norms to gain an accurate understanding of and effectively respond to social situations (Cialdini 2001; Deutsch & Gerard 1955). This informational normative influence is often referred to as descriptive norm (Cialdini et al. 1991). According to the 'Focus Theory of Normative Conduct' by Cialdini et al. (1991) descriptive norms inform individuals about the typicality of a specific behavior in a certain situation (the norm of 'is') and injunctive norms, a second type of social norms, tell individuals whether this behavior is approved by significant others (the norm of 'ought'). As

social norms are known to be one of the most powerful determinants of behavior change, they have been applied to change a wide range of behaviors including littering (Cialdini 2003), eating (McFerran et al. 2010), alcohol consumption (Lewis & Neighbors 2006), towel reuse (Goldstein et al. 2008), and energy consumption (Schultz et al. 2007; Siero et al. 1996). Social norm interventions are based on the assumption that individuals tend to overestimate the prevalence or typicality of undesirable behaviors and that they use the perceived descriptive norm to make behavioral choices (Schultz et al. 2007). Thus, social norm interventions try to reduce the prevalence of undesirable behavior by correcting the misperception regarding the predominant descriptive norm. To build an effective social norm intervention, it is important to choose a reference group that is relevant to the target group and to assure that the descriptive norm is made salient (Cialdini et al. 1991; Kallgren et al. 2000; Suls et al. 2002). Both factors determine norm adherence and are thus critical to an intervention's success. We will discuss the two aspects in the following.

To influence an individual in a specific situation, a norm needs to be salient. According to the 'Theory of Normative Conduct', a norm must be focal for an individual at the time of behavior to influence an individual's behavior (Cialdini et al. 1991; Kallgren et al. 2000). Similarly, the 'Theory of Social Impact' (Latané 1981) states that the social impact of a group increases when the strength or salience of the normative source is high. Unless norms are salient and in the focus of an individual's attention, they cannot enter the decision process to change potentially detrimental behaviors (Fischer 2008). Studies on the salience of social norms have used priming techniques or spreading activation approaches to direct the intention of an individual to a specific norm. For example, subjects in a study by Kallgren et al. (2000) had to read diary passages that contained normative statements which differed in their conceptual relatedness to the antilittering norm. The results showed that littering was only reduced when the salient norm was related to littering. Similarly, Cialdini et al. (1991) manipulated the salience of the antilittering norm by telling a confederate of the research team to either drop handbills in front of the subjects or to pick up a handbill that was lying on the ground. The latter condition was meant to increase the salience of the antilittering norm. In accordance with expectations, subjects littered less when the anti-littering norm was activated by the confederate picking up the handbill. Related to energy consumption behavior, social norms are made salient to the energy consumers by providing them with comparative consumption feedback. This type of feedback compares an energy consumer's consumption to that of other households in the neighborhood, for example (Fischer 2008). Comparative feedback has proven to have a large influence on energy consumption, that persists even after some months (e.g. Abrahamse et al. 2005; Schultz et al. 2007; Siero et al. 1996).

The second factor that determines norm adherence and thus the effectiveness of social norm interventions is the choice of the reference frame. Social norm interventions are based on the assumption that individuals will take the behavior of their peers into account when making decisions. Since an individual's personal identity comprises several levels of social identity (think of concentric circles around the self), there are multiple reference frames that can be used in social norm interventions (e.g., proximity, demographic variables) (Brewer 1991). In any case, individuals will only orient themselves to the behavior of the reference group when the group is relevant in some aspect to the individual. One important driver of the attributed relevance to a group is the perceived similarity. 'Social comparison theory' stipulates that people compare themselves to others to gain information for self-evaluation (Festinger 1954). These self-evaluation can aim at evaluating one's performance, ability, or opinion (Suls et al. 2002). Similar comparison targets are claimed to be especially useful as they allow drawing conclusions from differences in performance with regard to possible reasons. If the individual engages in a comparison with a person that differs in numerous attributes from him, he wouldn't know if a lower performance was caused by a lower ability or by differences in other attributes such as age, weight, and gender (Martin et al. 2002). However, Festinger did not specify the basis of similarity between the self and the comparison other (Martin et al. 2002). In most studies, similarity is defined with regard to personal characteristics or ability (Goldstein et al. 2008). Another theory that addresses the importance of similar others for social influence is 'Social learning theory' (Bandura 1977). According to Bandura, individuals learn from the observation of role models. One premise for social learning is the identification with the role model which is enhanced when the role model is similar to the learning individual. Identification with the reference

group or person is another factor that contributes to norm adherence (Goldstein et al. 2008). The membership to a social group contributes to the individual's social identity which forms an important part of an individual's self-concept according to the 'Social identity theory' by Tajfel and Turner (1986). It is argued that people conform to the norms of a group that is perceived to be an important part of their social identity and thus self-concept (Goldstein et al. 2008).

Both similarity and identity cannot only be interpreted in terms of personal attributes but also in terms of contextual characteristics. For example, Aarts and Dijksterhuis (2003) showed that people lowered their voice when they were confronted with pictures of a library where a situational norm of being silent is automatically activated. Goldstein et al. (2008) found that local norms are sometimes more effective in motivating people to show a certain behavior than global norms because the former may lead to behavioral choices that are tailored to the individual's specific situation. Larimer et al. (2001) found that fraternity members are more likely to reduce their alcohol consumption if they are provided with fraternity specific norms than more general norms on drinking behavior. The evidence suggests that social comparative feedback should be more effective if the reference frame addresses social norms of a group that is close in geographical proximity. However, since the reference frame in social comparative feedback varies in geographical proximity *and* group size, it is also possible that group size is more relevant than geographical proximity. Energy consumers could pay more attention to norms of large groups (if the frame of reference is the country's averaged energy consumption) than to norms of small groups (if the neighborhood's averaged performance is the frame of reference). In line with this, the 'Theory of Social Impact' (Latané 1981) states that social impact is not only a function of strength and immediacy, but also of the number of other people. However, in the context of energy consumption, we assume for two reasons that comparative feedback with reference groups that are close in geographical proximity will be more effective than more distant reference groups. First, the norms of close reference groups are more salient to the energy consumer than the norms of more distant reference groups. Besides, close reference groups are more relevant to the energy consumers than more distant groups because they share the same geographical context. We hypothesize the following:

H1: *Reference groups that are close in geographical proximity lead to higher energy savings than more distant reference groups.*

We further assume that the influence of social normative feedback on energy consumption depends on the environment of an individual. Specifically, we suggest that if an individual lives in a rural area he or she should be more affected by social normative influence than someone who lives in an urban area. In rural areas people live in very small cities where people have strong social relationships (social ties) in contrast to urban areas (Lev-Wiesel 2003). Strong social ties between two individuals mean that they are close to each other and interact frequently. Therefore, it should be important for individuals in rural areas who have more close social relationships to conform to normative standards in order to be liked and accepted (Aronson et al. 2009). Living in urban areas on the contrary is more anonymous and social ties amongst residents in urban areas are weaker than amongst residents in more rural areas (Lev-Wiesel 2003). Hence, it should be less relevant for individuals who live there to conform to the expectations and norms of others. Research has shown that the characteristics of social networks affect many aspects of our lives such as health behavior, social responsible behavior, and energy consumption. For example, Christakis and colleagues (2007) found that the chance of an individual to become obese increases if a close friend is obese, too. Centola (2010) conducted an experiment and assigned participants to a clustered-lattice network structure (high number of locally redundant ties) or a random structure and tested in which network health behavior spreads faster and further. They found that behavior spreads faster and further when individuals receive multiple influence attempts via locally redundant ties. Brewer and Kramer (1986) showed that people in large groups, where social ties are weaker, show less socially responsible or altruistic behavior than people in small groups. In the energy context, research has shown that stronger relationships between individuals in a social network can serve to improve energy saving behavior (Chen et al. 2012). Chen and colleagues conducted a field study in a dorm over five months and provided students with feedback on actual and past energy consumption. One group also received social feedback on building level and a second group received social feedback on peer level. They found that students in the last group saved most electricity. Based on survey data, they also found that strength and density of social networks affect energy conservation. To conclude, the studies all show that behavior is affected by

the characteristics of social relationships. Given that urbanity/rurality affects with whom and how we interact, we expect that energy consumers in rural areas will be more influenced by social normative feedback than energy consumers in urban areas. However, it is also possible that an individual's environment is not the key determinant for the development of social ties anymore. Due to the widespread use of the internet and online social networks like facebook, individuals can easily build and maintain social relationships over longer distances. Thus, they are not dependent on building social relationships with others in their area. However, research shows that urbanity/ rurality significantly affects social networks (Lev-Wiesel 2003). We hypothesize the following:

H2: *The effect of close reference groups on energy savings is moderated by population density. That is, energy consumers in rural areas will be more influenced by social normative feedback than energy consumers in urban areas.*

Empirical Study

Subjects and Design

Five hundred and sixty real energy customers of an Austrian utility company participated in this field study. Participants indicated that on average three individuals were living in the households (SD = 1.45) and that the houses were on average 126.8 sqm (SD = 57.59). The size of the cities where the participants lived ranged between 265 and 42,300 inhabitants (Med = 7096), data was obtained from the regional authorities of Vorarlberg). The study contained a one factorial between subjects design. We manipulated the reference frame of the descriptive normative feedback and compared the participants either with the averaged consumption of their neighbors, of people from their region (Vorarlberg), or with the averaged consumption of people from their country (Austria). The participants were randomly assigned to the experiment groups at the time of registration. After measuring the baseline consumption over two weeks we tracked consumption for the following four weeks (April – May 2010). We excluded households that did not provide information regarding the size of the household and/or their city (N = 73) because this information was needed to provide adequate descriptive normative feedback. Besides, we excluded households with electric heating systems and electric water heating systems (N = 142) from further analysis because their consumption patterns were over-proportionally high. Furthermore, we excluded both 2.5% at the lower and the upper end of the distribution (5% in total) from further analyses to guard the analyses against outlier-biases (N=23). If the baseline measurement was an outlier, the whole dataset from this household was discarded because a valid baseline is a prerequisite for the applied analytic approach. This procedure resulted in a final sample of 322 households that serve as a basis for the statistical analyses. An ANOVA shows that there were no statistical differences between the baseline consumption levels of the three experiment groups ($F(2,319)$ = .65, p = .524). Table 2 provides an overview of the descriptive statistics of the subsamples.

| Table 2. Overview of the subsamples used in the present study			
Subsamples	**N**	**M**	**SD**
Reference group: Neighbors	136	99.69	47.67
Reference group: Vorarlberg (region)	88	93.66	48.05
Reference group: Austria (country)	98	93.76	43.45

N = Sample size, M = Mean baseline consumption (in kilowatt hours), SD = Standard deviation (in kilowatt hours)

Procedure

To test our hypotheses, we developed a web portal called "Velix" in cooperation with an Austrian utility company that has about 120,000 residential energy customers. The web portal was designed to provide

customers with feedback on their electricity consumption and to help them to conserve electricity by providing energy saving tips. Velix served as the basis for an energy efficiency campaign that aimed at raising awareness about electricity consumption and at preparing customers for the introduction of smart meters. The underlying rationale for building this system was to create a behavioral intervention that uses IS to cost-effectively address a large number of people and that is capable of providing users with different kinds of feedback to rigorously evaluate their effectiveness on electricity consumption. The utility company promoted the campaign via various channels, including the company's customer magazine, ads in printed and online newspapers, and billboards. As part of the campaign, customers were incentivized for registering and transferring the readings of their electricity meter to the web portal. Since smart meters were not available for data collection in the considered region of Austria, our approach used self-reported meter readings. This allowed us for identifying the most effective reference frame for social norm interventions even before smart meters are introduced to the residential customers. We applied multiple strategies to assure a high validity of the data. First, we incorporated detailed graphical and textual instructions about the location of the electricity meter and how to read it. Utility companies have used this information for many years to support their customers, who read their electricity meters for billing purposes. Second, we implemented algorithms that assessed the validity of the transferred electricity meter readings. In addition, the meter readings were verified for a subset of the participants (N = 115) based on official utility bills ($r = .80$, $p < .01$). Incentives to foster participation included a gift worth EUR 5 to EUR 10 (USD 6 to USD 12) for three meter readings, the opportunity to participate in a monthly charity, and bonus points that could be traded for a number of energy-related products and services. All participants of the study had equal access to the incentive system. Between April 1st, 2010 and December 31st, 2011, a total of 10,700 users joined Velix and entered 319,169 meter readings. On average, visitors spent 4.59 minutes per visit on the web portal. For the present study, 560 users were drawn from the total number of users and randomly assigned to one of the experimental conditions.

After registration, users could participate in the "meter hunt", a game-like explanation to find the electricity meter and interpret its reading. If they already knew where their electricity meter is located and were already familiar with the data format, they could skip this game. To facilitate frequent meter readings, the users were provided with the possibility to set either an email or sms reminder. Upon registration, users were randomly assigned to different groups. In this study, the participants received descriptive normative feedback with different reference groups (neighbors vs. region vs. country). To promote the web portal, users could also invite their friends and earn bonus points for sending out the invitations. To increase knowledge and ability, we included saving tips and little tasks. One task for example was called 'meter sleep' and required users to decrease their consumption close to zero. This task should raise the awareness of the users about their standby consumption and help them to identify possible energy guzzlers. The experience chain is depicted in Figure 1.
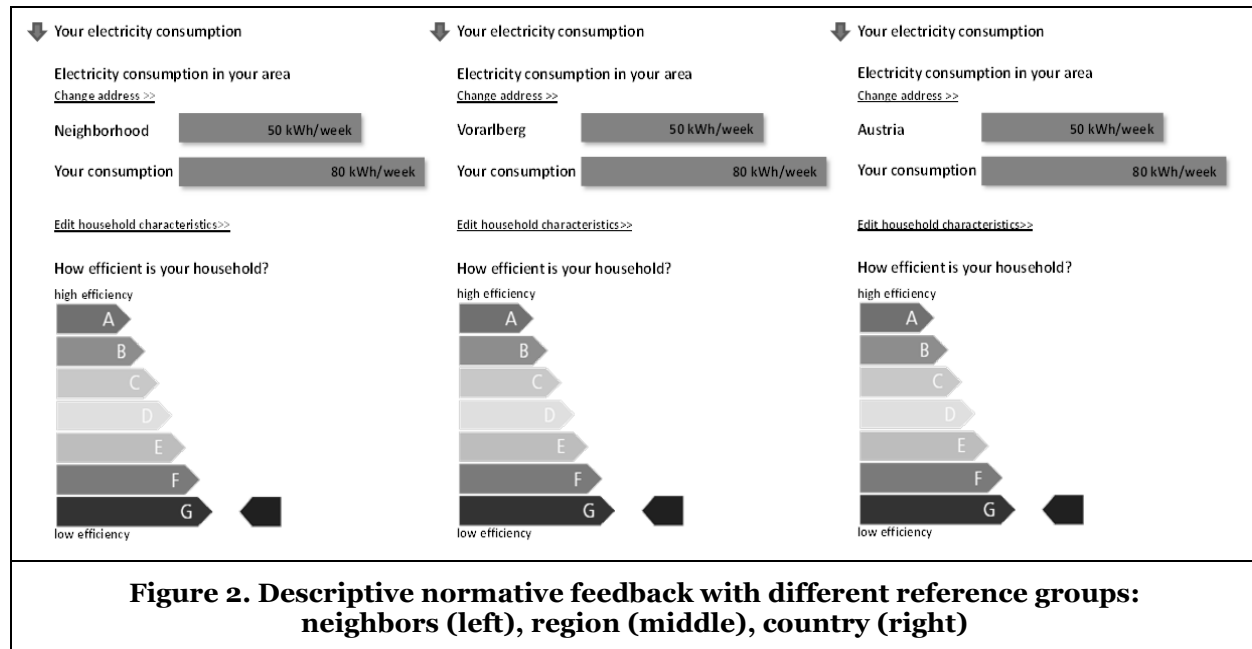
Figure 1. Experience chain of Velix
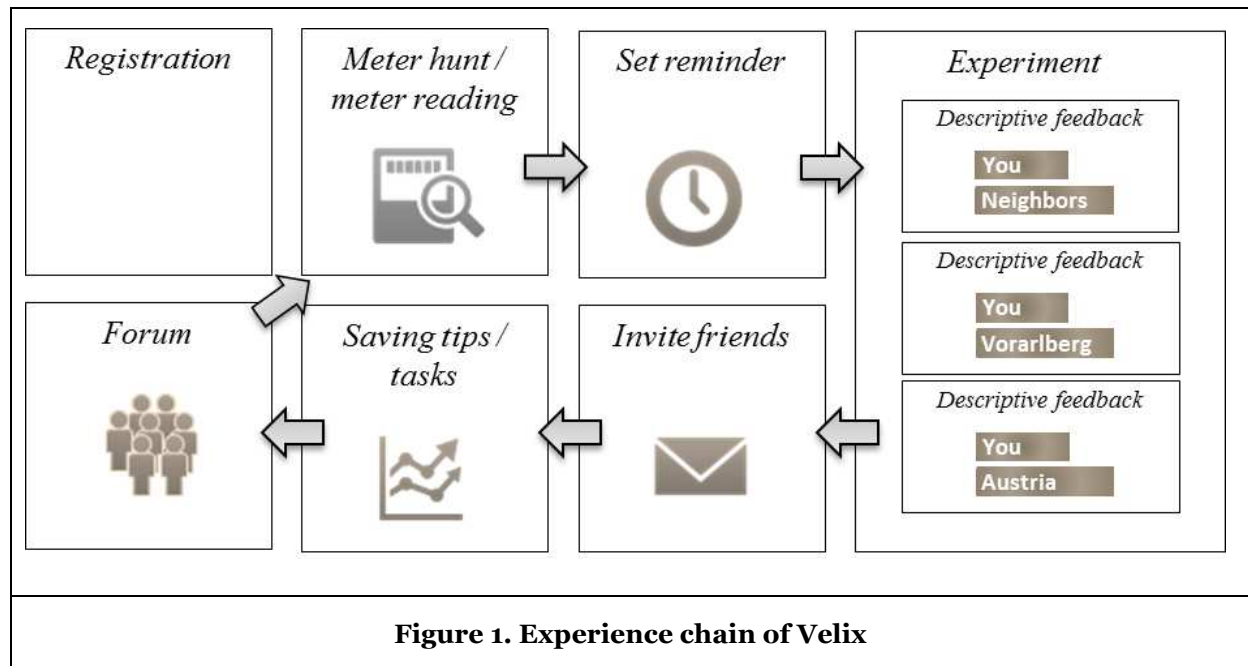
The data that was used by the web portal originate from both the utility company and the user. The utility company provided the consumption data that they used for billing purposes broken down on street level so that the data could be used to provide the users with descriptive normative feedback with different aggregation levels (neighborhood or region). Data on Austria's average consumption was taken from external resources. Besides, the energy saving tips were drawn from earlier energy efficiency campaigns and edited by the advertising agency. The user provided the web portal with data on household characteristics, address including streets, house number and city, personal characteristics, and meter readings. During the experiment, user ID and data input (e.g., username and password, meter readings with time stamps, and household characteristics, personal characteristics) were stored in a relational data base. Based on the group assignment upon registration, the users were presented with different types of feedback. To maintain control over the website, members of our research team programmed the entire system.

Intervention

To calculate the electricity consumption for each user, the system uses the electricity meter readings that are entered by the users. As soon as the user enters the meter reading for the second time and at least one week after entering the first reading, the baseline consumption was calculated. The intervention started immediately after the baseline consumption was measured. Electricity consumption was tracked over six weeks, between April and May 2010. The three experiment groups were provided with descriptive normative feedback which depicted a bar chart that compares the user's consumption with either the average consumption in the neighborhood (street level), the region, or the country (see Figure 2). If the street comprehended less than four households, the users were assigned to the next higher aggregation level (region) for reasons of privacy. In line with the procedure of Schultz et al. (2007) all users were also provided with injunctive normative feedback on their energy consumption to prevent boomerang effects of descriptive norms for energy consumers with low consumption levels. To indicate social approval, we used the European energy efficiency scale that indicates the energy efficiency level of a household based on consumption data and household characteristics. The scale ranges from A (high efficiency) to G (low efficiency). In a previous study (Loock et al. 2011) we were able to replicate the effects found by Schultz et al. (2007) showing that the efficiency scale is as effective as the smileys used by Schultz and colleagues to indicate social approval. During the study, users were only participating in one experiment, and they had not been previously assigned to another experiment. All customers were also provided with advice on how to conserve electricity. Customers could use a customer-care-hotline, a contact form, and/or a forum to

contact the utility company with questions regarding the feedback on energy consumption.

**Figure 2. Descriptive normative feedback with different reference groups:
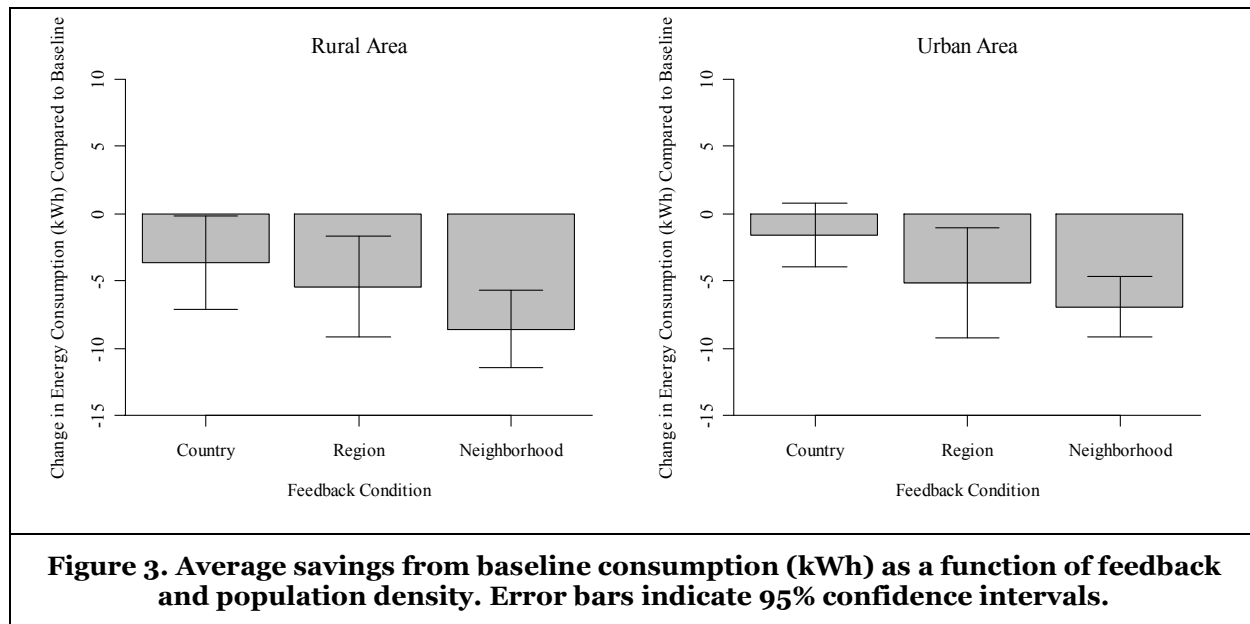neighbors (left), region (middle), country (right)**

Results

For each household, we collected up to five measurements (baseline plus four weeks of treatment), which results in a repeated measurement structure of our data. Repeated measurements over time are usually characterized by correlated error terms that follow an autoregressive pattern. That is, the shorter the temporal distance between two measurements of one observational unit, the higher the correlation between the error terms of these two observations. This data pattern violates the core assumption of traditional statistical techniques as they require completely independent observations. If this complex error structure is not considered in the analysis, a biased statistical test will be the consequence. Therefore we apply a linear mixed-effect model using the lme()-function that is available in the nlme package of the R statistical software (Pinheiro et al. 2009) for all subsequent analyses. The three experimental conditions were dummy-coded with the baseline measurement acting as the respective reference category. We estimated two separate models; one for consumers who live in rural areas and one for those who live in urban areas (based on a median split on city size). The savings Y of household i was modeled as follows:

$$Y_i = X_i\beta + Z_iu_i + \varepsilon_i,$$

Y_i was a 5×1 vector of the energy savings in kilowatt hours (kWh), X_i was the 5×4 design matrix of the independent variables (intercept, neighborhood reference, region reference, country reference), β was the 5×1 vector of the estimated fixed coefficients, Z_i was the 5×1 design matrix of the random effect (intercept), u_i was the 1×1 vector of the estimated random effects, and ε_i was the 5×1 vector of the residuals that were assumed to have a multivariate normal distribution with a mean of zero and a 5×5 variance-covariance-matrix R_i, which had an AR(1) structure. For people in rural areas, the model estimated that comparisons with the neighborhood (b = -7.78, p < .05) and with the region (b = -4.65, p < .06) lead to significant and marginal significant savings, respectively, whereas comparisons with the country (b = -2.36, p > .05) did not reduce energy consumption during the intervention. For people in urban areas, the model estimated that neighborhood comparisons (b = -6.55, p < .05) and comparisons with the region (b = -4.90, p < .05) lead to significant reductions in electricity consumption. Again, this group did not reduce electricity consumption significantly when compared to the country (b = -1.27, p > .05). The corresponding descriptive statistics are depicted in Figure 3. The results show that comparisons with reference groups that are close in geographical proximity work better than more distant reference groups. This effect is not moderated by population density.

Figure 3. Average savings from baseline consumption (kWh) as a function of feedback and population density. Error bars indicate 95% confidence intervals.

Discussion

Summary of Main Findings

In this paper we described the development and implementation of an IT artifact that aimed at motivating households to conserve energy. Specifically, we built a web portal that provided the customers of an Austrian utility company with feedback on their electricity consumption and suggestions on how to conserve energy. This platform was introduced in April 2010 and was used by over 10,000 customers. We used the web portal to conduct an experiment with a subset of 560 customers that were randomly assigned to different experimental conditions and tracked their electricity consumption over six weeks. We tested the effect of three kinds of social normative feedback that differed in their reference frame. The participants' consumption was either compared to the averaged consumption of the neighborhood, the region, or the country. Based on prior research from social psychology and Green IS we hypothesized that reference groups that are close in terms of geographical proximity are more effective in motivating energy conservation than reference groups that are less close. We were able to confirm that hypothesis. Furthermore, we tested the moderating effect of population density (urban vs. rural area) on the intervention's effects to be able to provide tailored social norm interventions. We hypothesized that social norms affect energy consumers in rural areas stronger than energy consumers in urban areas. We found no statistically significant difference between the two groups.

Implications for Theory and Practice

Our findings allow for drawing a number of implications for both theory and practice. First of all, we proved that social norm interventions are successful in motivating energy conservation. In contrast to prior studies in the field of Green IS, we used a large sample of real energy customers and formulated testable hypotheses based on theory from social psychology. We attribute the effectiveness of reference groups that are close in geographical proximity to their higher relevance and salience to energy consumers. This underlines that, in order to be effective, social normative feedback should use reference groups that are relevant to the energy consumer in terms of contextual similarities (see Goldstein et al. 2008) and that are able to make the prevalent social norm salient to actually affect behavior. If these two criteria for norm adherence are not met (e.g. comparisons with the country's averaged performance) social normative feedback does not have any effects on energy consumption. Although research on social

ties in urban vs. rural areas would suggest that energy consumers in rural areas respond stronger to social normative feedback than energy consumers in urban areas, we were not able to confirm this hypothesis. There is however, a trend, that energy consumers who live in rural areas where social ties are usually stronger than in urban areas are more affected by social normative feedback.

With regard to Green IS we showed that IS are successful in achieving energy savings at the individual level. For Austria, feedback systems with neighborhood comparisons would achieve energy savings of 2.56 billion kilowatt hours, a reduction of CO_2 emissions by 39701.51 tons, and monetary savings of 35.35 million Euro (44.28 million USD) assuming an adoption rate of 50% and a reversion of behavior by 50%.[1] This shows that behavioral interventions are an effective strategy for increasing residential energy efficiency. In addition, the results show that the design of energy feedback systems determines whether energy savings can be achieved or not. If feedback systems would use the averaged performance of Austria as a reference frame, they would not have achieved any savings at all. The choice of the reference frame thus determines whether the system achieves the intended goal ("reduce energy consumption"). Hence, it is important to consider user behavior in the design of IT-based efficiency campaigns. We suggest that system designers use the neighborhood or region as reference frame for social normative feedback. Based on our findings, it does not seem necessary to tailor the descriptive normative feedback to population density.

Limitations and Further Research

Even though every effort has been made to ensure the validity of our findings, the present study comes with limitations that provide opportunities for future research. A first limitation concerns a possible selection bias. Although we used a large sample of customers in our experiment, we cannot rule out that the voluntary participation of the customers creates a bias. Hence, the results of this study are not representative for the whole population. The study offers insights into the effects of real campaigns by showing the effects of social normative feedback for customers who are actually responsive to energy efficiency campaigns. A second limitation includes the operationalization of population density. We calculated a median split on city size, however, the area of Vorarlberg in Austria consists of a lot of very small cities so that urban areas are strictly speaking still rather rural than urban. It is possible that effects would be different if larger cities would have been considered. A third limitation includes our experimental design which did not allow for disentangling the effects of geographical proximity and group size. However, the tested reference frames represent natural units which are very easy to understand by energy consumers. Future studies could use an experimental design that manipulates both factors systematically. For example, the experiment could manipulate the relevance by providing comparisons with similar vs. non-similar households and the salience by manipulating the closeness to the own house in meters. Other possible avenues for future research include the investigation of criteria that are relevant for tailoring descriptive normative feedback apart from population density or to test other factors that might influence the perceived relevance of a reference group such as expert level, financial budget or value orientation. We conclude that IS can be used to enable social norm interventions and that they thereby contribute to solving environmental problems (Watson et al. 2008) if user behavior is considered in the design.

Acknowledgements

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[1] The scenario is based on 3.65 million households in Austria, an average annual energy consumption of 3,500 kWh per household, average costs per kWh of 13.8 Euro cents, CO_2 emissions of 155g per kWh, and savings of 8.02% (8kWh/99.69 kWh * 100) due to the neighborhood comparison.

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