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MOTIVATING ENERGY-EFFICIENT BEHAVIOR WITH GREEN IS: AN INVESTIGATION OF GOAL SETTING AND THE ROLE OF DEFAULTS[1]

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This study investigates the role of information systems in stimulating energy-efficient behavior in private households. We present the example of Velix, a web portal designed to motivate customers of a utility company to reduce their electricity consumption. In particular, we consider the effectiveness of goal setting functionality and defaults in influencing energy conservation behavior. For this purpose, we use the web portal as a test of the theoretical propositions underlying its design. Based on data collected from a field experiment with 1,791 electricity consumers, we test hypotheses regarding the structural relations between defaults and goals, the impact of defaults and goals on consumption behavior, and the moderating role of feedback on goal choice. Our results confirm the positive impact of goal setting on energy conservation. We show that default goals lead to statistically significant savings by affecting goal choice. However, if the default goals are set too low or too high with respect to a self-set goal, the defaults will detrimentally affect behavior. We also show that feedback on goal attainment moderates the effect of default goals on goal choice. The results extend the knowledge on goal setting and defaults and have implications for the design of effective energy feedback systems. The study's approach, which combines hypothesis-driven work and design-oriented IS research, could serve as a blueprint for further research endeavors of this kind, particularly with regard to feedback systems based on future smart metering infrastructures.

Keywords: Green IS, energy conservation, consumption feedback, goal setting, defaults, field experiment, design research

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The appendix for this paper is located in the "Online Supplements" section of the *MIS Quarterly*'s website (http://www.misq.org).

Introduction

The increasing scarcity of natural resources, the accelerating pollution of the environment, and the looming threat of global climate change have attracted the interest of IS scholars worldwide (Bose and Luo 2011; Jenkin et al. 2011b; Siegler and Gaughan 2008; Watson et al. 2008). A steadily growing research stream has emerged in recent years under the umbrella of "Green IS," which explores the potential contributions of information systems in support of sustainable practices across the entire firm (Watson et al. 2010). The thematic scope of the Green IS movement encompasses diverse topics, such as the improved eco-efficiency of business processes through automation, the development of sustainable strategies with the aid of decision support systems, and the overall optimization of environmental information flows (Thambusamy and Salam 2010).

Whereas the majority of Green IS studies are conducted at the organizational level of analysis (Jenkin et al. 2011a), the present work focuses on the cognitions of individuals by investigating the role of IS in stimulating energy-efficient behavior in private households. The practical motivation for our research emerges from the substantial and still increasing contribution of domestic energy consumption to global energy demand. In Western countries, households account for 20 to 30 percent of the total energy use (EEA 2001; EIA 2009). However, energy consumption shows high variance on the level of single households due to the many isolated decisions made by individuals (e.g., investing in better insulation or more efficient heating and cooling systems, purchasing more energy-efficient appliances). Therefore, changing consumption behavior may be an effective catalyst for increasing energy efficiency on a large scale (Dimitropoulos 2007).

To investigate how Green IS needs to be implemented in order to change residential energy consumption, we follow the design science research paradigm, which is increasingly accepted as a viable IS research approach (Fischer 2011; Hevner et al. 2004; Iivari 2007). Accordingly, an objective of our work is to create a technological artifact that is innovative and purposeful in terms of its ability to address a specific problem (Hevner et al. 2004). Thus, we respond to Melville's (2010) call for research on the effectiveness of IS design choices in influencing environmentally sustainable human behavior. Our second objective is to utilize the system as a test of the theoretical propositions underlying its design. For this purpose, we employ a "hypothetico-deductive, theory-testing mode of design science" (Baskerville 2008, p. 442), which is characterized by a design that is informed by kernel theories, which, in turn, can be refined by design research (Cao et al. 2006; Hevner et al. 2004; Kuechler and Vaishnavi 2008; Nunamaker et al. 1990; Walls et al. 1992).

We position our study within the larger context of intervention strategies based on findings from socio-psychological behavior research. We concentrate on a specific type of Green IS functionality based on goal setting theory, which posits that concrete and realistic goals result in higher performance than vague and nonambitious objectives (Mento et al. 1987). In addition, we test the effect of defaults, a well-known concept from the marketing literature, or "the option you get when you do not specify otherwise" (Brown and Krishna 2004). We propose that the combination of a goal setting functionality with default goals in a Green IS implementation may encourage consumers to adopt long-term eco-friendly behavior. To rigorously evaluate our hypotheses, we collected electricity consumption data from 1,791 utility customers in a field experiment and analyzed to what extent goals and defaults lead to higher energy savings. The results allow us to draw conclusions for both, Green IS design (i.e., which system design works) and the socio-psychological foundations of our research (i.e., how and why the system design works).

Following the six-step methodology of IS design research proposed by Peffers et al. (2008), the remainder of the paper is organized as follows. After having outlined the problem that motivates our research, we review prior Green IS design research in the next section and delineate the research gap addressed by the present study. We then develop our research model and a set of theoretical propositions, which lay the foundation for the design and implementation of a real-world IS as well as for its empirical evaluation. A detailed description of the system from a user's perspective is given in the appendix. We continue with a description of the practical demonstration phase, in which we collected data from a large sample of electricity consumers. For evaluation purposes, we subsequently provide an in-depth analysis of the collected data and the results of the statistical tests. We close with a discussion of our main findings, theoretical and practical implications, limitations, and suggestions for further research.

Changing Energy Consumption Behavior via Green IS

Research on energy consumption behavior has become an extraordinarily fruitful research stream in the social sciences in the past 30 years with two main paradigms dominating the field: (1) the economic paradigm and (2) the behaviorist paradigm (MacKenzie-Mohr et al. 1995; Rolls 2001). The former takes the perspective of rational choice theory, which posits that consumers seek to maximize their own expected utility (Elster 1986; Homans 1961). According to this view, the behavior of energy consumers is determined by costs, benefits, and individual preferences, with rational consumers being those who make reasoned choices based on the entirety of information available to them. The belief in the effectiveness of information provided the starting point for many of the early pilot projects conducted by utilities, which were based on the assumption that individuals would conserve energy if they were given sufficient information on different energy sourcing options, prices, and environmental impacts, among others (Lutzenhiser 1993). However, scientific evidence shows that individuals are ultimately bounded in their rationality because of the cognitive burden of information processing, which limits their ability to take deliberative actions (Simon 1955). A wealth of results from experimental and field research has shown that a variety of mental short-cuts (e.g., rules, habits, emotions) may reduce or even bypass cognitive deliberation entirely, undermining the assumptions that underlie the models of rational choice (Hassell and Cary 2007).

In contrast, the behaviorist paradigm assumes that an individual's behavior is determined by the complex interplay between intrapersonal factors (e.g., attitudes, values), interpersonal factors (e.g., norms, social comparison), and external ones (e.g., rewards, punishments) (Gifford et al. 2011). The different schools of psychological research have contributed a plethora of behavior models that may be relevant to the debate on environment-related behavior change (Jackson 2005; Vining 2003). None of the current models seems sufficient by itself to account for the complexity of behavior, but some are more widely used. Among the most prominent examples is the theory of planned behavior (TPB) proposed by Ajzen (1991), which posits that the intention to undertake a behavior precedes actual behavior. Behavioral intentions, again, are determined by attitudes toward the behavior, perceptions of social norms, and perceptions of behavioral control. In the years following its original publication, researchers have proposed several additions to the model, such as self-identity processes, anticipated emotions, or habit (Perugini and Bagozzi 2004). A second theory worth mentioning is Schwartz's (1977) norm-activation model (NAM), which explains pro-social behavior by the activation of personal norms (i.e., strong feelings of moral obligations). Both theories have been successfully applied in studies of environmentally aware behavior, sometimes in combination with NAM variables extending the original TPB (Abrahamse and Steg 2009).

TPB, NAM, and similar models take the role of meta-theories (Gregor 2006) in that they provide a conceptual framework for understanding human behavior across disciplines and for guiding the design of effective intervention strategies (Stern 2011). Following the latter avenue, several studies investigated the effects of behavioral interventions on energy consumption (Abrahamse et al. 2005). Scholars have aimed at both changing the context in which consumption decisions are made by offering rewards that render pro-environmental choices more attractive (Osterhus 1997; Steg and Vlek 2008) or by targeting an individual's perceptions, preferences, and abilities in order to induce eco-friendly behavior (Allen 1982; Poortinga et al. 2003; Steg 2008). Unfortunately, traditional intervention strategies suffer from a lack of scalability, as in the case of personal energy audits. Here, the strength of IS as an enabler of fully automatic processes of consumption data collection and analysis comes into play.

IS Enabled Intervention Strategies

Early behavioral interventions that aimed at motivating energy conservation have primarily focused on the basic effects of providing information on individual energy consumption. For example, Seligman and Darley (1977) provided their subjects with feedback on their electricity use. After one month, the subjects had reduced their consumption by 10.5 percent. Other, more sophisticated studies investigated the effects of specific aspects of feedback such as frequency (Dobson and Griffin 1992; Van Houwelingen and van Raij 1989), aggregation level (Dobson and Griffin 1992; Ueno et al. 2005), and content (Chen et al. 2011; Graham et al. 2011; Schultz et al. 2007) on energy consumption. Prior research indicates that feedback is more effective if it is provided immediately after the target behavior occurs (Geller 2002). With regard to feedback content, social feedback (e.g., peer comparisons) is more effective than individual feedback (Siero et al. 1996), but only if it is tailored to a specific situation, state of knowledge, or feeling (He et al. 2010).

Although the potential of IT for implementing the previously mentioned modes of providing feedback on energy consumption in a cost-efficient and scalable way is evident, only a small number of studies on feedback interventions make use of information systems (Oinas-Kukkonen and Harjumaa 2009). Examples can often be found in the human–computer interaction literature, where IS are used to test preferences for different information presentation formats. For instance, Shiraishi et al. (2009) presented a user study with six families over four weeks, who were confronted with an in-home display called "EcoIsland" that visualizes the users' current eco-friendly behavior to persuade them to change their lifestyle patterns and thereby reduce their CO_2 emissions. Other examples include "UbiGreen," a mobile tool used to track and support green transportation habits (Froehlich et al. 2009); "Energy Life," a system utilizing wireless sensors, mobile networks, and ambient interfaces (Björkskog et al. 2010); a public display showing electricity usage to educate consumers and curtail their power usage (Holmes 2007), and

Table 1. Overview of Related Studies Testing IS-Based Feedback Interventions

Author(s)	Intervention	System	Resource	Sample	Results
McClelland and Cook (1980)	Feedback	In-home display	Electricity	101 families	Feedback group saves 12%
Hutton et al. (1986)	Feedback, information	In-home display	Gas, electricity	3 cities	4–5% savings in two out of three cities
Van Houwelingen and van Raij (1989)	Feedback (frequency), goal setting	In-home display	Gas	325 families	Continuous feedback + goal setting leads to the highest savings (12.3%)
Dobson and Griffin (1992)	Feedback (breakdown, frequency)	Software	Electricity	100 households	Continuous and appliance specific feedback leads to savings of 12.9%
Abrahamse et al. (2007)	Feedback, goal setting, information	Web portal	Energy	189 customers	Feedback + goal setting + tailored information leads to 5.1% savings
Loock et al. (2011)	Feedback (content)	Web portal	Electricity	220 customers	Injunctive feedback always reduces consumption, descriptive feedback leads to increased consumption for below average consumers
Graham et al. (2011)	Feedback (content)	Web portal	Fuel	128 students	Combination of monetary and environmental feedback works best for reducing car use
Peschiera and Taylor (2012)	Feedback (content), competition	Web portal	Energy	44 dorm rooms	Social feedback is more effective when using peer norms instead of impersonal energy consumption norms
Chen et al. (2012)	Feedback (content)	Web portal	Energy	89 dorm rooms	Social feedback is more effective than individual feedback

a web portal used to socially visualize energy-saving behavior (Grevet et al. 2010).

The Green IS design proposals made in these earlier studies often refer to the social psychology literature; however, they usually neither formulate testable hypotheses nor attempt to evaluate them with the help of large data sets collected in naturalistic environments. Rather, the respective systems are evaluated in small-scale user studies that typically last only a few days or weeks. In contrast, manifold behavioral interventions exist that have shown their ability to trigger behavioral change or influence user choice in isolated lab studies (Abrahamse et al. 2005). However, when it comes to applying such intervention strategies to large-scale campaigns that are now becoming possible with IS-enabled energy conservation campaigns, it remains unclear which behavioral cues work best, how they can be combined, and how they should be parameterized. Traditional lab studies are hardly capable of answering such questions in a coherent setting as this would require extensive test groups. Only a few exceptions of related work can be found in the literature that utilize IT in one or the other form as a means of implementing rigorous experimental designs (see Table 1). However, even in these studies, information systems are limited to their role as transport media for executing traditional intervention strategies. No details are given on the technological details of the corresponding systems and the actual implementation of the employed intervention types, and no empirically proven IS design guidelines are derived for reuse in future projects. Against the background of this lack of synergies between theory and IS design, a window of opportunity has opened, particularly for IS researchers, with respect to Green IS applications that combine technological expertise and socio-psychological theory.

Research Objective and Theoretical Context

The objective of the present study is to address this research gap by a theoretically sound IS design and its empirical evaluation based on a large sample of real-world data, which could serve as a blueprint for future research endeavors in this emerging area. Among the many theories explaining human behavior, we chose the extended model of goal-directed behavior (EMGB) by Perugini and Conner (2000) as the theoretical locus of our research. EMGB poses a redefinition of TPB, which incorporates constructs from various new theoretical areas: (1) motivation, (2) habit, and (3) affect. The key construct introduced by the EMGB is desire, which represents appraisals and reasons to act that motivate behavioral intentions. In addition to attitudes and subjective norms, positive and negative anticipated emotions are hypothesized to influence the desire to perform a given action. The EMGB also posits that past behavior as a proxy for habit has an im-

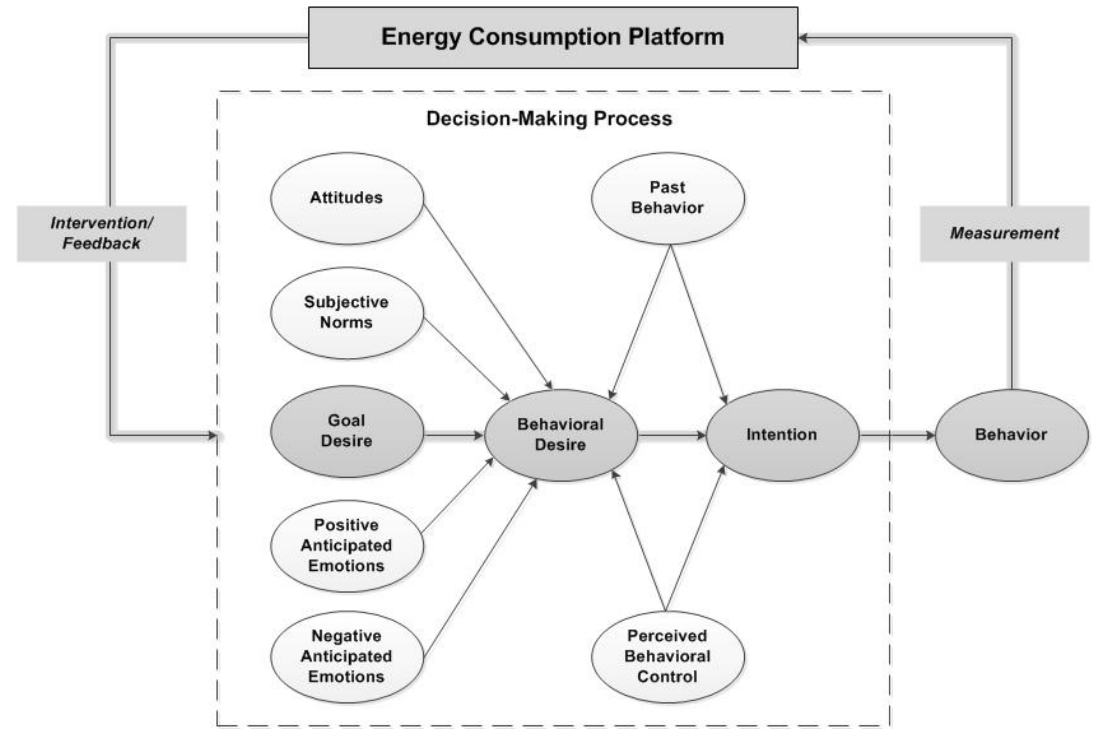

Figure 1. Theoretical Context and Research Focus of the Study (Shaded in Gray)

pact on both desires and intentions. Furthermore, the model distinguishes the desire to perform a given behavior from the desire to achieve a goal (i.e., the outcome of behavior), which is assumed to play a central role in any form of goal-directed behavior (Perugini and Bagozzi 2001).

The model offers various starting points for interventions on the human decision-making process. Among these, the present study sets the focus on the causal chain between goals and behavior. Our objective is to investigate the effectiveness of an IS in the form of a web-based energy feedback platform, which supports electricity consumers in their attempt to save energy by influencing their desire for a particular goal. For this purpose, the system implements an intervention strategy and measures the consumers' behavior in terms of energy consumption. Using the collected data, the system provides feedback on goal attainment, which again influences behavior. It should be noted that from a theoretical point of view, the concept of feedback mechanisms goes beyond the logic of TPB/EMGB in that behavior is not only influenced by its antecedents, but also vice versa. The rationale behind the use of feedback is often traced back to Bem's (1972) self-perception theory, which posits that individuals infer their attitudes by observing their own behavior. Feedback has been commonly used in behavioral intervention design, especially in the health context (Ajzen 2002; Armitage and Conner 1999). The extension of the EMGB by a feedback loop eventually results in the framework depicted in Figure 1, which provides the broader theoretical context to our research. On this foundation, the following sections discuss the concepts of goal-setting and defaults, which we then translate into a specific intervention strategy and a set of testable hypotheses to reveal the principles underlying its mode of action.

Theory Development

Previous scholars have inductively formulated goal-setting theory over a 25-year period by conducting over 400 laboratory and field studies (Locke and Latham 2002, 2006). The theory posits that difficult yet realistic goals lead to higher levels of goal achievement than easy goals. The applicability of goal-setting theory has been the subject of prior IS-related studies, for example, in the context of decision support systems (e.g., Huang et al. 2003; Reinig 2003) or software project management (e.g., Abdel-Hamid et al. 1999; Rasch and Tosi 1992). A second foundation of our study is the concept of so-called *defaults*, which we borrow from the marketing literature. In practice, defaults are used to "nudge…customers

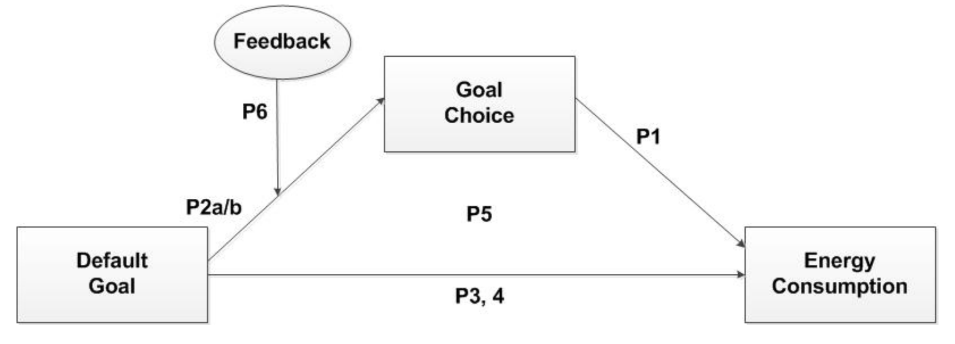

Figure 2. Research Model and Propositions

Table 2. Characteristics of Treatment Conditions

Condition	Description	Propositions
G^-D^-	Consumers are not provided with the functionality to set a goal and are accordingly not provided with a default goal	P1, 3
G^+D^-	Consumers set a specific saving goal, but no default goal is provided	P1, 2a/b, 4
G^+D^+	Consumers set a specific saving goal and are provided with a default goal	
$G^+D^+_L$	low default	P2–6
$G^+D^+_M$	medium default	P2–6
$G^+D^+_H$	high default	P2–6

toward better choices" (Goldstein et al. 2008, p. 99) and can have a massive impact on consumer behavior. Based on these two concepts, we developed the research model depicted in Figure 2, which proposes a causal relation from default goals and goal choice to energy consumption. In the following, we develop a set of theoretical propositions, starting with the basic effects of goal choice and default goal level (P1–4) and proceeding to more complex effects, such as mediation (P5) and moderation (P6).

Our propositions all refer to the effects of different treatment conditions on the energy consumption behavior of individuals. Herein, a condition is characterized by (1) the possibility of setting a goal and (2) the availability of a default goal if a goal can be set. Accordingly, we distinguish among three different categories of consumers: no-goal subjects (G^-D^-), goal and no-default subjects (G^+D^-), and goal and default subjects (G^+D^+). We further divide the treatment group G^+D^+ into three subgroups to compare the effects of low-, medium-, and high-level default goals on energy-saving goal choice and energy savings. Table 2 provides an overview of the different treatment conditions and the propositions to which they relate.

In a first step, we consider the impact of goals on energy consumption. Goals encourage behavior changes by acting as a reference point for a future desirable state. Locke and Latham (2002) define a goal as "the object or aim of an action, for example, to attain a specific standard of proficiency, usually within a specified time limit" (p. 705). Once a goal is set, it remains in the periphery of a person's consciousness as a reference point and guides his or her subsequent mental and physical actions (Locke and Latham 2006). Counterarguments against the influence of goals in the specific case of energy consumption may be seen in the role of energy as a low-involvement good, the habitual consumption of energy, and the consumer's feeling that energy savings are hard to achieve by behavior changes. In addition, energy-related goals may not be effective over a longer period of time, which would render any goal-based intervention ultimately ineffective. However, these arguments are weakened by scientific evidence, which indicates that goal-setting affects performance by more than only one mechanism. First, a goal directs a person's attention and effort toward the activities relevant to the goal and away from irrelevant activities (Locke and Latham 2002). Second, a goal affects one's persistence (LaPorte and Nath 1976). If individuals are free to choose the amount of time they would like to invest in achieving a goal, then ambitious goals will prolong the amount of time required to do so. Third, goals also indirectly affect action by leading individuals to desire, discover, and/or use knowledge and strategies related to the task at hand (Wood and Locke 1990). For these reasons, we argue that consumers who have a goal setting functionality and make use of it are more likely to conserve energy than consumers who do not have such functionality at their disposal.

P1. *Compared to consumers in the no-goal condition (G^-D^-), consumers who are offered a goal setting functionality and who set an energy saving goal (G^+D^-) will conserve more energy.*

If an individual must make a decision (here: choose a goal), then reference points in the given situation (e.g., the recommended savings goal) often become the most important factor in determining the decision outcome (Biswas and Grau 2008; Johnson and Goldstein 2003; Tversky and Kahneman 1981). Prior studies in the marketing literature have successfully applied defaults to provide consumers with a reference point that helped them evaluate other options. For example, in a laboratory study conducted by Pichert and Katsikopoulos (2008), more participants chose a green utility tariff when green electricity was the default than when electricity from nonrenewable or undeclared sources was the preselected option. Individuals typically evaluate the alternative options that are close to their reference point before focusing on the options that are more distant from their reference point (Chapmann and Johnson 1999; Thaler and Sunstein 2003). As a result, the default works as an anchor, which tends to influence an individual's decision in favor of adherence to the standard (Mussweiler and Strack 2000). Accordingly, we argue that default goals will work as an anchor for goal choice, and we expect that higher levels of default goals will lead to a choice of more ambitious goals. However, the impact of defaults may be small if the recommended goal is not perceived as "one's own goal" (Locke and Latham 2002, p. 708). In the case of energy savings, goal attainment may thus depend on goal commitment. Furthermore, providing default goals as anchors could also lead to bad choices if individual attitudes do not impact decisions enough to affect the prevailing default policy (Goldstein et al. 2008). In these cases, negative effects may occur if the default is not chosen carefully. Therefore, we expect that the use of default goals in a Green IS may negatively influence goal choice if they are lower than the preferred goal that an individual would have chosen if he or she had set a goal without any reference point.

P2a. *Compared to consumers in low default goal conditions ($G^+D^+_L$), consumers in high default goal conditions ($G^+D^+_H$) will choose more ambitious goals.*

P2b. *Compared to consumers in the goal and no-default condition (G^+D^-), consumers in the goal and default ($G^+D^+_L$) condition will choose less ambitious goals if defaults are set too low.*

Goal setting theory posits that difficult and specific goals lead to higher levels of goal achievement than easy and vague goals (e.g., do your best) (Locke and Latham 2002, 2006; Mento et al. 1987). Under high-level goals, individuals perceive a large discrepancy between their actual performances and their desired standards and attempt to reduce or eliminate this discrepancy by improving their performances (Kluger and DeNisi 1996; Locke and Latham 2002). However, a goal should still be realistic because goals need to be attainable and plausible (Craig and McCann 1978). If the goals are set too high, then the individual's belief that he or she can attain the goal (i.e., his or her self-efficacy) may be affected because the goals communicate normative information to the individual by suggesting the level of performance that he or she can expect to attain (Consolvo et al. 2009; Meyer and Gellatly 1988). With regard to energy savings, this assumption presumes that consumers are able to judge the feasibility of specific saving goals, which may not necessarily be the case for any type of consumption behavior. Considering these aspects, we expect that consumers who are provided with default goals and set a goal show significant savings— compared to consumers who do not have a goal-setting functionality—only for the case of medium-level default goals.

P3. *Compared to consumers in the no goal condition (G^-D^-), only consumers in the medium-level default goal condition ($G^+D^+_M$) will attain significant savings.*

Similarly, if the goals are too low, then they will only produce small discrepancies and, thus, trigger low levels of motivation. Unlike high-level goals, these low-level goals will further decrease one's persistence such that one will invest less time in solving a task (LaPorte and Nath 1976). Again, this presumes that energy consumers are able to see the low effort necessary to achieve low-level goals, which may not always be the case with regard to the ever-increasing demand for cheap energy. We hypothesize that if default goals are set too low (i.e., lower than the preferred goal that an individual would have chosen if he or she had set a goal without any reference point), they do not lead to any significant savings and it might be more advisable not to use defaults at all.

P4. *In contrast to consumers in the goal and no-default condition (G^+D^-), consumers in the low default goal condition ($G^+D^+_L$) will not achieve significant energy savings.*

Given the aforementioned relationships, we can assume that default goals indirectly affect energy consumption by affecting goal choice. Defaults represent a reference point, which affects goal choice in that the higher the default goal, the higher the goal choice becomes. The set goal will then create a discrepancy between a person's actual and desired performance. The higher this discrepancy is, the higher the energy savings that the consumer can achieve. However, this relation only holds up to a certain point because unrealistic saving goals decrease self-efficacy and, as a consequence, render goal attainment less likely. In sum, we expect that goal choice acts as mediator between default goals and energy consumption.

P5. *The effect of default goals on energy savings is mediated by goal choice.*

Feedback on energy consumption may have only minor impacts on individual behavior because consumers might not be able to relate their own behavior to feedback information that is affected by baseload consumption or the consumption of other household members. However, feedback has nonetheless proven to be an effective means to motivate energy conservation in prior studies, especially when combined with goal setting (Abrahamse et al. 2005; McCalley and Midden 2002). Feedback on goal attainment helps individuals evaluate their progress in relation to their goals (Neubert 1998). A discrepancy between goal and performance can trigger two possible reactions: Consumers will either modify their efforts or revise their goals (Illies et al. 2010; Kluger and DeNisi 1996) because individuals are motivated to remove or reduce the discrepancy between their goals and their performances (Carver and Scheier 1981). If the goal-performance discrepancy is negative, individuals are likely to adjust their goals downward, but if the discrepancy is positive, individuals tend to further increase their goals by setting goals that are higher than their past performances (Illies et al. 2010). Prior research has shown that the size of the adjustments correlates with the extent of the discrepancy (e.g., Donovan and Williams 2003; Williams et al. 2000). In terms of the previously hypothesized default–goal relationship, we argue that feedback on goal attainment will moderate the effect of default goals on goal choice. That is, consumers in the high default level condition will adjust their goals to a larger extent than consumers in the low default goal condition because the former are more likely to encounter goal-performance discrepancies.

P6. *Feedback on goal attainment moderates the effect of default goals on goal choice.*

Empirical Evaluation

In order to empirically test our research model, we implemented a web-based energy feedback system for electricity customers. Following Hevner et al.'s (2004) rules for conducting design research, we developed the system as an innovative and useful solution to a highly relevant problem: the reduction of household electricity consumption. For this purpose, we collaborated with an Austrian utility company to create a website called Velix, which allows consumers to periodically record their electricity meter readings and provides feedback on their consumption behavior. Velix is based on the assumption that the combination of novel IT and socio-psychological concepts can have a powerful and positive influence on individuals' energy consumption behaviors. To shed light on the specific roles played by goal setting and defaults on this issue, we designed and conducted an experiment, described next.

Experimental Design and Data Collection

In a first step, we operationalized the theoretical constructs from our research model (1) by setting the focus on household electricity meter readings as the measurement instrument for energy consumption, (2) by defining goal choice as a percentage value relative to baseline consumption, and (3) by determining specific default goal levels that are recommended by the Velix system. The rationale behind these specific experiment design choices for each construct is given in Table 3. As a result, we are able to directly convert our research propositions into a set of testable hypotheses H1–6 (see Table 4).

As mentioned earlier, our study design distinguishes among three different categories of electricity consumers: no-goal subjects (G^-D^-), goal and no-default subjects (G^+D^-), and goal and default subjects (G^+D^+). The first two groups represent our two control groups. We use G^-D^- to evaluate the absolute effects of goal setting and G^+D^- to determine whether default goals differ from self-set goals with regard to their impacts on goal choice and energy conservation. We further divide the treatment group G^+D^+ into three subgroups to compare the effects of different default goals on energy-saving goal choice and energy savings. Default levels were set to 0 percent, 15 percent, and 30 percent for low ($G^+D^+_0$), medium ($G^+D^+_{15}$), and high ($G^+D^+_{30}$) level default goals, respectively. They were chosen based on the literature and validated against input from the energy consultancy team of the partner utility which consists of 12 consultants. The team, formed in 1990, has gained extensive experience over the years. In 2011 alone, the team conducted 1,090 energy audits, each taking between 15 minutes and 8 hours. We randomly assigned all consumers who have registered with Velix since the release of the website in April 2010 to the five different groups in a between-subjects design. For all of the groups, the analyses considered only participants who were still active (i.e., the participants who entered electricity meter readings in the ob-

Table 3. Construct Operationalization

Construct	Operationalization	Rationale
Low Default Goal ($G^+D^+_L$)	Low Level Default Goal set to 0% ($G^+D^+_0$)	Energy conservation campaigns with low effects show savings around 0% to 5% (Becker 1978; Darby 2006; Ehrhardt-Martinez 2011). This is in line with the experience of the energy consultancy team, who regard savings around 2% as low, even though such weak effects are quite common for behavioral interventions. In order to formulate a low default level that is regarded as such even by informed customers, we selected 0% as unambiguously low default. In addition, this offers the advantage of having a ratio scale with a true zero.
Medium Default Goal ($G^+D^+_M$)	Medium Level Default Goal set to 15% ($G^+D^+_{15}$)	Medium level saving goals in the literature range from 5% to 20% (e.g., Abrahamse et al. 2005). The energy consultancy team regards 15% savings as a suitable goal for household customers with medium-level ambitions of conserving energy. Consequently, we chose 15% as the medium level default goal.
High Default Goal ($G^+D^+_H$)	High Level Default Goal set to 30% ($G^+D^+_{30}$)	Documented savings of 20% to 30% can be found in the literature for especially successful campaigns (Haakana et al. 1997, Staats et al. 2004). As the subsequent analysis requires a ratio scale (equidistant-distant + true zero) spacing, a default level of 30% was chosen.
Goal Choice	Set by consumers as percentage relative to baseline electricity consumption in kWh	Expressing changes in percent from a previous value is common practice in many domains (e.g., price or amount of goods, etc.). This is also true for the energy domain (e.g., Abrahamse et al. 2005; Ehrhardt-Martinez 2011). We therefore regard the concept as adequate for expressing saving goals.
Energy Consumption	Retrieved by consumers reading their electricity meters and entering the data into the energy feedback system	Electricity in households accounts for one-third of total domestic energy demand and as such represents an important share. Electricity meters are highly precise instruments, and the devices at the particular utility are easy to read by consumers. Moreover, it is possible to check the validity of the readings using billing data. Therefore, electricity meter readings can serve as indicator for energy consumption.

Tale 4. Testable Hypotheses

Proposition		Hypothesis
1	Compared to consumers in the no-goal condition (G^-D^-), consumers who are offered a goal setting functionality and who set an energy saving goal (G^+D^-) will conserve more energy.	Compared to consumers with no goal setting functionality (G^-D^-), consumers who are offered a goal setting functionality and who set an energy saving goal (G^+D^-) will conserve more energy.
2a	Compared to consumers in low default goal conditions ($G^+D^+_L$), consumers in high default goal conditions ($G^+D^+_H$) will choose more ambitious goals.	Compared to consumers with a default goal of 0% ($G^+D^+_0$), consumers with a default goal of 30% ($G^+D^+_{30}$) will choose more ambitious goals.
2b	Compared to consumers in the goal and no-default condition (G^+D^-), consumers in the goal and default condition (G^+D^{+L}) will choose less ambitious goals if defaults are set too low.	Compared to consumers who are offered a goal setting functionality but no-default goal (G^+D^-), consumers with a default goal of 0% ($G^+D^+_0$) will choose less ambitious goals.
3	Compared to consumers in the no goal condition (G^-D^-), only consumers in the medium-level default goal condition ($G^+D^+_M$) will attain significant savings.	Compared to consumers with no goal setting functionality (G^-D^-), only consumers with a default goal of 15% ($G^+D^+_{15}$) will attain significant savings.
4	In contrast to consumers in the goal and no-default condition (G^+D^-), consumers in the low default goal condition ($G^+D^+_L$) will not achieve significant energy savings.	Compared to consumers who are offered a goal setting functionality but no-default goal (G^+D^-), consumers with a default goal of 0% ($G^+D^+_0$) will not achieve significant energy savings.
5	The effect of default goals on energy savings is mediated by goal choice.	Consumers' goal choice mediates the effect of default goals on energy savings
6	Feedback on goal attainment moderates the effect of default goals on goal choice.	Feedback on goal attainment regarding personal energy savings moderates the effect of default goals on subsequent energy saving goal choice.

Table 5. Overview of the Subsamples Used in the Present Study

Subsamples		N	M	SD
G^-D^-	No-goal subjects	927	108.19	55.97
G^+D^-	Goal and no-default subjects	199	109.00	50.04
G^+D^+	Goal and default subjects			
$G^+D^+_0$	0% default	213	109.25	57.76
$G^+D^+_{15}$	15% default	242	108.26	48.18
$G^+D^+_{30}$	30% default	210	109.08	54.70

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

served period of time). Additionally, for the goal and no-default group G^+D^- and the goal and default group G^+D^+, we only considered participants who set two or more conservation goals. In sum, 1,960 consumers fulfilled these conditions.

Our approach used data from electricity meters that continuously measure behavior. The meter readings are transferred to the website by the consumers on a regular basis. To make data transfer as simple as possible for them, we applied multiple strategies. 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. For example, if a consumer entered a negative value or a reading that was lower than the previous reading, then he or she would receive an error notification, and the value would not be saved. We could also presume that the collected data were highly reliable because Velix offered no bonus points for low energy consumption and thus it was pointless for consumers to fake meter readings over a period of several weeks and receive unhelpful feedback. Additionally, we checked the validity of the transferred meter readings for a subset of 115 consumers. The correlation between the level of energy consumption in 2009, which was provided by the utility company, and the level of energy consumption in 2010, which was a projection based on the meter data that had been transferred by the consumers to the portal, was substantial ($r = .80$, $p < .01$). This correlation indicates that, in general, we can assume that there were no problems with media discontinuity. However, for the specific time period under consideration, we saw examples of extreme consumption data volatility in our dataset that could not be explained by household characteristics or behavior change alone but rather by other factors, such as construction work and absenteeism. To sort out such outliers, we applied Grubbs' (1969) test from the outliers package for R to the data in two subsequent steps. First, outliers with regard to the consumers' baseline consumption were removed, which lead to the exclusion of 4.18 percent of the participants. The baseline consumption level is each consumer's average weekly consumption before he or she sets a goal. Second, we detected outliers in terms of energy savings relative to the baseline and excluded another 4.63 percent of the participants. In both cases we used a tail-wise approach that removes outliers that differ statistically significantly from the mean at both tails of the data distribution. As a result, a final sample of 1,791 consumers was used for this study, which took place in a high use period between November 2010 and March 2011. Table 5 provides descriptive statistics of the subsamples, their energy consumption profiles, and the hypothesis tests that were conducted on these subjects. Note that the different groups did not differ with regard to their baseline consumption levels ($F(4,1786) = .029$, $p = .998$).

We introduced the goal-setting functionality at the end of November 2010 and tracked the participants' energy consumption over 4.5 months. For the G^+D^+ group, the participants could modify their proposed conservation goals with the help of two buttons for increasing and decreasing the value. In the G^+D^- group, no reference point was provided, that is, the consumer had to enter his or her conservation goal into an empty text box. Regardless of the condition, the consumers could choose a conservation goal between 0 and 100 percent. By contrast, the G^-D^- group did not have a goal-setting functionality. After setting a goal, we asked the participants to wait at least one week before entering their electricity meter readings again. After entering this reading, each participant received feedback on their goal attainment and learned if the goal had been met. The participants could again set conservation goals by following the same procedure used in the first goal-setting process (i.e., a participant who had previously set a 15 percent default goal again received 15 percent as their default goal).

Hypothesis Tests

In a first step, we conducted a one-factor between-subjects ANOVA to compare the effect of goal setting on energy savings in the goal-setting (G^+D^-, G^+D^+) and the no-goal (G^-D^-) conditions. On average, the participants in group G^-D^- increased their consumption by 4.09 percent. They likely did so because the study took place at the beginning of winter when electricity demand typically rises. Therefore, we normalized the savings in electricity consumption to 4.09 percent. Thus, savings in electricity consumption represent a reduction in the overuse of energy. For simplicity's sake, whenever we discuss energy savings, we are referring to a reduction in the overuse of energy. We found that goal setting has a statistically significant[2] effect on energy savings ($F(1, 1789) = 7.23$, $p < .01$). Consumers who had a goal-setting functionality at their disposal and who set a goal saved, on average, 2.3 percent (SD = 21.97) more than those in the no-goal condition. The results suggest that consumers with a goal-setting functionality save more energy than consumers who do not have that functionality at their disposal. Thus, hypothesis 1 is supported.

We continued with a one-factor between-subjects ANOVA to compare the effect of default goal level on goal choice in the low-default goal ($G^+D^+_0$), medium-default goal ($G^+D^+_{15}$), and high-default goal ($G^+D^+_{30}$) groups with the goal and no-default group (G^+D^-). We found that default goal level has a significant effect on goal choice ($F(3, 860) = 44.47$, $p < .01$). Consumers in group G^+D^{+0} chose, on average, a goal of 4.30 percent (SD = 5.81); consumers in the medium-default group $G^+D^+_{15}$ chose an average goal of 12.31 percent (SD = 6.85); consumers in the high-default group $G^+D^+_{30}$ chose an average goal of 19.13 percent (SD = 11.08). A *post hoc* test using Tukey HSD showed that the three default goal levels differed significantly with regard to goal choice. The results suggest that defaults affect goal choice in that higher default goal levels lead to higher goal choice. Therefore, hypothesis 2a is supported. However, only the mean score for the participants in the low-default goal condition was significantly different from the scores of those in the goal and no-default condition (M = 15.74, SD = 24.71). The medium-default and the high-default goal conditions did not significantly differ from the goal and no-default condition (see Figure 3). The results suggest that if the default goals are set too low, then they lead to a goal choice lower than that induced by the self-set goal condition. Therefore, we can confirm hypothesis 2b.

To examine the effect of default goal level on energy savings, we compared the low-default goal ($G^+D^+_0$), medium-default goal ($G^+D^+_{15}$), and high-default goal ($G^+D^+_{30}$) groups with the goal and no-default (G^+D^-) group and with the no-goal (G^-D^-) group. The results of the one-factor between-subjects ANOVA showed that default goal level has a significant effect on energy savings ($F(4, 1786) = 4.07$, $p < .01$). The consumers in group $G^+D^+_0$, group $G^+D^+_{15}$, group $G^+D^+_{30}$, and group G^+D^- saved, on average, 0.76 percent (SD = 23.36), 4.02 percent (SD = 19.53), 0.001 percent (SD = 24.83), and 4.18 percent (SD = 19.78) more than the consumers in group G^-D^-, respectively. *Post hoc* comparisons using Tukey HSD revealed that the consumers in groups $G^+D^+_{15}$ and G^+D^- saved significantly more energy than the consumers in group G^-D^-, whereas the consumers in groups $G^+D^+_0$ and $G^+D^+_{30}$ did not (see Figure 4). The results suggest that only medium-level default goals lead to significant savings. In addition, it seems that when the default goals are set lower or higher than the consumers' preferences in the form of self-set goals, they are not superior to the no-goal condition, in contrast to the self-set goals. Thus, the results support hypotheses 3 and 4.

After investigating basic effects, we continued with our assumption that the effect of default goals on energy savings was mediated by goal choice. For this purpose, we tested a nonlinear mediation model, as depicted in Figure 5. Based on our findings that supported hypothesis 2, we modeled the effect of default goals (X) on goal setting (M) as a positive linear relationship (path a). In accordance with goal-setting theory, we modeled the effect of goal setting (M) on energy savings (Y) as curvilinear (path b), with the medium-level goals leading to a stronger effect than the low and extremely ambitious goals. Following the findings from hypothesis 4, we assume that the direct effect of X on Y is curvilinear as well (path c'). Because the independent variable X has equal intervals and even a true zero, we regard X to be an interval-scaled variable.

We used bootstrapping to test the mediation model. As an alternative approach to Baron and Kenny's (1986) mediation tests, bootstrapping allows one to account for nonlinear causal relationships (Hayes and Preacher 2010). Moreover, the nonparametric test does not require the normality of the sampling distribution (Hayes 2009) and has been shown to perform better in terms of statistical power and Type I errors in small- to moderate-sized samples (Fritz and MacKinnon 2007). In this study, we used Hayes and Preacher's (2010) SPSS macro "MEDCURVE" to analyze 5,000 bootstrap resamples. As shown in Table 6, the default goal level had a significant and positive direct effect (path a) on the goal choice ($a = 0.4962$, $p < .01$). The direction of the effect is consistent with hypothesis 2. With respect to the effect of goal setting on

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[2] In the remainder of this section, the use of the term *significant* always refers to statistical significance.

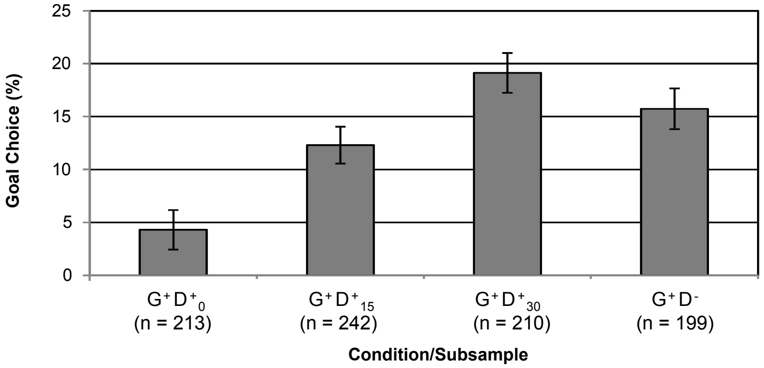

Figure 3. The Effect of Default Goal Level on Goal Choice Compared with Self-Set Goals in the Goal and No-Default Condition (error bars indicate 95% confidence intervals)

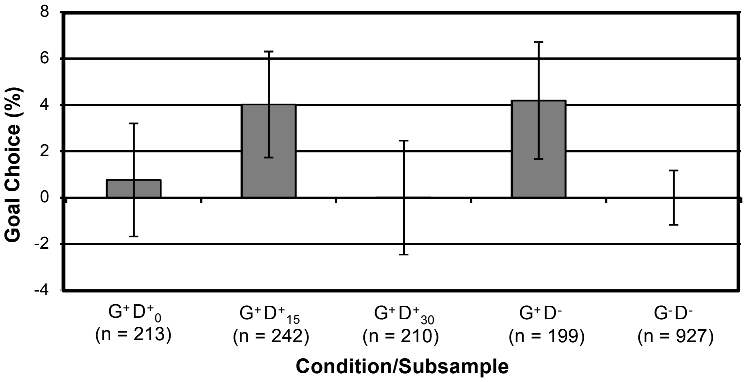

Figure 4. The Effect of Default Goal Level on Energy Savings Compared with the Goal and No-Default and No-Goal Conditions (error bars indicate 95% confidence intervals)

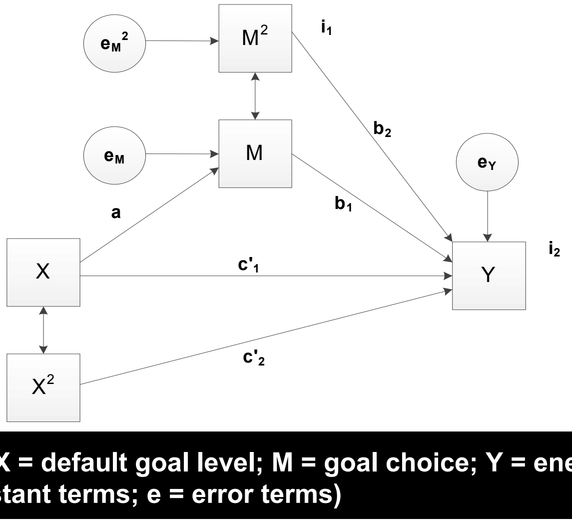

Figure 5. Mediation Model (X = default goal level; M = goal choice; Y = energy savings; a, b_1, b_2, c'_1, c'_2 = path coefficients; i_1, i_2 = constant terms; e = error terms)

Table 6. Direct Effects and Total Effect of Default Goal Level on Energy Savings

Path	Coeff	SE	P
Mediated Model			
a	0.4962	0.0265	.0000
b_1	0.6926	0.2186	.0016
b_2	-0.0069	0.0048	.1498
c'_1	0.0813	0.2716	.7648
c'_1	-0.0118	0.0082	.1524
i_1	4.4728	0.5068	.0000
i_2	-1.7039	1.6931	.3146
Unmediated model			
c_1	0.2371	0.2529	.0775
c_2	-0.2638	0.0081	.0495
i_{2u}	0.8873	1.5478	.5667

Table 7. Bias-Corrected Bootstrap Confidence Intervals for the Instantaneous Indirect Effect of Default Goal Level on Energy Savings

Default Goal	θ	95% CI
0%	0.3132	0.0630, 0.5830
15%	0.2624	0.1129, 0.4383
30%	0.2117	0.0852, 0.3650

energy savings (b paths), the coefficient of the linear term is positive and significant ($b_1 = 0.6926$, $p < .01$), whereas the coefficient of the quadratic term is negative and not significant ($b_2 = -0.0069$, $p = .15$). These findings lead to the following regression equation:

$$Y(x) = 2.7689 + 0.0813\,X - 0.0118\,X^2 + 0.6926\,M - 0.0069\,M^2$$

In a mediation model with nonlinear relationships, the instantaneous indirect effect of X on Y is the product of the first partial derivative of function M with respect to X and the first derivative of function of Y with respect to M. With $M(X) = i_1 + aX$ and $Y(M) = i_2 + b_1M + b_2M^2$, θ becomes

$$\theta(X) = ab_1 + 2ab_2i_1 + 2a^2b_2X = 0.3130 - 0.0034\,X$$

The term indicates that the indirect effect of default goal level on energy savings through goal choice decreases linearly as the goal default level increases. We derive θ for X = 0, X = 15, and X = 30 because these values correspond to the default goal levels in our study and represent the low, medium, and high levels. Table 7 shows the bias-corrected bootstrap confidence interval of the instantaneous indirect effect for 5,000 bootstrap samples. The results show that goal choice is a significant mediator of the relationship between goal default level and energy savings. Therefore, hypothesis 5 is supported.

To test the assumption that feedback on goal attainment moderates the effect of default goals on energy-saving goal choice, we used a two-way repeated measures ANOVA with a Greenhouse Geisser correction, the default goal level as the between-subjects factor, and feedback on goal attainment as the within-subjects factor (before first feedback, after first feedback). The default goal level had a significant main effect on goal choice ($F(2, 661) = 169{,}25$, $p < .01$). We also found that feedback has a significant main effect on goal choice ($F(1, 661) = 179.27$, $p < .01$). As expected, the interaction between the default goal and the feedback was also significant ($F(2, 661) = 32.98$, $p < .01$). *Post hoc* comparisons with Tukey HSD revealed that the consumers in group $G^{+}D^{+}_{0}$ ($M_1 = 4.25$, $SD_1 = 5.78$; $M_2 = 3.15$, $SD_2 = 4.92$), in group $G^{+}D^{+}_{15}$ ($M_1 = 12.31$, $SD_1 = 6.85$; $M_2 = 7.86$, $SD_2 = 5.88$), and in group $G^{+}D^{+}_{30}$ ($M_1 = 19.13$, $SD_1 = 11.08$; $M_2 = 11.23$, $SD_2 = 10.18$) lowered their conservation goals after receiving the first feedback on their goal attainment (see Figure 6). However, only the consumers in the medium and high default conditions significantly adjusted their savings goals downward. The results indicate that feedback on goal attainment moderates the effect of default goals on goal choice. Therefore, hypothesis 6 is supported.

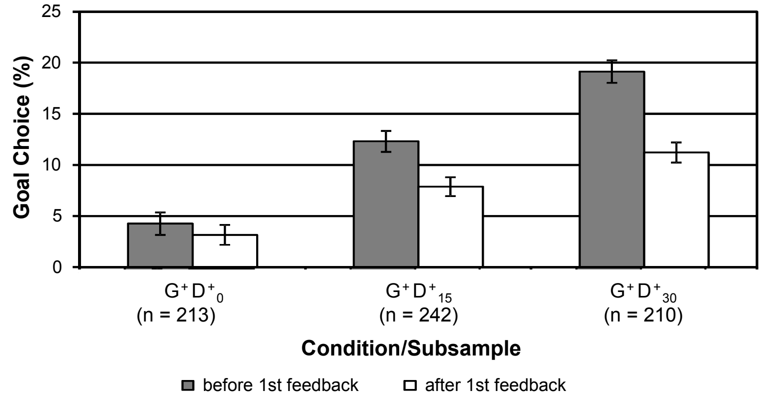

Figure 6. Effects of the Default Goal Level on Goal Choice Before and After Receiving the First Feedback on Goal Attainment (error bars indicate 95% confidence intervals)

Conclusions

The objective of the present study was to investigate the effectiveness of goal-setting functionality and defaults implemented in the user interface of a web-based energy feedback platform. We provided an example of theory-driven design research at the intersection of IT and behavior models from social psychology. Research in this emerging area with the aim of influencing energy conservation behaviors is practically relevant for a number of reasons. Many commercial organizations feel pressure from legal regulations to adopt environmentally sustainable strategies for their products and services (Murugesan 2008). For example, in the European Union, fixed energy consumption targets have compelled the member states to reduce their greenhouse gas emissions, increase their renewable energy use, and reduce their energy consumption (EC 2011). These political targets translate into obligations to achieve energy efficiency for firms (Schiffer 2008), and utility companies in particular, whose profits usually increase with the quantity sold. Some states in the United States (e.g., California and Oregon) recently introduced policies that require utilities to provide cause for and credibly document their reductions in energy consumption (Kushler et al. 2006).

In this context, information systems serve as an enabler for large-scale and cost-effective customer engagement. A far-reaching development that will further increase the potential of IS is currently underway in the utility sector where smart meters are gradually replacing the electromechanical induction watt-hour meters. Smart meters measure consumption data and feed them to a network at intervals from seconds to months. By 2020, due to regulatory requirements, 80 percent of all households in Europe will be equipped with smart meters (Renner and Heinemann 2011). Although widespread diffusion is still some years away, it is important to understand today how smart meter-based interventions may motivate end-consumers to change their behavior. For this purpose, we presented a Green IS implementation designed to encourage electricity consumers to reduce their energy consumption. The results allow us to draw conclusions on how consumption data should be organized and displayed not only with today's technology but also on the basis of future smart metering infrastructures. Specifically, our study has implications for behavioral theory and IS design and could serve as a blueprint for other research endeavors, which we discuss next.

Theoretical Implications

Based on socio-psychological theory, we formulated and tested a number of hypotheses regarding the structural relations between defaults and goals, the impact of defaults and goals on energy reduction, and the moderating role of feedback in a field experiment with 1,791 participants. With regard to the kernel theories underlying our study, the results have implications for the existing literature on goal setting and defaults. First, our results confirm that goal-setting functionality in a web-based energy feedback platform may stimulate a large number of consumers to conserve energy. With regard to the concept of defaults, we could show that defaults may have both positive and negative effects on behavior, not only in the context of individual consumer decisions (e.g., Johnson and Goldstein 2003) but also performance goals that require continual effort. Our data indicate that only medium-level default goals lead to statistically significant savings, whereas detrimental effects on behavior may occur if defaults are set too low or too high in comparison with a self-set goal. For our empirical study, we decided to set the default goal levels at 0 percent, 15 percent, and 30 percent, respectively. Future studies should test different default goal levels to replicate our findings and increase the validity of our results.

In addition, the fact that defaults influence continual behavior suggests that the effect of defaults cannot be merely explained by lazy individuals making a passive choice. Defaults have a normative character that informs consumers of the savings they are likely to achieve. Thus, default goals can induce active consumer behaviors because individuals have to engage in behavioral changes to obtain energy savings. Beyond the basic effect of default goals on actual energy savings, we were also able to uncover the underlying causal relationship. By showing that default goals indirectly affect energy consumption by influencing goal choice, we extend the existing knowledge on the default concept.

Finally, our results show that feedback on goal attainment moderates the effect of default goals on goal choice. Feedback allows one to critically check the appropriateness of the former goal choice and, as a consequence, allows individuals to reduce the discrepancy between their goals and their behaviors by lowering their new goals. It should be noted that in our study, feedback on goal attainment was a within-subjects factor, which means that every participant except individuals in the no-goal condition received feedback on their goal attainment as they chose a goal for the second time. This experimental design implies that feedback was not independent of the mediator goal choice. As a result, we had to restrict our analysis to the first time period before the participants received their feedback on their goal attainment. Future research will be necessary to test a moderated mediation for the full observation period with feedback provided only on energy conservation, not on goal attainment.

Implications for Green IS Design

The results presented in this study show that the savings achievable by goal-setting functionalities are ultimately worth the effort. Notwithstanding the complexity of effectively designing and configuring a feedback system for electricity customers, the savings observed over a large customer group constitute a substantial contribution to sustainable development with respect to cost and emissions. For example, for 10 million households 1 percent additional savings equals 1.2 billion kWh, which translates into about 120 million USD and 800 thousand metric tons of CO_2. The potential impact of this research may grow even further in the future with the diffusion of millions of smart meters, which provide an even better quality of data than the self-read metering data used in the present study. Future energy feedback systems may be implemented in different forms regarding the performance indicators to which goals refer, the number and levels of default goals, the granularity of the measured data (e.g., household versus appliance), and the timeliness, the periodicity, and the level of detail of feedback messages. Our results may support practitioners who are developing such systems by providing a number of well-founded and empirically tested design principles.

A first principle that can be drawn from our study is that goal setting can effectively nudge consumers toward energy conservation beyond one-time decisions. Consequently, practitioners implementing a Green IS should include some type of functionality that allows consumers to define their own goals instead of just providing information about their actual consumption or general energy-saving tips. Second, we showed that defaults influence goal choice and goal attainment. However, the impact of defaults on savings seems to be only on par with self-set goals in the best case and indistinguishable from the no-goal condition in the worst case. Therefore, we recommend that system designers consider defaults either with great care (i.e., if the most effective default goals are already known) or not at all because defaults may counteract the desired effects. If the exact impact of defaults on goal choice is unknown, experiments should be conducted to test and adjust the employed default goals. Third, our research showed that feedback influences goal adjustment. Feedback on saving performance poses the core functionality that consumers expect from any energy feedback system and hence cannot be omitted. However, feedback on unattained goals can easily demotivate or discourage consumers, and the presentation formats of feedback should be designed in a way that best limits this effect. In addition, tailored default goals should be given based on consumers' historical data and household characteristics to avoid frustration after consumers receive initial feedback on their performance.

Opportunities for Future Research

Beyond the immediate insights into the effectiveness of goals, defaults, and feedback, we believe that this paper opens a window to considerably more research opportunities surrounding the application of modern IS to the questions of energy consumption behavior. First and foremost, we argue that the research approach itself—that is, the combination of hypotheses rooted in the behavioral sciences and design-oriented IS research—can serve as a powerful tool to fundamentally extend our understanding of both user behavior within the IS context and consumer choice in general settings. This especially holds true for information systems that grant direct access to fine-grained behavioral data, for example, as smart metering does for electricity, gas, or water consumption. Such systems make it possible to measure the effects of behavioral interventions over time for large number of consumers, in real-world-settings, and with very little interference between measurement activity and measured object. Second, opportunities for future research arises from a large number of interventions that deserve better understanding as they might help to increase the overall effect of feedback systems on energy efficiency. Examples of interventions worth investigating are social normative feedback, competitions, framing, social incentives, and rewards, which could be investigated analogous to the approach we applied to goal setting and defaults in this study. Third, future research could apply longitudinal experimental designs in addition to cross-sectional designs to better understand the short-term and long-term effects of interventions as well as the interplay between multiple behavioral interventions that are sequentially introduced (such as goal setting and feedback in this study). Only with a detailed knowledge on the short-term and long-term effects as well as the interaction of interventions will system designers be able to unleash the full potential of smart metering infrastructures and thus yield a good cost–performance ratio. The behavioral interventions mentioned above hold the potential to influence many habits and decisions in both our corporate and private lives. The application of the knowledge that is to be acquired is hence not limited to electricity consumption but is applicable to other domains as well. In a private context, the acquired knowledge can be used to promote a healthy lifestyle (e.g., like Nike Plus and the corresponding online services); in an organizational context, such knowledge can be applied to promote sustainable car fleet usage (e.g., accounting systems capturing mileage and field consumption) or printer utilization. Not least, additional research issues arise from the consideration of other theoretical frameworks, such as the theory of interpersonal behavior (Schutz 1958), persuasion theory (O'Keefe 2002), or self-discrepancy theory (Higgins 1987), all of which could be applied to change individual behavior in different domains. In sum, we are confident that the IS researchers' strong roots in socio-psychological theory put them in a favorable position to structure problems related to Green IS, to identify feasible solutions, and to guide the subsequent design process of future Green IS.

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MIS Quarterly

SPECIAL ISSUE: IS & ENVIRONMENTAL SUSTAINABILITY

MOTIVATING ENERGY-EFFICIENT BEHAVIOR WITH GREEN IS: AN INVESTIGATION OF GOAL SETTING AND THE ROLE OF DEFAULTS

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Appendix

The Velix System

In the following, we describe Velix, a web-based energy feedback system that motivates its users to reduce their electricity consumption, developed by our group in cooperation with an Austrian utility company. The system provides consumers with feedback on their electricity consumption and combines energy record keeping with game-like tasks that center around environmental sustainability. The utility considers the system an integral part of their energy efficiency endeavors and made the portal available to all of its private customers.

In addition to achieving immediate energy savings, the system was developed to experimentally investigate socio-psychological concepts (e.g., goal setting, social norms, cost projections) that may help to promote eco-friendly behavior. To render related studies possible, the system allows for randomly assigning consumers to different treatment groups (i.e., experimental conditions) and for recording electricity consumption data for each household. It is thus possible to compare the effects of different interventions on energy demand. For the study at hand, we used the portal to test hypotheses regarding the structural relations between defaults and goals, the impact of defaults and goals on energy consumption, and the moderating role of feedback on goal choice.

In order to gather a large user base, the utility company informed their customers via their customer magazine and teamed up with a local media corporation that placed ads in various newspapers and a news website. Moreover, the company gave its customers incentives for using the system in the form of bonus points that can be traded for products in an online shop. Between April 1, 2010, and December 31, 2011, a total of 10,700 consumers registered with Velix.

The sequence of user interactions on the web portal is structured as depicted in Figure B1. After registration, consumers can participate in the “meter hunt,” a game-like instruction on how to find the electricity meter and interpret its reading. Participants who already know where to find their meter can directly enter the reading in the portal. Next, consumers are asked to voluntarily set a reminder to foster repeated system

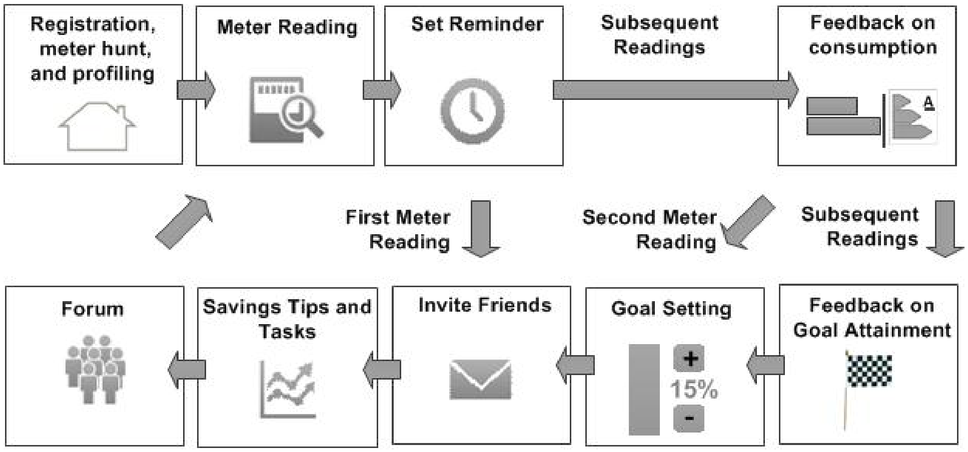


Figure B1. Experience Chain in Velix

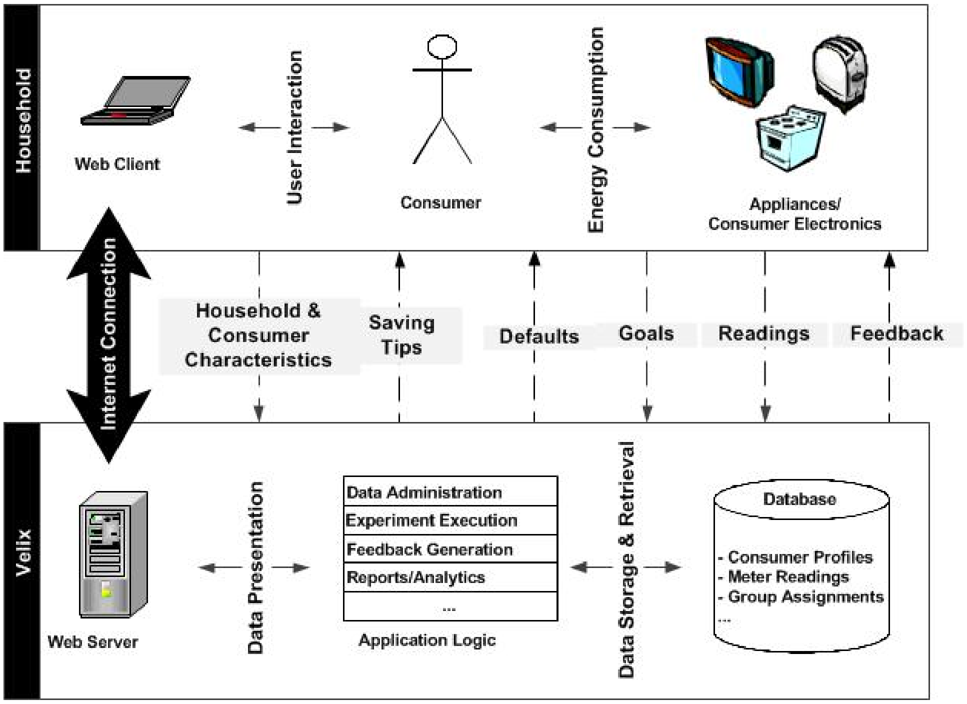


Figure B2. System Architecture and Data Flows

usage, either in the form of an e-mail or a text message sent to their mobile phone at intervals and times as selected by the users. Since it is not possible to determine household consumption with only one meter reading, several subsequent functionalities of the portal, such as neighborhood comparison, efficiency check, goal setting, and feedback on goal attainment are not enabled at the time of the first login but only briefly explained as an outlook to the next visit. However, during the first visit, consumers can invite other potential participants, receive savings advice, and read or write comments in a moderated forum. Following a subsequent meter entry at least one week after the first data input and after the completion of the household profile, consumers receive feedback on their performance. To provide tailored information for each consumer, the household profile includes data on the number of inhabitants, the size of the apartment or house, the type of space and water heating system, the number of household appliances, and the address/location of the residence. Figure B2 presents an overview of the system's architecture and the resulting data flows.

Consumers enter meter readings for day & night consumption

ZÄHLERSTAND EINGABE

HT/I 7853 , 0

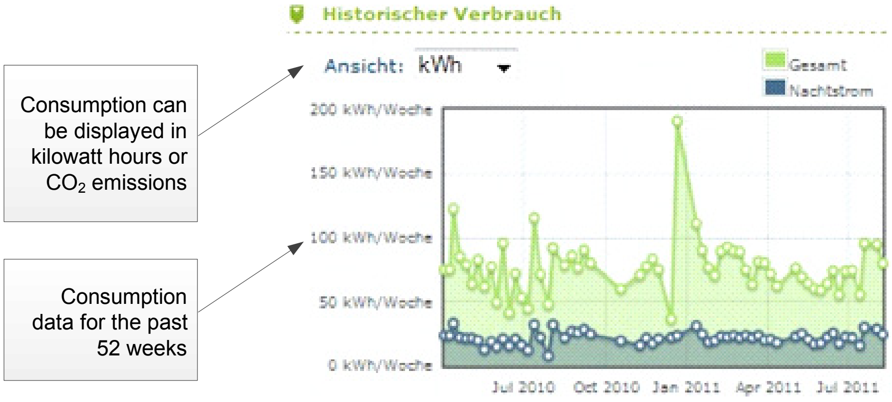
NT/II 45109 , 0

Datum 08.08.2011

Uhrzeit 07:37

Each data entry is associated with a timestamp

Figure B3. Data Entry Form for Meter Readings



Consumption can be displayed in kilowatt hours or CO_2 emissions

Consumption data for the past 52 weeks

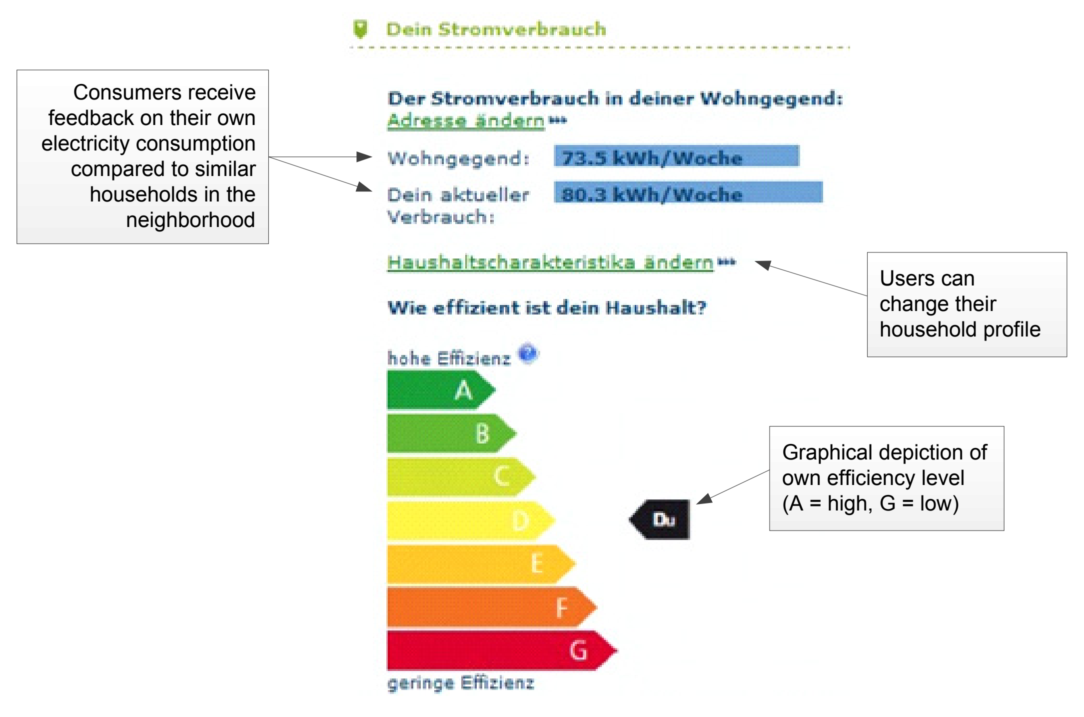
Figure B4. Graphical Depiction of Consumption History (Total and Night Only)

For the present study, every consumer was randomly assigned to different goal setting conditions upon registration. As described in the article, our study design distinguishes among three different categories of consumers: no-goal subjects (G^-D^-), goal and no-default subjects (G^+D^-), and goal and default subjects (G^+D^+). The first two groups represent our two control groups. We further divide treatment group G^+D^+ into three subgroups to compare the effects of low-, medium-, and high-level default goals on energy-saving goal choice and actual energy savings. Based on the assignment, the system provides each consumer with a different goal-setting functionality. The consumer is provided with feedback on goal attainment as soon as he or she enters the next meter reading. The time lapse between goal choice and feedback is at least one week. After having received feedback, the consumer could set a new goal. The consumer always remained in the same experimental condition throughout the study. In the following, we provide details on the most prominent Velix features including the goal-setting functionalities from the consumer's perspective.

As mentioned earlier, Velix currently depends on manual data collection by its users since no widespread smart metering infrastructure was available that allowed for conducting experiments with different treatment groups when the portal was launched in 2010. Meter readings may be entered at any time, as depicted in Figure B3. The website stores consumption data separately for day and night consumption at the household level. To motivate consumers to periodically enter their data, the system can be configured to send automatic reminders via e-mail or SMS. Between April 1, 2010, and December 31, 2011, consumers entered 319,169 meter readings. Checks to ensure the validity of the transferred meter readings are outlined in the article. In the long run, the portal may easily be extended by a smart metering interface without having to change any of the higher-level functionality and without qualifying the statement made in the study at hand.

Users can retrieve the historical data in the form of a table that depicts all of their meter readings entered in the past 12 months. In addition, the user may request a graphical depiction of his or her consumption history over time (see Figure B4).

Beyond the quantitative notation, Velix provides feedback on consumption efficiency in two ways (see Figure B5). On the one hand, the portal contrasts the weekly electricity consumption of each household with the corresponding average in the consumer's neighborhood. On the other hand, the consumer's current efficiency level is indicated using a scale from "A" (high efficiency) to "G" (low efficiency). To determine said efficiency level, the system takes household characteristics and electricity consumption into account. Household characteristics are collected during registration with the website when the consumer is asked to create a household profile. This profile includes the type of building, the total size of the house/apartment, the number of people living in the household, the number of appliances, and the type of heating. The calculations were reviewed and validated by the partner utility.



Consumers receive feedback on their own electricity consumption compared to similar households in the neighborhood

Dein Stromverbrauch

Der Stromverbrauch in deiner Wohngegend:

Adresse ändern

Wohngegend: 73.5 kWh/Woche

Dein aktueller Verbrauch: 80.3 kWh/Woche

Haushaltscharakteristika ändern

Users can change their household profile

Wie effizient ist dein Haushalt?

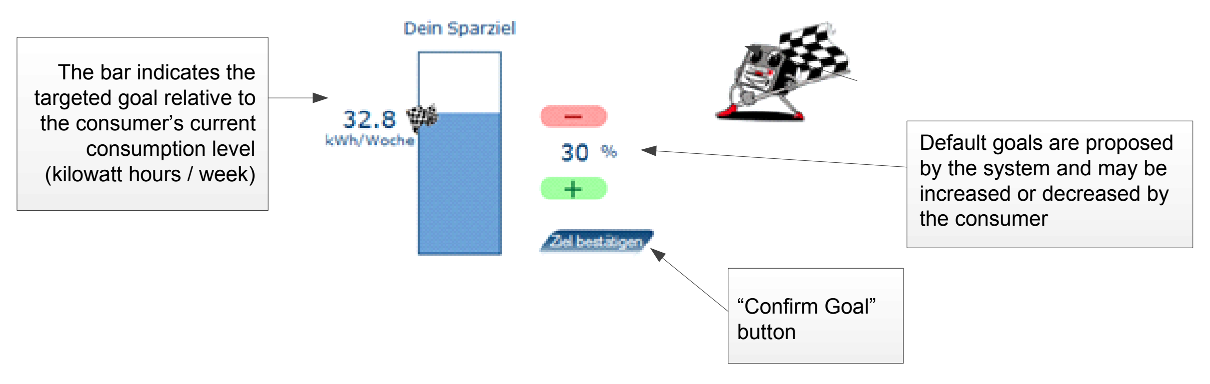
hohe Effizienz

geringe Effizienz

Graphical depiction of own efficiency level (A = high, G = low)

Figure B5. Feedback on Consumption Efficiency

The goal setting functionality included a bar graph of each participant's average consumption level in kilowatt hours. For the G^+D^+ group, we presented their default goals (0%, 15%, or 30%) next to the bar graph. The consumers could modify their conservation goals with the help of two buttons for increasing and decreasing the value. The participants had to push a button to set the goal (see Figure B6). As a result, the bar graph indicates the target consumption level. In the G^+D^- group, no reference point was provided, that is, the consumer had to enter his or her conservation goal into an empty text box (see Figure B7). Regardless of the condition, the consumers could choose a conservation goal between 0 percent and 100 percent. By contrast, the G^-D^- group did not have a goal-setting functionality.



The bar indicates the targeted goal relative to the consumer's current consumption level (kilowatt hours / week)

Dein Sparziel

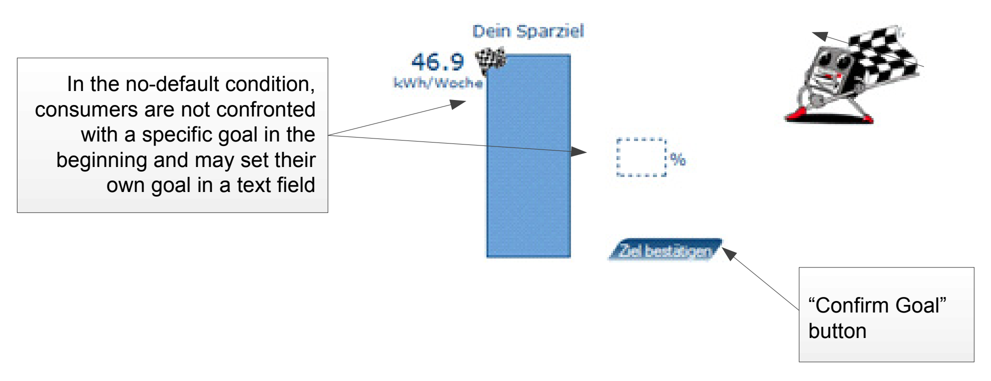
32.8 kWh/Woche

30 %

Default goals are proposed by the system and may be increased or decreased by the consumer

"Confirm Goal" button

Figure B6. Goal-Setting Functionality with Default Goals



In the no-default condition, consumers are not confronted with a specific goal in the beginning and may set their own goal in a text field

“Confirm Goal” button

Figure B7. Goal-Setting Functionality in the No-Default Condition