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Motivating Sustainable Resource Consumption Through the Design of Goal Setting in Smart Meter User Interfaces

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MOTIVATING SUSTAINABLE RESOURCE CONSUMPTION THROUGH THE DESIGN OF GOAL SETTING IN SMART METER USER INTERFACES

Research Paper

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Abstract

Smart meter user interfaces can be designed to promote sustainable resource consumption by individuals. Although goal setting is a promising artifact for smart meter user interfaces, it is still unclear how goal-related design features (DFs) should be designed to be particularly effective in motivating individuals. Drawing on goal-framing theory and employing a design science research approach, we designed and evaluated different design options for four goal-related DFs (i.e., consumption display, evaluative standard, goal incentive, reference group) in the context of households' energy consumption in three design-evaluation cycles. Our results suggest that while one design option for consumption displays and evaluative standards is better suited than others to motivate sustainable behavior, the effects of goal incentives and a goal's reference group depend on individuals' personal preference for either collaboration or competition. Our study contributes to information systems research with novel insights on goal-related DFs and how they affect sustainable resource consumption.

Keywords: Goal Setting, Green IS, Goal-Framing Theory, Design Science Research.

1 Introduction

Individuals are generally struggling when it comes to assessing their behaviors' environmental impact (auf der Landwehr et al., 2021). This is concerning, given that households account for about 25% of the global energy consumption (Eurostat, 2021). To support household members in reducing their energy consumption and thus, to contribute to the attainment of the United Nation's sustainable development goals, Green information systems (IS) research investigates how the design, implementation, and impact of technologies assist sustainable resource consumption (e.g., Henkel and Kranz, 2018, Malhotra et al., 2013). Specifically, as technology and behavior are inextricably linked, Green IS research investigates socio-technical artifacts and their impact on sustainable behaviors (Hevner et al., 2004, Gregor and Hevner, 2013): With the increasing installation of smart meters that regularly track and transmit resource consumption data, new opportunities are opening up to provide individuals with information about their resource consumption through smart meter user interfaces (UI) (e.g., Karlin et al., 2015, Wunderlich et al., 2019). By going beyond simply providing information, smart meter UI aim for digital user engagement to encourage reduced resource consumption in a gamified way (e.g., Cominola et al., 2021, Tiefenbeck et al., 2018, Mack et al., 2019).

A promising artifact for smart meter UI is goal setting, as goals and feedback on goal achievement motivate individuals and regulate their actions (e.g., Locke and Latham, 2006, Harkin et al., 2016). To tap this potential, smart meter UI can provide individuals the possibility to set themselves a goal for their future resource consumption. Previous Green IS research has shown that setting a goal can be an effective means for promoting sustainable behaviors (e.g., Loock et al., 2013, Wendt et al., 2021). This is further backed by decades of environmental psychology research that investigated how setting a goal for one's resource consumption affects individuals' future consumption behavior (see e.g., Karlin et al., 2015, Abrahamse et al., 2005 for an overview).

However, within both research streams, studies report widely varying results, with the induced reduction in resource consumption ranging from 2% to up to 30% (e.g., Loock et al., 2013, Abrahamse et al., 2007, Karlin et al., 2015). Apart from differences in terms of study design and duration, often cited reasons for these wide variations are (1) deficiencies in the actual goal design and (2) a lacking integration of psychological theories into the analyses (van Dam et al., 2010, Abrahamse et al., 2005, Karlin et al., 2015). Our study aims to address both of these critiques to provide a more nuanced understanding of the effectiveness of goal setting as a design artifact for smart meter UI.

With regard to the actual goal design, most previous studies incorporated several artifacts (i.e., goal as well as non-goal-related) within a single treatment, reporting only one overall effect (Abrahamse et al., 2005, Karlin et al., 2015). Moreover, even in studies that focused specifically on goal setting, a variety of goal-related design features (DFs) were included, such as differently designed consumption displays (Loock et al., 2011), reference groups (e.g., individual or group goals) (Abrahamse et al., 2007) or goal incentives (e.g., competition or monetary incentives) (Graham et al., 2011, Yim, 2011). In addition, most studies applied a one-size-fits-all approach that did not classify users based on characteristics (Abrahamse et al., 2005, Karlin et al., 2015) even though "the characteristics of users and their needs and expectations influence their preferences for a specific type" of smart meter UI design (van Dam et al., 2010, p. 91). The resulting variability of previous study designs and results does not allow for a conclusive assessment of the effectiveness of goal setting and makes it difficult to draw conclusions for the design of goal setting as an artifact for smart meter UI and goal-related DFs.

Hence, to better understand what goal-related DFs are particularly suited for smart meter UI to engage individuals in sustainable behaviors, we investigate the following research question:

What are design recommendations for goal-related DFs to effectively motivate sustainable resource consumption?

To address our research question and to derive design recommendations for goal-related DFs, we employed a design science research (DSR) approach (e.g., Kuechler and Vaishnavi, 2008, Hevner et al., 2004). We followed the design research cycle proposed by Kuechler and Vaishnavi (2008) from the awareness of a problem, to suggestions for and development of DFs, to their evaluation, and drawing conclusions. As kernel theory that advises directions for a design solution in DSR (Kuechler and Vaishnavi, 2008), our study adopts goal framing theory (GFT) to design and evaluate goal-related DFs. GFT is a promising lens to understand the effects of different goal-related DFs on sustainable behaviors. It postulates "that goals 'frame' the way people process information and act upon it" (Lindenberg and Steg, 2007, p. 117) and therefore determine how an individual looks at a given situation. GFT distinguishes three goals: hedonic goals (e.g., to feel better right now), gain goals (e.g., to increase one's financial resources), and normative goals (e.g., to act appropriately) (Lindenberg and Steg, 2007, Lindenberg and Steg, 2013). These goals can be activated individually or simultaneously by external cues (e.g., DFs), with one goal being focal in attention (i.e., the goal frame) and most likely to influence one's behavior (Lindenberg and Steg, 2007). In the context of sustainable behaviors, the normative goal frame is particularly effective, yet, not easy to be maintained in the cognitive foreground (Seidler et al., 2020, Lindenberg and Steg, 2007). Thus, when evaluating goal-related DFs for smart meter UI, it is essential to understand what DFs strengthen an individual's normative goal frame as well as what DFs increase compatibility between potentially coexisting gain and hedonic goals and the focal normative goal frame (Lindenberg and Steg, 2007).

Via three design-evaluation cycles, we developed, tested, and refined different design options of four goal-related DFs (i.e., consumption display, evaluative standard, goal incentive, and reference group) and evaluated their impact on individuals' goal frames and thus on individuals' motivation to reduce their resource consumption. Our results show that there is one design option for the DFs *consumption display* and *evaluative standard* each that is better suited than alternative design options to motivate individuals' sustainable behavior. Interestingly, with regard to *goal incentives* and a goal's *reference* *group*, it depends on an individual’s personal preference for either collaboration or competition which design option is most suitable.

With our study, we contribute to IS research and practice in several ways. First, by designing and evaluating four goal-related DFs, our results provide design recommendations for each DF and contribute to an improved understanding of how these DFs impact the effectiveness of goal setting as a design artifact for smart meter UI. Moreover, by employing a DSR approach and using GFT as kernel theory, we derive design knowledge that allows for improving goal setting as a design artifact with regard to its effectiveness, comprehensiveness, and reproducibility. In addition, our results reveal practical implications for providers and designers of smart meter UI and offer recommendations on how to design and evaluate goal-related DFs to effectively motivate users’ sustainable behaviors.

2 Theoretical Background

2.1 Goal-Framing Theory

GFT has been introduced by Lindenberg and Steg (2007) and posits that goals govern (i.e., “frame”) an individual’s attention and as such are decisive for what information becomes cognitively most accessible (Lindenberg and Steg, 2007). In the context of sustainable behavior, three overarching goals have been identified: hedonic, gain, and normative (Lindenberg, 2001, Lindenberg and Steg, 2013). Hedonic goals refer to improving one’s feelings and therefore to the satisfaction of the most basic human needs, which makes them very likely to be a priori the strongest goal frame, albeit with a comparably short-term time horizon (Lindenberg and Steg, 2007, Lindenberg and Steg, 2013). Gain goals focus on improving, guarding, and efficiently using one’s resources, such as money, time, or social status (Lindenberg and Steg, 2007). The gain goal frame implies prospective behavior and strategic planning and has a middle to long term time horizon (Lindenberg and Steg, 2013). Normative goals make individuals sensitive to what they think one ought to do to act appropriately according to self or others and usually require external support (e.g., from institutions, moralization, or explicit disapproval for not following norms). Normative goal frames have a long term time horizon and are particularly suited to induce behaviors that are required to create collective goods (Lindenberg and Steg, 2007, Lindenberg and Steg, 2013).

According to Lindenberg and Steg (2007), multiple goals can be active simultaneously, with one of them being focal in attention and most influential for an individual’s behavior. The remaining goals stay in the background, may or may not be compatible with the focal goal frame and thus impact its strength.

2.2 Goal-Framing Theory in the Context of Sustainable Behaviors

Previous research showed that the hedonic, gain, and normative goal frame are not equally well suited to motivate sustainable behaviors (e.g., Lindenberg and Steg, 2013, Seidler et al., 2020): The hedonic goal frame is least likely to induce sustainable behaviors as pro-environmental behaviors, such as taking public transportation instead of a car or reducing time in the hot shower, are not associated with pleasure for most people. Gain goals can be compatible with sustainable behaviors as less resource consumption can be accompanied by a decrease in costs. Yet, there are also situations where sustainable behaviors reduce one’s resources, for example taking public transportation may be more time-consuming or expensive than taking the car. Normative goals, on the other hand, are generally well suited to elicit sustainable behaviors as an intact environment is a collective good (Lindenberg and Steg, 2007, Lindenberg and Steg, 2013). However, individuals who engage in sustainable behaviors often have to act against their egoistic values (Lindenberg and Steg, 2013, Karlin et al., 2015). Thus, normative goals may be pushed into the cognitive background as they are weaker than self-interest (i.e., hedonic or gain) goals (Lindenberg and Steg, 2007).

As a response, previous research suggests two approaches to promote sustainable behaviors: Firstly, the normative goal frame can be strengthened by providing supporting normative information as an anchor for normative expectations (Koo and Chung, 2014, Lindenberg and Steg, 2007). Secondly, as several goals are usually competing for one’s attention, compatibility between normative goals on the one hand and gain and hedonic goals on the other should be ensured (Lindenberg and Steg, 2007, Seidler et al., 2020). Specifically, each goal can be triggered by external cues to make it focal, increase its salience, and thus its influence on individuals' motivation (Lindenberg and Steg, 2013). This approach has been applied by Seidler et al. (2020) who investigated how various gamification stimuli (e.g., point systems, performance feedback) affect an individual's goal frames in order to foreground the normative goal frame and to background hedonic and gain goals. In the context of goal setting, we expect goal-related DFs to activate one or even several goal frames. For example, incorporating normative elements (e.g., one's performance relative to others) into the goal-design likely impacts the normative goal frame. At the same time, the act of setting a goal itself may trigger positive or negative feelings (i.e., the hedonic goal frame) depending on an individual's competitiveness or other user characteristics and preferences (van Dam et al., 2010). As such, we consider GFT to be a well-suited kernel theory to advice the design of goal-related DFs (Gregor and Hevner, 2013).

3 Research Approach and Methodology

3.1 General Design Science Research Approach

In order to develop, test, and refine different goal-related DFs for smart meter UI and to evaluate their impact on an individual's motivation for sustainable behavior, we applied a DSR approach, which has become a well-accepted approach within IS research in recent years (e.g., Peffers et al., 2018, Hevner et al., 2019, Kuechler and Vaishnavi, 2008). DSR develops and evaluates new and practical artifacts with the intention to solve real-world problems that are of interest to practice and impact individual, organizational, or societal stakeholders (Peffers et al., 2018, Kuechler and Vaishnavi, 2008, Österle et al., 2011). For instance, DSR has been successfully applied to evolve design principles for IS that support sensemaking in sustainable transformations (Seidel et al., 2018), to develop a gamified app that encourages sustainable workplace behaviors (Oppong-Tawiah et al., 2020), or to develop IS that promote habit formation (Chung et al., 2021).

We followed the design research cycle proposed by Kuechler and Vaishnavi (2008), which is consistent with previous DSR literature (e.g., Hevner et al., 2004, Peffers et al., 2007) and provides a structured process for conducting rigorous design research. The cycle comprises five iterative process steps, each taken by a DSR action and determined by a corresponding outcome. The process steps are depicted in Figure 1 and structure the remainder of the paper: The first step, *awareness of the problem*, has been part of the previous sections which motivated our research question based on insights from prior research and introduced GFT as kernel theory. In the second step, *suggestion*, design requirements (DRs) and initial design principles (DPs) are derived based on theoretical conceptualizations. The third step, *development*, builds on these DRs and DPs and translates them into specific goal-related DFs of our instantiated artifact (i.e., goal setting). The goal-related DFs are designed and iteratively refined during the *evaluation* stage to derive design recommendations for each DF. The DSR process is completed with the *conclusion* by discussing the findings and providing implications for theory and practice. (Kuechler and Vaishnavi, 2008)

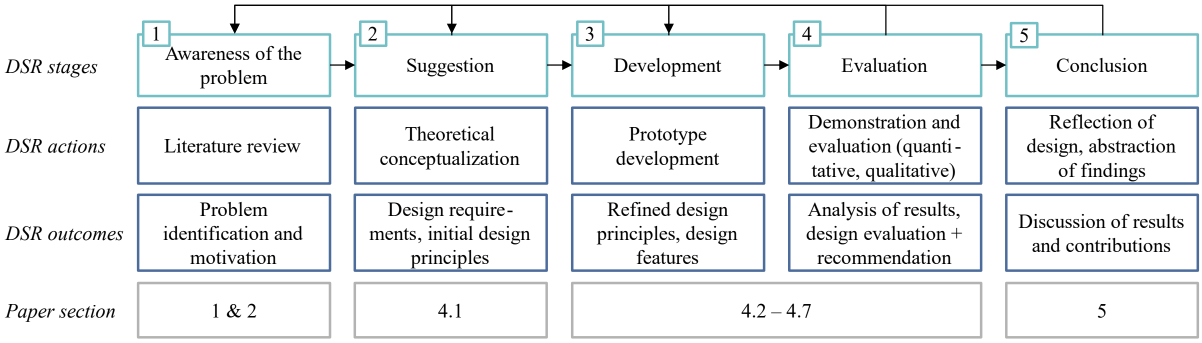

Figure 1. Design Science Research (DSR) design (adapted from Kuechler and Vaishnavi, 2008).

3.2 Methodology for Development and Evaluation of Design Features

The *development* phase follows on from the suggestion phase of the DSR process, which explores various approaches to address an issue based on prior research and develops generally defined DRs and DPs (Kuechler and Vaishnavi, 2008). DRs and DPs convey design knowledge beyond the mere instantiation of use case specific artifacts, but cannot be directly implemented as they describe a generic approach to a class of problems (Markus et al., 2002, Baskerville and Pries-Heje, 2010). Therefore, in the development phase, these directions for design are made concrete, leading to the development of artifacts, which are broadly defined as constructs, models or instantiations (i.e., implemented and prototype systems) (Vaishnavi and Kuechler, 2007, Hevner et al., 2004). In our study, the artifact in focus is goal setting and instantiations in the form of specific goal-related DFs are developed, that are implemented in a prototypical smart meter UI which is then demonstrated to potential users. Thus, by following the DSR process from suggestion to development, artifacts are not exempt from theories, but apply and test theories as well as extend them through experience and problem-solving approaches (Markus et al., 2002, Hevner et al., 2004).

The *evaluation* phase aims to receive feedback information on design options for each DF and its functionality, usability, and quality, but also to better understand the problem itself and hence to improve the solution and the design process (Hevner et al., 2004, Gregor and Hevner, 2013). According to Hevner et al. (2004), several evaluation methods exist, including observational (e.g., field studies), analytical (e.g., dynamic analysis, optimization), experimental (e.g., controlled experiment), as well as empirical and qualitative methods. The evaluation usually takes place in iterative design-evaluation cycles (Hevner et al., 2004) and can also comprise more than one evaluation method, for instance an experimental set-up combined with qualitative think-aloud approaches (Kuechler and Vaishnavi, 2008) or quantitative usage data combined with insights from focus group interviews (Seidel et al., 2018).

For the evaluation of the design options of our DFs, we opted for such a combination of quantitative and qualitative methods and built on findings from a previously conducted lab-in-the-field experiment (Wendt et al., 2021) for the first cycle, followed by semi-structured interviews during the second and third iteration of the design-evaluation cycle. Experiments are a common evaluation method for DFs that deal with an interaction between individuals and the DF itself (Kuechler and Vaishnavi, 2008). We opted for an online lab-in-the-field experiment which “leverage[s] the subjects’ real-world settings for the context to increase external validity and realism” (Karahanna et al., 2018, p. iv) and which is suitable to investigate actual behaviors. The quantitative analysis of the experimental data provided insights into the effectiveness of specific design options for goal-related DFs but did not allow for sufficient exploration of the underlying “why”. To that end, previous DSR studies demonstrated the added value of qualitative research in addition to quantitative results from an experimental set-up (Kuechler and Vaishnavi, 2008, Seidel et al., 2018). Therefore, we conducted two rounds of interviews which allowed us to better understand why certain design options of goal-related DFs are better suited than others to motivate sustainable behaviors, and to test and reiterate them accordingly.

4 Design Science Research Iterations and Outcomes

The objective of this study is the development and evaluation of goal-related DFs that represent previously identified DRs and DPs for the chosen class of IS (Sein et al., 2011), which is a smart meter UI that motivates individuals to reduce their resource consumption. Smart meter UI are designed to provide individuals with transparency about their household’s resource consumption (e.g., water, electricity, heating energy) by aggregating and visualizing data that is regularly provided by smart meters which are attached to the household’s appliances (e.g., Loock et al., 2011, Tiefenbeck et al., 2019). Although the potential of goal setting as a lever to promote reduced resource consumption is acknowledged, reviewing previous literature has shown that there is still an insufficient understanding of how goal-related DFs should be designed to effectively motivate sustainable resource consumption, with investigated goal-designs inducing a reduction in resource consumption that ranges from 2% to up to 30% (e.g., Loock et al., 2013, Abrahamse et al., 2007, Karlin et al., 2015). Thus, the DRs and DPs as well as the designed and tested goal-related DFs that are described in the following sections, aim to improve goal setting as an artifact for smart meter UI that can be offered to households to effectively motivate reduced resource consumption.

4.1 Suggestion: Design Requirements and Tentative Design Principles

The first step of the DSR approach not only raised our awareness of the problem underlying our research question but also pointed us to GFT as kernel theory that describes and explains how an individual's behavior is affected by various, potentially competing, goals. Previous research already put GFT in the context of sustainable behaviors (see chapter 2.2), which provides initial directions for solutions to our design research problem and the derivation of corresponding DRs and DPs: strengthening the normative goal frame and aligning the hedonic and gain goal with the normative goal frame. Figure 2 depicts the DRs and DPs that have been identified during the suggestion stage as well as the corresponding DFs that will be introduced in the development cycles (chapter 4.2, 4.4, and 4.6).

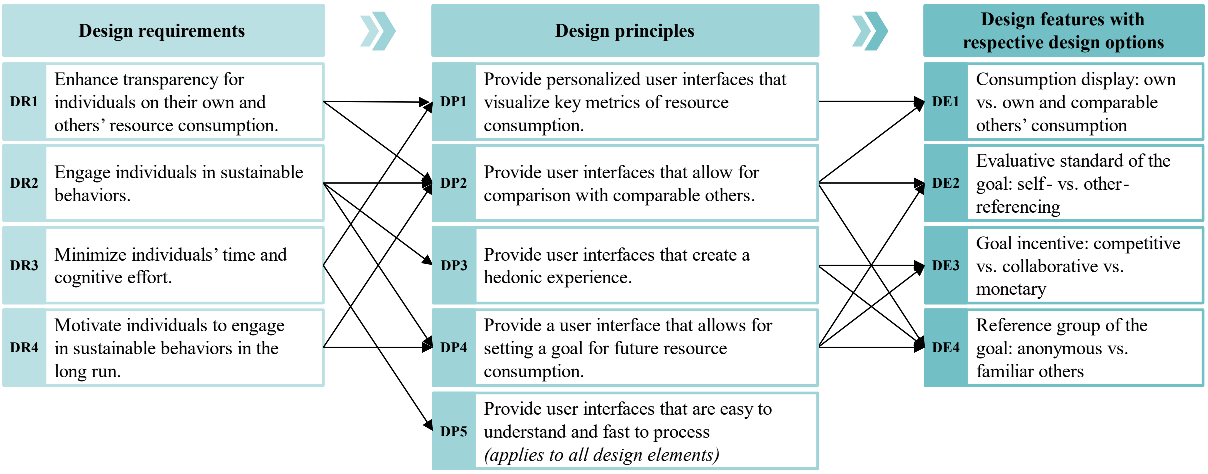

Figure 2. Summary of design requirements, design principles and design features with their respective design options.

4.1.1 Strengthening the Normative Goal Frame

According to Lindenberg and Steg (2007), several factors influence whether individuals act in accordance with their norms, including an adequate environmental knowledge (e.g., consciousness of environmental problems) and sufficient awareness of the environmental impact of one's own behavior. While the former is rather fostered by information provided by the media or energy suppliers, the latter can be addressed by the DFs of a smart meter UI. Accordingly, the first proposed DR is:

DR1: *Enhance transparency for individuals on their own and others' resource consumption.*

A successful measure to realize DR1 is the provision of transparency on one's own or on a group's performance (e.g., Abrahamse et al., 2007, Schultz et al., 2007, Loock et al., 2011). Self-monitoring enables individuals to form a stronger association with the own influence on the environment and therefore, is more likely to be influential (Shevchuk et al., 2019, Loock et al., 2013). Moreover, feedback that incorporates group performance, activates normative thoughts as it "triggers comparisons between the own performance and the performance of others (social norms)" (Lindenberg and Steg, 2007, p. 130). Thus, two DPs can be derived from DR1:

DP1: *Provide personalized user interfaces that visualize key metrics of resource consumption.*

DP2: *Provide user interfaces that allow for comparison with comparable others.*

Once individuals are aware of their resource consumption, the smart meter UI should create a sense of oughtness that encourages individuals to reflect on how they can improve their behaviors' environmental impact (Lindenberg and Steg, 2013). As such, our second DR is:

DR2: *Engage individuals in sustainable behaviors.*

An important means for addressing DR2 and for aiding self-regulated behaviors is providing reliable information on one's own resource consumption compared to others' resource consumption (Lindenberg and Steg, 2013), which is already part of DP2. Additional DPs that facilitate DR2 are related to the hedonic and gain goal frame and part of the subsequent sections.

4.1.2 Aligning Hedonic Goals with the Normative Goal Frame

Individuals are more likely to behave in a sustainable manner when they derive pleasure from it (i.e., hedonic experience) compared to when they are confronted with a moral norm (Lindenberg and Steg, 2007, Pelletier et al., 1998). Accordingly, to address DR2, another DP can be derived:

DP3: *Provide user interfaces that create a hedonic experience.*

However, pro-environmental behaviors are often not particularly joyful. Thus, other means to address DR2 are reducing the impact of hedonic goals that are incompatible with sustainable behaviors or making them compatible (Lindenberg and Steg, 2013, Lindenberg and Steg, 2007). For example, gamification elements such as goal setting and a yielded status from performing better than others can increase the hedonic experience of sustainable behaviors (Seidler et al., 2020, Shevchuk et al., 2019):

DP4: *Provide a user interface that allows for setting a goal for future resource consumption.*

An additional DR, which is closely related to DR2 because it lowers the burden to engage with a smart meter UI and thus, positively impacts the hedonic experience, is DR3:

DR3: *Minimize individuals' time and cognitive effort.*

DR3 is a rather generic DR for user-friendly IS design. Previous research at the intersection of Green IS research and persuasive designs already addressed the DR and derived corresponding DPs within the category of "primary task support", including self-monitoring of performance and personalization of content (see DP1) as well as the reduction of effort to perform the desired behavior (Corbett, 2013), leading to DP5:

DP5: *Provide user interfaces that are easy to understand and fast to process.*

4.1.3 Aligning Gain Goals with the Normative Goal Frame

Given that sustainable behaviors are most impactful when they are performed on a regular basis (i.e., sustainable habits) (e.g., White et al., 2019, Oppong-Tawiah et al., 2020), a fourth DR can be formulated:

DR4: *Motivate individuals to engage in sustainable behaviors in the long run.*

Compared to the rather short-term time horizon of the hedonic goal frame, the gain goal frame implies a more strategic and thus, middle- to long-term time horizon (Lindenberg and Steg, 2013). As such, aligning the gain with the normative goal frame and making sustainable behaviors compatible with the gain goal frame can be a successful means to realize DR4. One way to do so is to build on the increased sensitivity to incentive-related costs or benefits (e.g., with regard to status, money, or time) that can be observed when the gain goal frame is dominant (Lindenberg and Steg, 2007). Such cost interventions are most effective when they are combined with interventions that activate the normative goal frame (Lindenberg and Steg, 2007). Accordingly, benefits of sustainable behaviors with regard to status gains can be triggered by providing transparency on one's resource consumption in direct comparison to others (see DP2). Monetary benefits can also be emphasized by providing the option to set a goal for future resource consumption (see DP4) which may even be accompanied by explicit cues on the associated financial gains in the case of goal achievement (Lindenberg and Steg, 2007).

4.2 Development – Cycle 1: Design Features Based on Design Principles

Building on the suggested DRs and DPs, we started into the first design cycle with our initial DFs and developed a web-interface as a prototypical instantiation of the goal setting artifact. During the first development cycle, the focus was on DP1 and DP2 which were translated into two DFs that both refer to relative performance. We decided not to translate all DPs into DFs at once but to iteratively expand the prototype to reduce complexity and to allow for evaluation of each individual goal-related DF.

DF1, "consumption display", addresses DP1 and thus aims to provide a personalized UI that visualizes key metrics of one's resource consumption. To that end, two design options for such a consumption display can be considered: Either displaying one's own resource consumption only or displaying one's own and comparable others' resource consumption and thereby, one's relative performance. Previous Green IS research already indicated the benefit of the latter option (e.g., Abrahamse et al., 2007, Schultz et al., 2007, Loock et al., 2011), which allows for social comparison and as such, also addresses our second DP (i.e., to allow for comparison with comparable others). Therefore, we designed DF1, the consumption display, in accordance with both, DP1 and DP2, and visualized resource consumption in a simple, two-colored bar chart that showed one's own and comparable other's resource consumption of the previous month.

Since we thus have only one design option for the first DF, we implemented an additional DF for the first evaluation cycle. DF2, "evaluative standard" of the goal, also refers to DP2 as well as to DP4 (i.e., to provide a UI that allows for goal setting) and is designed to enable individuals to set themselves a goal for their future resource consumption. More specifically, under consideration of DP2 (i.e., to allow for comparison with comparable others) there are two design options for the evaluative standard of such a self-set goal: It can either be *self-referencing* (e.g., "I want to consume 10% *less than I did* last year") without any direct link to one's relative performance, or *other-referencing* (e.g., "I want to consume 10*% less than other households* do") which incorporates one's relative performance (e.g., Elliot et al., 2011, Harkin et al., 2016). For the first evaluation cycle, we implemented both design options.

4.3 Evaluation – Cycle 1: Experiential Evaluation of Design Features

The demonstration and evaluation of our initial two DFs are based on previous research (see Wendt et al., 2021 for details) that conducted a lab-in-the-field experiment in order to investigate the previously described DFs. Specifically, participants from 152 private households were asked to report their heating behavior which was then translated into their heating intensity and displayed via a web UI. In a subsequent step, participants could set themselves a goal for the upcoming four weeks that was either self- or other-referencing. They received feedback on the attainment of their goal at the end of the study period. To assess goal attainment and behavioral changes, *heating intensity reduction* was measured as the dependent variable and *motivation* (i.e., chosen reduction goal) as a mediating variable.

Based on the experiment, two key insights for the design of DF1 and DF2 could be derived: First, the experiment confirms that having a consumption display with information on one's own *and* comparable others' resource consumption motivates individuals more strongly to reduce their resource consumption than only being provided with transparency on one's own resource consumption (i.e., control group). Secondly, when it comes to a goal's evaluative standard, self-referencing goals are particularly well suited for better-than-average performing households, while other-referencing goals motivate worse-than-average performing individuals even more to set themselves an ambitious goal.

However, the experiment primarily shows how the DFs affected individuals' resource consumption, rather than why, which will be focus of the following design-evaluation cycles to better understand the activation of different goal frames. In order to refine the DFs for the next design-evaluation cycle, participants were asked for their feedback on the displayed consumption information which led to adjustments with regard to the consumption context (i.e., heating) and the further application of other-referencing goals. For the experiment, "heating intensity" was displayed as the measure for individuals' heating energy consumption. As an intensity in relative numbers is more complex to interpret than absolute numbers, we decided to switch the consumption context from heating energy to electricity consumption for the subsequent design-evaluation cycle to be able to display consumption data in absolute numbers. Moreover, even though other-referencing goals showed a more significant positive impact on resource consumption of worse-than-average performing individuals, we decided to proceed with self-referencing goals only. The experimental data shows that worse-than-average performers with an other-referencing goal set themselves an average reduction goal of 21%, whereas their peers with an self-referencing goal set themselves an average goal of 12% (see Wendt et al., 2021 for details). Even though this reflects higher motivation to improve for worse-than-average performing individuals with an other-referencing goal, previous research indicates that reduction goals of 5-10% are difficult, yet realistic, while reduction goals of 20% are unlikely to be achieved long-term (Abrahamse et al., 2007, Loock et al., 2013). Specifically, high goals may be achieved once, but are unlikely to be achieved in the long run, ultimately leading to frustration and lower self-efficacy (Liu et al., 2019, Loock et al., 2013). Thus, we argue that self-referencing goals are potentially better suited in the long run, also for worse-than-average performing individuals and conclude the first evaluation cycle as follows:

***Recommendation for* DF*1*:** *Provide transparency on one's own and comparable others' resource consumption to provide individuals with a reference point.*

***Recommendation for* DF*2*:** *Provide the opportunity to set self-referencing goals as they are easier to process than other-referencing goals and lead to more realistic goal choices.*

4.4 Development – Cycle 2: Refined Design Features Based on Evaluation

During the second development cycle, the focus was on refining the existing DFs based on the feedback from the first evaluation cycle as well as adding further DFs that address particularly DP3 (i.e., provide UI that create a hedonic experience) and DP4 (i.e., provide UI that allows for setting a goal for future resource consumption). DF3, "goal incentive", refers to the way the goal is motivated (i.e., incentivized). Previous research showed the significant impact of social influence on individuals' sustainable behaviors (e.g., Koo and Chung, 2014, Abrahamse et al., 2007). Also, engaging in such behaviors with like-minded people positively impacts an individual's motivation, particularly combined with gamification elements like goal setting (e.g., Shevchuk et al., 2019, Lindenberg and Steg, 2013). To that end, Shevchuk et al. (2019) name collaboration and competition among individuals as impactful means to motivate a target behavior and Lindenberg and Steg (2013) emphasize that the normative goal frame can be strengthened by cues that indicate one is pursuing a common goal jointly with others. Accordingly, we developed two design options for the goal incentive (i.e., DF3) for the second evaluation cycle: The *collaborative goal* asked individuals to set themselves a goal in order to contribute to a collaborative energy consumption reduction goal with a group of comparable others. The *competitive goal* emphasized the discrepancy between an individual's own and others' current resource consumption and encouraged individuals to set themselves a goal in order to either keep their superior position or to self-improve and to close the gap towards the average.

Moreover, we developed design options for DF4, a cue for the goal's "reference group" which refers to the previously mentioned group of comparable others. According to Lindenberg and Steg (2013), the activation of environmental norms is strengthened when these norms are supported from significant others. To tap this potential, we developed two design options for the reference group (i.e., DF4), *anonymous* and *familiar others*, which were also provided during the second evaluation cycle. *Anonymous others* refers to households with comparable characteristics (e.g., geography, living space, number of household members) but who are not identifiable. *Familiar others* refers to households with comparable characteristics that are identifiable and known by the individual, for example neighbors or friends who use the same mobile app and agreed to collaborate or compete with the individual. We also adopted the goal's reference group for DF1, "consumption display", and labeled comparable others' resource consumption with the same reference group as the goal to ensure consistency.

4.5 Evaluation – Cycle 2: Interview-Based Evaluation of Design Features

For the second and third evaluation cycle, we opted for semi-structured interviews as the evaluation methods to obtain a better understanding of why different DFs impact individuals' motivation to behave sustainably. During the second evaluation cycle, we conducted 20 interviews with a convenience sample of participants from households in the author team's social network, which is appropriate in the case of a homogeneous population (Neergaard and Ulhøi, 2007). Details on the participants' gender, age and housing situation (i.e., flat vs. house and rented vs. owned) can be found in Table 1. We introduced half of the interviewees to a collaborative setting fist, while the other half was initially provided the competitive scenario before switching perspectives. All interviews were conducted via a video-conferencing tool that allowed for screen sharing to provide interviewees with a visualization of our

DFs. Specifically, we developed UI that looked like actual smart meter UI (e.g., app screens) to allow for best possible identification of the interviewees with the situation. Each interview started with an introduction to the context before presenting a UI that asked for personal information, such as gender, age, housing situation, and existence of particularly high resource consumers (e.g., air conditioner, electric car). The subsequent screen showed interviewees a visualization of their own and anonymous others' resource consumption and asked them to set a self-referencing goal, either collaboratively or competitively. Following practices from previous research (Seidel et al., 2018), we asked the interviewees to speak aloud as they read and processed the screens and thought about a reasonable goal. Moreover, we asked questions about the reason behind the chosen goal, accompanying thoughts and emotions, and planned measures to achieve the goal. We then proceeded with a slightly adjusted screen, replacing the anonymous reference group with a cue for a familiar one and asked participants for any changes regarding their goal choice, thoughts, and emotions as well as for their preference. To conclude, we presented the alternative goal incentive and again asked for perceptional changes and preferences. All interviews were audio-recorded, transcribed and coded in order to conduct a qualitative analysis of the interviews (Saldana, 2013). To this end, we used the three goal frames as the initial coding scheme for each design option and looked for evidence that one of the goal frames became focal as well as for patterns with regard to the activation of one or more of the three goal frames by particular DFs.

ID	Gender	Age	Housing situation	ID	Gender	Age	Housing situation
I01	Female	20-29	Flat – rented	I11	Female	50-59	House - owned
I02	Male	50-59	House – owned	I12	Male	50-59	Flat – owned
I03	Male	20-29	Flat – rented	I13	Male	60-69	House – owned
I04	Male	50-59	House – owned	I14	Female	20-29	Flat – rented
I05	Female	20-29	Flat – rented	I15	Male	20-29	Flat – rented
I06	Male	20-29	Flat – rented	I16	Female	50-59	House – owned
I07	Male	50-59	House – owned	I17	Male	30-39	Flat – rented
I08	Male	60-69	House – rented	I18	Male	50-59	House – owned
I09	Male	20-29	Flat – rented	I19	Male	20-29	Flat – rented
I10	Female	50-59	House – owned	I20	Female	50-59	House – owned

Table 1. Interview participants for Evaluation Cycle 2.

Based on the interview data, we were able to derive several key insights for the general goal-design as well as for the preferred design options of DF3 and DF4. Generally speaking, the interviews confirm the coexistence of several goal frames for all design options of the goal-related DFs, with the normative goal frame being focal for most interviewees, followed by hedonic and partially also gain goal elements. With regard to DF3, the interviews indicate that neither the collaborative nor the competitive design is superior or generally preferred. Instead, it depends on the personal preference of interviewees whether they perceive more enjoyment from collaboration or competition and thus whether the hedonic goal frame is compatible with the normative goal frame or not. In the case of a personal preference for collaboration, *collaborative goals* strengthen the normative goal frame by a strong perception of commitment, perceived accountability towards the other collaborators, and social pressure to contribute to the joint goal. These aspects weigh even stronger when DF4 is operationalized as *familiar others*. Familiar others also positively affect the hedonic goal frame, as knowing the collaborators affords a stronger team spirit, social reward when the goal is achieved, and social interaction to achieve the goal (e.g., encouraging each other or sharing best practices). However, knowing one's collaborators can also cause negative social pressure as not achieving one's goal is related to stronger negative feelings than in the case of anonymous others. In the case of a personal preference for competition, *competitive goals* strengthen the normative goal frame by the even more explicit social comparison and the perceived social pressure to perform better than the average. For individuals who enjoy competition, the hedonic goal frame is triggered by a competitive goal and perceived as a competitive spirit. However, in combination with DF4 operationalized as familiar others, individuals have concerns about negative aspects of competition such as envy or resentment among competitors that are transferred from the smart meter UI context into real world relationships. Therefore, for competitive goals, *anonymous others* are the preferred design option for the reference group. As such, we conclude the second design-evaluation cycle with design recommendations for DF3 and DF4:

Recommendation for DF***3:*** *Offer individuals the opportunity to choose between a collaborative and a competitive goal incentive based on one's personal preferences.*

Recommendation for DF***4:*** *Pair the collaborative goal incentive with a reference group of familiar others and the competitive goal incentive with a reference group of anonymous others.*

Gain goals were barely mentioned for both types of goal incentives and seem to remain in the cognitive background. Nevertheless, some interviewees mentioned environmental or monetary gains as a benefit of their goal or social gains as a result of having the lowest consumption level in a competitive setting. As such, we decided to include monetary incentives more explicitly in the next design-evaluation cycle. Moreover, the interviews revealed that the clarity of the design was not yet optimal, particularly regarding the visualization of the consumption display and the introduction of reference groups.

4.6 Development – Cycle 3: Refined Design Features Based on Evaluation

The third development cycle further refined the design of the existing DFs based on the feedback from the second evaluation cycle. Specifically, we enhanced the visualizations for the consumption display in terms of clarity, made the overall design more appealing, and added one introductory screen to avoid any misunderstandings regarding the reference group cues. Moreover, to analyze whether or not monetary incentives within the goal-design positively impact the gain goal frame compared to non-monetary incentives (i.e., collaboration and competition), we developed an additional design option for DF3 and designed a UI with monetary incentive cues. Figure 3 illustrates exemplary UI from the third evaluation cycle for (a) collaborative goal incentives and a familiar reference group, (b) competitive goal incentives and an anonymous reference group, and (c) monetary incentives.

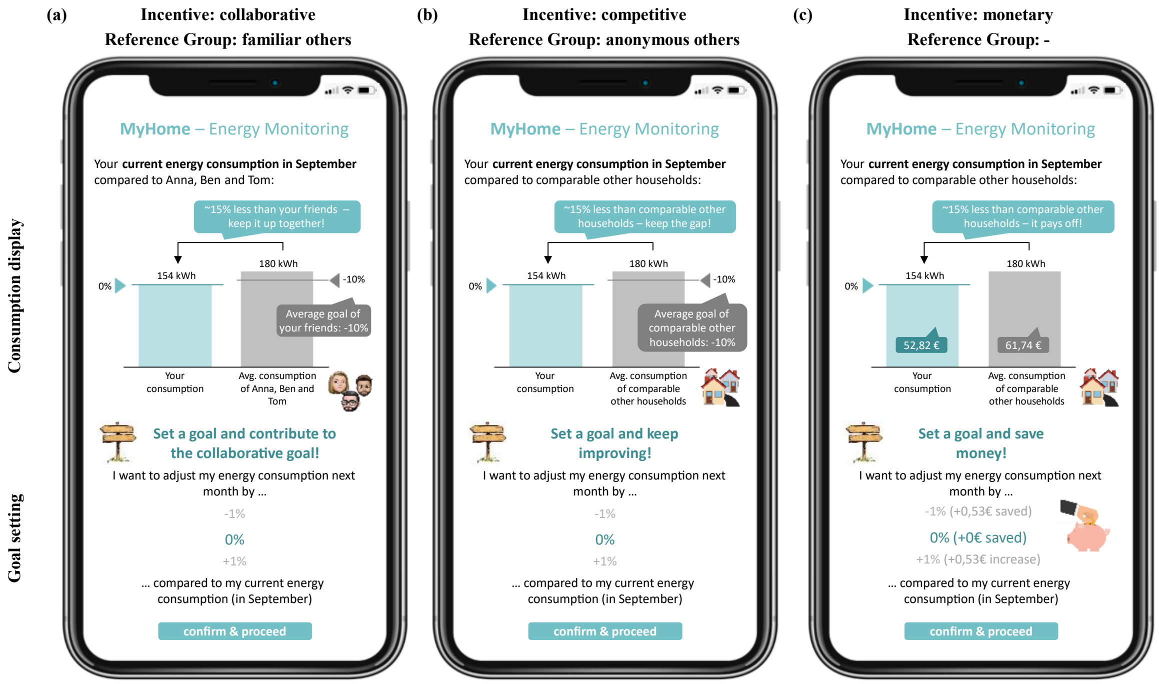

Figure 3. *Design options for the design feature "consumption display" (upper section) and "goal setting" (bottom section) with different goal incentives and reference groups.*

4.7 Evaluation – Cycle 3: Interview-Based Evaluation of Design Features

For the third evaluation cycle, we applied the same methodological approach as for the second cycle. We conducted another 10 interviews with a convenience sample of participants from households that were identified as potential users of smart meter UI (see Table 2 for details). The interviews were again conducted via a video-conferencing tool and followed the same procedure as described earlier. Each interviewee was provided with all three goal incentives to ensure for enhanced comparability when asking for participants' preferred design option. To analyze the interview data, we transcribed and coded the audio-recorded interviews and started with the codes from the previous evaluation cycle.

ID	Gender	Age	Housing situation	ID	Gender	Age	Housing situation
I21	Female	20-29	Flat –rented	I26	Female	70-79	Flat – owned
I22	Female	20-29	Flat – rented	I27	Male	20-29	Flat – rented
I23	Female	20-29	Flat – rented	I28	Male	20-29	Flat – rented
I24	Female	40-49	House – owned	I29	Female	20-29	Flat – rented
I25	Male	50-59	House - owned	I30	Male	20-29	Flat – rented

Table 2. Interview participants for Evaluation Cycle 3.

Based on the analyses of the interview data, the design recommendations from the second evaluation cycle are confirmed. In addition, we derive another key insight for DF3, goal incentive: The additional design option for DF3 (i.e., monetary incentives) is generally well received as most interviewees appreciate that monetary units are less abstract and therefore more tangible than units for energy consumption (i.e., kilowatt hour). Monetary incentives primarily address the gain goal frame and bring it to the cognitive foreground. Yet, monetary goals tend to lead individuals to set overly ambitious goals, since reducing energy consumption in households usually results in comparably small monetary savings. Aiming for high monetary savings and thus selecting high goals can lead to non-achievement of goals and, in the long run, to frustration and dropout. As such, we conclude the third design-evaluation cycle as follows: Whereas monetary incentives as part of the goal setting artifact are not effective in promoting sustainable behavior over the long term, information about financial gains can still be integrated into smart meter UI to make consumption information more tangible than stating one's energy consumption in rather abstract energy units such as kilowatt hour.

5 Discussion

Smart meter UI that provide goal setting as a design artifact are well-suited to engage individuals in sustainable resource consumption. However, previous studies on goal setting came to widely varying results with the induced reduction in resource consumption ranging from 2% to up to 30% which provides limited guidance on the optimal design of goal setting and goal-related DFs that can be reused in future projects (e.g., Loock et al., 2013, Abrahamse et al., 2007, Karlin et al., 2015). In order to address causes for such differences and to derive recommendations for effective goal design in smart meter UI, we set out to develop and evaluate design options for four goal-related DFs (i.e., consumption display, evaluative standard, goal incentive, and reference group). Applying a DSR approach and following the design research cycle proposed by Kuechler and Vaishnavi (2008) we designed and evaluated these DFs in a theory-based approach and derived design recommendations for DFs that motivate sustainable resource consumption by individuals. We find that with regard to the *consumption display* and *evaluative standards*, transparency on others and one's own consumption as well as self-referencing goals are the preferred design options with both strengthening the normative goal frame. When it comes to *goal incentives*, we find that it depends on an individual's personal preference for either collaboration or competition whether or not the individual's normative and hedonic goal frames are strengthened and aligned. Interestingly, this also correlates with a preference for either anonymous or familiar others as design options for a goal's *reference group*. Whereas individuals with a preference for collaboration prefer familiar others as collaboration partners, individuals in a competitive setting prefer anonymous competitors.

5.1 Contributions to Theory and Practice

Our study contributes to IS research and practice in several ways. First, we improve our understanding of how the design of goal-related DFs affects the way goal setting as a design artifact impacts individuals' resource consumption. Previous studies agreed on the importance of goal setting as a motivator for sustainable behaviors (e.g., Loock et al., 2013, Wendt et al., 2021). However, inconsistencies and deficiencies in prior study designs (e.g., mix of goal- and non-goal interventions, lacking information on goal-related DFs) do not allow for a conclusive assessment of the effectiveness of goal setting or conclusions for the optimal goal-design in the context of smart meter UI (e.g., Loock et al., 2013, Abrahamse et al., 2007). With the design and evaluation of four goal-related DFs in an instantiated prototype, we extend prior goal setting research and derive design recommendations for each DF. Thus, this study complements existing research on goal setting and improves our understanding of how to design goal-related DFs to allow for an effective goal-design for smart meter UI.

Moreover, with our DSR approach we provide a knowledge contribution that can be classified as an improvement (based on the framework proposed by Gregor and Hevner, 2013), as our study provides a refined solution (i.e., design recommendations for goal-related DFs) to a known problem domain (i.e., motivating reduced resource consumption through smart meter UI). Specifically, we leverage GFT as kernel theory and provide prescriptive knowledge by formulating general DRs and DPs which served as a basis for the development and rigorous evaluation of goal-related DFs. By that, we also address the need for theory-based evaluations of goal-related DFs to increase our understanding of causes for and solutions to the varying effectiveness of goal setting in previous studies (e.g., van Dam et al., 2010, Karlin et al., 2015). As such, we provide a more nuanced understanding of how and why different design options for goal-related DFs are superior to others and derive design knowledge for the improvement of current goal-designs in terms of effectiveness, comprehensiveness, and reproducibility.

In addition to this knowledge contributions, our study contributes to practice (i.e., the application environment of smart meter UI) and responds to calls for design- and impact-oriented Green IS research (Gholami et al., 2016, Malhotra et al., 2013). Specifically, we contribute to design-oriented research (Österle et al., 2011, Winter, 2008) which generally aims at designing better performing IS solutions, with benefits for practice as an important measure (Peffers et al., 2018). We extend existing research on sustainable behavior interventions in households and provide design recommendations for the development and evaluation of DFs for smart meter UI that are particularly suited to motivate individuals to reduce their resource consumption. Thus, we reveal practical implications for providers and designers of smart meter UI in the context of goal setting.

5.2 Limitations and Future Research

As every research, this study has some limitations. First, our study is focused on a subset of goal-related DFs and limited to three design-evaluation cycles for evaluation and refinement. Hence, we encourage future research to conduct additional iterations of the DSR cycle to elaborate on additional goal-related DFs (e.g., rewards, leaderboards) as well as on non-goal-related DFs (e.g., behavioral tips, notifications) that have also been mentioned by interviewees during our evaluation cycles.

Second, the evaluation cycles took place in an experimental setting and by conducting semi-structured interviews. Even though the set-up of the goal setting environment was designed as realistic as possible for both methodological approaches, we call for future research to validate our findings and to measure the induced effect on resource consumption in a field experiment, for instance, by providing participating households with a mobile app that is supplied by data from the households' appliances.

Third, our evaluations are based on feedback from German participants. Thus, further research might investigate whether cultural differences play a role in users' preferences for certain goal-related DFs.

Moreover, the study was conducted in the context of households' heating energy and electricity consumption. Future research could examine the impact of goal-related DFs in related contexts of sustainable behavior, such as reducing water consumption and waste production, or increasing the use of public transportation.

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