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Liliane Ableitner

Anna Kupfer

Verena Tiefenbeck

Samuel Schöb

Thorsten Staake

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## Extended Abstract

**Liliane Ableitner**
ETH Zurich
lableitner@ethz.ch

**Anna Kupfer**
University of Bamberg
anna.kupfer@uni-bamberg.de

**Verena Tiefenbeck**
ETH Zurich
vtiefenbeck@ethz.ch

**Samuel Schöb**
University of Bamberg
samuel.schoeb@uni-bamberg.de

**Thorsten Staake**
University of Bamberg
thorsten.staake@uni-bamberg.de

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Modern life all across the globe depends on energy – whether in business or in private context. The increasing demand drives well-known problems on different levels (e.g., scarcity of natural resources, pollution of the environment, energy security). The minimization of these negative outcomes is not only high on the political agenda of environmental and governmental institutions, but scholars and practitioners alike are investigating strategies how IS (Information Systems) can increase sustainability (Loock et al. 2013). According to Seidel et al. (2013) the primary function of Green IS is providing "action possibilities for sensemaking and sustainable practicing" (p. 1276), that users can then choose from. In other words, the goal of Green IS is thus to develop and to use IS that result in behavioral changes towards a more sustainable lifestyle (Dedrick 2010; Hilty et al. 2006; Köhler and Erdmann 2004; Kranz et al. 2015).

Research in the Green IS domain can build on a rich body of social science literature on behavior change. That literature generally distinguishes extrinsic motivations, primarily in the form of pecuniary incentives (e.g. financial rewards for reducing energy consumption, carbon tax) and non-pecuniary strategies for behavior change that build on the individuals' intrinsic motivation to protect the environment (Asensio and Delmas 2015; Ferraro and Price 2013).

The most established non-pecuniary approach is the provision of *feedback* to consumers on their resource consumption (e.g., car dashboards displaying fuel consumption). The increasing ubiquity of sensors and communication networks makes the collection and visualization of more and more fine-grained energy consumption data possible on a large scale. Millions of smart meters are being deployed in households across the globe, measuring utility consumption data (electricity, gas, water), which can be visualized to the consumer via in-home-displays, mobile apps or other user interfaces. Feedback can thus help consumers develop a better understanding of their utility consumption and enable them to act in line with their environmental preferences. A recent meta study shows that these measures yield to domestic electricity savings of 1-5% (McKerracher and Torriti 2013). Metastudies on behavioral interventions in the residential energy sector show that feedback is more effective when it is provided frequently over a longer time period and broken down into different end-uses (Asensio and Delmas 2015; Fischer 2008; Karlin et al. 2015). A recent study shows that real-time feedback that is provided on a specific behavior (hot water consumption in the shower) can result in large relative and absolute energy savings on the target behavior of 22% (Tiefenbeck et al. 2016).

Regarding pecuniary incentives, IS play an important role as they track consumption data and thereby provide the calculation base for consumer specific billing models. For instance, IS can enable the implementation of more complex pricing schemes to reduce electricity consumption during peak hours (Allcott 2011a). Another price-based behavior change strategy that can leverage IS are voluntary carbon offsetting programs. They draw on the polluter-pays-principle and impose a surcharge on individual consumption (in addition to the standard utility bill). Institutions or individuals can financially compensate the emissions caused by their energy use by investing in sustainability projects (e.g., planting trees in the rainforest), which in turn should lead to an equivalent reduction of greenhouse gas emissions. Even though on an ascending branch (Blasch and Farsi 2014) – especially in transportation – relatively few customers still have adopted voluntary carbon offsetting in practice (in aviation 2 to 9% of travelers) (Mair 2011).

In our work, we study both, the impact of feedback on resource consumption and voluntary carbon offsetting in the context of hot water consumption in the shower. More specifically, we explore which participants respond to the possibility of offsetting their shower-related carbon emissions, how participants respond to real-time feedback on their resource consumption in the shower, and the interplay of the two measures. Ex-ante, it is well conceivable that participants who choose to offset their shower-related carbon emissions ("offsetters") a) use *less* resources than other users, as they that know they will face additional charges for their consumption or b) that they use *more* resources than other users since they whitewash their consumption with money and have a better conscience. In a field experiment, 637 Dutch households were given a smart shower meter that tracks, stores, and displays energy use in real-time. Prior to the deployment of the devices, half of the participants could voluntary sign up for compensating their shower-related carbon emissions. The three-month study had 2x2 conditions: (real-time feedback yes/no) x (ex-ante possibility to abate carbon emissions yes/no) (Fig. 1). For each household we recorded the baseline consumption at the beginning of the study before (for two thirds of the participants) the real-time feedback intervention started. Prior to the study, participants answered surveys about demographics and environmental attitudes. During and after the study, consumption data was made available to the researchers via a mobile app (iOS and Android).

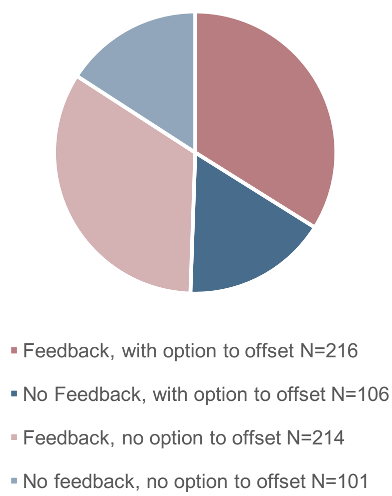


Figure 1: Study design by groups

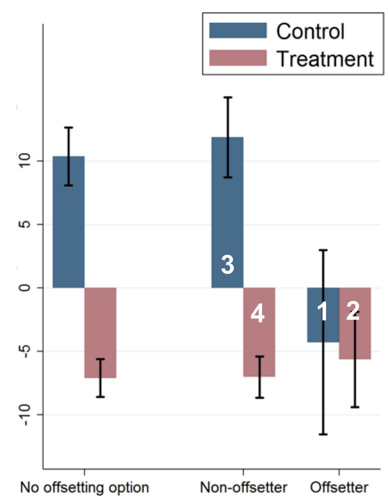


Figure 2: Relative Change of Water Volume compared to Baseline Consumption in %

For the effectiveness of real-time feedback, we find a substantial treatment effect of 20% compared to the control group's hot water consumption per shower. Remarkably, control group households increase their per-shower resource consumption by 5 to 20% compared to the baseline level. Yet, we have found this pattern consistently in all of our studies on real-time feedback so far and we are able to rule out seasonal effects as an explanation to these patterns. Our conjecture is the presence of Hawthorne effects – i.e., participants' altered behavior due to their awareness of being a part of an experimental study (Levitt and List 2011). We hypothesize that control group households reduce their resource use in particular at the beginning of the study compared to their pre-study behavior, as they know the data will be analyzed in the frame of the study . As participants get used to the measurement device, their consumption relapses towards their pre-study behavior.  That implies that these effects affect particularly the baseline period at the beginning of the study and results in an increase in consumption in the control group (Tiefenbeck 2016). The treatment effects of 20% are immediate and stable over the full duration of the experiment. Prior to the intervention, we gave half of the households (N=322) the possibility to offset their emissions by either 50% or 100% typically resulting in EUR 0.03 or 0.06 per shower taken, respectively; only 14% decided to do so.

Individuals who were exposed to feedback, but who were not willing to offset their emissions, strongly responded to feedback: they reduced their consumption significantly compared to the untreated group (Group 4 in Fig. 2). Participants who opted into voluntary offsetting were significantly more concerned about the environment than non-offsetters (p=0.025). In line with their environmental attitudes, they also used less energy per shower during the baseline period than non-offsetters. During the intervention phase, the consumption of the offsetters was reduced independently of the availability of feedback (Fig. 2, Group 1 and 2). In particular, the group of offsetters that has not received feedback (Group 1 in Fig. 2) reduced their consumption in comparison to their counterparts (no feedback and no offsetting, group 3 in Fig. 2). This suggests that offsetters do not need feedback as they pay attention to their consumption anyways. However, the fact that primarily environmentally friendly participants opted for the offsetting option makes it difficult to disentangle the results: Is their low baseline consumption driven by the abaters' pro-environmental attitude or by their awareness of direct costs associated with higher resource use? While in the case of our study, the collection of baseline data was not possible before participants could choose to offset their carbon emissions during the study, future studies should first collect baseline consumption data and then give the participants the option for carbon offsetting.

The findings of this study suggests that consumption feedback and carbon offsetting are complementary strategies to achieve resource conservation: offsetting programs seem to attract rather a small minority of the population (in our study 14%) and especially those people that care most about the environment. Given that they tend to use less resources to begin with, they do not have a large margin for additional resource reductions. In contrast, individuals who care less about the environment are difficult to reach with carbon offsetting programs. Yet, we find that that group uses more resources in our study, so at least in theory they have a larger savings potential. In line with prior studies (Allcott 2011b; Tiefenbeck et al. 2016) we find that feedback is more effective on high consumers. That can be explained by the fact that they have larger margins of adjustment: in our case, it is easier to cut a 10-minute shower short by one minute than a two-minute shower by one minute.

Our results show that high consumers who receive feedback achieve resource reductions of 30% compared to the control group. Thus, we conclude that consumption feedback is not only highly effective, but can also reach the broad mass of people that is usually not that concerned about the environment. This study shows that IS can employ different strategies to foster behavioral changes toward sustainability. We encourage further research in this area: If scholars find out what drives the broad mass to voluntarily adopt such Green IS, the resource saving potential can be exploited successfully on a large scale and be tailored to the individual's specific preferences and specific situation.

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