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CUSTOMER ENGAGEMENT FOR UTILITIES: INFORMATION SYSTEMS TO CURB RESIDENTIAL ENERGY CONSUMPTION

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Abstract

Following decades of stable profit margins in the residential market, utility companies face disruption of their established business model. Efficiency regulations, market decentralization, increased competition, self-sufficient consumers, and new customer demands undermine the established system of centralized production and distribution. As a consequence, utilities increasingly strive to become service providers. This entails the diversification of product offerings with regard to customer demands and needs. Yet, a data based understanding of prevalent demands and needs is mostly missing. However, such an understanding is necessary in order to develop services and establish personalized distribution channels to effectively advocate services. The energy efficiency market holds great potential for utilities as they possess the necessary data to establish meaningful services. Furthermore, services in the domain can serve various purposes, such as the fulfillment of regulatory requirements and the general support of sales processes by assessing relevant data and increasing customer loyalty. With respect to regulatory provisions, households can effectively contribute to goals aiming to prevent negative effects of CO_2 emissions as they account for 25 % of primary energy consumption in western countries. Thus, utilities can generate value on multiple levels by implementing programs to curb residential energy consumption.

For utilities, the value of such a program depends on the share of participating households, the ability to produce energy savings, and the support of sales processes. 35 years of research on energy conservation programs show that the ability to motivate conservation critically depends on the personalization and richness of information provided. In recent years, information systems (IS) could diminish the prior conflict of the ability for instruments to scale and the level of detail of those instruments. Thus, this thesis adds to both IS literature and practice by: 1) developing design principles and further developing an IS to curb residential energy consumption; 2) investigating behavioral strategies to maximize voluntary participation; 3) investigating mechanisms to reinforce continuous usage of the IS; and 4) evaluating the overall impact of the IS. Concretely, this thesis employs a design science research paradigm to develop the IS. It further contains two large scale field experiments with 20,000 and 2,355 real customers of a utility company, respectively, to further investigate motivational appeals to promote voluntary participation and mechanisms to increase user activity.

Design principles emphasize the importance of actionable consumption feedback and personalized advice in order to impact consumption. Adding to this informational layer, the IS focuses on maximizing user motivation in every phase of the action process. Importantly, the system avoids monetary reason. Inherent and external monetary rewards are further investigated in the two field experiments, respectively. The system further employs clearly defined and challenging goals and allows users to commit to relevant behaviors. By means of the interaction provided, the IS assesses relevant customer characteristics and needs to further personalize the IS and support sales processes in the domain of energy efficiency for the utility. The IS establishes a digital channel to the customer of the utility and allows for personalized interaction. Furthermore, the IS allows for the implementation of experimental designs including control groups.

Results of the first field experiment reveal detrimental effects of emphasizing inherent monetary benefits in promoting residential energy conservation programs. Highlighting the concrete self-benefit of saving money on the electricity bill resulted in signup rates of 8.3 %. However, signup rates drastically increased to 13.5 %, and 14.6 % when solely providing information on past consumption, and adding social normative appeals, respectively. Furthermore, monetary motives attract customer segments that are characterized by a higher energy efficiency at program start leading to a lower overall potential to save energy. Finally, monetary motives even showed to significantly increase consumption of households by 3.7 % and 4.7 % compared to when promotional appeals highlighting social normative motives and solely providing information on past consumption, respectively. Thus, programs can benefit from emphasizing altruistic and social normative aspects and avoid highlighting monetary motives as they probably speak for themselves.

While the first field experiment focuses on inherent monetary benefits of saving energy, the second field experiment investigates the effectiveness of independent monetary rewards to motivate energy conservation behavior. Results of the second field experiment show the effectiveness of bonus points to increase user activity on the IS to curb residential energy consumption in a goal directed manner. However, effects depend on type and height of associated incentives. In the IS, bonus points are employed as an element of gamification guiding user interaction across functionalities. Incentives were implemented as monetary or non-monetary (symbolic awards) and varied in their respective height. Compared to a control group, incentives significantly increased system usage of participants, and additionally increased energy savings by an average of 2.19 %. For both incentive conditions no effect on energy savings could be observed. However, monetary incentives were not necessarily superior to non-monetary incentives. Participants given a high symbolic incentive showed a similar increase in activity and caused no additional costs. Furthermore, participants who were given a monetary incentive showed a steeper decrease in activity compared to a control group pointing to potential detrimental effects on intrinsic motives to use the IS.

This thesis contains a number of contributions to theory as well as practice. Concretely, individual results add to literature in the field of information systems, Green IS, behavioral economics, and offers insights for the successful design of energy conservation programs.

Zusammenfassung

Energieversorger sehen sich im Privatkundenmarkt nach Jahren stabiler Gewinnmargen mit der Disruption ihres etablierten Geschäftsmodels konfrontiert. Effizienzregulierungen, Marktdezentralisierung, steigender Wettbewerb, autarke Konsumenten und neue Kundenbedürfnisse untergraben das etablierte System von zentraler Produktion und Vertrieb. Als Konsequenz begehen Energieversorger zunehmend einen Wandel hin zum Servicedienstleister. Dies beinhaltet die Diversifikation des Produktangebotes entsprechend der Ansprüche und der Bedürfnisse ihrer Privatkunden. Ein datenbasiertes Verständnis prävalenter Ansprüche und Bedürfnisse fehlt dabei häufig. Ein solches Verständnis bildet jedoch die notwendige Voraussetzung für die Entwicklung von Services und der Etablierung personalisierter Vertriebskanäle zur effektiven Vermarktung der Angebote. Der Energieeffizienzmarkt birgt ein grosses Potential für Energieversorger, da sie über die relevanten Daten zum Angebot wichtiger Services verfügen. Darüber hinaus bieten Services in dem Bereich verschiedene mögliche Nutzen, wie die Erfüllung regulatorischer Vorgaben und der generellen Unterstützung vertrieblicher Prozesse durch die Erfassung relevanter Daten und der Steigerung der Kundenloyalität. Privathaushalte können in Bezug auf regulatorische Vorgaben einen entscheidenden Beitrag zur Vermeidung negativer Konsequenzen der CO2 Emissionen leisten, da sie in westlichen Länder 25 % des Primärenergieverbrauchs verantworten. Auf diese Weise können Energieversorger durch die Implementierung von Programmen zu Reduktion des Energieverbrauchs privater Haushalte Werte auf mehreren Ebenen generieren.

Der Wert solcher Programme hängt für Energieversorger vom Anteil teilnehmender Haushalte, der Fähigkeit zur Generierung von Energieeinsparungen und der Unterstützung von Vertriebsprozessen ab. 35 Jahre Forschung zur Wirksamkeit von Energiesparprogrammen zeigen, dass die Eigenschaft eines Programmes zur Motivation von Energieeinsparungen massgeblich von der Personalisierung und Detailgenauigkeit der dargestellten Informationen abhängt. In den vergangenen Jahren konnten Informationssysteme (IS) den vormaligen Widerspruch zwischen der Skalierbarkeit von Instrumenten und dem Detailierungsgrad dieser Instrumente vermindern. Die vorliegende Dissertation trägt folgendermassen sowohl zur IS Forschung als auch zur Praxis bei: 1) Die Entwicklung von Design-Prinzipien und die Weiterentwicklung eines IS zur Verringerung des Energieverbrauchs privater Haushalte; 2) Die Untersuchung verhaltenswissenschaftlicher Strategien zur Maximierung der freiwilligen Teilnahme; 3) Die Untersuchung von Mechanismen zur Verstärkung der kontinuierlichen Nutzung des Systems; und 4) Die

Evaluierung der Wirksamkeit des IS. Zur Entwicklung des IS wendet die vorliegende Arbeit einen Design Science Ansatz an. Zur weiteren Untersuchung motivationaler Ansprachen zur Bewertung der freiwilligen Teilnahme und Mechanismen zur kontinuierlichen Nutzung des Systems, enthält die Arbeit zwei grossangelegte Feldexperimente mit 20‘000, bzw. 2‘355 echten Kunden eines Energieversorgers.

Zur Beeinflussung des Energieverbrauchs heben die abgeleiteten Design Prinzipien die Bedeutung von handelbarem Verbrauchsfeedback und personalisierten Empfehlungen hervor. Basierend auf dieser Informationsebene maximiert das IS die Nutzungsmotivation in jeder Phase des individuellen Handlungsprozesses. Das IS verzichtet dabei auf monetäre Gründe zur Motivation der Nutzung. Inhärente und externe monetäre Belohnungen sind jeweiliger Gegenstand der beiden Feldexperimente. Weiter beinhaltet das IS klar definierte und herausfordernde Ziele und ermöglich Nutzenden das Commitment zu relevanten Verhaltensweisen. Über die Interaktion erfasst das IS relevante Nutzercharakteristika und -bedürfnisse zur weiteren Personalisierung des IS und zur Unterstützung vertriebsrelevanter Tätigkeiten des Energieversorgers im Bereich der Energieeffizienz. Das IS etabliert einen digitalen Kundenkanal für den Energieversorger und ermöglicht die personalisierte Interaktion. Weiter ermöglicht das IS die Implementierung experimenteller Designs inklusive Kontrollgruppen.

Ergebnisse des ersten Feldexperimentes veranschaulichen schädliche Effekte der Betonung inhärenter monetärer Vorteile in der Bewerbung von Energiesparprogrammen für Privathaushalte. Das Hervorheben des konkreten Selbstnutzens monetärer Einsparungen auf der Stromrechnung führte zu Teilnahmeraten von 8.3 %. Die Anmelderaten steigerten sich jedoch drastisch, wenn lediglich Informationen zum Stromverbrauch des vergangenen Jahres (13.5 %) oder zusätzliche sozial normative Information (14.6 %) angezeigt wurde. Darüber hinaus ziehen monetäre Motive eher Kundensegmente an, die eine vergleichsweise höhere Energieeffizienz zum Zeitpunkt des Programmstartes kennzeichnet, was ein geringeres Potential für die Realisierung von Energieeinsparungen bedeutet. Weiter erhöhten, die durch das monetäre Motiv angeworbenen Haushalte, ihren Stromverbrauch im Vergleich zu Haushalten, denen lediglich Information dargestellt wurde, um 4.7 % und im Vergleich zu der Ansprache sozial normativer Motive um 3.7 %. Folglich können Programme von der Betonung altruistischer und sozial normativer Aspekte profitieren und das Hervorheben monetärer Motive vermeiden, da diese wahrscheinlich für sich selbst sprechen.

Während das erste Feldexperiment inhärente monetäre Vorteile von Energieeinsparungen fokussiert, untersucht das zweite Feldexperiment die Effektivität unabhängiger monetärer Belohnungen zur Motivation von Energiesparverhalten. Ergebnisse des zweiten

Feldexperiments zeigen, dass Bonuspunkte die Nutzeraktivität auf dem IS zielgerichtet steigern. Die Effekte hängen allerdings von der Art und der Höhe assoziierter Anreize ab. Die Implementierung der Bonuspunkte in dem IS erfolgte als Element der Gamification und führte Nutzer durch die verschiedenen Funktionalitäten des Portals. Bonuspunkte wurden entweder als monetäre oder nichtmonetäre Anreize (symbolische Auszeichnungen) eingesetzt und in die Höhe der Anreize variiert. Im Vergleich zu einer Kontrollgruppe steigerten die Anreize die Systemnutzung der Teilnehmer signifikant und förderten zusätzlich die Reduktion des Stromverbrauchs um durchschnittlich 2.19 %. Für die jeweilige Art der Anreize konnte kein Effekt auf Änderungen im Stromverbrauch festgestellt werden. Allerdings waren monetäre Anreize nichtmonetären Anreizen nicht zwingend überlegen. Teilnehmende, denen die symbolische Auszeichnung in der hohen Bedingung geboten wurde, zeigten eine ähnliche Steigerung der Aktivität, ohne die assoziierten Kosten. Weiter zeigten Nutzende, die einen monetären Anreiz erhielten, eine stärkere Abnahme der Aktivität im Vergleich zu einer Kontrollgruppe. Dies ist ein Hinweis auf die potentiell schädlichen Effekte monetärer Anreize auf die intrinsische Motivation zur Nutzung des IS.

Diese Dissertation beinhaltet Beiträge für die Theorie sowie Praxis. Konkret tragen die einzelnen Ergebnisse zur Literatur in dem Bereich der Informationssysteme, der Green IS und der Verhaltensökonomie bei und bieten Erkenntnisse für das erfolgreiche Design von Energiesparprogrammen.

Disclaimer

This thesis contains texts already published or prepared for publishing by the author in the context of the following publications:

> Lossin, F., & Staake, T. (2016) Advertising programs to curb residential energy Consumption: The Costs of Emphasizing Monetary Savings. *In Preparation for Energy Policy*.
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Contents

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Abbreviations

ACRE	Action to Curb Residential Energy Consumption
ANOVA	Analysis of Variance
AG	Aktiengesellschaft
API	Application Programming Interface
BfE	Bundesamt für Energie, Swiss federal ministry of energy
°C	degrees Celsius
CE	Customer Engagement
CET	Cognitive Evaluation Theory
CHF	Swiss Francs
CI	Customer Intelligence
CO_2	Carbon Dioxide
CRM	Customer Relationship Management
d	Cohens d
d.f.	degrees of freedom
DP	Design Principle
DSR	Design Science Research
e.g.	exempli gratia
e-mobility	electric mobility
EC	European Commission
e-mail	electronic mail
et al.	et alii
EU	European Union
EUR	Euros
ETH	Eidgenössische Technische Hochschule
ewz	Elektrizitätswerk der Stadt Zürich
F	F statistic
GCT	Goal Content Theory
Green IS	Green Information Systems
ICT	Information and Communication Technology
IEA	International Energy Agency
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IP address	Internet Protocoll address

IS	Information Systems
IT	Information Technology
kWh	Kilowatt-hour
M	Mean value
min	minutes
n	sample size
p	P value
p.	page
PV	Photovoltaic power system
R^2	coefficient of determination
SD	Standard Deviation
SDT	Self-Determination Theory
SE	Standard Error
SME	Small and Medium-sized Enterprises
t	metric ton
t	t value
TAM	Technology Acceptance Model
Tukey HSD	Tukey’s Honest Significance Difference test
USA/ US	United States of America
USD	US Dollars
vs.	versus
W	Watt
Wald *Z*	Wald statistic
χ^2	Chi-square
η^2	Eta-squared

1 Introduction

Energy as a Service: Online Efficiency Platforms for Power Utilities

This chapter introduces the practical and theoretical motivation in Section 1.1 and the objectives and contributions to theory and practice in Section 1.2. It gives a brief overview of the general methodological approach in Section 1.3 and closes with the outline of this thesis in Section 1.4.

1.1 Motivation – Disruptors of the Power Utility Market

In a recent survey, 94 % of executives in the power utility market expect a “complete transformation or important changes to the power utility business model” (PricewaterhouseCoopers, 2013, p.4). Change is driven by general global trends and impacting different areas relevant to business and general strategy (PricewaterhouseCoopers, 2014, 2016). The most important general trends affecting the market are current technological breakthroughs and climate change and their associated societal and regulatory consequences. Partially depending on, and interacting with these general trends, new consumer expectations and behaviors, increasing competition, and policies shape the future of the power utility market. Together, general trends and market specific changes form opportunities that can potentially disrupt the entire value chain of the energy market (Christensen, 2006). The focus of this thesis is on European utility companies and their residential customers. Private households account for about 25 % of total primary energy consumption in western countries and thus take an important position in shaping the future market (International Energy Agency, 2015). Regulations and technology are currently the main drivers of change. However, utility companies dominate the market, both in terms of infrastructure and customer perception. Furthermore, the classic utility business model of centralized conventional production and distribution is disappearing. The following sections provide more detail on the trends affecting the power utility market and their disrupted areas, before laying out strategies for utilities to face those challenges.

1.1.1 Global Trends Affecting the Energy Market

Within the last 40 years, the global primary energy demand has doubled (International Energy Agency, 2015). While this development went hand in hand with many highly encouraging trends such as increasing life expectancies and a much smaller share of people living in absolute poverty, the growing hunger for fossil fuels has detrimental effects not only on the climate but also raises questions regarding energy security and imposes a threat to geopolitical stability. As a global mega trend, **climate change** is directly and indirectly transforming the power utility industry. Electric utilities account for over one third of global greenhouse gas emissions (European Environment Agency, 2012). As a response to the diverse negative effects of climate change, ambitious policy measures have been put in place. These measures aim to increase the share of renewables in the power mix and curb energy consumption to limit negative consequences. The 21st conference of the United Nations Framework Convention on Climate Change in Paris, 2015 produced a historic global consensus in fighting climate change. The 195 participating countries, including the USA, the EU, India, and China, aim for a reduction of their carbon footprints to limit global warming to a maximum of 2°C. Reaching this ambitious goal requires an estimated cut-back in emissions by 40 - 70 % by 2050 compared to 2010 levels (Tollefson & Weiss, 2015). Climate change shapes power market policies affecting future business models and opportunities. Private households play an important role in reaching these ambitious goals, as they account for 25 % of primary energy demand (International Energy Agency, 2015). Moreover, residential energy consumption has a high plasticity as it is largely determined by decisions and consumption behaviors of individual consumers (Dietz, Gardner, Gilligan, Stern, & Vandenbergh, 2009). In the EU and Switzerland, more specific targets and associated incentive systems have been formulated and put on the political agenda, as discussed in the next section.

Besides shaping political agendas, climate change is indirectly transforming the industry by creating a societal demand for solutions limiting consequences. Governmental subsidies to support an increase in renewable power generation are interacting with an increased societal demand and willingness to invest. Furthermore, information on consumption and impact is increasingly demanded by consumers. Both, political regulations and societal demands pave the way for new technological trends affecting the energy market as outlined in the following.

Technological advancements affect the market mainly in the areas generation, distribution, storage, and communication. Technologies are driven by regulation such as subsidies (e.g., for PV systems) or mandatory deployment of infrastructural components (e.g., of smart meters). Overall, they lead to a transformation from centralized to decentralized power markets, more renewable generation and less CO_2 in the power mix.

Driven by advancements, consumers are enabled to take a new role in the energy market. Mobile devices and the Internet of Things enable consumers to communicate with producers and distributers in real time. Consumer-side applications, such as smart meters, can provide additional benefits to consumers as they allow for better co-operation between generation and consumption. Within the next five years, the EU demands network operators to equip 80 % of residential homes with smart meters (European Commission, 2014a). Smart meters add a high frequency informational layer on a before rather static system. This paves the way for new approaches enforcing a higher engagement of customers: most prominently, time of use pricing and incentivized demand response to account for fluctuations of the grid, and an efficient use of energy change the way utilities will approach their customers. Utilities can additionally use new technologies, like smartphones and cloud-software solutions and combine them with infrastructural components, such as smart meters to provide services that improve customer relationships and allow utilities to become an “energy partner” (PricewaterhouseCoopers, 2013). Furthermore, the Internet of Things allow appliances (e.g., freezers or water heaters) to become part of the grid and automatically shift their load to off-peak periods. The consumer potentially benefits from being empowered and able to manage her own energy use. The convergence of the aforementioned technologies enables consumers to receive unprecedented insight into and control over their personal energy consumption. However, for utilities, this requires strong information and communications technology (ICT) competences as they are in the position to retrieve and analyze the data and provide customers with the relevant information.

As a consequence, these developments reinforce an ongoing change of infrastructure of the distribution network (level 1-7) that enables the grid to become *smart*. The smart grid enables a bidirectional flow of energy, information, and revenue. This allows for more distributed generation and efficient distribution management (Farhangi, 2010). As generation is currently decentralized and getting more closely embedded within the demand centers, this reflects a necessary adaption of infrastructural requirements.

Decentralized generation by consumers is expected to have a significant impact on the power utility market (PricewaterhouseCoopers, 2013). Following a price decrease of 80 % for photovoltaics (PV) modules over the last five years and governmental subsidies for storage systems (e.g., Germany), the market for residential solar systems is steadily increasing (IEA, 2014). The availability and affordability of storage devices enables households to dramatically increase their potential self-sufficiency (Weniger, Tjaden, & Quaschning, 2014). Thereby, they can enhance the ongoing boom of a consumer-led evolution of electricity supply systems (Agnew & Dargusch, 2015). In Germany alone, the market potential is estimated to grow rapidly with 100,000 storage systems sold annually by 2018 – compared to about 10,000 systems sold in 2013 (Grigoleit, Rothacher, & Hildebrandt, 2014). The associated drop in sales revenue and grid usage poses a significant threat to utility companies in liberalized and non-liberalized markets.

1.1.2 Disrupted Areas and Effects

As a result of technological advancements and climate change, several areas in the utility power market face disruption. The trends need to be on the agenda of every utility for two reasons: First, they pose an existential threat to the existing business model. Second, they provide opportunities to grow.

Government policies require utility companies to meet ecological goals amongst their residential customers. Amongst the most prominent examples are the 20-20-20 targets of the European Union and the Energiestrategie 2050 in Switzerland. Both legal frameworks name three superordinate key measures to reach the common targets: (1) A reduction of final energy consumption by an increase of energy efficiency, (2) an increase of the share of renewable energy sources, and (3) a reduction of carbon-dioxide emissions caused by energy consumption (Die Bundesversammlung der Schweizerischen Eidgenossenschaft, 2013; European Union, 2009, 2012). For 2020, the European Union and Switzerland set up quantifiable goals: The EU aims for a decrease of 20 % in carbon-dioxide emissions (compared to 1990 levels), a share of renewables in the energy production of 20 %, and a 20 % improvement in energy efficiency. The current draft of the Swiss Energy Act aims for a reduction of annual energy consumption per capita of 16 % in 2020 compared to 2000 levels and a reduction of total electricity consumption by 3 %. In the draft, utilities are obliged to support reaching these goals with obligatory directives such as the system of so called *white certificates*. Under those schemes, utilities are incentivized to reduce the amount of energy sold – a mechanism that stands in harsh contrast to their existing business model. Concretely, utility companies are obliged to realize a share of the yearly savings in end use energy (e.g., 2 % as stated in the draft for the Swiss energy act) and are planned to be fined if they fail to meet their targets (e.g., with 5 Rp. per kWh of target in Switzerland). However, actual penalties are to date only drafted and not implemented in actual provisions. Nonetheless, these obligations and associated penalties will create a new economic need to decrease end use energy consumption for utility companies and to seek for cost efficient ways to do so.

Besides regulatory measures to limit climate change, consumer behavior and expectations are changing on various levels. This is due to societal efforts to limit the consequences of climate change, regulations, and technological developments. For one, consumers evolve to prosumers. Prosumers produce, store, and feed electricity back into the grid. As a consequence, revenues by utilities are threatened. To respond to this development, utilities are increasingly positioning themselves as partners for energy relevant products and services, to ensure their share in the value chain. This in turn leads customers to expect their utility to provide products related to in-home energy generation, consumption (e.g., solar systems, or heat-pump installations), and associated services (e.g., maintenance).

New business opportunities as well as lower barriers to enter a more diversified value chain increase **competition** in a market that has long been protected by regulation. With external players entering the market, the threat for utilities to lose their position is increasing. Companies such as Google and their smart thermostat Nest[1] pose a serious threat to incumbents. Especially companies with a background in ICT have capabilities to provide new products and services in the energy sector. This is mainly due to the necessity of strong data processing and analytics capabilities that have long not been core functions of utilities, but are much more developed in other industries. Additionally, third party providers (e.g., online comparison portals) and more tailored offerings (e.g., local green electricity) decrease switching barriers in established market models resulting in higher customer churn rates. Following the trend in other industries, distribution channels are moving from the physical to the digital space (PricewaterhouseCoopers, 2016). Online channels, like social media or personal web-offerings are on the rise to engage with customers. Here, customer expectations shaped by online experiences in areas such as media, travel, and retailing shape customer expectations.

In response to the disruption, utilities need to align their offerings with the requirements of their customers and provide relevant and cost-effective services for as many customers as possible (PricewaterhouseCoopers, 2013). Thus, to ensure future revenue, utilities are

[1] https://nest.com/, accessed on 22.04.2016

becoming service providers. This implicates that the classical value chain of a utility to provide energy and the associated infrastructure as a commodity is diversified and comprises more individualized products and services with lower margins. For utilities, this requires a new customer centric focus for two reasons: First, to assess customer needs in order to develop new product offerings. Second, to provide relevant service offerings for individual customers based on their needs (Frei, 2008).

Additionally, higher competition and lower barriers to entry emphasize the need for utilities to differentiate from competitors by providing added value. In this context, new services that are focused on the individual customer (e.g., information regarding historic consumption behavior) can create lock-in effects that increase switching costs. In the context of distribution, branding becomes an essential foundation of successful sales and marketing efforts. Well-established utilities face the challenge to be trusted as “modern” players in the market.

For several reasons, utility companies have to focus on data processing and analytics capabilities. First, following the general economic trend, the energy market is becoming more data-driven (European Commission, 2014b). Existing and future business models will be processed in the digital space. Second, customer Intelligence (CI) forms the basis for customer centric business models. CI thereby describes a data derived understanding of the customer experience, customer needs, and the ability to predict relevant future customer behavior. Third, the amount of available data is growing in the energy market as well as other markets.

Overall, opportunities require strong capabilities in data mining, data processing, and data analytics to provide sophisticated and custom online experiences, as introduced in the following section.

1.1.3 Strategies for Utility Companies to Face Market Challenges

Due to regulation and technological developments, utility companies lose the basis for their traditional business model of suppling consumers with energy. As the value-chain is becoming more diversified, utilities need to be responsive at operating within multiple business models as the current model won’t be displaced as a whole (PricewaterhouseCoopers, 2014). However, new opportunities for utilities arise as the market offers various potentials. Generally, the energy market is growing as consumption steadily increases. Additionally, utility companies have a large customer base they can use to grow in non-traditional segments. New consumer facing appliances such as smart-home, e-mobility, and PV production open new business opportunities. Energy efficiency services provide an obvious opportunity for utilities to grow, as they can benefit from regulatory incentives and their knowledge in providing the service. Customer knowledge and direct channels to customers are important as they provide the basis to expand the product portfolio and establish new business. In this context, information systems (IS) help to achieve both, customer knowledge and communication channels.

Utilities need to diversify their offering in order to be perceived as a service provider. This can be achieved by establishing a strong network of (third party) partners. Amongst the most prominent of recent examples, E.ON[2] established partnerships with several companies[3] to provide all related services to PV installation, monitoring, and maintenance. Importantly, E.ON provides this bundled package of services and keeps in control of customer relationship. This partnership model can be seen as a blueprint for efforts of various utilities that strive to provide services by partners but try to maintain customer interaction, revenue, and control of processes with relevance to the grid. The basis to maintain position is to form a partnership. However, a partnership requires a CI to offer relevant services. Therefore, utilities increasingly need to invest in approaches to engage and interact with their customers to deepen the understanding of the capabilities and needs (Gangale, Mengolini, & Onyeji, 2013). Again, data mining and analytics capabilities form the foundation for successful market positioning.

Figure 1 shows a customer centric view on current and future offerings by utility companies. Generally, utilities strive to maximize profit per customer. In the traditional model, they do so by developing their customers along a commodity product by means of cost reduction (e.g., reduced cost to serve by online instead of paper-based billing) and upselling of premium products. In the new business, utilities develop customers along a much more diversified path. Various products and services are currently gaining momentum.

[2] E.ON Energie Deutschland GmbH, https://www.eon.de/, accessed on 22.04.2016

[3] IBC Solar, http://www.ibc-solar.de/; ENVARIS, http://www.envaris.de/de/, both accessed on 22.04.2016

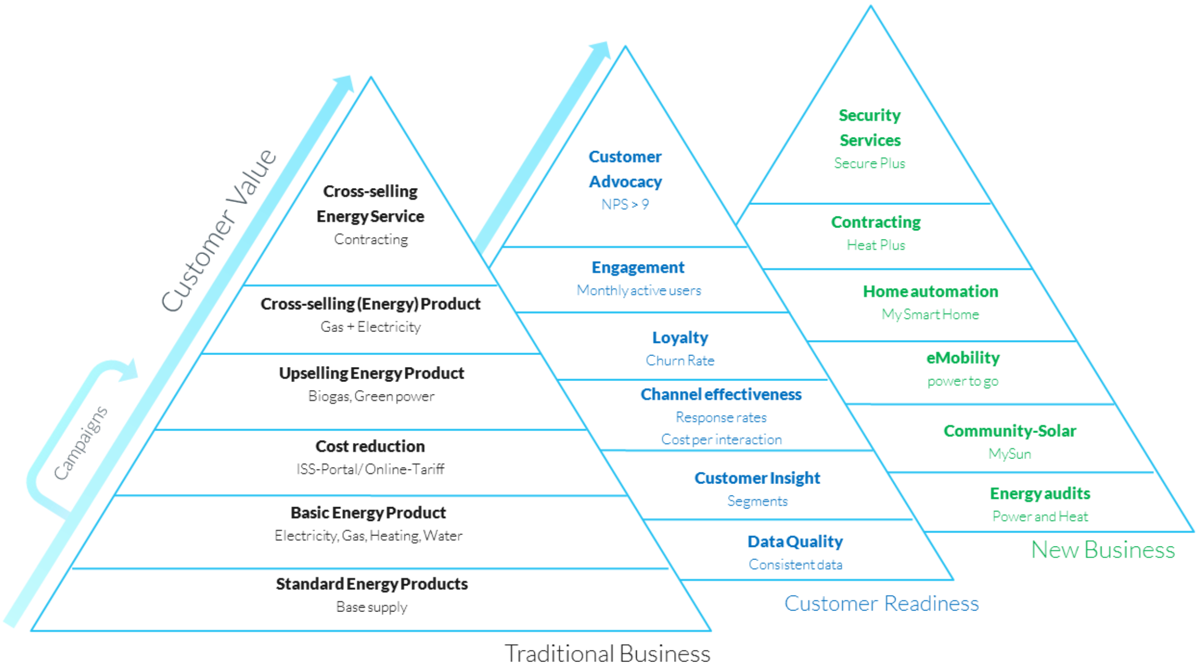

Figure 1 Customer evolution in the traditional and new utility business (Source: BEN Energy AG, 2016)

Amongst the most prominent examples are bundled solar solutions that include production, storage, managing software, and tariffs (e.g., E.ON Aura, 2016[4]), e-mobility load systems and service packages (e.g., CKW, 2014[5]), and smart-home platforms aiming to serve as a centralized management system for energy consumers (e.g., RWE, 2016[6]). Development, design and distribution of these products require detailed CI as they refer to specific needs and involve voluntary consumer behavior. To ensure success of the new business, utilities thus need to focus on their customers. Concretely, customer data and insights, channel effectiveness, recurring engagement as well as customer advocacy become drivers of future success.

Energy efficiency is a topic of general societal relevance and consumer interest. Energy efficiency services provide an opportunity for utilities to capture multiple benefits. On one hand, they allow utilities to fulfill current or potential future energy efficiency regulations. On the other hand, they can increase customer readiness by enabling utilities to deepen their understanding of the customer by forming a data-driven customer intelligence of relevant household properties and interests. They furthermore give the opportunity to establish contact by means of new communication channels. Importantly, households care for energy efficiency services: In a representative survey by the Swiss Mobiliar Lab for data analytics,

[4] https://www.eon.de/pk/de/solar.html, accessed on 22.04.2016
[5] https://www.ckw.ch/privatkunden/strom-beziehen/mobilkraft.html, accessed on 22.04.2016
[6] https://www.rwe-smarthome.de/web/cms/de/2768534/home/, accessed on 22.04.2016

researchers showed that amongst tenants in Switzerland energy efficiency services were ranked as the most attractive ones, even outscoring popular services such as home grocery delivery (Mobiliar Lab for Analytics, 2015). Additionally, utilities hold relevant data to provide meaningful offerings in the domain of energy efficiency to effectively curb residential energy consumption.

IS-based customer engagement (CE) is believed to be a successful means, on one hand, to motivate residential energy savings and, on the other hand, to gather relevant information at scale (Delmas, Fischlein, & Asensio, 2013; Gangale et al., 2013). IS for behavioral control (e.g., online platforms) yield the unique opportunity to enable instant access to household-specific information on consumption, saving potentials, and context information. This includes, for example, social norms to deliver personalized guidance that aid the decision making process and alters habits. Furthermore, it also brings forth the implementation of behavioral mechanisms to motivate the voluntary interaction with the system. IS scholars have successfully incorporated findings from behavioral sciences and implemented scalable and cost-efficient solutions to control domestic energy consumption, like consumption feedback (e.g., social normative feedback) and goal-setting campaigns (Asensio & Delmas, 2015; Loock, Staake, & Landwehr, 2011; Loock, Staake, & Thiesse, 2013). However, in practice, systems fail to produce the wanted outcomes: Mostly, approaches are facing non-technical problems such as low adoption rates, rapidly decreasing interaction over time, and the inability to motivate energy savings (AECOM, 2011; Delmas et al., 2013; Ehrhardt-Martinez, Donnelly, & Laitner, 2010; Schleich, Klobasa, Brunner, Gölz, & Götz, 2011). For utility companies, the cost effectiveness of a system to promote residential energy efficiency depends on the number of participants, the efficacy of the intervention and the increase in customer readiness for the utility.

1.2 Objectives and Contributions

To address the aforementioned shortcomings the goal of this research is to develop an IS that enables utility companies to curb residential energy consumption and increase customer readiness at scale. The general research question of the thesis is:

> *How does an IS by a utility company curb residential energy consumption and increase customer readiness for the utility?*

More specifically, the thesis addresses the question by pursuing the three following sub-questions:

- What are design principles of IS by utility companies to stimulate energy conservation at scale and increase customer readiness for the utility?
- How can the IS maximize the number of participants?
- How can the IS maximize user activity?

The thesis investigates these questions by focusing on the individual at different stages of the action process (Heckhausen & Gollwitzer, 1987). A consistent finding of studies in economics, psychology, and pro-environmental behaviors is that there can be a wide gap between intention and action (Allcott & Mullainathan, 2010; Dietz, 2010). That is, intentions to change ones behavior are easily stated or provoked in experimental settings, but are not very likely followed through by means of actual behavior change. A majority of American consumers, for example, state their intention to behave more energy efficient (Leiserowitz et al., 2009). Actual behavioral observations, however, show a mismatch between stated and actual behavior with far less consumers living up to their own well intentioned goals (Leiserowitz et al., 2009). Furthermore, due to the Hawthorne effect, experiments might overestimate treatment effects. (D. Schwartz, Fischhoff, Krishnamurti, & Sowell, 2013). Research focusing on the overall effectiveness of interventions to curb residential energy consumption needs to account for the discrepancy by measuring actual behavior in real-world contexts. Field experiments provide a suitable means to do so, if they occur in real-world settings. Thus, a main contribution of this thesis is the development of an IS-based energy efficiency platform for a real utility company allowing to conduct field experiments. The development follows a design science approach (Hevner, March, Park, & Ram, 2004) and provides design principles for IS-based interventions to curb residential energy consumption. The IS strives to capture all stages of the decision making process and thus allows to conduct field experiments that are needed to investigate the aforementioned questions and obtain results with high external validity.

To investigate how to maximize the number of participants using the IS, this thesis aims to shed light on the effectiveness of different appeals to promote programs to curb residential energy consumption. Practice is still mainly driven by the approach to highlight the individual benefit (e.g., saving money) to motivate participation – with limited success, as evident in the energy efficiency gap (Dietz, 2010). Lab-based research highlights potentially detrimental effects of emphasizing monetary benefits. They can shift the normative reference frame and even reduce the likelihood to participate (D. Schwartz, Bruine de Bruin, Fischhoff, & Lave, 2015). Evidence in the field and insights on possible influences of different appeals on outcome measures (e.g., energy savings) are currently missing. Thus, the thesis focuses on the most common approaches, that either appeal to altruistic, normative, or self-benefit motives of the consumer (Delmas et al., 2013; White, MacDonnell, & Dahl, 2011), and investigates possible selection effects of different appeals that might affect outcomes.

To maximize the value in terms of customer readiness for the utility and to increase the effectiveness of the IS to curb energy consumption, the thesis aims to increase user interaction with the IS over time. As highlighted in Section 1.1.3 the future success of utility companies critically depends on data mining and analytics capabilities. Thus, creating a data basis with relevant customer data can be achieved by a goal directed interaction steered by the business needs of the utility. The present work strives to maximize goal-directed interactions by means of incentives (Ba, Stallaert, & Whinston, 2001; Gneezy, Meier, & Rey-Biel, 2011). Therewith, the thesis contributes to IS-research on incentive-alignment and green IS in general by investigating the effectiveness of incentives to motivate goal directed interaction and contribute to positive outcomes. Generally, IS-based feedback systems show to be promising in curbing residential energy consumption at scale (Asensio & Delmas, 2015; Tiefenbeck et al., 2015). In the IS context, incentives are widely used to further increase the effectiveness of systems (Ba et al., 2001). In the context of energy conservation, incentives have often failed to achieve positive treatment effects (Delmas et al., 2013). However, most interventions incentivized the abstract goal of energy savings by using moderate monetary payments. In other contexts, incentives show to achieve positive treatment effects and, for example, motivate participants to exercise more frequently or adhere to psychotherapeutical interventions (Gneezy et al., 2011; Volpp et al., 2009). Incentives are either monetary or non-monetary and can be implemented in different scales (Heyman & Ariely, 2004). Outcomes seem to critically depend on the interaction of type and size of incentives as well as operational implementation. Using incentives as mechanisms of gamification seem to be a promising approach in the IS-context (Hamari, 2015). However, it is still an open question how different types and scales can motivate system usage and contribute to positive effects in the context of energy savings. Thus, the thesis investigates how different types of incentives in different scales can motivate usage of an IS-based approach to reduce residential energy consumption in a game like context and contribute to positive treatment effects.

In summary, the thesis has the following objectives, which address the aspects mentioned in Section 1.1 and together aim to answer the general research question:

1) Design approaches to implement scalable and personalized feedback IS to curb residential energy consumption and engage users over time.
2) An investigation of the effectiveness and impacts of motivational appeals to foster initial participation.

3) A better understanding of the impact of different incentive types and sizes to motivate system usage and energy savings.

Following the theoretical background, these research objectives are further detailed in Section 2.4 to specifically contribute to literature in IS, behavioral economics, and energy policy.

1.3 Research Approach

The research was conducted in close collaboration with ewz, the municipal utility of Zurich, Switzerland. ewz serves 225,944 residential customers and is owned by the City of Zurich. The collaboration was funded by Energieforschung Stadt Zürich (EFZ), a municipal initiative to support applied research contributing to the long-term goals of the so called 2000-watt-society. The project started in April 2013 and lasted for two years. The research team was led by the author and comprised both, other researchers from the Bits to Energy Lab[7] and the implementation and research partner BEN Energy[8], an ETH-Spinoff company that already successfully deployed behavioral change IS for research purposes (Graml, Loock, Baeriswyl, & Staake, 2011; Loock et al., 2013).

This thesis utilizes a *Design Science Research* (DSR) paradigm in order to design the artifact and investigate the topics described in Chapter 2 (Hevner et al., 2004). Addressing a specific problem by means of an innovative artifact is a main objective of the thesis. The author thereby responds to the call by Melville (2010) to investigate effective design approaches " [...] for developing information systems that influence human actions about the natural environment" (Melville, 2010, p.9). The focus of the present work is primarily to find solutions to existing problems and explain specific phenomenon with a high relevance. A DSR approach that is concerned with "the systematic creation of knowledge about, and with, design" (Baskerville, 2008, p. 441) is thus favored. Accordingly, this thesis incorporates iterative, multiple build and iteration phases. A first phase derives requirements and based on these requirements conceptualizes and further develops an existing IS[9]. Secondly, a field experiment assesses the second research objective and investigates how to promote the program. In a third phase, a second field experiment investigates incentive mechanisms to maximize value for the utility and energy savings, thus, pursuing the third objective. Finally,

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[7] The Bits to Energy Lab is a research initiative of the ETH Zurich, the University of St. Gallen, and the University of Bamberg

[8] https://www.ben-energy.com, accessed on 22.04.2016

[9] This thesis builds on the functionalities provided by Graml et al., (2011) and further develops the IS as described in Chapter 3 in more detail

findings are discussed in terms of contributing to theory, general practice, and specifically the IS developed within the thesis.

Concretely, an IS comprising a web portal, mobile app, a postal mailing, and different e-mailings was developed within the framework of the project and implemented as smartsteps[10] for the utility partner. smartsteps aims to provide households within the city of Zurich with feedback on their energy consumption and personalized advice on how to save energy. It engages the user by applying a gamification approach combining storytelling, individual progress, social proof, feedback, challenges, and bonus points. A detailed description of the design objectives, approach, and implementation is provided in Chapter 3. The campaign within the research project ran from the 28th of February 2014 to the 1st of April 2015. Following the research project ewz decided to proceed with smartsteps and provide the platform as a service for their residential customers and future research projects. Within the research project, the platform was successful in attracting 3,980 customers by means of three direct mailing campaigns[11] addressing a randomly chosen subset of households. The marketing campaigns were the only marketing efforts to promote smartsteps. A detailed description of the project implementation and timeline is provided in Section 3.4. At the time of the study there was no smart meter infrastructure available to automatically provide consumption feedback. Consequently, feedback was provided on the basis of consumption information obtained by ewz and self-entered meter readings by consumers. The feedback, was delivered in the same way and form as if it was based on smart meter data. Thus, derived design guidelines do account for portals that build on a smart metering infrastructure.

To empirically pursue the second and third research objectives, two large scale field experiments were carried out using the platform designed for this purpose. With 20,000, resp. 2,355 households, both studies were set up as randomized control trials. In the first experiment participation rates amongst contacted households, a households' energy efficiency, and utility consumption data (electricity) served as dependent variables. The first experiment is described in Chapter 4. In the second experiment, usage information of the web portal and the mobile application and utility consumption served as the dependent variable. The second experiment is described in Chapter 5. For both experiments, participants were randomly assigned to experimental groups to test the effectiveness of different motivational appeals and incentive mechanisms, respectively, to ensure internal validity of the experiments. For the first study, a logistic regression model is used in order to estimate effects of the treatment on the bivariate decision to sign up for the portal. For both studies, effects of the respective treatments on utility consumption are estimated using a difference-in-

[10] https://www.smart-steps.ch, accessed on 22.04.2016

[11] In total, 42‘000 mailings were sent to households within the city of Zurich

difference strategy, to account for time trends that affect all treated and not-treated households alike and minimize variance of the data.

To estimate causal effects on electricity consumption, the utility company provided electricity consumption information of all households within the supply zone from 2010 till 2013. For all registered households, and a group of 10,000 randomly picked households not contacted within the campaign, the utility additionally provides consumption information until November 2015.

Electricity consumption generally shows to vary greatly among households and over time. In Zurich, the mean electricity consumption is at 2,600 kWh per year. However, 25 % of households consume more than 3,300 kWh or less than 1,200 kWh. Thus, an analysis of total consumption can easily underestimate effects of interventions, because even for unrealistically large effects a high sample size would be needed to detect effects with statistical significance (e.g., sample size of $n > 1{,}000$ are needed to detect an effect of 260 kWh at a significance level of 5 %). This is due to the high standard deviation, even exceeding the mean consumption with about 2,900 kWh. Changes in electricity consumption offer a measure that is much less variable between households with a mean of about 39.2 kWh and a standard deviation of about 1,300 kWh (Degen, Efferson, Frei, Goette, & Lalive, 2013). The data provided allows to use changes in electricity consumption as a measure for estimating treatment effects. Therefore, to detect an effect size of our intervention that is estimated to be in the magnitude of 7 % (Abrahamse, Steg, Vlek, & Rothengatter, 2005; Loock et al., 2013), or an average change of 182 kWh an $n > 400$ is needed. Thus, the field experiments need to be employed at large scale. Figure 2 displays the required sample size that is needed to detect effects on the reduction of the intervention on electricity consumption at a 5% level of significance.

The vertical axis shows absolute savings. The estimation takes into account approximate standard deviation

$$z = \frac{y^E - y^C}{\sqrt{2/N\sigma}}$$

where σ is the estimated standard deviation of change in electricity consumption for both groups, y represents the mean change of electricity consumption for treatment (E), and control group (C), respectively, and N represents the overall population.

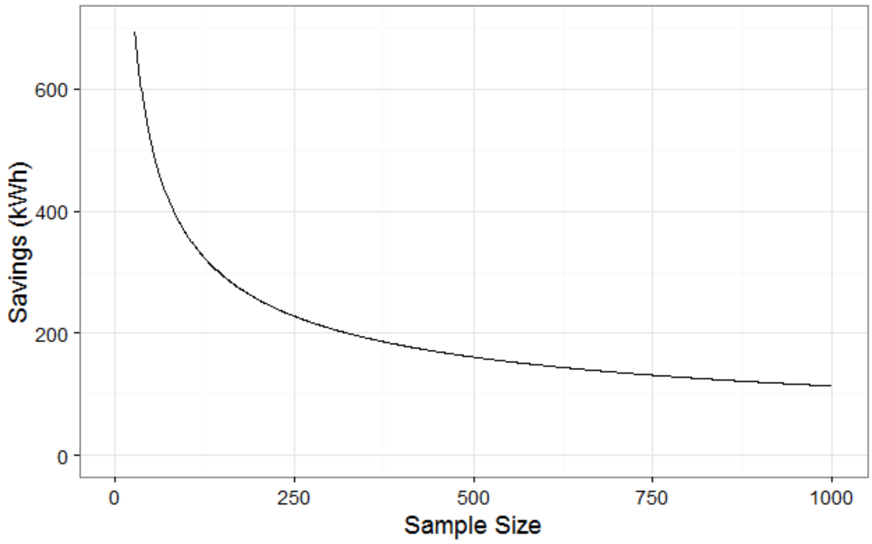

Figure 2 Required sample size; Displays n to detect effects on the reduction of the intervention on electricity consumption; Line indicates upper bound of confidence interval at 5 % level of significance;

1.4 Thesis Outline

Chapter 1 describes the general motivation, context, and overview of the thesis. Chapter 2 provides the theoretical foundation for the issues addressed in the thesis. It reviews energy consumption of private households and the smart meter roll out to give an understanding of the behaviors addressed in this thesis and the context of target behaviors. The chapter further reviews interventions to curb residential energy consumption with a focus on feedback interventions and different informational strategies and how they affect the individual. Lastly, the chapter shows how green IS address the topic by means of scalable systems. Chapter 3 describes the design and implementation of the artifact developed following a DSR. Chapter 4 and Chapter 5 introduce the two field studies conducted to empirically evaluate the research questions: Chapter 4 describes a study to investigate the effectiveness of different marketing appeals to initially motivate program participation. Chapter 5 presents a study to evaluate the effects of different incentive types and sizes employed in a gamified setting to motivate system interaction and thereby energy savings. Chapter 6 concludes with a general discussion of the main findings and implications of the thesis and gives an outlook for future research and the limitations of the present work. The structure of this thesis is shown in Figure 3.

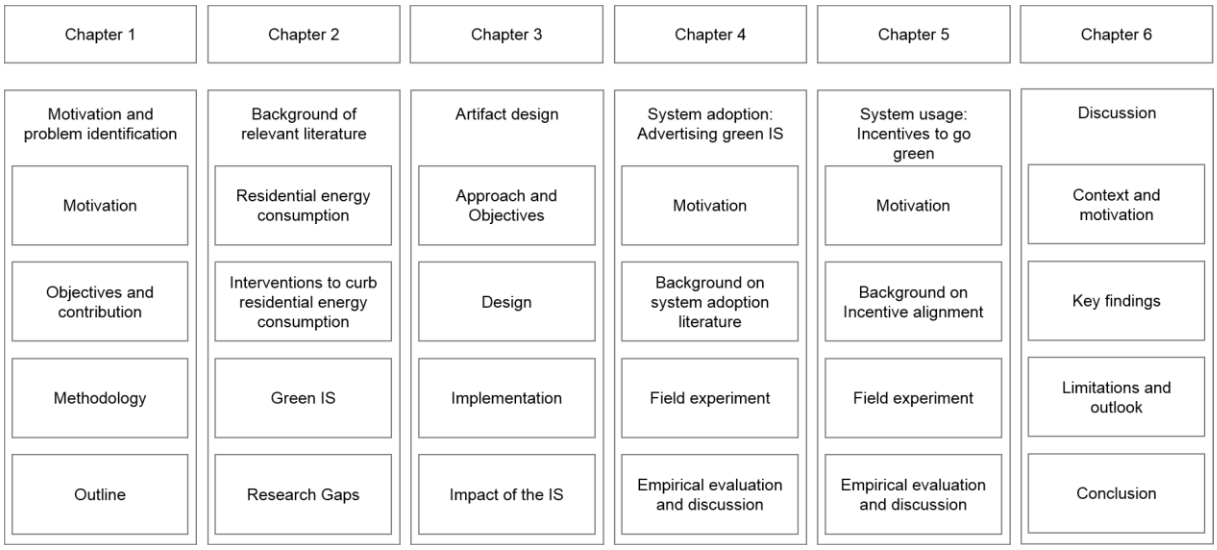

Figure 3 Structure of the thesis

2 Theoretical Background

Approaches to Impact Residential Energy Consumption at Scale

This chapter provides an overview of the relevant literature for the topics addressed in this thesis. Section 2.1 discusses the relevance of residential energy consumption. It introduces its determinants and provides an overview of smart metering as a technical infrastructure. A description of feedback interventions and informational strategies gives an overview of approaches to curb residential energy use in Section 2.2. Finally, Section 2.3 reviews literature on green IS as a rather new discipline to focus on residential energy use by means of scalable systems paying respect to psychological factors determining behavior of individual residents.

2.1 Residential Energy Consumption

As identified in Chapter 1, for utility companies, addressing their customers and providing meaningful services for households to reduce their energy consumption has a high relevance on multiple levels. Aim of Section 2.1.1 is to understand the relevance of residential energy consumption in the context of climate change and its determinants to show potential strategies for interventions to curb consumption. Section 2.1.2 addresses economically irrational behavior that to some degree determines residential energy consumption by reviewing the energy efficiency gap. Finally, Section 2.1.3 gives an overview of smart metering as a technology driven opportunity to measure and address relevant behaviors.

2.1.1 Relevance of Residential Energy Consumption

In order to fulfill the ambitious goals of government policy discussed in Section 1.1.2, both the supply and the demand side have to undergo fundamental changes. Governmental policies, such as a potential carbon tax or the success of national and international cap-and-trade programs, face political resistance and implementation issues, respectively, and do not sufficiently contribute to meeting the goals (Avi-yonah & Uhlmann, 2009; Dietz, Ostrom, & Stern, 2003). On the demand side, residential consumers have been identified to hold a large potential to effectively reduce fossil fuel use and thus carbon emissions to mitigate climate change (Dietz et al., 2009). Curbing residential energy consumption provides a short-term option to meet near-future goals and does not necessarily rely on complex and timely policy provisions. Furthermore, it can buy time to develop new technologies, institutions, and policies to meet longer-term targets (Dietz et al., 2009).

Residential energy consumption accounts for approximately 25 % - 29 % of primary energy consumption and for 20 % of CO_2 emissions in the US, EU, and Switzerland (Bundesamt für Energie BfE, 2013; European Environment Agency, 2012). Figure 4 shows the share of residential energy consumption and other sectors in Switzerland.

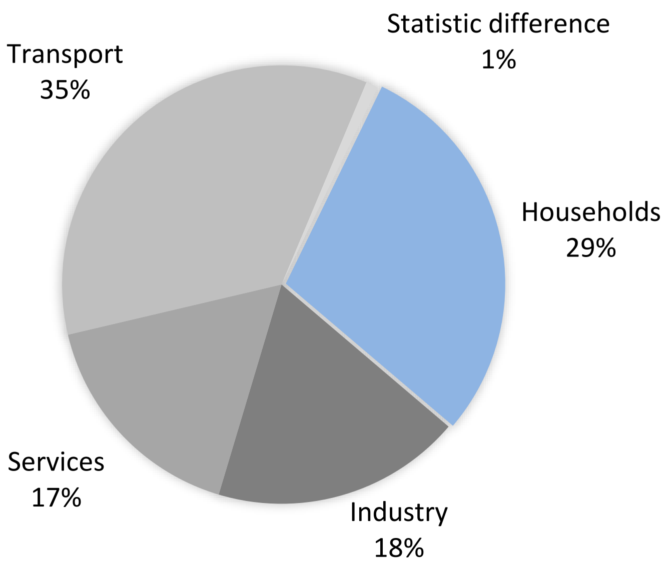

Figure 4 Energy consumption by sectors; Source: BfE (2013)

Importantly, within households, energy consumption varies greatly. This is largely due to differences in the efficiency of appliances (e.g., efficiency of heating system), number of appliances (particularly for electricity consumption), and usage behaviors (e.g., ventilation) of the residents. Both areas reflect the areas identified to induce substantial energy savings. In the US, the reasonably achievable emission reductions are estimated with 20 % in the household sector within 20 years (Dietz et al., 2009). This estimate considers the most effective and non-regulatory interventions only.

Residential energy consumption is, aside from technical parameters, determined by human behavior (Dietz et al., 2009; G. Gardner & Stern, 2008; Haas, Auer, & Biermayr, 1998). Importantly, households do not demand energy per se. Energy consumption usually enables consumers to receive services they wish for, making it a *derived demand* (Thøgersen & Grønhøj, 2010). In Switzerland, space heating constitutes the largest share of residential energy demand (71 %), followed by water heating (13 %), and cooking (4 %). See Figure 5 for a detailed breakdown of energy consumption by end use in Swiss households. Other energy uses by residential households include room climate, entertainment and ICT, lighting, wet cleaning, refrigeration, and other electronics.

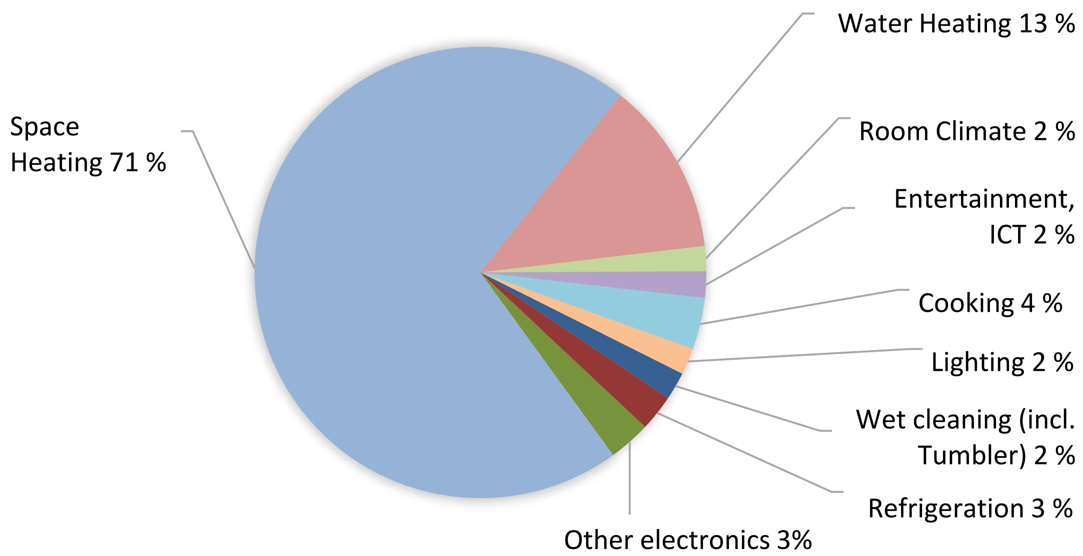

Figure 5 Energy end uses in Swiss households in percent of total use; Source: BfE (2014)

In summary, residential energy consumption is mainly determined by space heating and water heating, but also includes various other end-uses. Curbing residential energy consumption therefore requires targeting a set of different end-uses and associated behaviors.

Depending on the situation of households (e.g., being owner or tenant), the ability to take different actions to curb energy consumption varies greatly. Generally, owners have a wider range of potential actions as they can replace core components of their home that are usually rented to tenants (e.g., heating systems). Abilities also vary depending on regional specifics.

In Switzerland, for example, tenants usually do not have control over the purchase of many white goods, such as refrigerators or washing machines.

Behaviors determining energy consumption can be divided into efficiency improvements and curtailment behaviors (Gardner & Stern, 2002). Efficiency improvements are one-shot behaviors that involve replacing less efficient with more efficient appliances or modifications to improve the efficiency of systems that are already operating (e.g., installing a more efficient shower head). Curtailment behaviors describe the change of ongoing, often habitual behaviors with the goal to use appliances less frequently or intensively (e.g., switching off lights). Efficiency behaviors are usually more effective in reducing households energy consumption (Dietz, 2010). Controversially, households' estimates are biased and they rate the effectiveness of curtailment behaviors to be higher than of efficiency behaviors, revealing substantial misperceptions (Attari, DeKay, Davidson, & de Bruine, 2010). This is due to the systematic underestimation of high consuming appliances (e.g., heating) and the overestimation of highly salient appliances (e.g., light bulbs). Misperceptions partially determine the energy efficiency gap, as discussed in the following section.

2.1.2 The Energy Efficiency Gap

The traditional approach of policy makers to foster resource conservation relies on a rational model of human behavior and is based on pricing mechanisms or regulations (e.g., subsidies for home retrofitting, phase-out of incandescent light bulbs). However, both interventions are likely to face political resistance. Furthermore, their implementation is often slow and costly and fails to produce positive effects (Dietz et al., 2009). Even though curtailment and efficiency measures could substantially reduce energy consumption and associated financial costs, households fail to take advantage (Dietz, 2010). This phenomenon of the unexploited economic potential of energy efficiency is commonly known as the energy efficiency gap (Hirst & Brown, 1990).

According to Hirst & Brown (1990), the energy efficiency gap is caused by structural and behavioral barriers. Structural barriers include uncertainties about energy processes, regulatory policies, codes and standards, and supply infrastructure limitations. Behavioral barriers include incomplete information, individual attitudes towards energy efficiency, and misplaced incentives. For residential consumers, mainly behavioral barriers account for the efficiency gap. Thus, minimizing the energy efficiency gap for the residential sector requires an understanding of the mechanisms underlying behavioral barriers on the level of single individuals.

Misplaced incentives are especially evident for efficiency behaviors, the most effective means to curb residential energy consumption. Land-lords, for example, do not profit from efficiency gains by weatherization provisions because their tenants pay the energy bill. Furthermore, consumers tend to dismiss strong long-term benefits to avoid short-term costs (Benartzi & Thaler, 2007). As a result, compared to a rational projection of life-cycle costs, consumers undervalue efficient energy use by appliances in their decision process. Another reason or the efficiency gap is caused by insufficient ecological motivation for energy efficiency improvements by a large share of the population. This is, for example, expressing in low participation rates of subsidized or even free retrofit programs (Hoicka, Parker, & Andrey, 2014). However, depending on which aspect of energy efficiency programs and measures are emphasized, participation rates vary substantially (Stern, Gardner, Vandenbergh, Dietz, & Gilligan, 2010), as further analyzed in Chapter 4. As humans rely on heuristics in the decision making process, behavior is likely to be guided by misperceptions and resulting incomplete information. The above mentioned biased perceptions about energy consumption of appliances and the effectiveness of efficiency and curtailment behaviors are one causal reason for the energy efficiency gap (Attari et al., 2010). As Dietz (2010, p. 16007) puts it: “Underestimates of energy use / savings seem to permeate all sectors of […] society”. One of the mechanisms driving the misperceptions is the anchoring effect (Attari, 2010). Participants estimate quantities of energy consumed compared to a well-known reference point. This leads to an underestimation of high consuming- and overestimation of low consuming appliances. Additionally, research identified appliance size, replacement of human labor, cognitive dissonance, and variable anchors to systematically bias perceptions (Baird & Brier, 1981; Frederick, Meyer, & Mochon, 2011; Kempton, Harris, Keith, & Weihl, 1985; Kempton & Montgomery, 1982). Table 1 gives an overview of main findings from the most relevant studies investigating systematical biases in the perception of energy consumption.

Table 1 Overview of studies on the perception of energy consumption

Study	Findings
Baird & Brier (1981)	Subjects have a general understanding of the energy consumption by appliances, but rank their consumption as a function of size.
Kempton & Montgomery (1982)	Subjects use running time and replacement of human labor for estimating the energy consumption of appliances. Subjects use money for energy calculations.
Kempton et al. (1985)	Subjects name mostly curtailment measures and overestimate lighting. Misperceptions might occur due to cognitive dissonances caused by the lack of effectiveness by energy conservation measures taken in the past.
Attari et al. (2010)	Subjects name mostly curtailment measures as effective measures to save. Average underestimation of energy consumption by a factor of 2.8.
Frederick et al. (2011)	Anchoring influences the estimation of energy consumption and distorts the tendency towards over- or underestimation.
Attari (2014)	Subjects mostly named curtailment measures to effectively save energy related to water heating. Subjects are more likely to list effective measures for others, rather themselves. Subjects underestimated water use by a factor of 2 on average.

Overall, the energy efficiency gap manifests as behavioral barriers underlying everyday decisions: Misperceptions, misplaced incentives, dismissal of long-term benefits over short term costs, and ineffective appeals to engage households with the topic provide barriers, but on the other hand opportunities to lower residential energy consumption. Current technological developments allow to overcome misperceptions and can increase the salience of means to curb consumption by providing consumption feedback, incorporate incentives, and appeal to more effective motives for engagement, as further discussed in the next sections.

2.1.3 Smart Metering for Behavioral Change

Smart meters can provide a unique opportunity to curb residential energy consumption at scale. As an integral component of the smart grid, smart meters enable a two way communication between a households meter and a central system (e.g., by the utility). Smart meters make electricity, gas or water consumption data available for remote reporting and monitoring. As a central advantage, smart meters are pervasive: The EU plans to equip 80% of households with smart meters for electricity by 2020 (European Commission, 2014a). Full roll-outs have already been completed in Sweden (2009), Italy (2011), Finland (2013), and Malta (2014). Figure 6 shows the current state of the smart meter roll-out in the EU and results of cost-benefit analysis. In Switzerland, 80 % of households are estimated to being equipped by 2025 (Ecoplan, 2015). This provides a unique opportunity to implement programs for residential energy efficiency at high reach. For most countries, the cost benefit analysis of a roll-out is positive. To some parts outcomes depend on different saving potentials due to different household characteristics across countries. For Switzerland, the cost benefit analysis also depends on the respective roll-out strategy, with better projections for a full roll-out: Overall, benefits of 1.26 to 1.68 billion CHF outweigh costs of 0.83 billion CHF for a Swiss roll-out (Ecoplan, 2015). Benefits are mainly on the side of end-consumers, such as private households, and the service industry.

Smart meters can enable households to make better informed decisions when cutting back their energy consumption. For end-consumers smart meters aim to provide information via smartphone/ gateway to an in-home/building display or auxiliary equipment and support advanced tariffing and payment systems. As discussed in Section 2.1.2 concrete information can effectively bridge the efficiency gap as it corrects potential misperceptions. The key components enabling the information transmission comprise metering and associated devices, communication and data processing infrastructure, and devices to display the information inside the home. Devices to display information are in-home displays, installed with the meter, cloud-solutions powering web and mobile applications or paper-based reports. Various factors determine the frequency of information transmission to consumers. Factors include regional data-security provisions, system architecture aspects providing direct or indirect data-transfer to consumes, and utility specific configurations. This leads to the availability of feedback ranging from real-time to hourly, daily or aggregated at a monthly level.

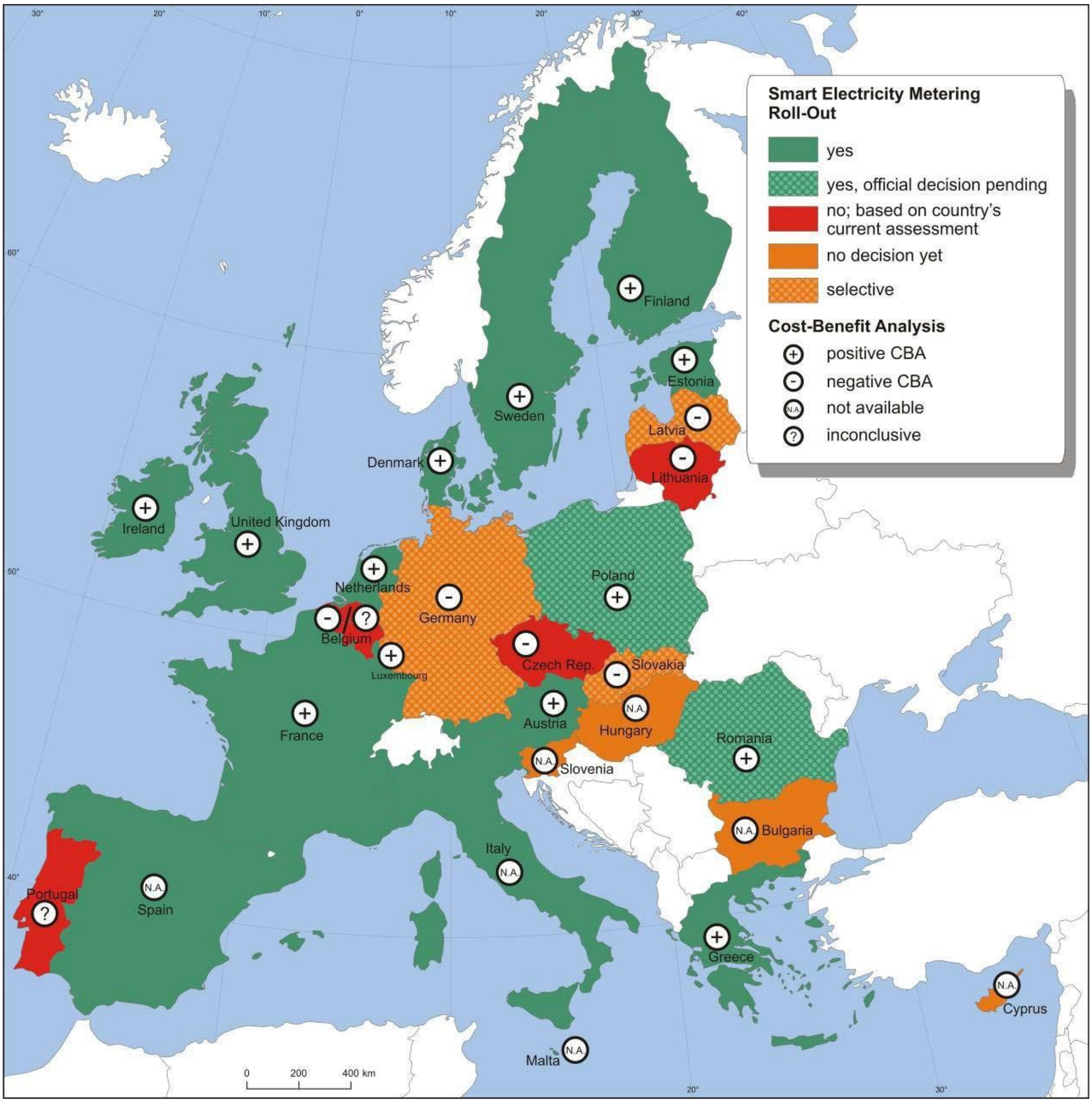

Figure 6 Overview of the smart metering roll-out in the EU; CBA outcomes and intentions for electricity smart metering large-scale roll-out (more than 80% of consumers) for members of the EU, by 2020 (Status - July 2013; Source: European Commission (2014)

Smart meters provide an opportunity to target household actions by supporting both efficiency and curtailment behaviors. Providing relevant information is not trivial, as household situations and thus available means to curb consumption are very diverse. In this context, smart meters offer different opportunities that go beyond the pure delivery of consumption information: Based on smart meter data, residential efficiency programs can be personalized on different levels. Specifically, the data enables the determination of situational characteristics, identification of specific measures, and long-term monitoring.

Situational characteristics help to determine the potential actions households can take (e.g., tenants cannot engage in weatherization provisions). Beckel, Sadamori, Staake, & Santini (2014) developed an approach to infer household characteristics from their electricity consumption using supervised machine-learning techniques. The researchers could infer characteristics related to a households socio-economic status, its appliance stock, or its dwelling (Beckel, Sadamori, et al., 2014). For some of the characteristics predictive accuracy exceeded 80 % (mean accuracy 70 %) making it a valuable approach to implement targeted efficiency programs.

On the level of concrete actions, efficiency improvements usually involve the change or modification of single appliances (Stern, 2000). Accordingly, feedback on appliance-level holds the most actionable information. Such information includes for example the identification of inefficient appliances. Energy efficiency programs could target households with specific inefficient appliances and offer energy efficient replacements. Nonintrusive load monitoring is a popular approach to infer appliance-level electricity consumption from aggregated smart meter data of households. Algorithms can already reliably identify cooling appliances, stoves, dishwashers and other appliances with high electricity consumption (Beckel, Kleiminger, Staake, & Santini, 2014). However, much work is to be done as appliance recognition and detection of inefficiencies is still in its early stages. Until now, appliance-level load determination is to a large degree dependent on self-reports of households or so called smart plugs with voltage sensors. Besides efficiency improvements, curtailment behaviors can effectively reduce in-home energy consumption. To support curtailment behaviors, feedback can visualize consumption over time. First, it can create a general awareness for one's energy consumption. Second, feedback can show the effectiveness of curtailment behaviors implemented by households. Additionally, channels used to deliver the feedback can be enriched with other information, such as saving tips or motivational elements as discussed in Section 2.2.

Studies that estimate the general effectiveness of smart meter based interventions to motivate energy savings (and load shifting) provide mixed results. The Swiss impact assessment for a smart meter roll-out estimates the potential for smart meter enabled electricity conservation of on average 2.7 % and up to 5 % for more responsive users (Baeriswyl et al., 2012; Ecoplan, 2015). Load shifting potentials are estimated to be relatively large with about 10 % of total end consumer load. A comparable analysis for Germany resulted in savings ranging from 0.5 % to 2.5 %. Savings thereby showed to be linearly depending on the absolute amount of energy consumed (Ernst&Young, 2013). Both analyses emphasize the importance of the user-technology-interaction to achieve desired effects. Field studies of smart meter roll-outs support the size of the estimated effects. In a large field study, Degen, Efferson, Frei, Goette, & Lalive (2013) report savings of 3 % - 5 % for smart meter based consumption feedback.

Only few studies investigate the voluntary initial adoption of smart meter technology users. Field studies often report a high adaption rate of around 20 % (Schleich et al., 2011) but have a strong pre-selection bias or take multiple costly measures to recruit participants. Furthermore, studies commonly emphasize the research aspects of the project in the recruitment process. Thus, more research is needed to get a more realistic estimate of an adoption rate if the feedback technology requires an opt-in decision by the households. Once the technology is initially adopted, system usage usually shows a rapid decline. Lower energy savings seem to be associated with a decline in usage frequency. An Austrian review of smart meter studies reports that online portals fail to get participants back on the website after the first initial use (Kollmann & Moser, 2014). However, bonus systems and reminders could effectively motivate continuous system usage (Kollmann & Moser, 2014). A more detailed analysis of motivators is needed as well. Overall, the results of the field experiments suggest that smart meter technology combined with elements to facilitate interaction have the potential to foster energy conservation. However, to stimulate significant overall savings, a large number of consumers have to initially adopt the technology provided.

To summarize, curbing residential energy consumption is a meaningful and instantly available mean to support governmental targets and fight climate change. Residential energy consumption and the energy efficiency gap are to a large degree determined by human behavior and associated misperceptions. Furthermore, residents do not have a direct, but a *derived demand* for energy with different options to curb their consumption. Consequently, interventions need to deal with a wide set of potential behaviors. Interventions targeting residential energy consumption need to consider irrational characteristics that are not accounted for in traditional approaches. Contrasting the traditional approach, instruments influenced by the behaviorist paradigm have shown to be powerful and instantly available means to curb energy consumption (Allcott, 2011b). In the domain of smart metering this approach has so far not gained enough attention. The following section outlines feedback interventions as a basis for informed decision making by households followed by an overview of behavioral and motivational strategies to increase the effectiveness of programs to curb residential energy consumption.

2.2 Interventions to Curb Residential Energy Consumption

Various informational strategies are applied in interventions to curb residential energy consumption. Most prominently, feedback interventions have been identified as effective and put forward on policy agendas, as described in the last section. For utilities, interventions pose an instantly available mean to correspond to demand side management provisions and provide relevant services to their customers as outlined in Section 1.1. The last sections described smart meter driven feedback applications as struggling with mostly non-technical problems, such as limited interest by the population, and the inability to produce effects, even though they are estimated to potentially be cost-effective on the level of national economy. This chapter reviews interventions to curb residential energy consumption with a focus on but not limited to electricity consumption. The following two sections review informational strategies commonly used to motivate households to curb their consumption. First, feedback interventions are categorized based on distinct characters of their timeliness and reviewed in terms of their efficacy. Second, other informational strategies, namely saving advice, social norms, and normative information are reviewed. The third Section 2.2.3 introduces behavioral mechanisms driving environmental behavior.

2.2.1 Classification and Efficacy of Consumption Feedback

Feedback on utility consumption can be an effective tool in encouraging conservation by creating a general awareness and help individuals to derive conservation strategies. Feedback in the energy context can take several forms, ranging from yearly electricity bills to real-time appliance level efficiency information. To categorize feedback research, the EPRI (2009) developed a scheme to separate distinct delivery mechanisms. Figure 7 shows the approach by EPRI (2009). Categories differ in terms of information availability and cost to implement. Information availability ranges from indirect to direct feedback. Indirect feedback is summarizing consumption after it occurs. Direct feedback is provided in real time. Expenditures for implementation increase with information availability due to infrastructural and communication costs.

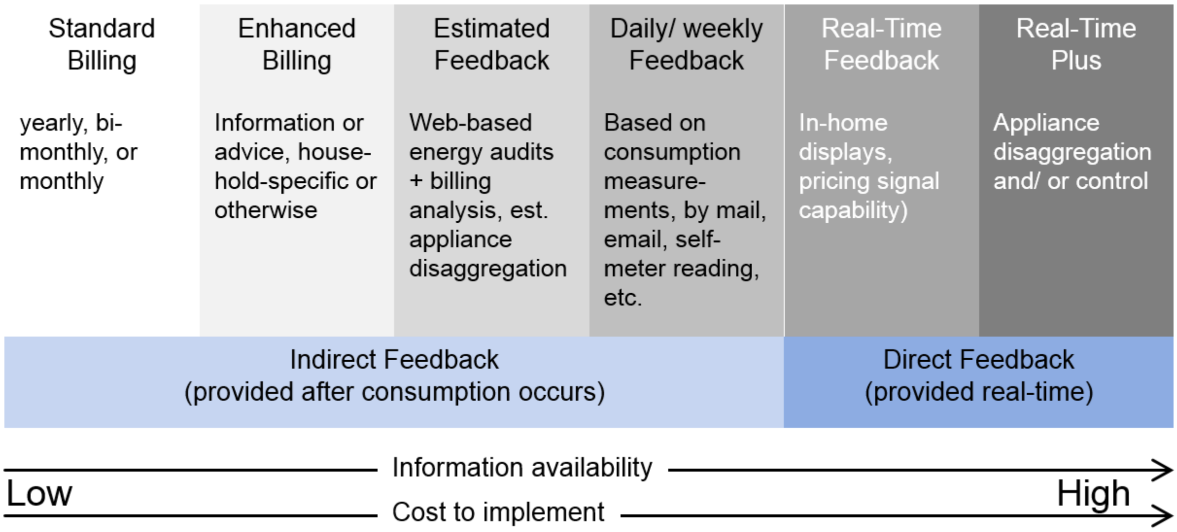

Figure 7 Classification of feedback delivery types. Source: Adapted from EPRI (2009)

Ehrhardt-Martinez et al. (2010) report an increase of electricity savings as a function of increasing frequency and specificity of information in their meta-study. Concretely, they find median savings of 12 % for "real-time plus" feedback, 9.2 % for "real-time" feedback, 8.4 % for "daily/weekly" feedback, 5.8 % for "estimated" feedback, and 3.8 % for "enhanced billing". However, the reported median savings have to be considered carefully as a number of the 36 studies under consideration lack rigor. Particularly, sample sizes and recruitment processes, as well as study designs (e.g., existence of control group) are not considered in the analysis but have shown to impact saving effects (Delmas et al., 2013; McKerracher & Torriti, 2013). Particularly the participation in feedback campaigns is highly relevant to assess efficacy on an aggregated level (e.g., national). Saving effects across the studies under consideration by Ehrhardt-Martinez et al. (2010) are not consequently assessed on the same level of aggregate (e.g., complete customer base of utility vs. opt-in by participants). Generally, participation rates for interventions using an opt-out design are much higher. The use of an opt-out design can be restrained by governmental or company policies, data security regulations, or technological limitations. This topic is addressed in Chapter 4 in more detail, both theoretically and empirically.

To date, the most common form of consumption feedback is the standard billing of utilities. As this represents the status quo for all energy consumers, additional efforts are defined as interventions. The most common intervention is *enhanced billing*, as provided by German utilities on a yearly level (due to regulatory provisions) or delivered by the US based company called Opower[12] to millions of households in the US (Allcott & Rogers, 2014). Opowers' home energy reports provide households with a monthly or bimonthly feedback on their energy

[12] https://opower.com/products/energy-efficiency, accessed on 20.05.2016

use, social comparisons, general information and advice on how to save energy. The company's product has been subject to research, investigating the overall impact and effect of the timeliness of feedback on electricity savings. Allcott (2011) evaluates a series of programs run by the company with a total of 600,000 participating households. The average program showed to reduce consumption by an estimated 2 %. In a subsequent analysis, Allcott & Rogers (2014) showed that a more frequent delivery of feedback increased treatment effects: Households saved 0.5 % more electricity when provided with a monthly instead of a quarterly home energy report. The authors point to the cost-effectiveness of the intervention as the design requires an opt-out by households (around 1 %) and saving effects therefore nearly account for the whole set of households the intervention is offered to. However, as physical mailings are still a rather cost-intensive communication, and programs could benefit from providing feedback at higher frequencies, digital channels are a promising approach to further engage households.

Daily / weekly feedback delivered via at least one digital channel to the households is more commonly used by utilities for customers that do not have smart meters yet (e.g., Loock et al., 2013). Communication is delivered via web- or mobile applications, emailing or text messages. Similarly, most smart metering trials provide feedback on a daily level, or at most in a 15-minute interval. Thus, it is conceptually somewhat difficult to clearly differentiate between studies as frequency of feedback potentially overlaps. As discussed in Section 2.1.3, recent electricity smart metering trials, with information typically aggregated on the household level, lead to savings of 2 % - 4 % (Buchanan, Russo, & Anderson, 2015; Degen et al., 2013; ISE, 2011; McKerracher & Torriti, 2013; Schleich et al., 2011). Older reviews report a range from a negative treatment effect to savings of 20 % (Abrahamse, Steg, Vlek, & Rothengatter, 2007; Ehrhardt-Martinez et al., 2010; EPRI, 2009). This high variance of outcomes between studies is likely caused by differences in study design and, again, the rigor of studies. Delmas, Fischlein, & Asensio (2013) showed that saving effects for less robust studies without a control group were larger (above 10 %, $SD = 12.1$) than for studies with a control group design and considering external influences such as weather data, yielding savings of around 2 % ($SD = 1.1$). Furthermore, most studies focus on a rather short-term duration, as 60 % of the studies used for evaluation in the meta review by Delmas et al. (2013) had durations of 3 months. Also, studies usually employ a different combination of actual feedback strategies within a single treatment condition (Abrahamse et al., 2005; Delmas et al., 2013). Persistence of effects and long-term effects as well as the efficacy of the single feedback components in place are thus mostly referred to as important for future research. Consequently, different feedback types, persistence of effects, participation rates amongst households, household characteristics, and behavioral determinants on the level of single individuals need to be considered in detail to determine the overall efficacy of feedback interventions.

A promising approach to curb residential energy consumption is real-time feedback as it best highlights saving potentials for consumers. Recent research indeed shows the effectiveness of feedback delivered in high frequency and specificity leading to savings above 8 % for electricity and 25 % for shower behavior, respectively (Asensio & Delmas, 2015; Tiefenbeck et al., 2015). For smart metering, in-home displays showing consumption and potential dynamic pricing information are particular interest. Highly relevant results are obtained by the Energy Demand Research Project (AECOM, 2011): The large field trial involved over 60,000 households and was conducted between 2007 and 2011 by the four largest energy suppliers in the UK. The program aimed to determine the impact of different information based interventions. Surprisingly, households provided with an in-home display not necessarily decreased their consumption as only one of four utilities reported a significant saving effect on electricity consumption. Also, saving effects were rather small with around 1 %. These results show that effects are not produced by the technology per se, but the actual intervention in place (e.g., injunctive feedback). Conceptually, technology serves as a mediator to enable and deliver interventions that account for the effects.

In summary, results emphasize the advantages of delivering feedback that highlights saving potentials to consumers. Feedback with a higher frequency than the status quo and as specific as on a level of broad appliance categories can serve this purpose. However, research that implements high research standards (e.g., a control group design) is sparse. Meta-analysis often include results with questionable validity. Thus, it is problematic to determine the efficacy of feedback interventions in the energy context by reviewing a large portion of existing studies. As in other domains the absence of treatment effects can be due to mechanisms on the level of single individuals. In the work context, Kluger & Denisi (1996) report the absence of treatment effects of positive *and* negative feedback on performance. Efficacy of feedback is found to critically depend on motivational factors elicited by the feedback. This is due to the psychological process of steering attention away from the task and on the self. Similarly, in the energy context, the efficacy of interventions critically depends on psychological mechanisms and motivational strategies, as discussed in the following sections.

2.2.2 Common Approaches to Motivate Energy Savings

Informational strategies can go beyond consumption feedback as discussed in the previous section. A basic distinction of informational strategies is whether they focus on pecuniary information or not (Delmas et al., 2013). Informational strategies put a program into a specific context as they direct consumer attention on specific quantifiable outcomes. Thereby, informational strategies influence the overall effectiveness on two distinct dimensions: Firstly, the willingness to initially adopt a program and secondly, the efficacy of the program to curb consumption. The influence on program participation is specifically dealt with in Chapter 4. The present sections review informational strategies commonly applied with a focus on their overall effectiveness.

Most commonly, applied strategies to encourage energy savings amongst households focus on monetary information, concrete advice on how to save energy, and social comparisons, respectively. The information is mostly combined with feedback on individual consumption and less commonly with one of the other strategies (Abrahamse et al., 2005; Delmas et al., 2013). Importantly, the efficacy of feedback in stimulating energy conservation shows to be moderated by informational strategies. Thus, consumption feedback appears to be necessary but not sufficient to induce savings (Delmas et al., 2013). The following sections review the aforementioned strategies and their ability to produce effects.

Saving Advice Saving tips for consumers and personal home energy audits present two of the strategies studied by research (Allcott & Rogers, 2014; Degen et al., 2013; Schultz, Nolan, Cialdini, Goldstein, & Griskevicius, 2007). Both aim at increasing knowledge of the consumer on how to save energy. From a psychological perspective, the approach intents to elicit behavior change by increasing awareness of an issue and the perceived capability of an individual to solve that issue (S. H. Schwartz, 1977). Additionally, advice on how to save energy usually involves information on the impact of actions in order to correct common misperceptions (Attari et al., 2010; Attari, 2014). Therewith, audits and saving tips increase awareness and perceived behavioral control of households. Energy saving advice and personal audits are commonly provided as services by utility companies to assist their residential customers. Moreover, saving advice is part of many smart-meter based interventions reviewed in Section 2.1.3 (Gangale et al., 2013). Meta-analysis results show that depending on the level of involvement with saving advice, interventions can have positive and negative treatment effects on energy savings, respectively (Delmas et al., 2013). Home energy audits showed to have a positive effect on energy savings, whereas simply providing saving tips showed not to be sufficient. This is in line with earlier findings, showing that saving advice needs to be tailored to the capabilities and needs of people in order to produce effects (Abrahamse et al., 2007).

Social Norms One of the most powerful options to promote sustainable behaviors commonly used by utilities and researchers is the application of social norms (Cialdini, Kallgren, & Reno, 1991; Goldstein, Cialdini, & Griskevicius, 2008; Nolan, Schultz, Cialdini, Goldstein, & Griskevicius, 2008; Schultz et al., 2007). Social norms represent the beliefs about the behavior of others. They can be further classified into descriptive norms and injunctive norms (Cialdini et al., 1991). Descriptive norms are beliefs of what most people are doing, whereas injunctive norms are beliefs concerning what most people approve or disapprove of. Social norms have been proven to effectively influence ecological behavior, such as littering (Cialdini, 2003), towel reuse (Goldstein et al., 2008), and energy consumption (Abrahamse et al., 2005; Allcott, 2011b; Loock et al., 2011). In the energy domain, social norms are widely applied to enhance the effectiveness of consumption feedback information, as provided by smart meter applications or paper based reports (Allcott & Rogers, 2014; Gangale et al., 2013).

Descriptive, as well as injunctive norms can powerfully direct behavior – even though consumers commonly underestimate the influence. Nolan et al. (2008) showed that participants' believed to be more directed by personal benefit information than social normative information. However, the actual behavioral outcome demonstrates the opposite. Social normative feedback activates extrinsic and intrinsic motivation, a concept elaborated in detail in the following chapter. Across 31 studies, Delmas et al. (2013) could, however, not show a significant treatment effect of social normative feedback for all consumers. This is due to smaller sample sizes for social comparison compared to individual use feedback. Moreover, the efficacy of social normative information shows depend on characteristics of the respondent. Descriptive normative information can either produce energy savings or undesired boomerang effects depending on whether households are consuming more or less than the reference group (Loock et al., 2011; Schultz et al., 2007). This counter intended effect can be avoided by simultaneously adding injunctive messages. Overall, providing social normative information can be a powerful strategy to increase the efficacy of feedback campaigns to curb residential energy consumption.

Pecuniary Information Efficiency and curtailment behaviors usually involve physical or financial expenditures. Increasing the salience of positive financial consequences is an economically logic approach and fairly long subject to research (Hutton & McNeill, 1981). Particularly, given that amortization of efficiency improvements is not instant. From a classic economic perspective, behavior is mainly motivated by self-interest (Miller, 1999). Accordingly, energy conservation behavior that does not inherent a direct personal benefit is not motivating as such. Analogously, many programs aim to increase or emphasize the positive economic outcomes of environmental behaviors. However, as described in Section 2.1.2, the energy efficiency gap shows that decisions and behaviors made by individuals can alter from predictions by a classic economic framework. The following paragraphs review the various forms pecuniary information can come in: savings, price increases, rewards or rebates, and dynamic pricing.

Information on monetary savings emphasize how a reduction of consumption potentially translates into savings, e.g., on the electricity bill. Bittle, Valesano, & Thaler (1979) performed an experiment that provided households with daily feedback on their expenditures for electricity of the previous day. Households given the monetary feedback decreased their consumption by 14 % compared to a control group. However, the relatively small sample (n = 30) and inconsistency of effects call for a need to further investigate the approach. Asensio & Delmas (2015) provide such a study by investigating effects of real time feedback on costs and as far down as to the appliance level. The results show that monetary information led households to increase their energy consumption by 2.0 % – 4.9 %, depending on their baseline electricity consumption. Price increases and dynamic pricings are employed to investigate effects of costs on overall consumption and time of use. In a field experiment, Allcott (2011a) showed that dynamic pricing information could induce price-elasticity amongst households. Households conserved energy during peak-hours, but did not increase consumption in off-peak times. Overall, households reduced their expenditures by 1 % – 2 % compared to their total energy expenditures. Thus, effects seem to be rather small. Rewards and rebate payments are usually implemented so that participants receive a payment when reaching a predefined energy saving goal. Slavin, Wodarski, & Blackburn (1981) gave biweekly payments in the magnitude of the electricity saved to the residents of different apartment towers if they met a specific saving goal. Participants saved electricity in the order of 6 % compared to a temperature-adjusted baseline. However, between towers, effects varied greatly, again calling for more robust research. Monetary information has also found to negatively impact conservation programs as it can, for example, shift the focus away from altruistic motives. Concretely, explicit rewards may "[…] fail when they undermine the moral values that lead people to act altruistically or in other public-spirited ways." (Bowles, 2008, p. 1605). The mechanisms and cross-domain findings are discussed in more detail in the next section.

Overall, results concerning the efficacy of monetary information as a strategy to curb residential energy consumption show to be inconsistent. But despite the mentioned positive outcomes, meta-analysis results show the influence of monetary savings information and rewards on savings to be negative (Delmas et al., 2013). One possible explanation for this is that monetary benefits under consideration were negligible and thus failed to control behavior. However, negative effects on saving behavior are likely to hint to the impact of psychological mechanisms, such as the aforementioned shift of normative reference frames or the crowding out of intrinsic motivation, which are discussed in the following chapter.

2.2.3 Behavioral Mechanisms to Motivate Energy Savings

In the previous two chapters, feedback and other informational strategies to stimulate energy savings were introduced by means of providing information about ones energy consumption to increase awareness, increase the salience of potential measures to save, and put them into a specific context. The described informational strategies can provide a context that implies specific, quantifiable outcomes (e.g., monetary savings). Outcomes can appeal to psychologically distinct drivers of environmental behaviors: self-benefit or normative concerns and altruism (White & Simpson, 2013). In the following, mechanisms and interactions between both drivers for environmental behavior are reviewed (Bowles, 2008; Stern, 2000; White & Simpson, 2013).

Normative Concerns and Altruism

Individuals do not always behave to maximize economic benefits, as evident in the energy efficiency gap. As introduced in the previous chapter, normative appeals can effectively steer behavior (Schultz et al., 2007). Moreover, individuals can act altruistically or in other ways contribute to the community. In the energy context, various models build up on altruism and normative concerns as drivers for proenvironmental behavior. Schwartz (1977) proposed in his norm activation model the personal norm to be the main driver of behavior. The personal norm is described as the perceived moral obligation to show or inhibit a certain behavior. Awareness of the consequences of actions and the ascription of responsibilities serve as determinants of the personal norm.

Stern (2000) investigated determinants of environmentalism which he defines behaviorally as "[...] the propensity to take actions with proenvironmental intent" (p.411). He developed a theory building on some concepts of altruistic behavior to explain environmentalism. In the model, environmentalism behavior is explained by three causally working factors: (1) personal (especially altruistic) values; (2) personal beliefs about ecological issues, adverse consequences of valued objects, and the perceived ability to reduce the (ecological) threat; (3) proenvironmental personal norms, describing a sense of obligation to act in line with ecological standards. In the private sphere of environmentalism behavior, the model explains 19.5 % of the variance (Stern, 2000). Furthermore, Stern (2000) finds that compared to egoistic values, altruistic values are stronger determinants for proenvironmental behavior – a finding repeatedly confirmed by research (e.g., Xu, Arpan, & Chen, 2015).

Social psychological theories underline the important role of moral concerns and altruism in the context of proenvironmental behavior. However, the theories fail to integrate external factors such as behavioral constraints. Or as Stern (2000) puts it: "Because environmental intent and environmental impact are two different things, theories explaining environmentalism are necessarily insufficient for understanding how to change environmentally important behaviors." (p.415). Thus, they fall short in explaining causal variables for specific behaviors. Concretely, attitudinal factors (e.g., towards a certain product), contextual forces (e.g., material incentives, social norms), personal capabilities (e.g., skills or knowledge), and habits or routines are not included in the models. Importantly, causal variables such as contextual forces aiming to strengthen the self-interest of individuals (e.g., external incentives) potentially interact with internal forces such as the intrinsic motivation of individuals.

Intrinsically motivated behaviors are characterized as interesting, joyful, and have an inherent satisfaction to the individual (Ryan & Deci, 2000). Cognitive evaluation theory (CET) aims to specify social and environmental factors that facilitate or undermine intrinsic motivation, namely autonomy, competence, and relatedness (Deci & Ryan, 1988). Feedback, communications, and other social-contextual events that contribute towards a feeling of competence during a behavior can enhance intrinsic motivation for that behavior (Ryan & Deci, 2000). Thus, challenges at an optimal level or feedback promoting the individuals effectiveness can facilitate intrinsic motivation. Importantly, findings show that the feeling of competence needs to be attributed by an internal perceived locus of causality in order to have positive effects (Kluger & Denisi, 1996). Extrinsic rewards on the other hand can undermine intrinsic motivation (Deci, Koestner, & Ryan, 1999). In the context of programs to curb residential energy consumption, diminishing effects of extrinsic factors on intrinsic factors are a repeatedly observed but poorly understood phenomenon. Monetary information is proposed to diminish intrinsic motivation, thereby threatening the (long-term) efficacy of interventions. The following sections review self-interest as a common motivational appeal to enforce energy savings and the mechanisms underlying potential harmful effects of this appeal on intrinsic motivation.

Self-Benefit

Self-benefit or self-interest appeals highlight a benefit (e.g., monetary) to the individual as a result of engaging in a behavior (Nolan et al., 2008). Self-benefit appeals can motivate prosocial behaviors, like helping in charitable organizations (Holmes, Miller, & Lerner, 2002). Researchers have explained these findings in the marketing domain by means of social exchange theory (Mathur, 1996). "Exchange theory posits that individuals engage in specific activities when they perceive their outcome to be at least equal to the costs of engaging in those activities" (Mathur, 1996; p. 109). Importantly, both input and output can either be material or psychosocial. To some extent, the theory underlies a separability assumption that positive effects of self-benefit and other appeals, such as normative appeals, simply add up. However, the effectiveness of self-benefit appeals for example shows to be dependent on self-image concerns, and show that if those are threatened, self-benefit appeals are less effective compared to prosocial appeals (White & Peloza, 2009).

In the context of programs to motivate energy savings, self-benefit appeals usually highlight the monetary savings or benefits of a household, thereby incentivizing target behaviors. Findings of the efficacy of self-benefit motives are ambiguous, as discussed in Section 2.2.2. However, latest research points to both, harmful psychological mechanisms and resulting negative treatment effects elicited by monetary motivators to stimulate savings (Asensio & Delmas, 2015; D. Schwartz et al., 2015). Bowles (2008) showed that the separability assumption fails in a way that self-benefit appeals such as incentives undermine ethical or altruistic motives. He lists four reasons for the failure of the separability assumption: “incentives may frame a decision problem and thereby suggest self-interest as the appropriate behavior, or affect the long-term development of preferences, or compromise the individual’s sense of autonomy, or convey information affecting behavior” (Bowles, 2008; p. 1606). These processes play an important role when implementing programs to curb residential energy consumption as their influence may undermine effects. The following paragraphs review findings from behavioral economics explaining the reasons for failure of the separability assumption with a transfer to the energy context.

Decision Frames Self-benefit appeals, such as monetary incentives, change the context of a behavior and signal an expected consumer response (Bowles, 2008; Kahneman & Tversky, 1984). In the context of ecological decisions and behavior, individuals may decide to act proenvironmental out of altruistic or intrinsic motivations and normative considerations: While recycling PET bottles or batteries, for example, is not financially incentivized it is a prevalent behavior amongst consumers. Incentivizing altruistically motivated actions by means of monetary outcomes does not only change consequences of these specific actions, but also the respective normative perception. Gneezy & Rustichini (2000) showed how external incentives and normative perceptions can interact. To reduce delayed pick-ups from kindergarten the researchers introduced a fine of approximately two dollars for parents. However, the fine did not reduce delayed pick-ups, but increased the quote significantly. The fine appeared to legitimize delayed pick-ups by paying the fine. Thus, by framing delayed arrival as something parents had to pay for, delayed pick-ups did not pose a violation of moral or social norms.

Analogously, D. Schwartz et al. (2015) showed how framing participation in an energy saving program differently can alter underlying normative reason. Willingness to participate was either framed as associated with financial benefits (“reduce your electricity bill”), ecological benefits (“do something good for the environment”), or both. Depending on the framing, participants reported different levels of environmental reason underlying their willingness to participate. When promoted with financial benefits, the weight given to underlying environmental reasons nearly halved, even when environmental benefits were highlighted as well (D. Schwartz et al., 2015). Highlighting financial benefit aspects of the program shifted participants' attention away from environmental benefits. Furthermore, as environmental motivation appeared to be the main driver for the willingness to participate, participants shown a financial benefit frame reported a generally lower willingness to enroll. Importantly, results are not consistent with the overjustification effect, where individuals attribute their behavior to monetary motives instead of intrinsic ones only when giving extrinsic incentives, because the monetary benefits emphasized in the study are inherent in saving energy and no external rewards (D. Schwartz et al., 2015). However, the impact of self-benefit vs. environmental benefit frames on *actual* participation in energy saving programs and the impact of those frames on overall outcome and associated determinants is still undetected and a contribution of the present work in Chapter 4.

Endogenous Preferences In addition to the discussed influences on single decisions, incentives can induce long-term behavior change by altering motivations. Concretely, incentives can induce more self-benefit-focused behaviors even after they are withdrawn (Bowles, 2008). In a public goods experiment, participants were either awarded no incentive (supporting free riding) or an incentive to increase contributions to the public good (Falkinger, Fehr, Gächter, & Winter-Ebmer, 2000). The incentives showed to be highly effective, however, if participants were asked to play the game later without incentives, the level of contributions significantly dropped below the level of participants who never experienced incentives. This has also been demonstrated in an experiment by Heyman & Ariely (2004). Participants either received a monetary payment, a social gesture in form of candy, or no compensation at all for completing an easy set of tasks. The height of compensation was also varied from medium to low, respectively. Effort of participants compensated with money showed to strongly depend on the size of compensation. Surprisingly, participants that were not compensated at all showed the same effort as participants rewarded the higher monetary compensation. The group compensated with candy performed at that same level, however, performance showed not to depend on height of compensation. Thus, incentives that appeal to the benefit of individuals can direct the attention to a rational consideration of costs and the sole monetary benefits or a "money market" as labeled by Heyman & Ariely (2004).

This holds also high relevance for the energy domain and programs to initiate behavior change amongst consumers. Incentives alter the frame individuals employ to take decisions and thereby perceived endogenous preferences. Of course, this only holds true if the aforementioned effects persist more than just a few hours and alter everyday behavior. In this case, a shift of decision frames could decrease positive spillovers or lead to an increase in consumption for households that can afford and may find it personally convenient to consume more energy.

Self-Determination Building on self-perception theory, appealing to self-benefits by means of explicit rewards may lead to an *overjustification effect* (Lepper, Greene, & Nisbett, 1973). “People are said to make postbehavioral attributions about the causes of their own behavior based on a consideration of the behavior and the conditions within which it occurred. When people are rewarded for doing an interesting activity, they are likely to attribute their behavior to the reward and thus discount their interest in the activity as the cause of their behavior, leading to postbehavior intrinsic motivation that is lower than it would be if they had not gotten the reward” (Deci et al., 1999, p. 630). Explicit rewards can weaken intrinsic motivation by canceling self-regulatory processes. By causally attributing ones behavior to an external locus of control, the perceived individual autonomy diminishes. As an effect, rewards can persistently reduce enjoyment of an activity. In a classic field experiment, Lepper et al. (1973) showed that in the presence of expected rewards, children showed less interest in an otherwise intrinsically motivated activity – drawing. For unexpected rewards, however, no diminishing effect of rewards on intrinsic motivation was found. Besides tangible rewards, deadlines, directives, pressured evaluations, competitions and imposed goals have found to diminish intrinsic motivation as they as well serve towards an external locus of causality (Ryan & Deci, 2000). Surprisingly, latest evidence suggest that the sole act of measurement can have similar effects on intrinsic motivation, by drawing focus on output (Etkin, 2016). As a result, incentivized or even quantified behaviors, even though they are supported at first, can be enjoyed less in the future and as a consequence engaged in less frequently. Programs to reduce domestic energy consumption by means of explicit rewards, such as payments, rebates or other externally imposed goals, can fail to produce effects for the described harmful effects on self-regulatory mechanisms.

Explicit Benefits Convey Information Explicit benefits or incentives are implemented with the purpose to steer behavior in a desired direction. Incentives thereby convey information regarding the objectives and goals of the system they are implemented in. Furthermore, they implicitly hold information regarding the beliefs concerning the agent (e.g., that he would not act without the incentive), showing also to crowd out intrinsic motivation. Sliwka (2007) could show that the conveyed information crowded out intrinsic motivation in the working context due to a lack of trust that was implicitly perceived by workers. As described earlier in the experiment by Heyman & Ariely (2004), different types of rewards also change the behavioral outcome as they frame the transaction to either take place in a "money market" or "social market". For the energy context this provides both, careful consideration especially of the type of incentives and opportunity, as incentives can direct attention to concrete behaviors (e.g., heating behavior) that are neglected by consumers due to misperceptions.

2.3 Green Information Systems

The two sections before reviewed residential energy consumption and different approaches to motivate conservation amongst consumers. The studies reveal that explicit feedback and advice on utility consumption can be effective means if delivered in an adequate timely format and if the content is tailored to situational and motivational constraints of the individual. The following section describes how IS can effectively focus individual consumption behaviors by bridging the gap between reach and relevance of information. Section 2.3.2 shows how the incorporation of concepts from psychology and behavioral economics can enhance the effectiveness of such systems and points to existing gaps in the current literature of green information systems (green IS), as a rather young discipline.

2.3.1 Information Systems to Control Residential Energy Consumption

Information and communication technology (ICT) can play a key role in managing residential energy demand. ICT provides the opportunity to create scalable artifacts that hold the potential to interact with environmental issues on different levels. On a very concrete level, applications like smart meter, teleworking or smart-home can directly reduce environmental impacts, whereas on broader levels ICT holds the potential to shift consumer patterns, or even transform industry and society (Williams, 2011). In recent years the ICT industry has actively driven a sustainable economic development. Green IS has emerged as a result of this development as a new discipline that analyses, designs and implements systems to increase the efficiency of energy demand and supply systems (Dedrick, 2010; Melville, 2010; Seidel, Recker, & vom Brocke, 2013; Watson, Boudreau, & Chen, 2010). In the context of green IS, the main body of research focuses on the organizational level of analysis and the potential contribution of IS to support sustainable practices across the entire firm. However, research in green IS not only recognizes the direct ecological impact of IT infrastructure production and usage but also second-order effects like the impact of information and communication technologies on industrial processes and third-order effects like a change of lifestyle and economic structures (Wunderlich, 2013). Thus, besides targeting the organizational level of analysis, green IS focuses on raising environmental awareness and encourage everyday life practices as well as ecological choices by single consumers.

As discussed in Section 2.2.1, the status quo for residential consumers in terms of feedback on their energy usage is the standard billing process of their utility. Thus, feedback is limited to a bi-monthly or yearly frequency (in Switzerland) and very unspecific as it aggregates various appliances and behaviors over a long period of time. For consumers, the feedback neither appeals to reasons why they should engage in energy savings, nor does it allow to tell what measures they can take, and how to implement those measures in their specific context. Interventions providing individually tailored means and information on how to decrease energy consumption exhibit larger effects on energy savings compared to generalized interventions providing the same means and information to all participants (Abrahamse et al., 2007; Delmas et al., 2013). However, tailored interventions (such as, for example, a personal energy consulting) often lack scalability due to high financial and labor costs. Indeed, a large scale intervention providing tailored information and suggestions to save energy has so far not been applied as a cost efficient way to cause moderate energy savings on a large scale.

In recent years, IT-based IS, such as web portals or mobile applications, have been able to eliminate the prevailing conflict between scalability and degree of customization of an intervention. (Daft & Lengel, 1986; P. Evans & Wurster, 1999). Concretely, IS can provide users with individual consumption feedback on a high frequency, as ICT allows for collecting and processing consumption data at scale. Moreover, IS allows to enrich information based on individual properties of households. By means of a recommender system, for example, the labor intensive process of finding tailored advice on how to save energy can be automated (Adomavicius & Tuzhilin, 2005).

The utilization of information systems as low-cost and high-scale means of mass-communication to motivate sustainable behavior on the level of single individuals has led to promising results, as a significant reduction in energy consumption (Asensio & Delmas, 2015; Tiefenbeck et al., 2015). However, research into IS-based interventions to control domestic energy consumption and the implementation of behavioral instruments is still in its early stages. More research is needed to advance our understanding of how IT artefacts need to be designed in order to motivate residents to adopt the technology and consequently achieve positive effects (Loock et al., 2013; Watson et al., 2010). Specifically, a good understanding of how system and information characteristics shape the initial adoption and continuous usage of a system and evidence in the field is crucial.

2.3.2 Behavioral Interventions to Increase System Effectiveness

IS researchers have acknowledged the fact that individuals play a big role in the realization of the ambitious goals of energy policy (Watson et al., 2010). Systems that pay respect to users' motivations and other behavioral aspects hold the potential to make substantial impact. Mostly lab-based studies point out the importance of aspects from behavioral sciences in motivating energy savings amongst households (Abrahamse et al., 2005). Based on findings in the lab, concepts such as social normative information, goal-setting, and elements of gamification are believed to increase the overall effectiveness of feedback-based interventions (Schlagenhaufer & Amberg, 2015; Steg, Dreijerink, & Abrahamse, 2005). However, only a few studies empirically investigated the effectiveness of interventions in the field, even though the technical implementation is feasible. Table 2 provides an overview of field studies suggesting the effectiveness of IS-based interventions to motivate residential energy savings.

Table 2 IS-based field studies; interventions to motivate energy savings

Author(s)	**Intervention**	**IS**	**Resource**	**Sample**	**Result**
McClelland & Cook (1980)	Feedback	In-home display	Electricity	101 families	Savings of 12 % for feedback group
Hutton, Mauser, Filiatrault, & Ahtola (1986)	Feedback, Information	In-home display	Gas, electricity	3 cities	4-5 % savings in two out of three cities
van Houwelingen & van Raaij (1989)	Feedback (frequency), goal setting	In-home display	Gas	325 families	Continuous feedback + goal setting leads to the highest savings (12.3 %)
Dobson & 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 reduces consumption, descriptive feedback leads to increased consumption for below average consumers

Graham, Koo, & Wilson (2011)	Feedback (content)	Web portal	Fuel	128 students	Combination of monetary and environmental feedback works best for reducing car use
Chen, Taylor, & Wei (2012)	Feedback (content)	Web portal	Energy	489 dorm-rooms	Social feedback is more effective than individual feedback
Loock et al. (2013)	Feedback (content), goal-setting	Web portal	Electricity	1,960 customers	Defaults influence goal-choice, with an optimal goal leading to savings of 4 %
Tiefenbeck et al. (2015)	Feedback (real-time and device specific)	Smart shower meter	Water, energy for water heating	697 households	Real-time feedback leads to a cut back of shower related energy consumption of around 25 % by raising the salience of resource consumption
Asensio & Delmas (2015)	Feedback (real-time and device specific)	Web portal	Electricity	118 households	Consumption feedback combined with health related messages motivated savings of 8 %, in combination with monetary information consumption increased by 4 %

Note: Adapted from Loock et al. (2013)

The studies listed underline the importance of an understanding of the mechanisms and total effectiveness of behaviorally-enriched interventions as outcomes are dramatically impacted by behavioral aspects. Loock et al. (2013) could show in a field study that the implementation of psychological concepts into the design of such studies improved their overall effectiveness. The authors showed that by implementing higher editable default values for a saving-goal the height of the self-set goal increased. Default values thus *nudged* people to commit to more challenging goals. Thereby, the authors could increase savings by up to 2.3 %. However, if people committed to unrealistically high saving goals, positive treatment effects disappeared. In a field-study, investigating the impact of an IS-enabled social normative feedback intervention to motivate ecological travel choices, Flüchter and Wortmann (2014) showed that in the short run the intervention yielded the desired effect. However, introducing a competition as an external motivator to a subgroup of the participants negatively affected the intrinsic motivation of those participants and thereby undermined the target behavior in the end.

Similarly, studies estimating the effectiveness of a smart meter rollout in Europe show savings of 0.5 % to 5 % with the effect size depending on the user-technology interaction (Baeriswyl et al., 2012; Ernst&Young, 2013) and sample size (small samples appear to be biased towards higher intrinsic motivation and technology affinity), as reviewed in Section 2.1.3. In addition, a decline in usage frequency, which is a common phenomenon observed in the first pilot studies, seems to be negatively associated with energy savings. Incentive systems to use the portal can effectively motivate continuous system usage (Kollmann & Moser, 2014). Thus, incentivizing actual user engagement to support the positive outcomes of a green IS seems like a promising approach. However, it is still an open question of how IT artefacts have to be designed in order to achieve the desired engagement and motivate long-term system usage.

2.4 Research Gaps

Several studies have been carried out to investigate the potential of IS to motivate energy savings and specific aspects of the artifact design. Based on the literature and findings from behavioral sciences, the thesis aims to develop a new IS to provide a tailored and scalable approach to induce energy savings. The present work does so by involving a utility company as a stakeholder and realistic provider of such a service in general. Furthermore, the thesis adds to the literature of program design and design of IS-artefacts in particular, investigating different stages in the decision process: Reach, usage, and impact. Therewith, the thesis aims to further the understanding of factors influencing the overall effectiveness of energy efficiency interventions as a mean for demand management and customer engagement. Specifically, the thesis addresses research gaps in the following three areas: Principles of system design, strategies to support initial technology adoption, and design specific mechanisms driving voluntary interaction and energy savings.

Artifact Design IS to curb residential energy consumption appear promising if they provide actionable consumption feedback and tailored information at the highest possible specificity to participating households (Delmas et al., 2013; EPRI, 2009). Yet, a comprehensive framework how such a system can be embedded in a real-world application context is missing. It needs to be assessed how, in a real-world setting, an IS can provide detailed information at scale. Pointing to the real-world setting, as services are commonly provided by utility companies as a service for their customers (Gangale et al., 2013), the system as well needs to pay respect to the business needs of that environment. While established work focusses on short-term efficiency interventions by utility companies (Graml et al., 2011; Loock et al., 2013), benefits are likely to increase with the level and duration of interaction or in other words the degree of customer engagement (Gangale et al., 2013; PricewaterhouseCoopers, 2016). Thus, the following research question manifests:

What are design principles of IS by utility companies to stimulate energy conservation at scale and increase customer readiness for the utility?

The question is addressed in Chapter 3 and, based on empirical evidence, refined in the concluding discussion of the thesis.

For the respective business environment, the effectiveness of a system to promote residential energy efficiency depends on the number of participants, the efficacy in reducing households' energy consumption, and the indirect benefits. Thus, the thesis at hands empirically contributes to research gaps in regarding initial technology adoption, factors influencing energy savings and the increase in customer readiness of engagement for utilities.

Artifact Adoption Saving energy holds different inherent benefits for consumers. As discussed in Section 2.2, these can appeal to either the self-interest or normative concerns and altruism of the consumer, or both, respectively. In practice, programs usually appeal to both, driven by an approach to highlight all possible benefits (Gangale et al., 2013). Lab studies show that emphasizing one aspect over another can strengthen or weaken the motivation of consumers to participate in the program (D. Schwartz et al., 2015). For practitioners, the research contributes to programs requiring an opt-in decision by the consumer. However, latest developments show that for most of the smart meter programs in

Europe such an opt-in decision is required – not for the installation of the metering infrastructure, but the access to the information it provides – due to cost-efficiency and regulatory provisions. Thus, insights to the overall effectiveness of appeals to advertise programs are of high practical relevance and contribute to the theory of how to design scalable IS. Furthermore, different appeals may not only differ with respect to their effectiveness in attracting households to adapt the promoted IS, but also interact with characteristics of the recipients (e.g., its energy efficiency). Different message appeals may therefore attract different segments of customers, leading to different outcome related potentials, such as the ability to save energy by the households. The research on this matter is sparse and limited to results from laboratory studies (D. Schwartz et al., 2015). This makes results prone to overestimation of actual sign-up rates induced by a hypothetical bias (Murphy, Allen, Stevens, & Weatherhead, 2005) and provides low external validity. This leads to the necessity to pursue the following research question in a real-world context:

How do different message appeals influence participation rates in IS-based programs to curb residential energy consumption and affect positive outcomes?

Therefore, a field experiment involving 20,000 real households strives to investigate the effectiveness of different appeals to advertise the artifact, interactions of the appeals with household properties, and the impact on energy savings. The field experiment to address the research gap is described in Chapter 4.

Continuous Usage and Impact As discussed in previous chapters, the treatment effect of IS-based programs to motivate energy savings seems to depend on the frequency of voluntary user-interactions. Moreover, in a setting of bidirectional communication, increasing interaction points over time is also associated with a higher level of user information that potentially provide value for the utility (PricewaterhouseCoopers, 2016). As the voluntary user-technology interaction strongly depends on motivational characteristics of the system, an understanding of mechanisms and the design of artifact to motivate interaction over time is highly valuable for both, research and practice.

In this context, incentive mechanisms to promote target behaviors (such as financial rewards) are widely applied across fields. Incentive mechanisms are used to promote the compliance to psychotherapeutical interventions (Budney, Moore, Rocha, & Higgins, 2006; Giuffrida & Torgerson, 1997; Volpp et al., 2008), to increase business sales and to support customer retention (Bolton, Kannan, & Bramlett, 2000), and as a motivator for private households to reduce their energy consumption (Abrahamse et al., 2005; Delmas et al., 2013). However, effects of incentive mechanisms to promote energy conservation campaigns show to be rather inconsistent and temporary (Abrahamse et al., 2005). A reason for this might be that most interventions incentivize actual energy savings rather than actions and decisions which directly or indirectly contribute to the superior, somewhat abstract goal of saving energy. It is promising to reward concretely defined actions rather than abstract achievements by rewarding them within a scheme of a reinforcement schedule. Such a schedule directly links the actions and decisions to the reward and thus serves as a positive reinforcement in an operant learning paradigm (Staddon & Cerutti, 2003). In IS-research on gamification, results to increase user engagement by means of game elements, such as bonus points, seem promising (Lounis, Pramatari, & Theotokis, 2014; Schlagenhaufer & Amberg, 2015). However, effects are likely to depend on the type and height of incentive in place (Heyman & Ariely, 2004) and field experiments showing the overall effectiveness are missing. To shed light into the evident gaps the thesis pursues the following research question:

How do the type and size of external incentives designed to support IS mediated sustainability programs affect user engagement and energy savings?

Consequently, it has to be investigated how an individually tailored energy efficiency campaign can be integrated in a largely scalable IS and how incentive mechanisms can be applied to motivate the long-term usage of such a system. Therefore, we designed a large-scale field experiment (n =2,355) to investigate the effects of incentive mechanisms on usage behavior and energy savings. Specifically, by measuring how different incentive types and heights influence the IS usage-patterns and the electricity consumption of the participants. The study is conducted in a highly realistic environment with customers of the partner utility using the IS as a real product. Thus, the inferences based on the data are limited to the specific group of potential users of the IS but are characterized by high external validity. The study is described in Chapter 5.

3 Artifact Development

Multi-Channel Engagement for Behavioral Change

This chapter provides an overview of the artifact developed to answer the research questions. Importantly, the development is the main outcome of the present research. The thesis thereby pursues a design science framework as introduced in Section 1.3 and further detailed in Section 3.1. Section 3.2 introduces the objectives of the technical artifact from the different stakeholders perspectives, derives deign principles, and reviews state of the art engagement strategies in the field. Section 3.3 describes the artefact design, including the approach to maximize user motivation, a description of the process employed to pursue the design objectives, and instruments in place. Section 3.4 gives an overview of the implementation of the artifact and explains the system architecture. The chapter concludes with an analysis of the impact of the IS in Section 3.5.

3.1 IS Research Approach

The framework applied to design the IS is displayed in Figure 8 and borrowed from Hevner et al. (2004). The research framework combines behavioral science and design-science paradigms and serves to understand, execute, and evaluate IS research (Hevner et al., 2004).

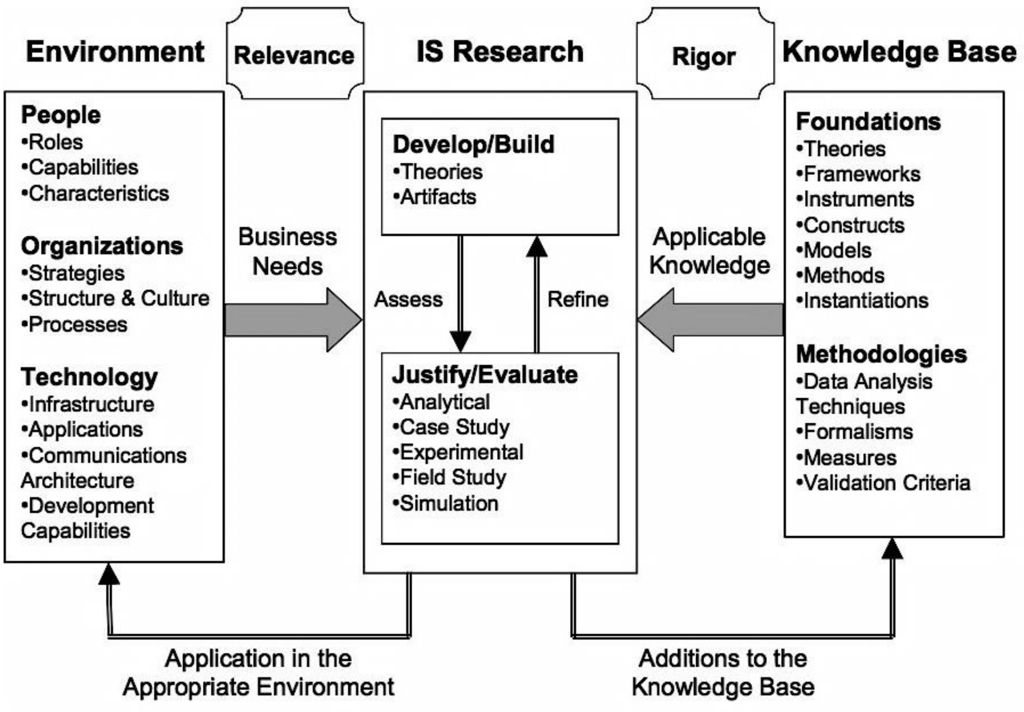

Figure 8 IS research framework by Hevner, March, Park, & Ram (2004)

The problem space is defined by the environment that holds the phenomenon of interest. The environment is characterized by people, (business) organizations, and their existing or planned technology (Hevner et al., 2004). Business needs are derived from the environment and classically shaped by the perception of goals, tasks, problems, and opportunities by people within an organization. However, as green IS is more recently also focusing on individuals in a context outside of the organizational setting, business needs are partially shaped by consumers and their capabilities, characteristics, and roles within society. Organizational strategies, structure and culture, and processes give the context to assess and evaluate the business needs. Existing technology infrastructure, applications, communications architecture, and development capabilities serve to position and relativize business needs. Paying respect to the business needs shaped by the environment maximizes the relevance of the research.

Business needs are defined by the environment. Based on those needs, two complimentary phases provide the framework for IS research: 1) development and justification of theories to explain aspects of the business needs and 2) building and evaluation of artifacts to meet the business needs. *Development* and *justification* of theory is addressed by means of behavioral sciences. *Building* and *evaluation* is addressed by means of design science. However, both closely interact.

IS research is accomplished through and from raw materials provided by a knowledge base (Hevner et al., 2004). The knowledge base consists of foundations and methodologies. The develop / build phase utilizes theories, frameworks, instruments, constructs, models, methods, and instantiations from prior IS research and related disciplines. Methodological techniques offer procedures for the justify / evaluate phase. Rigor is provided by correctly applying methodologies and foundations.

The following sections provide an assessment of the business needs from the environment of utility companies, the needs of their customers, and a research perspective. The knowledge base builds on the theoretical background provided in Chapter 2 and applied to synthesize the business needs into design principles. The design principles serve as a basis for artifact design.

3.2 Objectives and Design Principles of the IS

The system is designed to pursue research with high practical and theoretical relevance. Therefore, it needs to incorporate goals from a research as well as a business perspective, and the goals and needs of the actual user. The section provides a synthesis of trends for utilities to master future challenges as derived in Section 1.1.3. It further outlines the goals of the different stakeholders involved, and the theoretical background reviewed in Chapter 2. The section concludes by providing design principles for the IS to answer the research questions.

3.2.1 Synthesis of Business Needs and Applicable Knowledge

Utilities increasingly employ engagement programs and services to support their customers in energy efficiency related topics (Gangale et al., 2013). They do so to follow policy regulations and/ or internal provisions (e.g., energy savings), influence time of demand (load shifting), and pursue sales targets by means of customer engagement (e.g., increase customer loyalty and collect customer information). The present section provides an overview of relevant business needs of the environment as described in Section 1.1 and derives design principles for a system successfully responding to those needs based on theoretical concepts reviewed in Chapter 2. The environment is composed of the utility companies in general and ewz in particular and the energy consumer. The specific needs of ewz, the utility partnering in the project, were derived in various workshops including stakeholders from strategic energy auditing, residential energy auditing, customer services, marketing, communications, and sales.

Curbing Residential Energy Consumption As described in Section 1.1, due to policy regulations, utility companies have a growing economic interest to increase energy efficiency amongst their residential customers. Besides international and national regulations, such as the 20-20-20 targets of the EU and the Swiss Energiegesetz, utilities are often bound to policy directives of the respective state or district they are located in. The focus on state or municipal provisions is the result of a common pattern of ownership: many utilities are (partially) owned by the state or city. Thus, to follow legislative provision, a clear objective of the system is to motivate energy savings.

In the case of the municipal utility of Zurich, Switzerland, with whom the author and BEN Energy jointly developed and implemented the system, an objective was to support the goals of the 2000-watt-society. The 2000-watt-society is a model that strives to limit residential energy demand to 2000 W of continuous load per person (primary energy) and emissions of 1 t of CO_2 per person per year. The model is part of the municipal ordinance of the city of Zurich and aimed to be realized till 2050. Amongst 17 other institutions, ewz is obliged to support the targets by reducing the energy demand of its residential and SME customers and increasing the share of renewables in the grid (ewz, 2014; Stadt Zürich, 2014).

The review in Section 2.2.1 shows that consumption feedback can be a suitable mean, or at least the basis for interventions pursuing this goal. Furthermore, utilities hold the data to proactively provide their customers with consumption feedback. Importantly, feedback shows to be successful in stimulating conservation when delivered at a reasonable frequency that allows consumers to derive actions and in an effective manner, such as a combination of an injunctive and descriptive normative context (Cialdini, 2003; Loock et al., 2011). Furthermore, personal advice showed to be effective in stimulating energy conservation and gained scalability by means of IS, as discussed in Section 2.3. As overall effects are estimated to be moderate for single households (Delmas et al., 2013), the artifact needs to address a sufficient sample of households in order to have impact.

As a result, the following two design principles were derived:

- *The system should provide a large number of consumers with actionable descriptive and injunctive consumption feedback.*
- *The system should provide personal assistance on how to save energy.*

Continuous Involvement Energy consumption is usually seen as a low involvement good for most consumers (Graml et al., 2011). Consequently, most consumers are not willing to spend a lot of time thinking about and providing resources to curb their households' energy consumption (Dietz et al., 2009). Thus, the barrier to engage in a IS providing information and means to reduce one energy consumption should be as low as possible. Requiring additional hardware for participation and infrastructure most likely increases initial barriers and should be avoided. Therefore, measuring energy consumption should not require a smart meter infrastructure as to date this would exclude a vast majority of households in Europe and Zurich in particular. This infrastructural requirement can be successfully circumvented by enabling users to manually enter their own meter readings on the system (Graml et al., 2011; Loock et al., 2013).

- *The system should allow users to enter their meter readings in order to continuously monitor their energy consumption.*

Focus on Motives As reviewed in Section 2.1.2 residential energy consumption is largely determined by the behavior of single individuals. Efforts to reduces ones consumption, however, do not necessarily follow an economic rational or are driven by environmental considerations. As stated before, feedback, both normative and injunctive at the highest possible frequency as well as personal assistance on how to save energy are promising means to curb consumption and provide assistance valued by consumers. Section 2.2.3, however, points to the strong influence of different motivational appeals to enforce behavior change. Generally, it shows that emphasizes on monetary reasons to engage may have counter-intended effects, as weakening other motives to engage or a shift of normative perceptions. The thesis provides an empirical investigation of the underlying motives to initially engage with the IS (Chapter 4). Based on this, the following design principle states that:

- *The system should exclusively focus on enforcing altruistic and normative motives of the consumer to engage in energy saving and avoid monetary reason.*

Furthermore, the decline in usage of an IS as a function of time is a relevant problem as it seems to be negatively associated with the efficacy of the intervention. Various applications provide all available information and instruments from the start. An evaluation of different phases of the decision process, however, shows that different phases of the decision process emphasize different aspects of the decision context and an overload of information is not necessarily helpful (Heckhausen & Gollwitzer, 1987). Thus, IS should consider every step of the decision process as distinct and design the system to maximize user motivation along the distinct phases:

- *The system should strive to maximize user motivation in every phase of the decision process.*

Elements of Gamification Additionally, goal-setting can increase the effectiveness of a IS targeting behavioral change and avoid negative effects of feedback such as the crowding out of intrinsic motivation (Etkin, 2016; Loock et al., 2013). Goal setting serves as an antecedent strategy to direct behavior in a certain direction and increase performance (Locke & Latham, 2002). Importantly, goals can be automatically suggested by the system but have to be accepted and set by the users to ensure effectiveness (Locke & Latham, 2002). Goals can serve as guiding elements to steer user behavior in a desired direction and thereby support the user. As the goal-process can be seen as continuous, it is necessary to always provide users with subsequent goals. Additionally, the progress of completing single goals should be summed into an indicator of overall progress (Etkin, 2016).

- *The system should provide users with clearly defined and challenging goals and indicate their continuous progress.*

Relevant Advice Lastly, public commitment to behave energy efficient and knowledge sharing regarding ones actions showed to promote target behaviors (Abrahamse et al., 2005). First, people tend to stick to behaviors more resiliently if publicly committed. Secondly, users presented the behavior of others are influenced by this normative information in a direction making them more likely to show the behavior. Thereby, community aspects of the system become salient.

- *The system should allow users to (publicly) commit to relevant behaviors and use this information as normative feedback for others.*

Supporting Sales Targets by Means of CE IT-based residential energy efficiency programs offer the opportunity to directly support sales activities of a utility company by increasing customer loyalty and deriving relevant and actionable customer insights. For utility companies, energy initiatives provide opportunities to differentiate from competitors and increase customer satisfaction and loyalty. This feature can integrate into a communicational and marketing strategy. The service as such aims to address to a prevalent need of the consumer and provide added value.

ewz is positioning as a service provider with emphasis on energy efficiency and green electricity. Thus, the system should operationalize this positioning. Offered as a service the system should attract new customers in a liberalized market. Furthermore, it should allow to assess suitable customers for available services. Additionally, it should gather data suited for product development to estimate interest in possible products and services.

Indeed, when asked, a large portion of customers articulate the intention to behave ecologically and therefore hold the aforementioned need a system can serve. In an increasingly competitive market with growing churn rates and high acquisition costs for new customers, customer loyalty is of substantial importance. Increasing customer loyalty by providing services that aim to increase customer satisfaction are established strategies in retail (Bitner, 1990) and energy retailing in particular (Walsh, Dinnie, & Weidmann, 2006).

Deriving relevant and actionable customer insights is considered as a basis to establish as service provider in the energy market (PricewaterhouseCoopers, 2014). As described in Section 1.1.3 positioning as service provider poses the need to build a broad portfolio and network of partners as customer demands are diverse. CI can be described as knowledge of the diverse demands and needs of the customer. CI can be operationally used to individually address customers based on their demands and needs. Customer engagement provides the opportunity to gather relevant customer data by enabling a bidirectional communication. Thus, it can serve as a scalable approach to gather information from a portion of customers that serve as a ground truth to enable a CI for all customers.

Consequently, the following design principle is derived:

- *The system should provide various customer interactions that gather relevant data assessing customer characteristics and needs and use this data to provide added value to the customer.*

Opt-in designs show to be superior to opt-out designs in engaging customers and inducing energy savings (Ehrhardt-Martinez et al., 2010). However, due to high costs associated with the installation of in-home displays, missing digital contact information for most clients, and regulatory provisions the need for an initial opt-in decision by the user is likely. However, an opt-out design can follow the initial subscription by proactively pushing relevant information to the customer.

Due to regulatory provisions, ewz is required to get the customers permission to provide information in high frequency. At start of the project ewz only held a limited number of digital contact information. A goal for the IS was to establish a personalized and direct channel to the customer in order to provide relevant offers or marketing relevant information.

Accordingly, the following design principles are derived:

- *The system should enable personalized digital communication and push the information directly to the user.*

- *The system should comprise all relevant channels to initially recruit and continually re-engage users.*

The research aims to expand the theoretical understanding of mechanisms driving initial system adoption and continuous usage. Results should provide a basis for refining the system to increase its effectiveness in pursuing goals from a utility as well as a user's perspective (Hevner et al., 2004). Research in the field of energy relevant behavior often shows a gap between lab-based evidence and actual behavioral observations – the so called intention behavior gap. Results with high external validity are needed to ensure the practical impact of findings. Field experiments provide the best suitable mean to investigate causal behavioral mechanisms providing results with high external validity. Field studies require control of all possible influencing conditions to allow for successful manipulation of the factors under investigation. The present thesis aims to not only investigate single interactions, but initial and recurring IS usage behaviors. Thus, the system needs to span over the whole process of usage and control every step along to allow for successful manipulation.

- *The system should allow for experimental manipulation of content elements and control groups.*

Besides aspects with relevance to system design, practical aspects of implementing field experiments need to be considered. Measuring treatment effects is amongst the most challenging aspects of field experiments dealing with dependent variables that show a high variance. This is the case for energy relevant behaviors, as described earlier. The sample size needed has been derived in Section 1.3 and concludes that a sample sizes of at least 500 households per experimental groups is required.

3.2.2 Overview of Design Principles

The business needs were assessed from a general market overview and specified for the needs and structural prerequisites of the utility. However, the functions of the system are addressing general trends and needs seen in the power utility market. The system objectives are supported by the design principles that incorporate theoretical concepts and findings reviewed in Chapter 2. The design principles are summarized in Table 3.

Table 3 Design principles

#	Design principle
DP 1	The system should provide a large number of consumers with actionable descriptive and injunctive consumption feedback.
DP 2	The system should provide personal assistance on how to save energy.
DP 3	The system should allow users to enter their meter readings in order to continuously monitor their energy consumption.
DP 4	The system should exclusively focus on enforcing altruistic and normative motives of the consumer to engage in energy saving and avoid monetary reason.
DP 5	The system should strive to maximize user motivation in every phase of the action process.
DP 6	The system should provide users with clearly defined and challenging goals and indicate continuous progress.
DP 7	The system should allow users to (publicly) commit to relevant behaviors and use this information as normative feedback for others.
DP 8	The system should provide various customer interactions that gather relevant data, assessing customer characteristics and needs, and use this data to provide added value to the customer.
DP 9	The system should enable personalized digital communication and push the information directly to the user.
DP 10	The system should comprise all relevant channels to initially recruit and continually re-engage users.
DP 11	The system should allow for experimental manipulation of content elements and control groups.

The design principles provide the basis for the design of the IS that is introduced in Section 3.3. Furthermore, specific aspects of the design principles are further empirically investigated in the field experiments introduced in Chapter 4 and Chapter 5.

3.2.3 Common Engagement Strategies

This section provides an overview of existing engagement solutions building on the different theory-driven approaches reviewed in Chapter 2. In the smart grid context, the number of consumer engagement projects involving residential energy customers in Europe is increasing (Giordano et al., 2013). However, utilities are still slowly moving forward, as consumer behavior change is hard to predict leading to uncertainties in their business case. Around 75 % of existing projects are to some degree funded by public authorities (Gangale et al., 2013) reflecting their interest in pursuing associated goals.

Most solutions have a strong focus on understanding the customers in terms of their reaction to the new technical solutions (76 %) and on assessing needs and user experience (74 %) (Gangale et al., 2013). Reaction to new solutions for example comprise consumption feedback and effects of incentives such as provided by dynamic pricing. The insights delivered by observing consumer responses are aimed to improve existing or allow for new segmentations along non-traditional factors. As business models of utilities are becoming more customer centric and reliant on customer interactivity, the benefit of establishing a digital channel to a broad customer base is obvious (PricewaterhouseCoopers, 2016).

However, a vast majority of programs (70 %; Gangale et al., 2013) in the smart grid context in Europe solely focus on providing consumers with information, even though it is not sufficient to establish customer engagement and evoke behavioral change, as discussed in Section 2.2.2. Programs commonly deliver consumption feedback and additional information, such as pricing information, via in-home display or web-applications. Only few examples strive to establish more customer focused engagement mechanisms, for example by turning the process of engagement into a game (Gamberini et al., 2011). Besides incorporating game elements such as bonus points, the approach incorporates the concept of goal setting by providing levels and social normative feedback. Incorporating concepts from behavioral sciences have shown to increase overall program effectiveness, (Abrahamse et al., 2005; Loock et al., 2011, 2013), however, apart from the studies reviewed in Section 2.3, few engagement strategies are built on these principles.

A central aspect of customer engagement programs by utilities are what motivational forces they appeal to (e.g., altruism vs. self-interest). Therefore, programs employ informational strategies more carefully to gain insights into the effectiveness of different approaches in promoting engagement. Motivational factors by smart grid projects in Europe are (1) the reduction/ control over electricity bills, (2) environmental concerns, and (3) better comfort. However, most studies combine financial and environmental concerns leading to 71 % of programs appealing to monetary benefits (Gangale et al., 2013).

3.3 Interaction Design

The interaction is designed to pursue the objectives and principles derived in Section 3.2. To gain control of every phase within the action process of a user, the IS needs to arch over different channels. This enables full control over motivational factors and the implementation of improvements in every stage of the decision process. Thus, the platform comprises a web portal, mobile application, and personalized electronic- and physical mailings. The following section gives an overview of the process employed to engage users over different channels. Section 3.3.1 describes the engagement process employed to maximize the users' motivation over every stage of the decision process following the formal phases of the Rubicon model (Heckhausen & Gollwitzer, 1987). Section 3.3.2 describes the engagement process of the IS arching over channels. Lastly, mechanisms and methodologies underlying the "saving advice" instrument are presented.

3.3.1 Design to Maximize User Motivation

As reviewed in Chapter 1 and Chapter 2, the mere feedback of utility consumption information does not motivate households to reconsider their long-term energy consumption. Various social psychological models strive to capture determining factors and their causal relation in forming environmental decisions. As discussed in Section 2.2.3, models often lack power in predicting energy related behaviors. However, socio-psychological models are increasingly used to structure the knowledge base employed to design IS (Hevner et al., 2004). The Motivation-Opportunity-Ability (MOA) model devised by Ölander and Thøgersen (1995, see Figure 9) shows a model successfully used in previous design science approaches (Graml et al., 2011; Loock et al., 2013). The model states that an intention to act is not solely triggered by cost/benefit considerations, but rather the prevalent social norms and fundamental attitudes also play a significant role in our decision making. Whether or not the intention to act is translated into behavior depends on the individual capabilities of the individual (knowledge, skills and abilities, habits) and also on opportunities (e.g. in terms of finance and time).

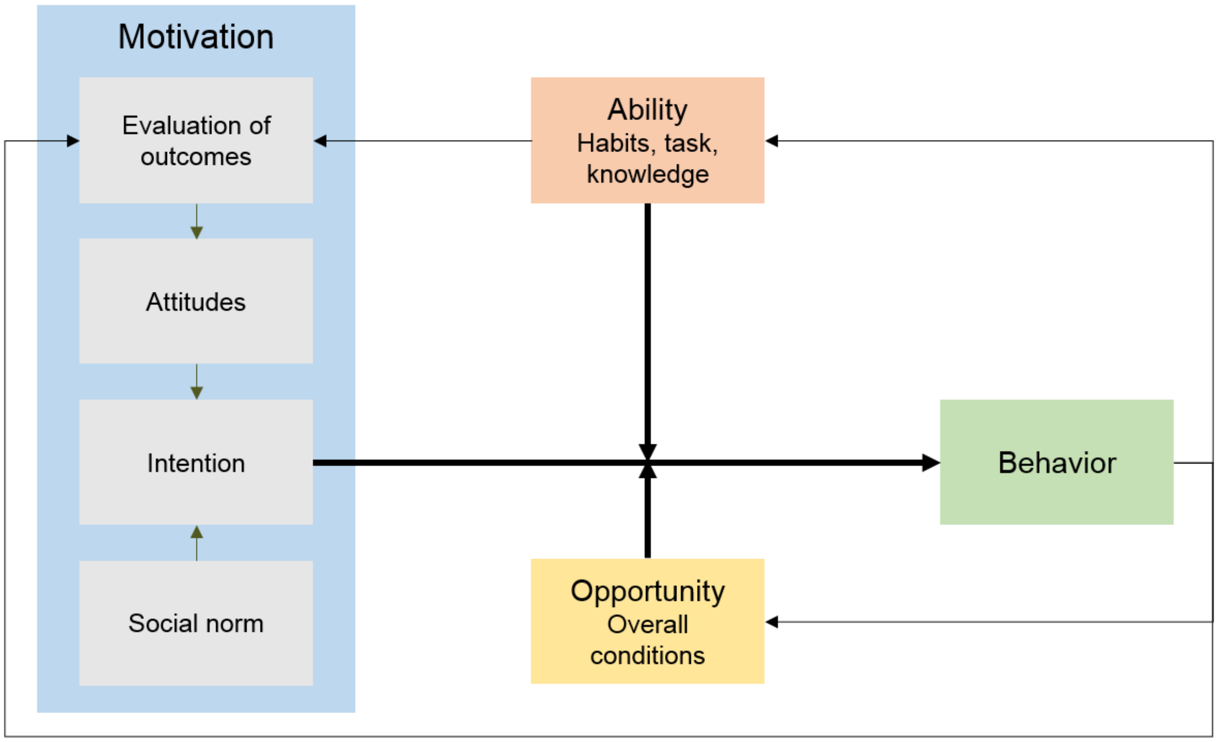

Figure 9 Motivation-Opportunity-Ability Model (MOA) devised by Ölander and Thøgersen (1995)

Given the restricted rationality in play and the importance of habits in our actions, any approach to altering a behavior must take these particular factors into consideration. The instruments derived in Section 3.2.2 can be used at every control lever of the MOA model.

To achieve the objectives of the system, it is necessary to continually motivate customers to use its offerings. This requires a deep understanding of the process the customer goes through for every action. Within the platform, three interdependent actions can be distinguished:

- Initial use of the platform (Registration)
- Implementing featured content (e.g., filling in household information in order to obtain a efficiency check)
- Repeated usage of the platform

The process of taking action can be divided into four formal phases with distinctive characteristics according to the Rubicon Model (Heckhausen & Gollwitzer, 1987) – pre-decision, pre-action, action und evaluation. The characteristics of each phase have to be considered individually to maximize customer motivation, as stated in design principle five.

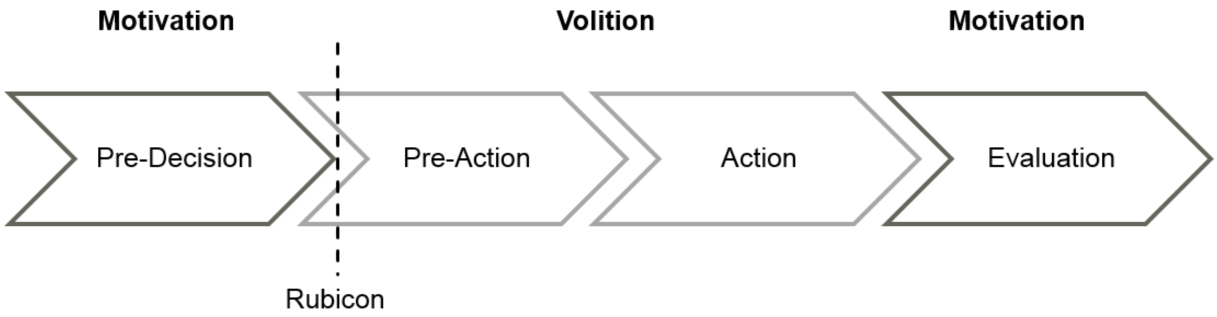

Figure 10 Formal stages of the Rubicon model (Heckhausen & Gollwitzer, 1987)

The customer faces a decision in the pre-decision phase. All the possible alternative actions are presented and the customer uses the information available to weigh up the options. In the pre-action phase, the customer has already formed an intention to act and there is a plan to implement this as a concrete action. In the action phase, the customer carries out the action, based on the decision taken at the end of the evaluation phase. Motivation is a factor across all the phases and thus, characteristics of each phase of the process of taking action are considered in order to motivate users effectively and sustainably.

The MOA model integrates motivation, contextual and habitual factors in this regard to make valid predictions about environmentally-related behavior. Based on the action phases within the Rubicon Model, the following section considers which components of the MOA model are relevant in each phase and the practical implications they have. The design process considers all types of intended action (use, implementation, and repeated usage).

The following design concepts are the result of various workshops conducted by members of the B2E Lab and BEN Energy and two co-creation workshop led by the author, involving stakeholders from marketing, communication, customer service, and strategic energy consulting of the partner utility ewz.

Pre-Decision – The Customer is Made Aware of the Portal According to the MOA model, generating motivation depends on various factors. On the one hand it depends on person's determination to achieve a particular, desired action outcome. On the other hand it depends on the person's attitude towards possible actions and, furthermore, on the social norms influencing those actions. Cost-benefit considerations that occur in this context are not restricted in any way to the purely financial dimension. On the side of costs, factors such as time requirements and difficulty are considered far more while enjoyment, acting in line with personal moral obligations, and success are important factors on the benefit side of the evaluation.

If a customer is at this point of the process of taking action, it is important to clarify the incentives of the desired action (e.g. registering on the platform) and show that these incentives can be achieved. Direct reference to the individual clearly establishes the practicality of desired incentives and forms the intention to act.

Pre-Action – the Customer is Now a User If the intention to act is created, individual factors decide whether the intention is implemented. These are the individual abilities to implement generated intentions, habits that determine previous behavior and knowledge of the options for implementing the intention. It is therefore important that the platform does not overload the user at this point of the process of taking action.

To achieve the goal of turning customers into platform users, it is important that the customer sees how easy and user-friendly it is in terms of registering and use. In order to motivate the user to implement a behavior, the user is provided with relevant information in a clear format. Setting out interesting and realistic goals makes it easier for users to implement information and tips they have been presented with. Long-term objectives (such as "reduce heating costs") only become feasible for many people when they are set out as concrete and tangible short-term objectives. The "SMART goals" are particularly relevant here (Doran, 1981). "SMART" is an acronym that sets out the particular characteristics desirable in the goals the user is given:

- Specific — Step by step
- Measurable — Feedback
- Attainable — Must seem achievable
- Relevant — Commitment must be established
- Time bound — Time as reference frame

Individualizing content is also essential because ingrained behavior and routines have to be addressed directly in concrete terms to instigate change. It is also important that the individualization avoids giving people advice or offers related to products or services that are not of interest – such as Swiss tenants who cannot act on information and offers on new heat pumps and thus do not want to receive it.

Action – the User Achieves the Objective by Acting In general there is a distinction between one-off actions, such as purchasing an energy-efficient domestic appliance, and recurring behavior, such as routinely switching the lights off and on, leaving a room or regularly using the portal. The first are often rational actions that are planned for longer and are, above all, instigated by persuasive information. In using the platform for the first time, the information provided in advance plays a crucial role. Nonetheless, easy access is very important to ensure that customers are not lost as a result of additional hurdles in the registration process.

For regular platform usage and continuous implementation of the content available, the habits and routines we have touched on are relevant; these are difficult to establish and to break. Creating "mental links" – when faced with situation X, I do Y – is an effective way to create routines. Contingent reinforcement is a promising approach in this regard. Desired behavior leads to a specific reinforcement, as for example bonus points in a gamified setting (Thiebes, Lins, & Basten, 2014). It is particularly effective when the reinforcement is offered intermittently so that every action is not followed by the same reinforcement and only some of the desired actions are rewarded. Only actions that are generally low interest should be reinforced, to ensure the intrinsic motivation that comes from within is not undermined. The offers on the portal should also be communicated regularly. This is particularly relevant at the initial stage of usage, as the user requires incentives and stimulation to establish the habit of visiting the platform. An example of a successful transfer like this is the online portal Xing, which sends a regular e-mail newsletter about the current developments in the users' personal fields and those they are familiar with.

Evaluation – Reviewing Achievements Evaluating achievements, such as registering on the platform or the implementation of an energy-saving advice, creates the starting point for future intentions to act and therefore future motivation. To this end, users are presented with new courses of action and the value of their commitment is underlined. Users also have the chance to show their commitment by acting proactively. Proactive behaviors refer to actions that are initiated by the users themselves and go beyond simply adopting saving advice, for instance.

The artifact at hand needs to include these findings from motivational research to increase the commitment of users as effectively as possible. After a customer has decided to use the platform, the information the customer receives when using the platform is relevant to the customer interaction. In determining the optimum information, the goal here is to lead to a change in customer behavior. This can be related to saving energy directly (e.g., curtailment behaviors) or indirectly (e.g., motivating peers).

3.3.2 Engagement Process to Pursue System Objectives

From a user's perspective, the engagement platform is designed to provide one journey over different channels. These channels are used separately to establish initial and ongoing contact with customers and to engage with them by means of a personalized digital communication. Figure 11 illustrates the customer engagement process which takes places via the different channels of the platform. The system thus pays respect to the second design objective. The initial contact through a mailing aims to address a representative sample of customers to register on the web portal. After customers have registered, regular engagement is achieved by establishing routine activities and sending behavioral prompts as push messages. Re-engaging the users serves the design need to provide various customer interactions that gather relevant data assessing customer characteristics and needs over time.

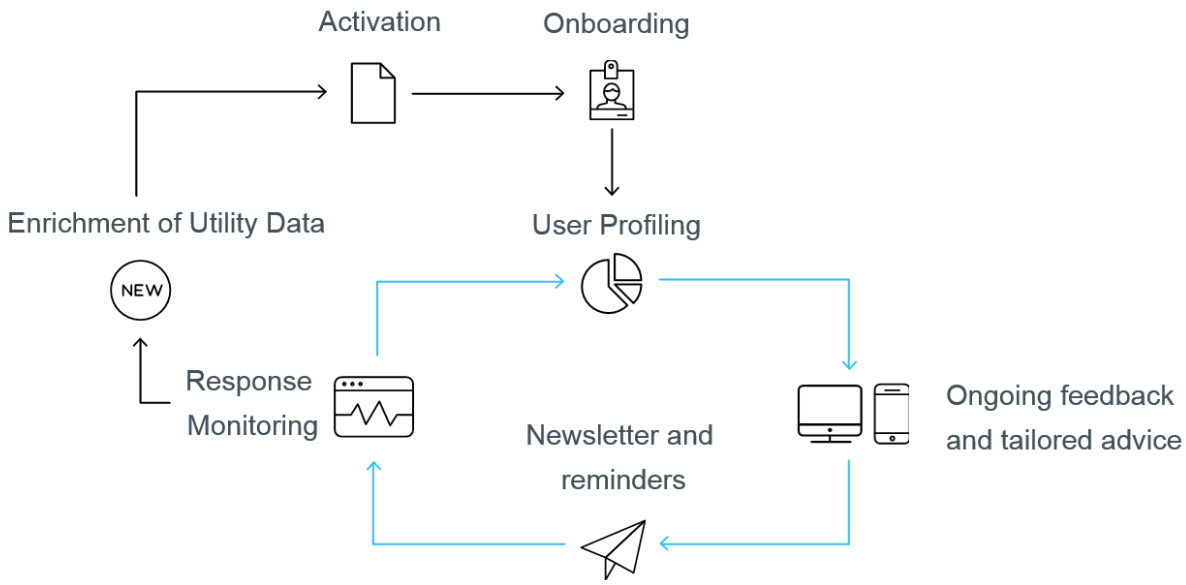

Figure 11 Customer engagement process

To establish initial contact, customers receive a personalized ***activation*** mailing in order to achieve a critical amount of customers on the portal. This mailing is personalized on the basis of information provided by the utility, mainly historic consumption. It provides a feedback on the users' past year's electricity consumption and sets the information in a context that can vary between mailings (e.g., social normative, monetary, or descriptive). The mailing generates interest, creates curiosity and aims to motivate customers to register online. Mailings are also used to test different ways to approach customers experimentally. With a focus on understanding the effectiveness and interactions of initially appealing to different motives to participate. In an ***onboarding*** procedure, users are prompted to initially determine their energy efficiency based by entering their household characteristics. As a consequence, users receive their first normative feedback. Information on household characteristics can be used to tailor content for the next steps in the engagement process and is added to the ***user profile*** that contains all relevant data. All information further provided by the users on the portal (e.g., their usage and the products and services they have used in the past) is stored here and integrated into a recommender system. This system predicts the preferences of other users for particular content (e.g. saving advice) based on a tag-based filtering approach (Adomavicius & Tuzhilin, 2005). The user is afterwards prompted to the instruments employed in the system: ***Consumption feedback and tailored advice*** on how to save energy. The user embarks on challenges in various areas (e.g. light, cooking) that are further divided into individual steps. According to DP 6, the challenges serve as clearly defined and challenging goals. This content is not available to everyone from the start but is released by levels. Using this approach, the customer stays focused and is not overwhelmed. The content on the platform is customized as a result of the data analysis. The customization matches the information gathered to address specific customer needs. Customers are addressed in line with their individual user profile and receive customized advice for further increasing energy efficiency. ***Newsletters and reminders*** are sent regularly to communicate information about the platform. Individual customer information gained through the customer's behavior and usage of the portal is incorporated into the design of the next mailing. According to DP 9, the newsletter summarizes the recent activity of the user and presents new available content on the portal. To establish portal use as a routine activity, the customer sets an e-mail reminder for entering meter readings (e.g. weekly). Customers also receive e-mail reminders about their behavioral commitments (e.g. "I am testing the seal on my fridge at the weekend."). ***Response monitoring*** is tracking the users' reaction to contents and mailings provided by the system. It allows for further *enrichment* of the user's profile and ***enrich data*** of the utility company. Thus, data can be used at the utility for different purposes, such as input for product development or targeting of service offerings (e.g., energy contracting).

3.3.3 Relevant Energy Conservation Measures

Tailored advice on how to save energy, as provided in personal energy audits, can successfully induce energy savings (see Section 2.2.2 for review). For households, a variety of potential curtailment and efficiency measures can curb in-home energy consumption. The present section provides an empirical evaluation of the most effective measures that can be taken by households in the given setting.

To evaluate the macroeconomic effects of actions to curb residential energy consumption (ACRE) one has to consider potential savings and actual implementation by the target population. Only by combining potential savings and information regarding implementation one can derive actual energy savings which is defined as the effect of ACREs (Dietz, Stern, & Weber, 2013). The following analysis was conducted for the city of Zurich and aims to improve the selection of relevant ACREs for energy advisors.

Different purposes for energy consumption exist. Figure 5 in Section 2.1.1 shows the energy consumption of Swiss households for the different purposes. Heating is contributing the most to overall energy consumption and, combined with hot water, already accounts for over 80 % of total energy consumption. The remaining energy is consumed by sole electric appliances. The present analysis therefore considers the following energy end uses: Space Heating, Water Heating, and electric appliances.

Besides differences in end-use purpose, ACREs also differ regarding the behavior that is required for implementation. According to the review in Section 2.1.2, efficiency and curtailment behaviors depict distinct behaviors in the context of energy saving. However, in the IS context, efficiency behavior can be further subdivided into behaviors that involve the purchase of appliances and those that don't, as the purchase usually involves an altering user story. Thus, the analysis differentiates between the following types of behavior:

- Investment: Energy savings are the result of new appliances
- Efficiency: Energy savings are the result of single-shot behaviors that optimize operation of appliances
- Curtailment: Energy savings are the result of end-user behavior change

In the literature, the focus in analyzing the effectiveness of ACREs is either on psychological mechanisms underlying the acceptance of different types of ACREs (Abrahamse et al., 2005), or CO_2 savings resulting by a nationwide implementation of an ACRE (Dietz et al., 2009; G. Gardner & Stern, 2008). No present analysis focuses on both, acceptance of the population and actual impact on energy savings. The present analysis aims to close this gap. The method for data collection and analysis to determine the actual efficacy of ACREs and a discussion of the results obtained is described next.

Methods and Data Collection The following three sections detail the procedure to determine the efficacy of ACREs. First, the maximum of potential savings in kWh is computed for each ACRE. Second, the ability by households to execute the ACRES is determined. Lastly, the method for calculating the efficacy of ACRES based on both values is presented.

Max savings by ACREs

The ACREs were initially selected based on publications by departments of the city of Zurich and the BfE (Department of Energy, 2014; energieschweiz, 2013a). In total 62 ACREs (longlist) were finally selected in cooperation with experts of ewz. The actions were selected for the online energy audition context. Following the advice of the experts no actions involving big investments (e.g., weatherization) were recommended. Appendix III lists the longlist of ACREs.

The maximum potential energy savings are calculated based on a typical Swiss household. The household was defined by EnergieSchweiz and ewz (energieschweiz, 2014a; ewz, 2008). The model household lives in a 4.5 room apartment and has 4 inhabitants. The household consumes 3,500 kWh of electricity per year (excluding heating and water heating). Energy demand for space heating was estimated with a yearly 15,000 kWh (Baudirektion Kanton Zürich, 2014). Energy demand for water heating was estimated with 3,600 kWh per year. Appendix IV lists detailed information regarding assumptions and sources underlying the estimation of potential savings.

Implementability by households

To check the ability to implement the selected ACREs by households, participants of the online energy efficiency campaign described in Chapter 3 were asked to implement the ACREs. In total, 1,099 participants interacted with an average of 9 ACREs ($SD = 12.4$). Participants could respond to the request by choosing between four preset possibilities:

- "Yes, I join in"
- "I am already doing this"
- "I do not think this makes sense"
- "I cannot do this"

Determination of efficacy

To determine the efficacy of an ACRE, Dietz et al. (2009) multiply the maximal savings with the share of the (US) population expected to implement the actions in the next years. This approach is adapted for the present analysis. Results are given as a score value for each ACRE, the *saving score*. The saving score gives the actual energy savings to expect form an ACRE. It further allows comparisons of single actions. In contrast to the two factors used by Dietz et al., (2009), the *saving score* comprises of four factors:

*Saving Score = Max. Savings * implementation potential * (1-Penetration) * willingness to implement*

The four factors represent:

- Max. Savings: The maximum energy savings estimated for the respective ACRE
- Implementation potential: Share of population to possibly implement the ACRE

- Penetration: Share of population that already implemented the ACRE
- Willingness to implement: Share of population actually implementing the ACRE; the other share is generally able to implement the action but not willing to

The saving score is given in kWh and is weighted by the dimensionless factors. 32 ACREs (shortlist) were shown to participants of the energy efficiency portal. For these actions the *saving score* could be calculated. The detailed results are listed at the end of this section in Table 4.

Results and Discussion Figure 12 displays the *saving scores* and maximum potential savings calculated for the typical household. It shows that few ACREs can realize a big share of potential savings. Eight of the ten most effective ACREs deal with the end use areas space heating and water heating. Misperceptions by consumers can discourage behaviors in exactly these areas (Attari et al., 2010; Attari, 2014). Thus, targeted information campaigns and correction of misperceptions for ACREs concerning space heating and water heating are a useful approach.

Present results do not imply that any of the ACREs is not appropriate. However, as the time spend on curbing one’s energy consumption at home is usually limited, prioritizing ACREs with high scores in the implementation seems practical.

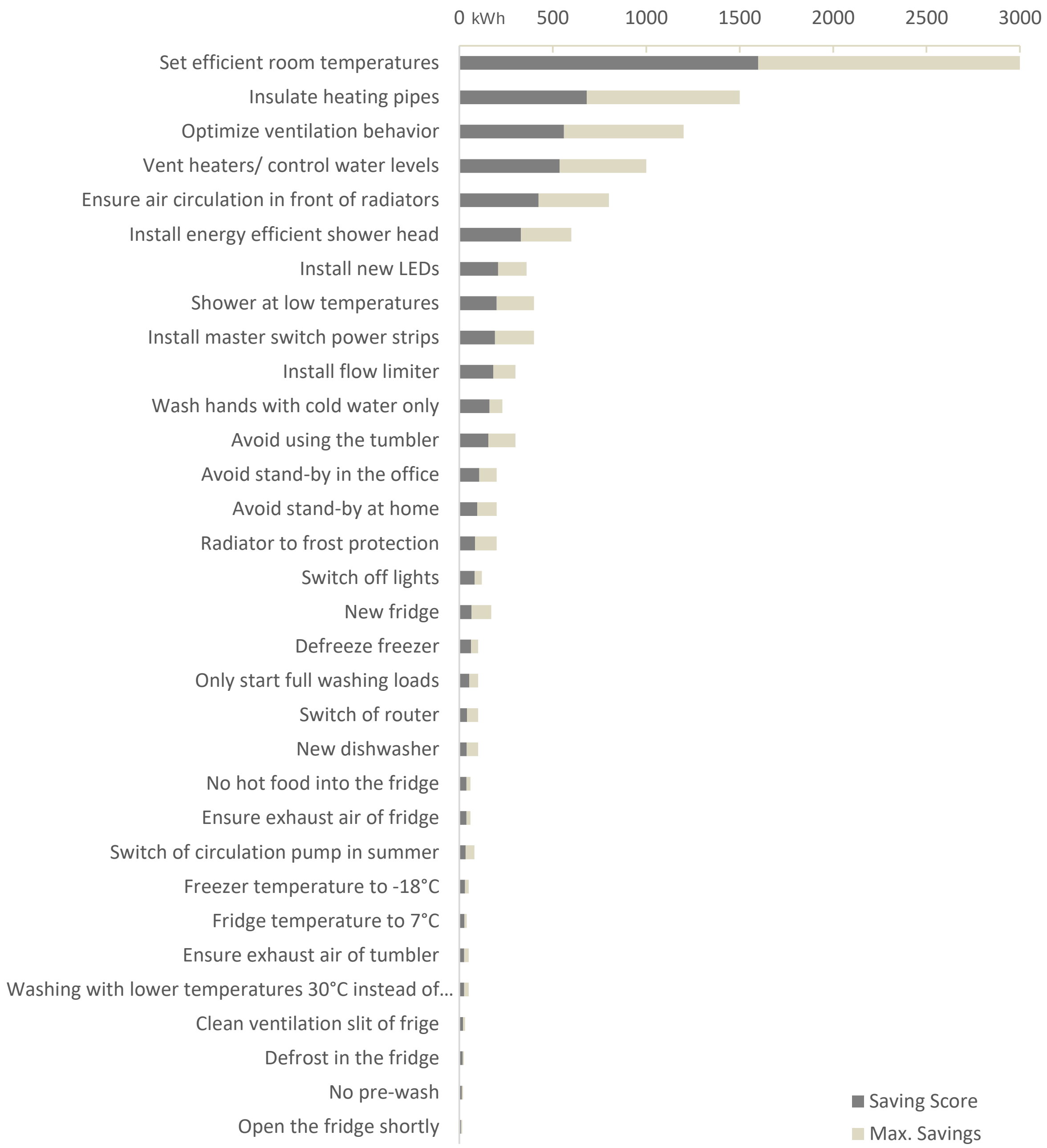

Figure 12 Maximum potential savings and saving scores in kWh; ordered by decreasing saving score.

Table 4 Actions to Curb Residential Energy Consumption (ACRES)

ACRE	End use	Type of behavior	Max. savings	n (number of raters)	Penetration	Willingness to implement	Implementation potential	Not interested	*Saving Score*
Unit			kWh/ Year		%	%	%	%	kWh/ Year
Set efficient room temperatures	Space Heating	Eff.	3000	390	36	98	97	2	1600
Insulate heating pipes	Space Heating	Invest.	1500	11	45	100	100	0	682
Optimize ventilation behavior	Space Heating	Curt.	1200	257	33	87	94	9	560
Vent heaters/ control water levels	Space Heating	Eff.	1000	307	39	95	92	3	536
Ensure air circulation in front of radiators	Space Heating	Eff.	800	304	38	97	99	2	424
Install energy efficient shower head	Water Heating	Invest.	600	102	32	94	98	4	329
Install new LEDs	Electric apl.	Invest.	360	45	36	97	100	2	208
Shower at low temperatures	Water Heating	Curt.	400	8	13	71	100	25	200
Install master switch power strips	Electric apl.	Invest.	400	314	31	93	98	5	191
Install flow limiter	Water Heating	Invest	300	11	40	100	91	0	182
Wash hands with cold water	Water Heating	Curt.	230	40	25	100	100	0	161
Avoid using the tumbler	Electric apl.	Curt.	300	420	39	94	95	4	156
Avoid stand-by (in the office)	Electric apl.	Curt.	200	328	32	98	98	1	106
Avoid stand-by (at home)	Electric apl.	Curt.	200	717	29	91	97	6	96
Radiator to frost protection	Space Heating	Eff.	200	38	34	96	92	3	84
Switch off lights	Electric apl.	Curt.	120	163	0	97	93	3	82

ACRE	End use	Type of behavior	Max. savings	n (number of raters)	Penetration	Willingness to implement	Implementation potential	Not interested	*Saving Score*
Unit			kWh/ Year		%	%	%	%	kWh/ Year
New fridge	Electric apl.	Invest.	170	55	40	81	78	12	65
Defreeze freezer	Electric apl.	Eff.	100	192	24	97	99	2	63
Only start full washing loads	Electric apl.	Curt.	100	417	40	98	99	1	54
Switch off router	Electric apl.	Curt.	100	1056	23	87	89	10	41
New dishwasher	Electric apl.	Invest	100	64	30	86	78	10	39
Ensure exhaust air of fridge	Electric apl.	Eff.	60	6	28	100	99	0	38
No hot food into the fridge	Electric apl.	Curt.	60	70	29	96	100	3	38
Switch off circulation pump in summer	Space Heating	Eff.	80	93	37	93	76	4	34
Freezer temperature to -18°C	Electric apl.	Eff.	50	171	27	97	96	2	30
Fridge temperature to 7°C	Electric apl.	Eff.	40	286	17	96	99	4	27
Washing with lower temperatures 30°C instead of 40°C/60°C	Electric apl.	Curt.	50	465	33	89	97	8	26
Ensure exhaust air of fridge	Electric apl.	Eff.	50	120	40	94	93	4	26
Clean ventilation slit of fridge	Electric apl.	Eff.	30	120	21	99	98	1	20
Defrost in the fridge	Electric apl.	Curt.	25	20	20	100	100	0	18
No pre-wash	Electric apl.	Curt.	20	134	30	99	99	1	13
Open the fridge shortly	Electric apl.	Curt.	15	31	26	91	100	6	9

3.4 Artifact Implementation

The development of the overall system included a) the creation of applications/media/user-interfaces for different channels and customer devices, b) setup of the experimental design to pursue all research questions, c) recruitment of users, and d) sending of surveys. The implementation was a common effort of the utility ewz, the Bits to Energy Lab, and BEN Energy. Within the projects the partners had the following roles and responsibilities:

Bits to Energy Lab	- Project lead development and research - Concept for user motivation and interaction process - Implementation of study design and surveys - Generation of energy advice
ewz	- Project Lead implementation - Portal operation - Content generation (challenges)
BEN Energy	- Part of development and research team - Implementation web portal and mobile application - Implementation mailings

The project started in April 2013 and followed the timeline displayed in Table 5.

Table 5 Project timeline

Date	Milestone
19.11.2013	Detailed concept of the smartsteps platform
28.02.2014	Go-Live: Web portal on live system (smart-steps.ch)
14.03.2014	Invitation to participate in smartsteps sent to 20,000 households in the city of Zurich via postal mailing
20.04.2014	Invitations to participate in smartsteps sent to 2,000 households in the city of Zurich via e-mailing
11.06.2014	Workshop „smartsteps 2.0“ to concept evidence based improvements shown in Figure 18
20.11.2014	Invitation to participate in smartsteps sent to 20,000 households in the city of Zurich via postal mailing
26.03.2015	Communication of end of the research phase

The next section provides an overview of the different system components, followed by a description of the data flow and system architecture, and a general description of system usage.

3.4.1 Overview of Artifact Implementation

To pursue the design objectives, smartsteps comprises a web portal, a mobile application (for iOS), personalized e-mailings and postal mailings. Users are guided over channels and functionalities following the process described in the previous section. The present section gives an overview of the different systems displayed in Figure 13.

The web portal comprises different sub-sites as shown in Figure 14. The subsites provide users with different functionalities. The author developed the site structure and configured the functional elements on each sub-site. To increase usability of the portal, the user is guided over the different functionalities by means of a story flow board. The story flow board is shown at the top of the page and points the user to the next action to take on the portal. The following section provides an overview of the different sub sites and the story flow implemented.

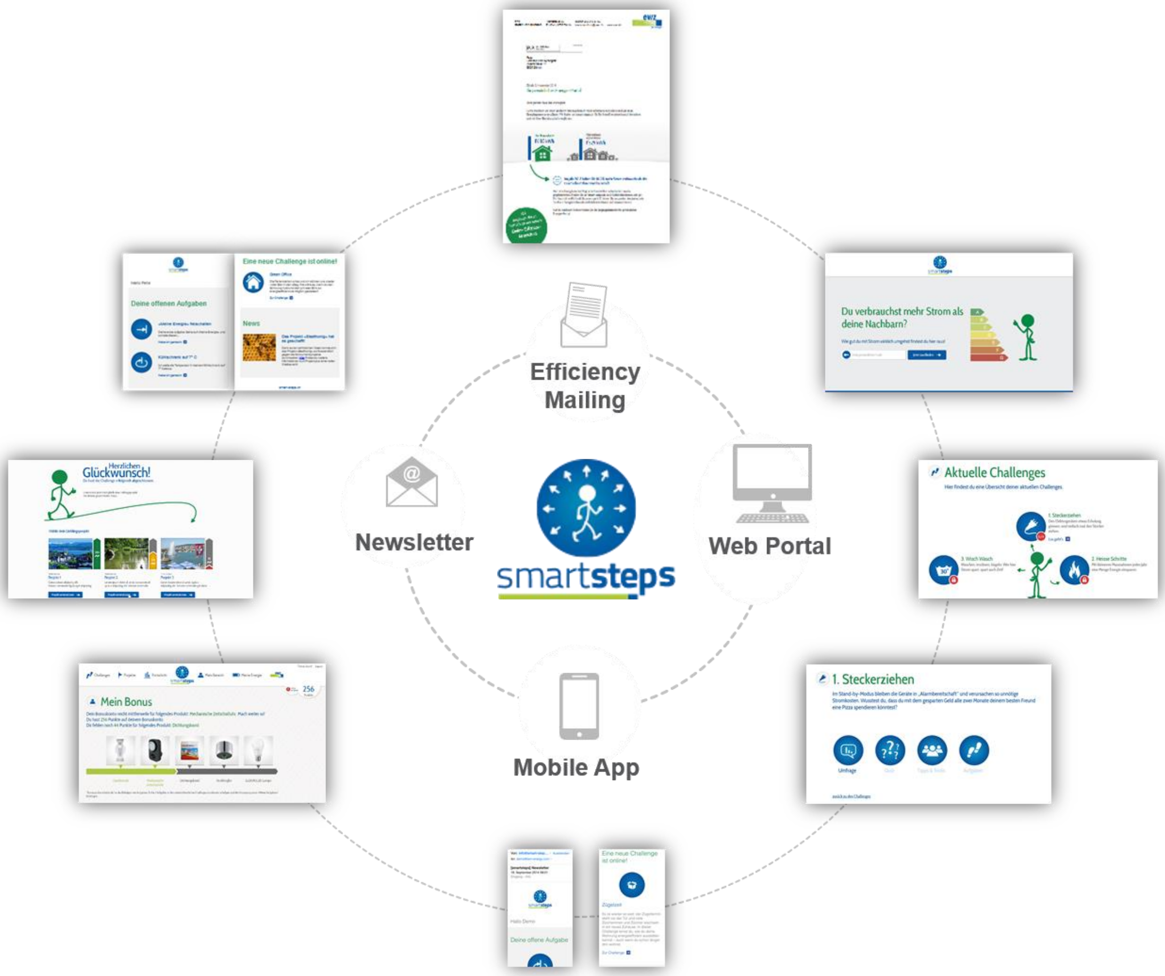

Figure 13 The smartsteps platform

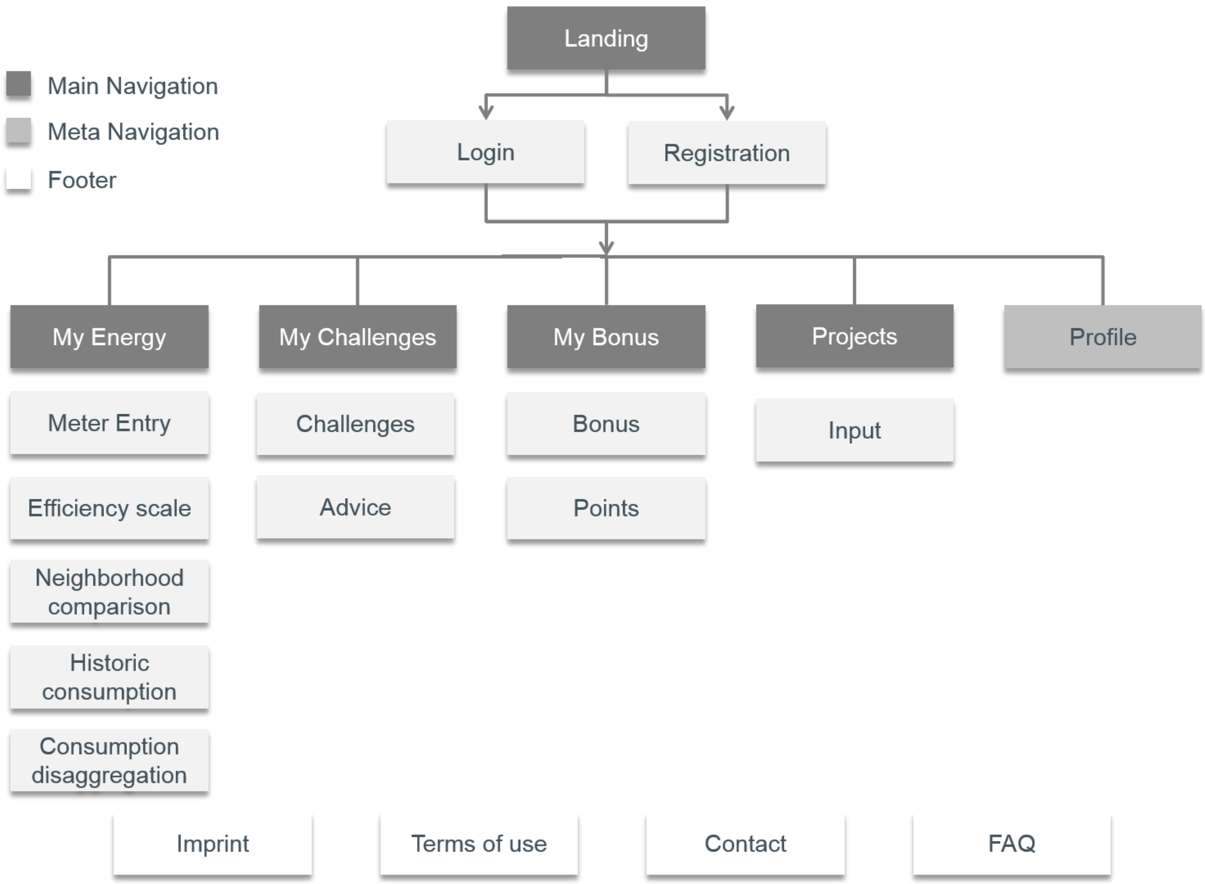

Figure 14 Site structure of the web portal

Landing The *landing page* aims to increase awareness of the functionalities and the value for the user. Therefore, a video describing core functionalities and their purpose was implemented and jointly developed by the author and a design agency[13]. The design objective of the page is however to motivate people to register. Thus, a call to action and according button at the top of the page leads to the registration section. The landing page is displayed in Appendix I.

My Energy The *My Energy* page allows users to enter their meter readings in order to continuously monitor their energy consumption (electricity, gas, and hot water) (DP 3). For this purpose, it provides a graph visualizing historic consumption. The portal provides behavioral feedback to the user's electricity consumption by means of an efficiency scale (injunctive feedback) and a neighborhood comparison (social normative feedback) (DP 1). The implementation of these features is shown in Figure 15. The page furthermore allows users to break down their consumption by appliances. Therefore, it provides a table and a list

[13] Web Guerillas, https://webguerillas.com, accessed on 04.06.2016

of appliances with pre-filled but editable consumption values in kWh. The complete page is shown in Appendix II.

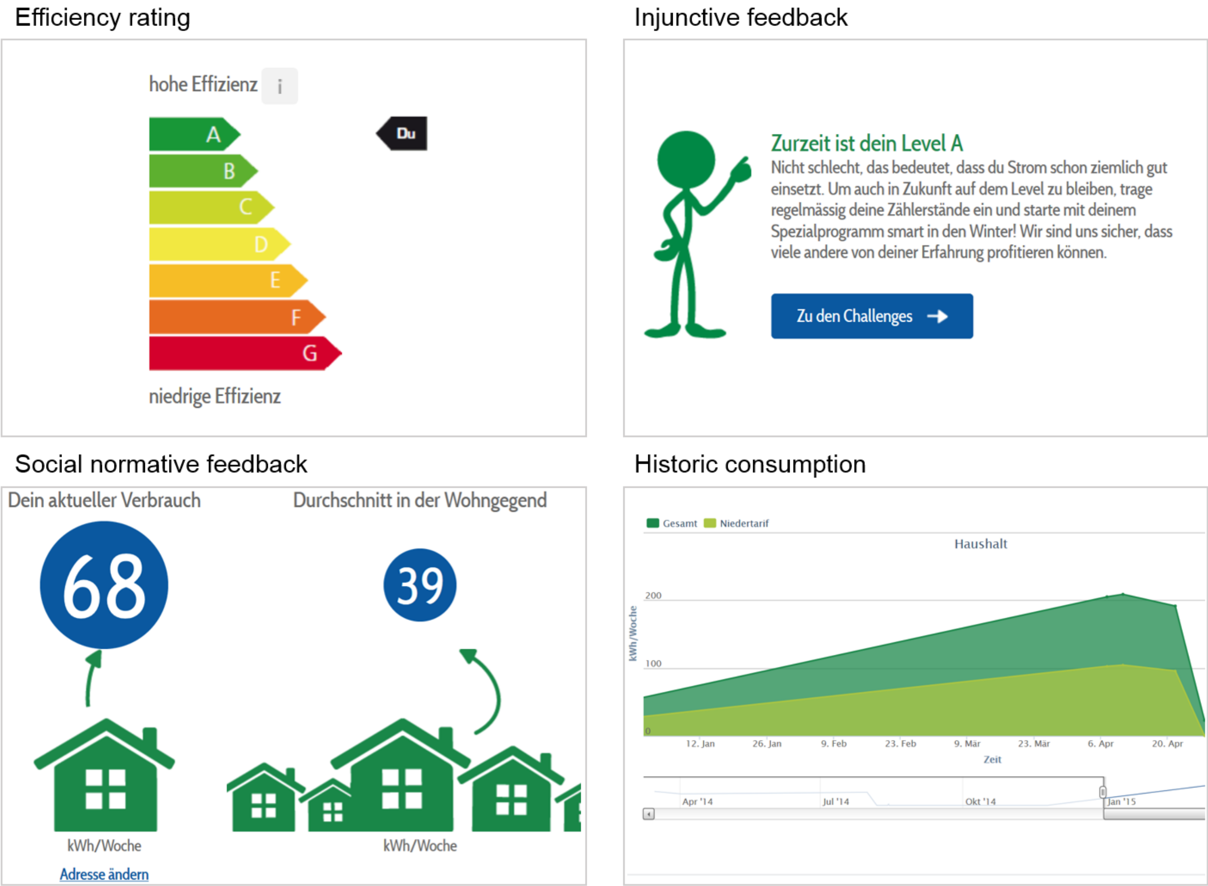

Figure 15 Web portal implementation of the "My Energy" feedback elements; showing (a) efficiency rating, (b) injunctive feedback in German language, (c) neighborhood comparison and (d) historic consumption

My Challenges To give the user personal assistance on how to save energy in an entertaining way, the portal guides the user through *energy challenges*. Challenges were conceptualized by the author. Content for the challenges was provided by the partner utility ewz. Within the challenges users answer questions regarding their household characteristics and energy relevant behaviors, received quiz questions, and can commit to concrete saving advice and provide tips to other portal users. In that sense, the system allows users to (publicly) commit to relevant behaviors and use this information as normative feedback for others (DP 7). Furthermore, challenges structure the interaction over time, as they are released in timely intervals. In the time course of the project challenges in the following areas were implemented:

- Cooking
- Doing the dishes

- Electronic devices in the kitchen
- Lighting
- Cooling and freezing
- Laundry
- Home electronics
- Heating
- Warm water
- Garbage
- Energy data

Challenges serve as clearly defined and challenging goals dealing with a specific topic around the in-home energy consumption. For all their activities, users collect bonus points. The functionality of the bonus points is explained in more detail in Chapter 5 that empirically investigates their effectiveness to pursue the second research question. In general, bonus points serve to indicate the continuous progress of users and are additionally shown on a separate sub-page. Thus, combined with challenges, bonus points implement the sixth design principle. The questions asked in the challenges are designed to tailor energy saving advice for the user. Challenges are tailored by means of a recommender system (Adomavicius & Tuzhilin, 2005). The recommender system operates based on a hybrid approach of tag-based and collaborative filtering. Furthermore, questions provide the user with a social benchmarking: After answering a question users get a feedback showing the aggregated answers of other all other users. Furthermore, continuous questioning provides various customer interactions that gather relevant data, assessing customer characteristics and needs to the utility. The user flow of the challenges is displayed in Figure 16.

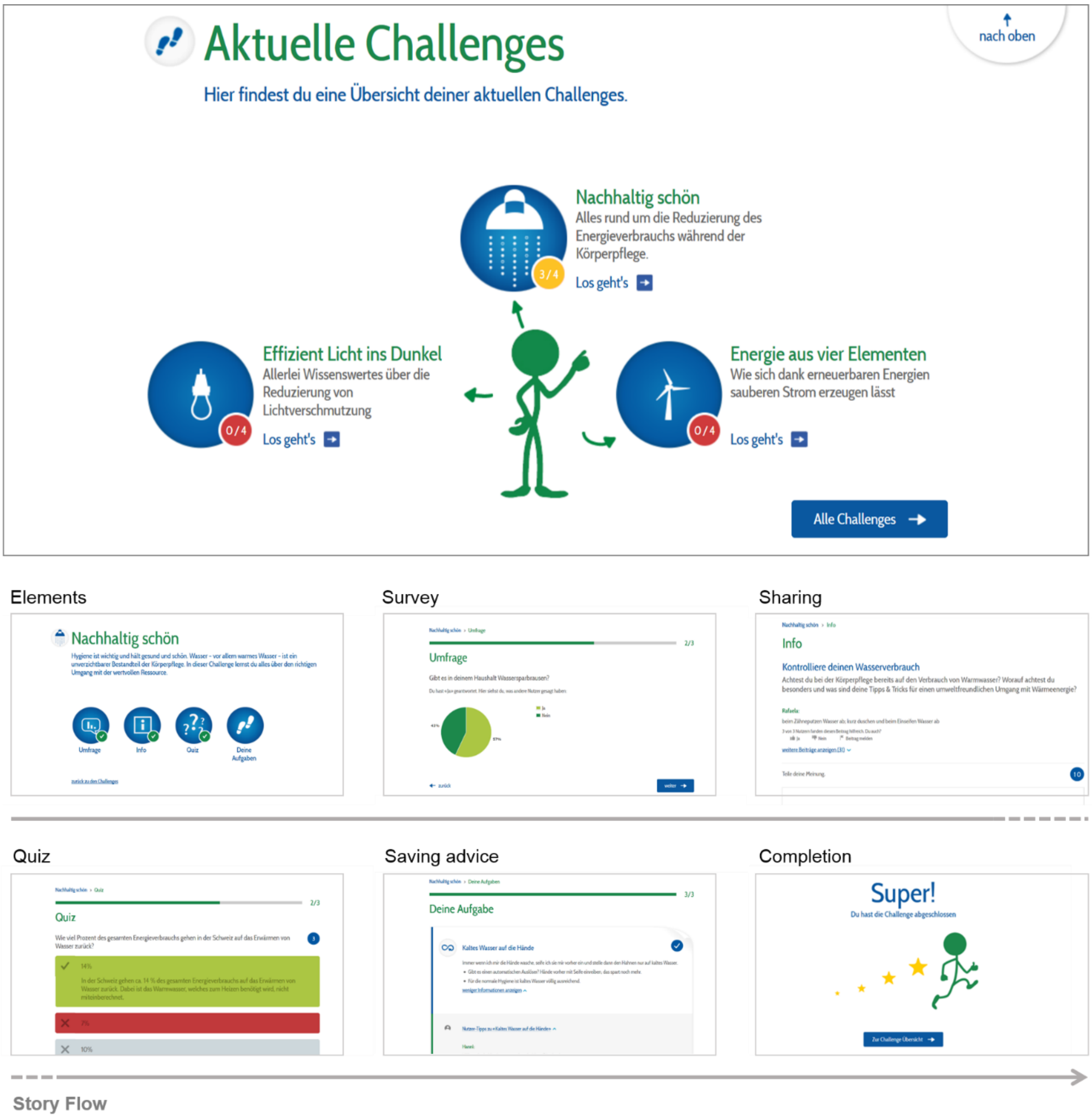

Figure 16 Challenge user flow

My Bonus The My Bonus page displays the individual progress on smartsteps. The page was manipulated to implement the experimental design described in Chapter 5. The section further lists all past events that added to the bonus points. The section aims to visualize the continuous progress of users.

Projects Finally, the projects page aimed to increase the community characteristics of the portal by offering users an opportunity to suggest ewz the implementation of real-world projects. Projects were restricted to aiming to support the goals of the 2000-watt-society and provide a value for the general city community. The section is conceptualized to enable users to directly shape their community in a crowdfunding manner. Projects can be suggested, voted for and implemented with the support of ewz.

Mobile Application The mobile application features the most relevant functions of the web portal: Energy monitoring, benchmarking, and concrete saving advice. The app is synchronized with the web portal to allow for a consistent user experience across channels. Screenshots of the mobile app are presented in Figure 17.

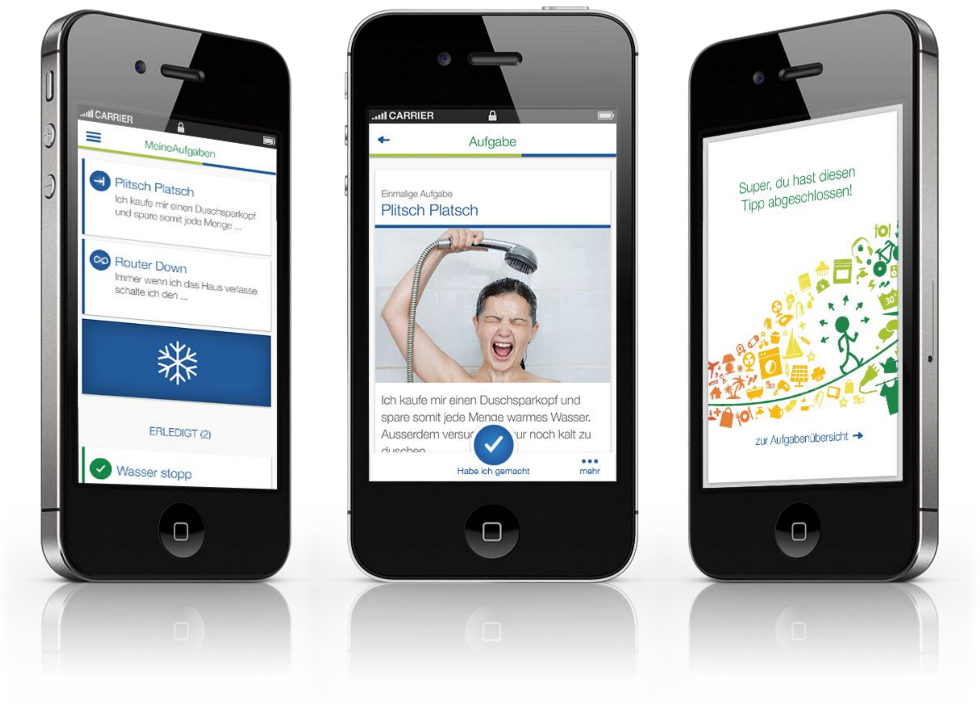

Figure 17 smartsteps mobile application

Newsletter The newsletter re-engages users with the portal. It displays new available contents and active reminders set by the users. The newsletter is personalized, as the recommender system selects the most relevant content, and provides content individually over time. The main functionalities of the web portal and mobile application are listed with a short description in Table 6.

Table 6 Portal functionalities

Feature	Description
Energy Monitoring (also on mobile app)	- Enter meter reading (plausibility check of meter readings) - Meter management (several meters, up to two tariffs per meter) - Comment function for each meter reading - Graphical and tabular presentation of historic consumption
Behavioral Feedback (also on mobile app)	- Classification of efficiency level based on meter readings and household characteristics (for main meter only) - Neighborhood comparison of weekly energy consumption - Consumption breakdown based on entered appliances
Customer Engagement and Personal Advice (personal advice on mobile app)	- Bonus points for completed tasks (as an activity indicator) - Efficiency content (quiz questions and personal recommendations from other users) - Customer survey for content personalization - Personal advice on how to save energy - Reminder functionality with individual reminders for various tasks - News
Personalization	- Storytelling with individual coaching through different challenges divided into various steps - Release of additional content and functionalities based on user behavior and time progress - Recommender system to personalize content for each user by means of a tagged based filtering approach

Mailing The postal mailings potentially reach all customers of the utility. The mailings are personalized with feedback on individual energy consumption. Chapter 4 displays and empirically evaluates different variants of the mailing, developed to pursue the second research question. All mailings contain a code to uniquely identify each recipient on the web portal and allow to upload individual information on historic consumption in the backend, as further detailed in the following section.

3.4.2 Data Flow and System Architecture

Besides the web portal, mobile application, postal mailings and e-mailings, the system contains an analysis DB (raw) and analytics engine. These system components are offline systems and databases used for preparing customer data for use in mailings, e-mails and the operational database. The operational database is the main database for the Web Portal, containing everything from the configuration and content for the portal, apps and e-mails to the pre-loaded and user-generated customer data.

Furthermore, the system comprises utility systems, such as standard CRM and billing systems used by utilities to execute their business processes, containing data ranging from base customer data to consumption, billing and personal data, and credentials. The system also connects to a shop application programming interface (API) that was in the present implementation not operationally used. Figure 18 shows the different system components and data flows.

The system allows to present different content elements or even page configurations and widgets to users. Thus, it enables the implementation of experimental designs (DP 11) such as the one described in Chapter 5.

The author defined the functional requirements of the smartsteps system components and third party systems, configured pre-existing system components[14], and jointly developed new components (Challenges, E-Mailing, Mailing, Mobile app) with BEN Energy. Furthermore, the author defined the data flow in accordance with the ethics committee of ETH Zurich and the commissioner for data protection of the city of Zurich.

[14] Mostly comprising monitoring functionalities used in Graml et al., 2011; Loock et al., 2011, 2013

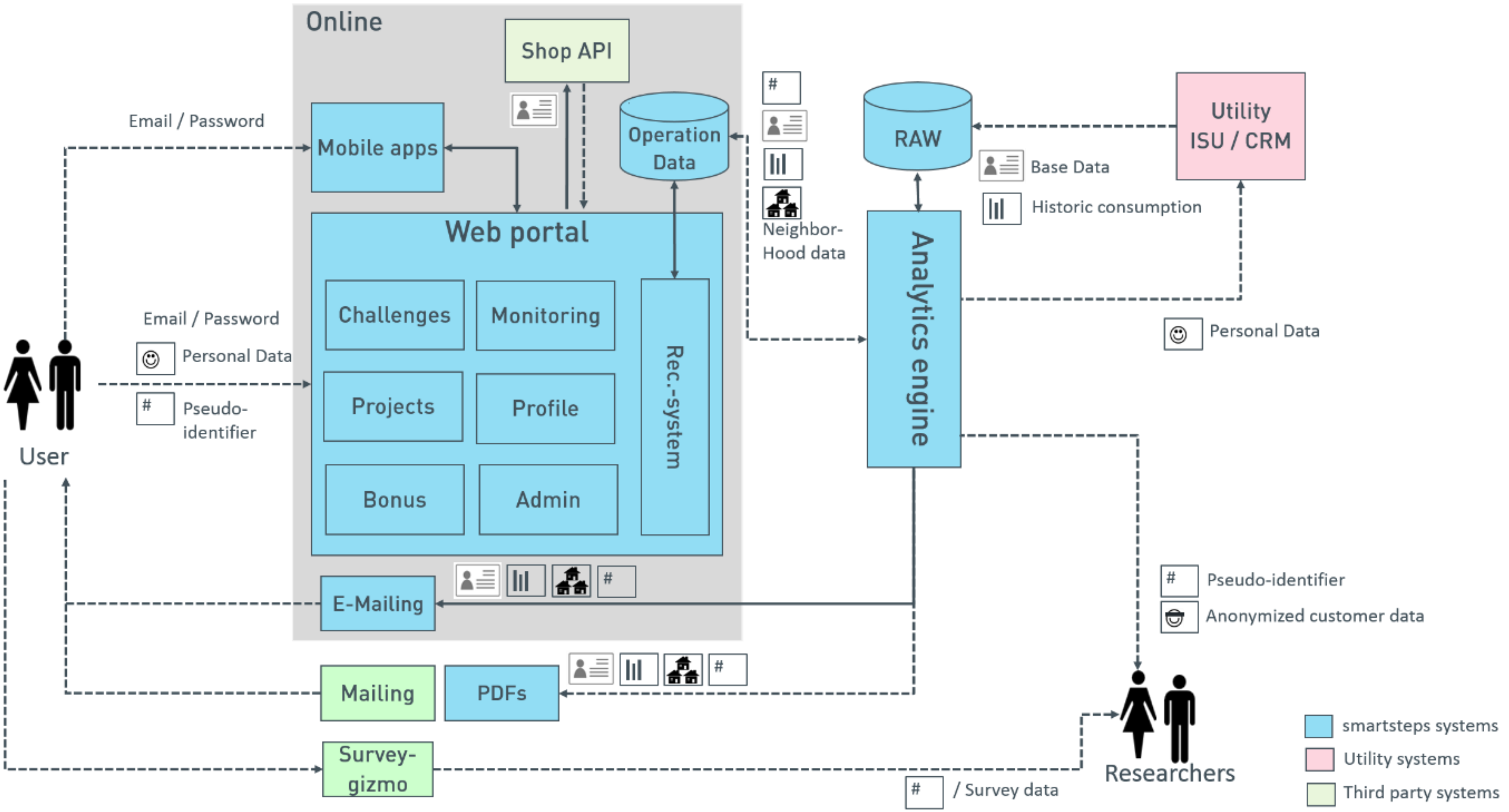

Figure 18 Platform data flow and system components

3.4.3 Adaptions During the Course of the Project

Results of the first months served as the basis for adaptions of the live system in October 2014. The adaptions aimed to improve general usability and amount of data input by users. Identification of areas to improve smartsteps and concrete solutions to implement were identified in a common workshop lead by the author and involving stakeholders from ewz (Energy services, Marketing, and Communications) and BEN Energy. Changes were implemented before the last mailing campaign.

Concrete goals of improvements were:

- Improvement of sign-up rate following the mailing
- Improvements on relevant usage related metrics (Usage frequency, comments, data input)

Figure 19 shows the results of the first month and the recommendations based on those results.

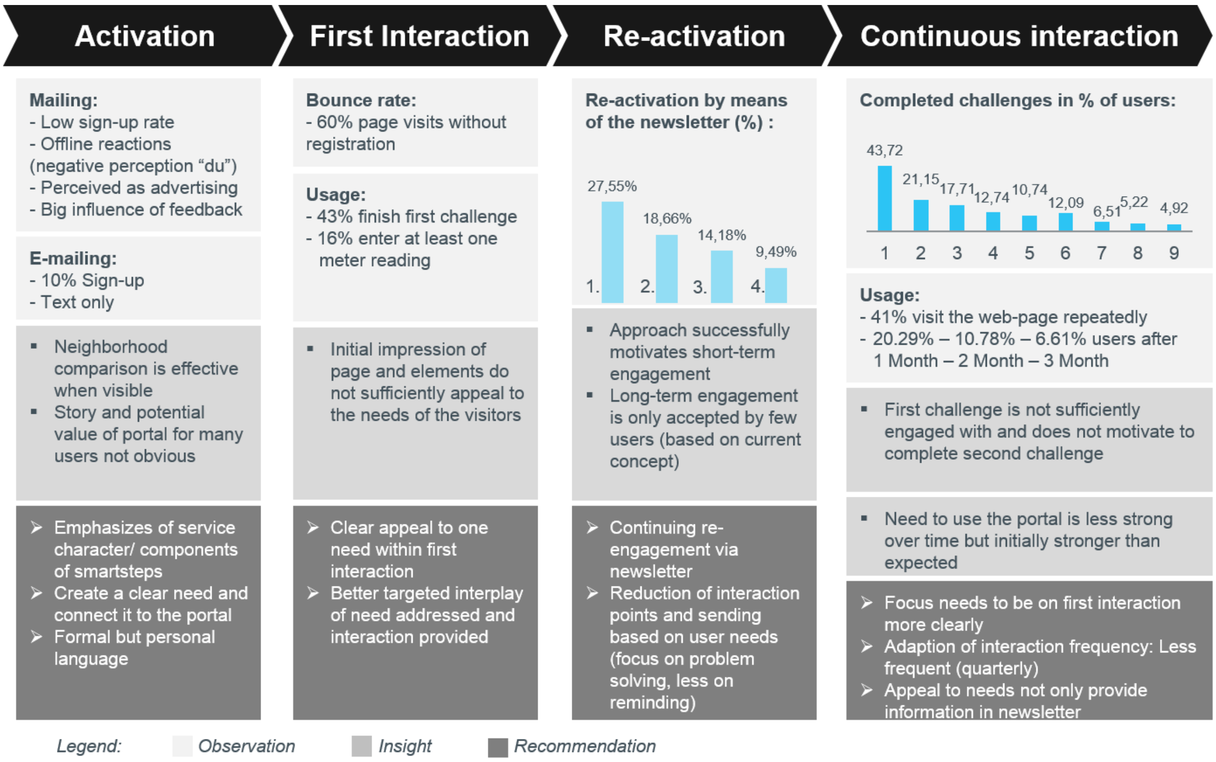

Figure 19 Observations, insights, and recommendations to further improve smartsteps

Most relevant adoptions were concerning the postal mailing and the first user interaction on the web portal. The initial version of the portal did not contain historic consumption information of the past years in the user profile due to data security reasons. In the course of portal adoptions the data security concept was improved so that the historic consumption information of users was loaded into their profile at the time of sign-up. Access of the past years' consumption information on the live portal allowed to give immediate injunctive consumption feedback with no input of meter readings needed. This furthermore allowed the implementation of the *My Energy story board* to dynamically guide users across different functionalities of the My Energy page. The story board is displayed in Figure 20. Portal adaptions increased the relevant usage metrics that were identified with ewz in the following scope:

- Increase of sign-up rate of the postal mailing from 4.22 % to 12.57 %
- Increase of mean time spent on the web portal from 4 minutes to 6 minutes
- Increase of share of active[15] users from 43 % to 75 %

Figure 20 smartsteps "My Energy" story flow

[15] Active users are defined as interacting with more than one content element on the web portal

3.5 Impact of the IS

The business environment identified in the present chapter poses the objectives to the IS to curb residential energy consumption and support sales related activities of the utility company by means of customer engagement. A reduction in consumption is approached by means of feedback and relevant advice how to save energy. To maximize effects, the system focuses on compelling motives to maximize reach. Relevant advice for the given context has been introduced in Section 3.3.3. Compelling motives are investigated in Chapter 4. The present section adds to the research by providing an overall analysis of the system's reach and an analysis of the energy savings by the users. A support in sales related activities by means of customer engagement comprises, establishing a digital communication channel to the customer, fostering long-term interaction, and continuous involvement. Chapter 5 introduces the field experiment to investigate bonus points as an element of gamification to maximize interaction. The present section investigates the ability of the system to support sales relevant activities more generally.

3.5.1 Reach of the Program

Within the project, 42,000 households within the city of Zurich were contacted via mailing[16]. In total 3,558 users registered after receiving a mailing. 482 users registered who did not receive a mailing, presumably due to word of mouth, as no further marketing efforts were taken. Figure 21 shows the registrations on the smartsteps web portal over time. The postal mailings were sent out on the 14th of March and the 20th of November 2014, respectively. The e-mailing was sent on the 24th of April 2014. Figure 21 clearly shows the peaks in registrations directly after the two mailings.

[16] 40,000 households were contacted using a postal mailing over two campaigns with 20,000 mailings each. Signup rates were 4.22 %, and 12.57 %, respectively. 2,000 households were contacted via e-mailings (sign-up rate 10 %).

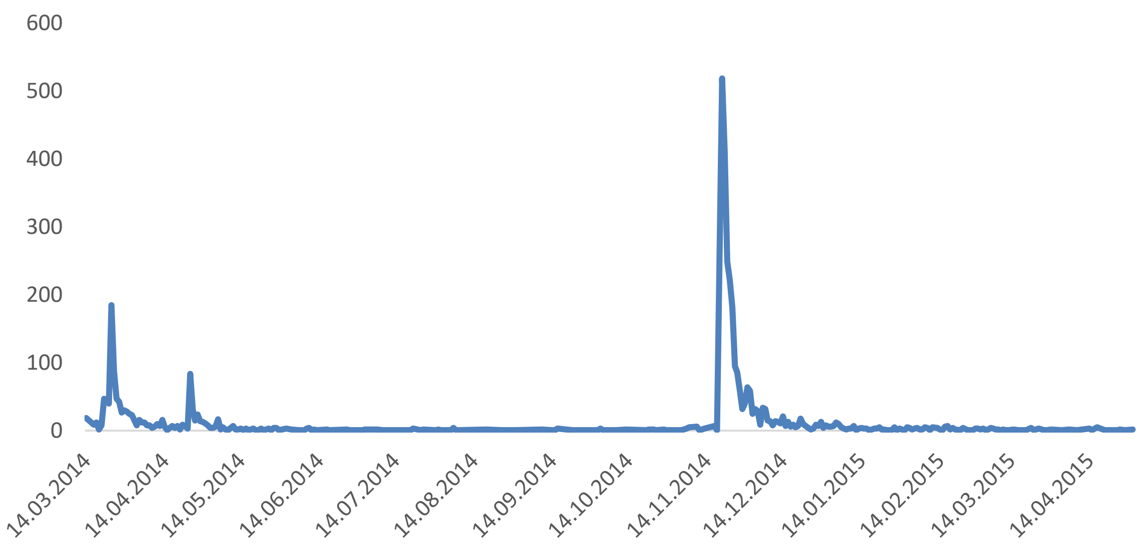

Figure 21 Registrations on the smartsteps web portal

For all mailings, the share of female recipients was 47 %[17], while the share of female users was 37 %. Figure 22 shows the age distribution of registered users compared to the city of Zurich. Registration on the portal required an age of 18 years or higher.

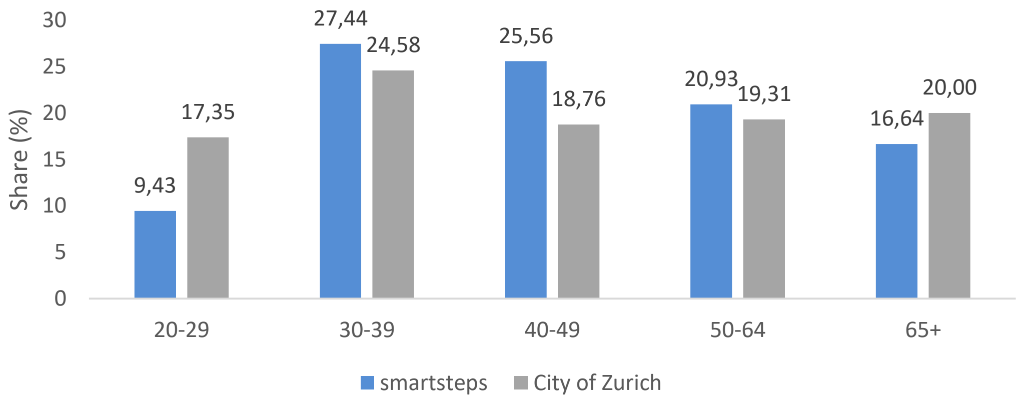

Figure 22 Age of the smartsteps users and the city of Zurich; Source: (Degen et al., 2013)[18]

Additionally, interest in the portal offering varies for the different postal codes within the city of Zurich. For both physical mailings, sign-up rates for the postcodes significantly

[17] Recipients of the mailings are the contract partners of ewz. For contracts involving multiple household members, all persons in the household were addressed.
[18] Data on age of users was assessed on the portal for a subset of n = 430

correlate p (3,558) = .42, p = .0058. Sign-ups for the different post codes contacted via mailings are displayed in Figure 23.

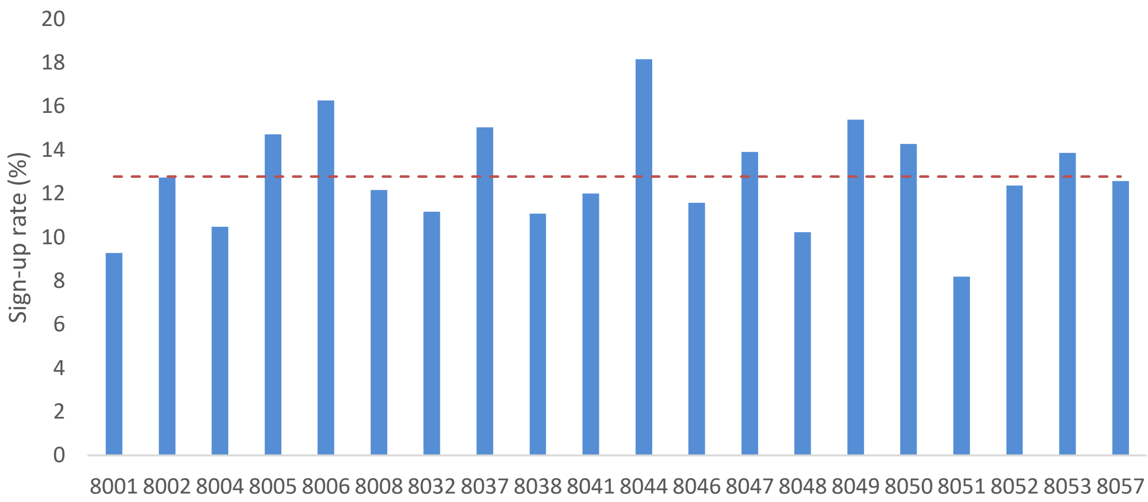

Figure 23 Sign-up rates for the different zip-codes in the city of Zurich; dashed line indicates mean sign-up rate; zip-codes with less than 250 recipients were removed from the analysis

Furthermore, households participating on the portal have a significantly higher consumption in kWh (M = 2,543, SD = 1,366) compared to households not registered during the course of the project (M = 2,196, SD = 1,230); t(4,845) = 11.55, $p < .001$. Figure 24 shows the density distribution of participating and non-participating households.

This indicates potential to further maximize campaign success by selectively targeting households with a higher probability to join the program. Some data available to all utility companies can already serve that purpose (e.g., consumption information and address) as successfully demonstrated by Sodenkamp, Kozlovskiy, & Staake (2015) by means of a machine learning algorithm. Furthermore, insights can also serve to tailor and allocate other campaigns around the topic of energy efficiency.

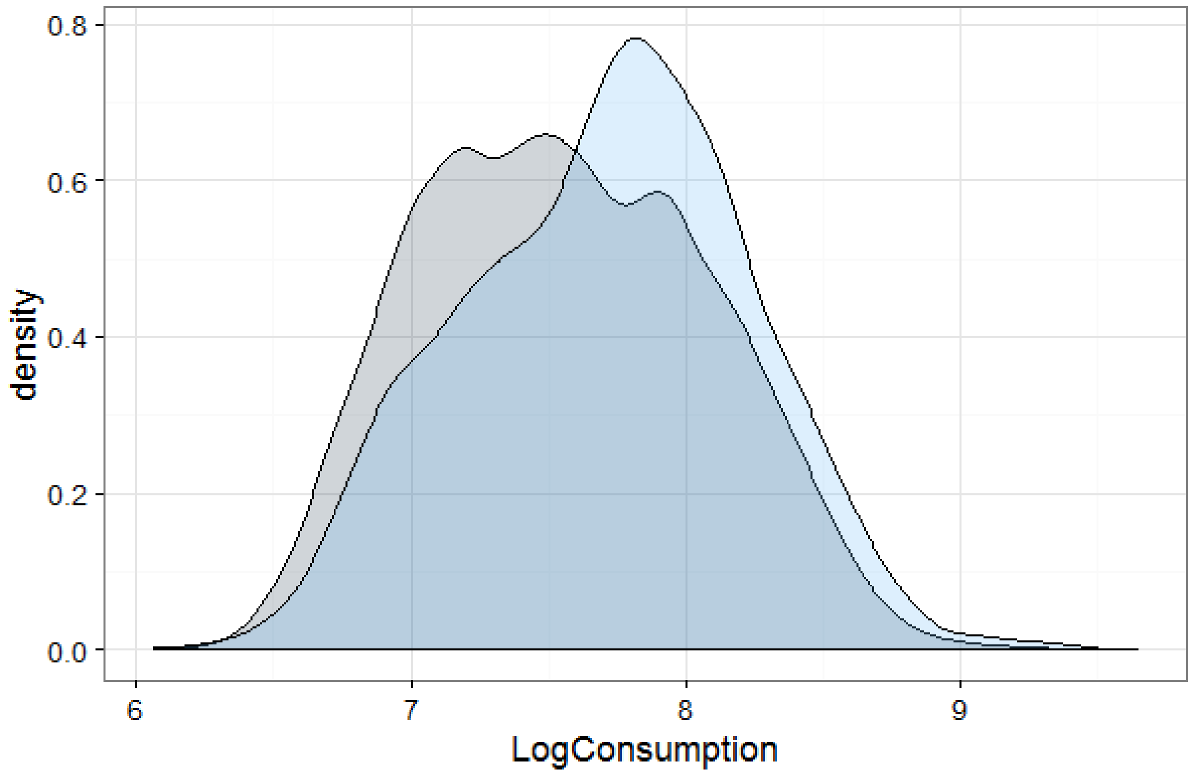

Figure 24 Distribution of logarithmic electricity consumption; distributions show households registered on smartsteps (blue) and non-participating households (grey)

3.5.2 Impact on Energy Consumption

One objective of the platform was to curb residential energy consumption at scale. To evaluate the impact of the IS on the energy consumption of the electricity consumption meter readings of all users contacted by mailing (n = 3,558) and a group of randomly selected households not contacted during the course of the project (n = 16,442) was obtained from the utility partner ewz. Consumption information was available from January 2011 till November 2015. For most households consumption measures were available on a yearly basis. Electricity consumption information captures about 30 % of total primary energy consumption of household in Switzerland (excluding mobility) (Bundesamt für Energie, 2014). Thus, it only captures a share of total energy consumption as the rest is provided by gas and oil, primarily for space heating and water heating – the most effective areas to curb ones consumption (as discussed in Section 3.3.3). However, in the City of Zurich, data for gas and oil consumption is mostly not available as it is provided by landlords and around 90 % of the households are tenants. Therefore, changes in electricity consumption are the best available proxy for an impact of the IS on energy consumption.

In a first step it was determined whether consumption occurred before (t_{-1}) or after intervention start (t_1). Intervention start (t_0) was defined as registration on the web portal after receiving the mailing. Thus, the households not contacted were assigned a date for t_0 so that distribution of t_0 matched that of the users. This required estimation of a meter reading at time of t_0, because data was mostly available on a yearly basis and t_0 likely to be located in between data points. Estimation was weighted by seasonal influences on consumption for the whole population. Therefore, estimation of t_0 was based on a weighted linear trend of individual consumption. Data for seasonal variations in electricity consumption was obtained from Swissgrid[19].

Complete data sets with sufficient meter readings to estimate t_{-1} and t_1, respectively, were available for 2,798 users and 14,033 households not contacted during the course of the project. t_{-1} showed to significantly differ for the user group (M = 2,547; SD = 1,361) and not contacted households (M = 2,286; SD = 1,618); $t(4,523) = 8.96$, $p < .0001$. This is due to selection effects discussed in the previous section. Thus, comparing the consumption trends of the user group and the all households not contacted in a difference-in-difference approach would violate the assumption of a randomly selected treatment group. Therefore, a control group was randomly selected amongst the group of not contacted households to match the consumption distribution of the user group. The control group (n = 4,154) was selected using a Monte Carlo algorithm so that consumption at t_{-1} (M = 2,551; SD = 1,622) did not differ from the user group; $t = -0.14$, $p = .89$. Thus, the control group is used for all further analysis. Another systematic differentiation of the user group was whether they used the portal for monitoring or engagement (e.g., challenges). Generally, all users had the same access to monitoring and engagement functionalities. However, a considerable share of households did not use the monitoring functionalities. Thus, two subgroups were formed whether users monitored their consumption and used the engagement functionalities. Table 7 shows the descriptive consumption information for the different groups considered in the analysis.

[19] http://www.swissgrid.ch/swissgrid/en/home/reliability/griddata/generation.html, accessed on 01.12.2015

Table 7 Consumption information

		Baseline		**Difference**		
	n	*M*	*SD*	*M*	*SD*	%
User group	2,798	2,547	1,361	-41	496	-0.83
Monitoring	287	2,635	1,364	-114	421	-2.48
Engagement	806	2,342	1,175	-33	660	-0.73
Not contacted	14,033	2,286	1,618	-38	601	-0.68
Control group	4,154	2,551	1,622	-50	612	-1.22

Note: The groups Monitoring and Engagement are self-selected sub-groups amongst the User group

Both, the user group and the control group reduce their consumption by 0.83 % and 1.22 %, respectively. The difference in difference is however not significant; $t(6{,}717) = -0.62$, $p = .53$. Similarly, trends of consumption by users of the Engagement group do not significantly differ from the control group; $t(1{,}090) = -0.66$, $p = .51$. Users of the monitoring functionalities reduce their consumption by 2.48 %. This trend in consumption significantly differs to that of the control group that reduced their consumption by 1.22 %; $t(375) = 2.41$, $p < .05$. In a difference-in-difference approach users of the monitoring functionalities thus save 1.28 % compared to a control group.

Results point to the importance of consumption feedback (descriptive, injunctive, and social normative) to stimulate energy savings amongst households that has been widely observed elsewhere (Delmas et al., 2013). Even though savings were small with 1.28 % (for households making use of the monitoring functionalities) they were reached without any additional infrastructure or hardware. Furthermore, with the deployment of smart meters and the increasing availability of data feedback can be sent to all participating households increasing the scale of savings. Chapter 5 investigates the influence of incentives to increase activity on the platform and therewith energy savings.

3.5.3 Value of Customer Engagement

During the runtime of one year the portal was visited by 11,567 unique visitors. Table 8 lists general statistics with relevance to portal usage. Even though marketing was limited to the 42,000 direct mailings, 11,567 people visited the web portal. The time spent on the portal is an estimated average of 26 minutes per single user.

Table 8 Usage metrics

Metric	Result
Visits	19,216
Unique Visitors	11,567
Registered Users	3,980
Page Views	100,951
Page Views/Visit	5.25
Avg. Time on Site (min.)	5.28
Returning Visitors (%)	31.21

Note: Visits is defined as a group of interactions within 30 minutes, Unique visitors is defined as unique IP-addresses for all Visits.

Interactions with content elements is one key purpose of the IS as it increases customer readiness for the utility and thus depicts a large share of the value for sales related activities. During the course of the project the research team implemented improvements increasing the usability of the portal as described in Section 3.4.3. However, the possibility to generally compare the overall activity is limited as users registered in the beginning were allowed to continuously use the portal and users who registered after the changes were implemented had less time to use the portal. Table 9 gives an overview of the interaction with content elements on the portal.

On average users visited the portal twice. 55 % of the users completed the efficiency check, resulting in a dataset containing all relevant information to determine the energy efficiency of a household[20] for 1,717 households. Further energy related information was assessed within the challenges. On average users completed 3.24 survey questions. Additionally, users received advice on how to concretely reduce their energy consumption an average of 3.09 times.

Table 9 Interaction with content elements

Content Element	**Interaction**	
	M / %	*SD*
Efficiency Check	55 %	0.50
Social comparison	7 %	0.26
Meter readings entered	0.58	2.96
Challenges completed	1.08	3.00
Survey Question	3.24	4.10
Saving Advice	3.09	8.5

Time served to the customer and information obtained has a direct relevance for the utility. Both dimensions support sales related activities and increase customer readiness. The utility partner ewz could derive direct value for their operating result. Figure 25 is taken from the ewz business report (2014) and shows the internal view of ewz on the IS and is. Importantly, data obtained via the IS is not only aimed to be fed back as raw data to the utility company. Using supervised machine learning techniques, the data is delivering value for two use cases. First, the data is used as ground truth to estimate the "characteristics" obtained for the whole customer group (Beckel, Sadamori, et al., 2014). Characteristics can enrich the existing data of the utility (e.g., primary heating type) and be used as input for a (geo spatial) segmentation of customers. This can benefit product development or used for targeting energy efficiency campaigns at scale. Second, behavioral data, such as the response to the direct mailing campaigns is used to estimate a similar behavioral response for future campaigns in order to optimize the cost-benefit ratio (Sodenkamp et al., 2015). Out of the 3,980 users, 10.60 % were

[20] Dwelling type, primary heating, warm water heating, number of electrical appliances, living space, and number of inhabitants

not contacted by any marketing efforts. Thus, those users joined following recommendations by others.

Figure 25 Innovation portfolio ewz; Source: ewz (2014)

4 Advertising Green IS

The Costs of Emphasizing Monetary Savings

4.1 Introduction

As outlined in Chapter 1, utility companies are incentivized to realize saving potentials of their residential customers and can powerfully contribute to limiting CO2 emissions in western countries. On the one hand, regulatory provisions mandate utilities to realize savings amongst their residential customers e.g., in form of white certificates (Gangale et al., 2013). On the other hand, in liberalized markets utilities increasingly utilize the topic of energy efficiency to distinguish themselves from competitors, engage their residential customers to better provide new services, and realize load shifting potentials (Gangale et al., 2013). Generally, the total effectiveness of programs depends on the efficacy of instruments and number of households participating. A variety of programs has proven their potential to make substantial and economical meaningful impact on residential energy consumption (Delmas et al., 2013). However, most programs focus on the efficacy of the instruments used to realize savings and technological parameters of scalability, while neglecting the willingness of the general population to engage with their utility and mechanisms driving initial program participation. As participation rates are often low, it is essential for utility companies and program administrators to address factors driving program participation and impact more specifically.

Over the past few years, a series of studies have investigated the impact of feedback technologies (e.g., in-home displays) in larger opt-in studies. Amongst participating households, these studies have shown to substantially contribute to reducing residential energy consumption. In a meta study investigating experimental studies to motivate energy savings from 1975 to 2012 Delmas, Fischlein, and Asensio (2013) report average savings of 2 % for high quality studies. The authors suggest that by targeting behavioral change information and education, programs could effectively contribute to the efforts of reducing overall energy consumption. While the effectiveness of different informational strategies has been subject to research (such as price vs. non-price information to motivate energy savings), the effects of different informational strategies on the initial decision to join a program are mostly neglected. This is rather surprising given that the overall impact of a program depends on both, its reach (i.e., the participation rate amongst households) and its impact amongst those who opt-in.

Participation in residential energy efficiency programs that require an opt-in decision strongly depends on the message appeal used for program promotion (D. Schwartz et al., 2015; White & Simpson, 2013; Xu et al., 2015). Importantly, for individual consumers, saving energy always holds multiple benefits: A reduction of financial costs and contributing to the societal objective of doing something good for the environment. Thus, most prominently, programs appeal to self-benefit reasons, or altruistic motives, and social normative concern, or a combination of those motives, respectively (D. Schwartz et al., 2015). As further outlined in Chapter 2, self-benefit appeals highlight somewhat external reasons to participate (external rewards and punishments) and social normative concerns appeal to a somewhat internal locus of causality (congruence). However, both are categorized as extrinsic motivators (Ryan & Deci, 2000). Altruistic appeals emphasize intrinsic motives to engage in a behavior (interest, enjoyment). A classic economic interpretation would assume that programs should maximize their reach by emphasizing all associated benefits of engaging in the program. However, psychological theory, as well as findings in behavioral economics and first laboratory results in the area of energy saving program adoption suggest that emphasizing one benefit might overrule another by shifting the normative reference frame (D. Schwartz et al., 2015). Specifically, D. Schwartz et al. (2015) shows that emphasizing one motive over another can even decrease the willingness to participate. Extrinsic motives (e.g., monetary benefits) for example may suppress intrinsic motives (e.g., doing something good for the environment). Yet, the latter have shown to be more powerful predictors of environmental behaviors in the long run (Xu et al., 2015) and extrinsic motivators may even reduce the probability for positive spillover in pro-environmental behaviors in general (L. Evans et al., 2013). Additionally, individual-level characteristics (e.g., environmental attitudes) and perceived attributes of the program (e.g., trust of sender) interact with the type of message appeal (Clark, Kotchen, & Moore, 2003; Kalkbrenner & Roosen, 2015). However, there is still missing evidence and researchers should look into the effects of informational strategies on program participation and whom the program appealed to (Hoicka et al., 2014).

Given the ongoing deployment of smart-meters and smart-grid infrastructure, the topic is highly relevant. As highlighted before, utility companies are expected to be one of the main providers offering programs to assist households in controlling and reducing their energy consumption for various economic benefits of engagement (Gangale et al., 2013). Therefore, the research team that implemented the IS as described in Section 3.4 conducted a large scale field experiment (n = 20,000) in collaboration with the project partner ewz investigating messages providing either historic information on consumption or appealing to social normative concerns and self-benefit reason, respectively and their effect on both, a) participation (reach) and b) impact (energy savings).

4.2 Advertising Programs to Curb Residential Energy Consumption: Hypothesis Development

The following sections provide a general overview of the adoption of IS-based programs, a review of the effectiveness of different informational strategies in place, and the effects of the message appeals on relevant outcomes. The review leads to the derivation of hypothesis tested in the field study.

4.2.1 Overview of Literature on Program Adoption

Utility programs that aim at engaging their customers and smart meter programs are likely to require an opt-in decision by the customer due to regulatory provisions and for reasons of cost-effectiveness (Gangale et al., 2013). Additionally, as the frequency of the interaction with the feedback instruments seems to be positively associated with effects on energy savings (Allcott, 2011b), web portals and other technological platforms to access information on a high frequent level are promising means to curb consumption that, however, require an opt-in by the consumer. Thus, a critical success factor for the long-term reach of a program is getting an opt-in decision by the consumer.

A variety of studies investigate the effectiveness of informational strategies like smart metering enabled consumption feedback and combined behavioral strategies to motivate energy savings (Asensio & Delmas, 2015; Gangale et al., 2013; Loock et al., 2013). Abrahamse, Steg, Vlek, and Rothengatter (2007) report that a combination of feedback, goal setting, and tailored information leads to energy savings of 5.1 %. However, the potential reach of the programs under investigation varies greatly and especially personal audits show to insufficiently scale as costs almost linearly increase with program size. In recent years, IT has helped to diminish the conflict between a scalable intervention on one, and the necessary level of detail and the degree of customization of the classical instruments on the other hand (Daft & Lengel, 1986; P. Evans & Wurster, 1999). First large scale field experiments show the effectiveness of this approach by adding instruments from behavioral sciences to IT-driven feedback instruments. In a large field experiment, Loock et al. (2013) developed a scalable IT-based feedback system for an Austrian utility. They added goal setting and defaults as behavioral mechanisms inducing behavioral change and report savings of 4.2%. Recently, by implementing a solution that enables IT-based consumption feedback in real time and as granular as on the level of single appliances, Asensio and Delmas (2015) could realize average electricity savings of 8.2 %. The driver of the relatively high savings effect was the implementation of messages related to health and environment as the informational component of the program. All of these studies proclaim a certain degree of acceptance and usage of the underlying technological system but mostly do not report actual sign-up rates for those programs, which would be crucial to determine overall effectiveness. However, even if absolute sign-up rates for programs were reported, they would be likely to depend on various exogenous factors, e.g., media attention or particular events (e.g., the nuclear blast of Fukushima). Therefore, it is important to determine and better understand the mechanisms influencing successful program promotion.

To date, most studies investigating program participation are conducted in lab settings (e.g., Schwartz et al., 2015) and measure the self-reported willingness to participate in hypothetical programs as the dependent variable. Thus, many studies suffer for a hypothetical bias that leads to an overestimation of the willingness to enroll. Researchers try to overcome this bias by emphasizing the effort associated with a program within the experimental procedure. The relatively high willingness to enroll underlines the general acceptance of energy saving efforts by a vast majority of the population. However, actual sign-up rates for programs are usually way below those projected in lab settings. Asensio and Delmas (2015) report a participation rate of 20 % of the contacted households, but participants were selected amongst a highly educated subgroup of the population. For smart meter based feedback studies by utility companies, few programs report signup rates and the informational strategies used for promotion. A large German field trial by 10 municipal utilities reports participation rates of around 10 % (ISE, 2011), but advertised the program as a research project. In Italy, a large smart meter field study providing households with a cost free in-home display to monitor their electricity consumption reports an opt-in rate of 21 % (Lombardi et al., 2014). However, none of the actual field studies systematically investigates the mechanisms driving the opt-in decisions to use the technology provided.

The success of promoting programs to reduce residential energy consumption is known to depend on the incentives in place, but more importantly, on the marketing and implementation of programs (Stern et al., 1985). The failure of residential consumers to gain economic benefits by investing in energy efficiency and adapting their behavior accordingly is widely considered as market failure or the energy efficiency gap (Brown, 2001; Dietz, 2010). In other words, individuals' willingness to engage in energy efficiency programs (e.g., online based smart meter portals) depends on rational-economic considerations, but also on misperceptions of effective energy conservation strategies, consumer inertia, and the informational strategy employed to promote the program. Moreover, Asensio & Delmas (2015) showed that whether appealing to intrinsic or extrinsic motives of consumer can drastically change the impact of the intervention. However, the general interest of households and the mechanisms driving participation in IT-driven programs to reduce individual energy consumption is lacking generalizable evidence. Therefore, we systematically investigate the effectiveness of the aforementioned motivational appeals in promoting an energy efficiency program and evaluate energy savings of the thereby selected groups.

4.2.2 Informational Strategies to Enforce Program Participation

Programs to support residential households in reducing their energy consumption can appeal to different motives. Concretely, for saving energy the benefits can be categorized into altruistic, social normative and self-benefit appeals (e.g., Bénabou & Tirole, 2006, and further detailed in Section 2.2.3). The consequence of saving energy usually holds multiple benefits for individual consumers (D. Schwartz et al., 2015). Common practice in smart metering projects is to emphasize economic benefits that appeal to the monetary benefits of consumers. Savings on the electricity bill through the usage of online portals that require an opt-in by consumers is the standard approach: Over 50 % of programs in the smart grid context approach consumers with the motivational theme to reduce and/or get control over their electricity bill (Gangale et al., 2013). Similarly, other programs to promote pro-environmental behavior in general emphasize financial reasons to motivate participation and energy savings amongst residential consumers, like the UK's *energy saving trust* campaign, Switzerland's *energy Switzerland* campaign or the German *CO_2-online* campaign ("co2online," 2016, "Energie Schweiz," 2016, "Energy Saving Trust," 2014). Additionally, utilities increasingly introduce smart pricing programs to reward participants for load shifting of peak demand and face similar questions of how to increase reach and impact of these programs. In the US alone, more than 8 million households are targeted in such smart pricing campaigns (Institute for Electric Innovation, 2014).

For retrofitting, participation has been known to depend on, for example, minimizing convenience and type of financial instruments in place (Stern et al., 1985). Thereby, larger incentives show to increase participation rates (Stern et al., 1985). In the case of retrofit programs, financial incentives tend to result in higher participation rates and verified improvements (Hoicka et al., 2014). However, the incentives in place ranging from 650 - 2370 USD were substantial, compared to the modest annual energy savings per household of 65-80 USD for households with a medium capita electricity consumption (Asensio & Delmas, 2015). In Germany, even lower estimated monetary benefits of around 28 EUR per household and year (based on a yearly bill of around 800 EUR and savings of 3.7 %) consumers qualified savings as *not very high but noticeable* (ISE, 2011). In energy research, low financial benefits are considered as market barriers that prevent consumers from engaging in energy saving programs (Brown, 2001).

In the literature there is still mixed evidence of the effectiveness of the approach to appeal to financial benefits showing both, positive and negative, effects to promote program participation. However, latest results show potentially harmful effects of emphasizing economic benefits by investigating psychological mechanism to initially adopt programs. D. Schwartz et al. (2015) found that emphasizing monetary benefits associated with successful program participation can even reduce the willingness to enroll[21]. Additionally, the authors find that monetary benefits negatively affect the perceived importance of environmental reasons to participate. The effectiveness of financial benefits to motivate program participation most likely depends on its size. Thus, an informational strategy successfully building on financial motives requires high additional incentives as benefits are small. However, various studies have shown that non-financial motives can powerfully enhance the effectiveness of energy efficiency programs: Asensio & Delmas (2015) showed that information on financial benefits even had counter-intended effects as it led to an increase in consumption. Allcott (2011) could show that the application of social normative information impacted consumer behavior comparably to the effect of a price increase of 11 % to 20 %. Informational strategies targeting social normative concerns are widely applied as contextual information, for example when providing consumption feedback by telling households how much electricity they consume compared to their neighbors (Abrahamse et al., 2005; Allcott, 2011b; Nolan et al., 2008). Mostly used to motivate energy savings, the application of social norms is also likely to motivate initial participation in IT based programs.

[21] The authors did not provide participants with a concrete monetary amount of savings, but stated that participants typically reduce their electricity bill by 5%.

To summarize, programs can be marketed by appealing to various motives underlying inherent consequences of conserving energy. Most commonly, appeals either emphasize monetary reasons or social normative concern (Allcott, 2011b; Delmas et al., 2013; D. Schwartz et al., 2015). To date, the effectiveness of each of these strategies in motivating households to voluntarily join the programs offered is still unclear. This leads us to our first hypothesis:

H1: Participation rates in programs to curb residential energy consumption depend on the motives the programs appeal to.

Additionally, as the effectiveness of social normative consumption feedback appears to depend on how people perform compared to the reference group (Loock et al., 2011). Likewise, potential financial benefits increase with the households' consumption. However, although absolute electricity consumption strongly correlates with a household's income (e.g., Allcott, 2011a), relative financial benefits for households with a higher consumption are smaller and thus less appealing. Therefore, we hypothesize the following:

H2a: For social normative appeals, the effectiveness in motivating program participation increases with the electricity consumption of the targeted households.

H2b: For social self-benefit appeals, the effectiveness in motivating program participation does not increase with the electricity consumption of the targeted households.

4.2.3 Effects of Message Appeals on Outcomes

Different characteristics of the target group for energy saving programs (e.g., demographics or attitudes towards the environment) can predict opt-in decisions and are likely to interact with the informational strategy to promote the program. Clark, Kotchen, & Moore (2003) report the influence of both, psychological and demographic factors in the decision to participate in a green electricity program. Specifically, they reported higher participation rates amongst more altruistic and environmentally concerned people and households with a higher income and larger size. Additionally, the willingness to participate in community energy schemes is determined by social norms and trust, followed by environmental concern and income (Kalkbrenner & Roosen, 2015). Different informational strategies are likely to attract different segments of the population. As economic reasons for participation are likely to attract households more independently of their attitude towards the environment, we argue that self-benefit appeals attract households with a lower energy efficiency.[22]

H3: Appealing to the self-benefit of consumers attracts households with lower baseline energy efficiency.

Initially appealing to extrinsic benefits of a program negatively affects the participants' intrinsic motivation to work towards the targeted outcomes (Deci et al., 1999). Self-benefit appeals focus on theses extrinsic outcomes. As intrinsic motives best predict energy savings, initial program appeals may not only effect initial participation rates but also the associated outcomes. Therefore, we assume that:

H4: Energy savings depend on the type of initial message appeals.

To test our hypotheses in a rigorous setting with high external validity, we conducted a randomized controlled field experiment that is described in the following section.

4.3 Field Experiment

We used the direct mailings developed to promote the smartsteps portal as described in more detail in Section 3.4. smartsteps was offered as a free service to residential customers of the partner utility company. smartsteps was communicated to customers as a support to monitor and reduce electricity consumption. By varying the message content, we measured effects on signup rates for the program and associated content-specific selection effects. Households were randomly assigned to one of three conditions. Each condition provided a specific message and graphic display based on the households' individual electricity consumption. The first condition solely provided customers with information on past year's consumption. The second condition added financial benefit information by stating the amount of potential savings in the magnitude of 10 % based on the households' last year's electricity bill. The third condition compared the households past year's consumption to the respective street median consumption. To check for potential selection effects by message appeal, participants were asked to provide information on household characteristics to assess their energy efficiency upon signup. To quantify effects on program outcomes we tracked the target households' electricity consumption before and after the program roll-out.

[22] Enegy efficiency is defined as consumption relative to relevant household characteristics such as dwelling type, number of appliances, and number of people living in the household.

4.3.1 Sample and Data

We received the customers address information and data on each household's electricity consumption of the utility companies' total 225,944 residential customers. Median electricity consumption showed to be below national Swiss average (median = 1,842 kWh/year, *SD* = 1,553 kWh). This is not surprising given the urban service territory. Customers with an electricity consumption > 20,000 kWh/year, and < 300 kWh/year were excluded as we could not assume that these households were residential, and occupied, respectively. Consumption information was available for three years before program promotion. For households participating in the program consumption information was also provided for one year after the program by the partner utility ewz. From the customer set, 20,000 households were randomly selected to receive a mailing. ewz served as the sender of the messages and no research background was mentioned, ensuring high external validity of results. At the time of the campaign, the mailings were the only effort to promote the program.

4.3.2 Mailing Campaign

The mailings contained general information about the service and an individual feedback of the households last year's electricity consumption in kWh. The portal was described as a service supporting the users in reducing their energy consumption in order to contribute to a smart energy future, and thus generally appealed to altruistic or pro-environmental motives of the consumers. The mailing framed the web portal as an opportunity to *get more information on individual consumption and assistance in conserving energy*. The call to action motivating the signup on the web portal at the back of each mailing stated that the web portal aims to *approach new ways for a smart energy future* and that each recipient can *contribute their share*. Thus, mailings generally highlight an altruistic motivation of contributing something to the greater good and not emphasize extrinsic reasons. All mailings are listed in Appendix V.

To test the effectiveness of different motives to sign up for the online program described in Section 3.4, we experimentally varied the message appeal. The mailings showed the households' electricity consumption in the previous year, or additionally appealed to social normative concerns, and self-benefit of consumers, respectively. A neutral variant, displaying the household's last year's electricity consumption was designed to not direct the message appeal. To appeal to social normative concerns, and self-benefit motives, respectively, further information that set the household's last years' electricity consumption in a different context was added: The mailings either added social normative information, and potential monetary savings, respectively. This variation and associated messages followed the manipulation proposed by White & Simpson (2012). A social normative message appeal was added by comparing the household's electricity consumption with the median consumption of the respective street as a reference group. A monetary message appeal was added by calculating the potential monetary savings based on yearly decrease of consumption by 10 %. The different mailing variants are displayed in Figure 26.

Each household received one of the mailing variants, which were randomly assigned to the respective household. Due to marketing provisions by the utility different amounts of each variant were sent out: This resulted in 12,000 mailings showing a social normative comparison (b), 6,000 mailings with pecuniary information (c), and 2,000 mailings showing the absolute consumption information only (a).

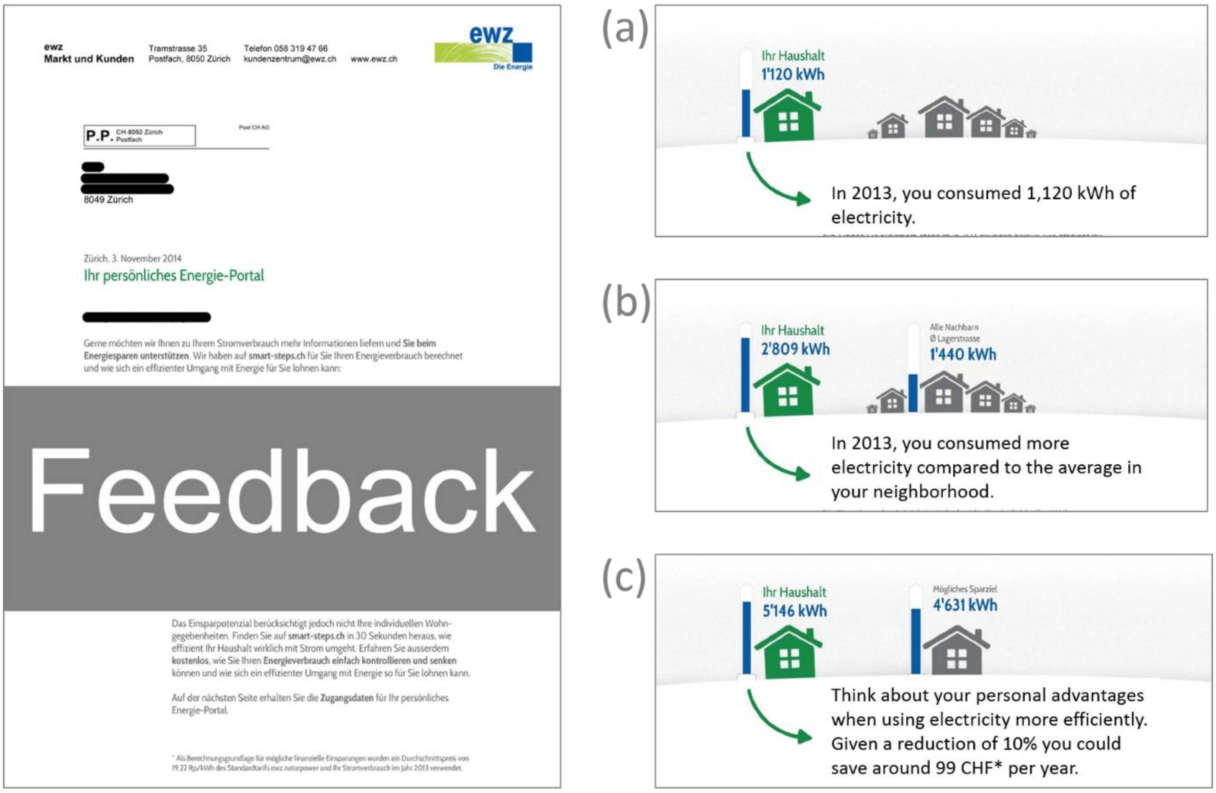

Figure 26 Mailing Variants (a) Info only condition, showing descriptive feedback and call to save energy, (b) social normative condition, showing comparison and call to save energy, (c) self-benefit condition, showing estimated monetary saving potential and call to save energy

4.3.3 Experimental Procedure

The mailing provided each recipient with an individual code that could be used to sign up for the online portal and participate in the program. The code enabled us to uniquely identify each household and automatically uploaded the household's consumption information in the backend of the system. The code was not mandatory for sign-up, however, within the first two weeks after mailing delivery 96 % of participants (households who signed up) entered a code to sign up.

To test whether the savings potential for customers who were given an additional external motive for participation differs, we assessed the individual energy efficiency of every household signing up for the program. For that purpose, we collected household-specific properties determining overall consumption in the first interaction on the portal. Households were asked to provide relevant information in order to receive the injunctive feedback in form of an efficiency scale as described in Section 3.4.1. Efficiency levels were calculated based on relevant household characteristic and the annual electricity consumption. Specifically, the calculation considered the households dwelling type, primary heating, warm water heating, number of electrical appliances, living space, and number of inhabitants. Characteristics were weighted with an estimate provided by the implementation partner BEN Energy AG and gave a range of consumption that characterizes each efficiency level for the specific household properties. The actual consumption was than matched with the values for each efficiency level.

4.4 Results

In total, 2,514 of the 20,000 households receiving a mailing signed up for the program by registering on the portal. This corresponds to a total signup rate of 12.57 %. Compared to the participation rate of comparable campaigns the rate can be considered relatively high (e.g. compared to the 2.1 % reported by Sodenkamp, Kozlovskiy, & Staake, 2015). Descriptive results are displayed in Table 10. 13.8 % of the households signed up for the portal after receiving the *info only* appeal, 12.9 % after receiving the *social normative* appeal and 7.9 % after receiving the *self-benefit* appeal regarding potential monetary savings.

Table 10 Results of the mailing campaign

	Info Only		Social Normative		Self-Benefit	
	Number	Consumption	Number	Consumption	Number	Consumption
Mailings	2,000	1,956	12,000	1,922	6,000	1,917
Sign-ups	270	2,229	1,748	2,414	496	2,197
Rate	13.50 %		14.57 %		8.27 %	

Note: Consumption shows median electricity consumption per year; Sign-up is defined as entering contact information and agreeing on terms and conditions on the smartsteps web portal.

A logistic regression was calculated to predict signup based on message appeal, baseline electricity consumption of the consumers, and the respective interaction of both. Logistic regressions are commonly used when dependent measures are dichotomous. In logistic regression, it is possible to complete planned contrasts only by selecting a single group as a basis for comparison with the others. Thus, the *info only* condition and the low consuming households (following a median split) were dummy coded as zero and served as the respective comparison groups. The results of the logistic regression are shown in Table 11.

Results of the logistic regression revealed that message appeal and baseline consumption were highly significant predictors of signup, all p's $< .0001$, and that they interact significantly, $p < .001$ (Table 11). Adding social normative information did not significantly increase sign up rates (15 %) compared to the *info only* condition (14 %) Surprisingly, adding information on financial benefits significantly decreased sign-up rates: Compared to the *info only* condition (14 %) significantly fewer households signed up (8 %), $p < .0001$. Thus, hypothesis one is supported.

As shown in Table 11, the probability to sign up for the program is significantly higher for households with high consumption with an odds ratio of 1.62, $p < .0001$. This effect increases when providing households with a social normative comparison of their consumption, $p = 0.084$ as suggested by hypothesis 2a. Supporting hypothesis 2b, this does not apply to financial benefit information: Even though households with a higher consumption were shown higher potential financial benefits, their sign up rate did not significantly increase compared to high consumers that received only environmental information, $p = .731$. Sign up rates for high and low consuming households (above vs. below population median) are shown in Figure 27.

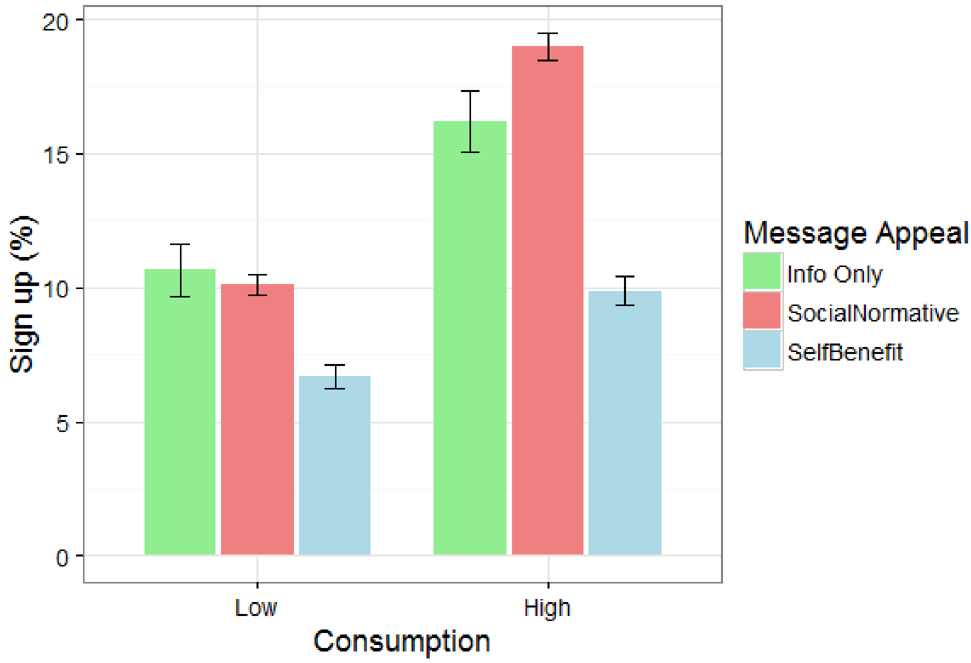

Figure 27 Participation rate as a function of message appeal; Error bars indicate SE of the mean.

Table 11 Logistic regression of signup rates

	β	***d.f.***	**Wald *Z***	***p* value**	**Odds ratio**
Message Appeal		2	31.04	< .0001***	
Baseline Consumption		1	13.00	< .0001***	
Message Appeal * Consumption		2	9.30	.0095**	
Info Only vs. Social Normative	-0.057 (0.11)	1	-0.50	0.615	0.95
Info Only vs. Self-benefit	-0.512 (0.13)	1	-4.04	< .0001***	0.56
Consumption low vs. High	0.484 (0.13)	1	3.61	.0003***	1.62
Social Normative * High Consumption	0.249 (0.14)	1	1.73	0.084 .	1.28
Self-benefit * High Consumption	-0.057 (0.16)	1	-0.34	0.731	0.95
Constant	-2.126 (0.10)	1	-20.50	< .0001***	0.12

*Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1 (Consumption Dummy Coded 0/1 after median split),* $R^2 = 0.036$ *(Nagelkerke). Model* $\chi^2(5) = 382.72$, $p < .001$.

4.4.1 Selection Effects of Appeal Type

Generally, more households with high consumption participate in the program. If social normative feedback is given, this effect is enhanced and more high consumers decided to join the program. We further do not find evidence for a boomerang effect. The additional provision of social normative information to low consumption-households did not reduce sign up rates. When potential monetary savings are shown, the participation rate did not increase with savings size, compared to the general trend when no monetary benefits are mentioned. However, aside from differences in electricity consumption, at the time of sign-up, program participants significantly differ in their energy efficiency level; $F(2,\ 1{,}526) = 2.93$, $p = .054$, $\eta^2 = .004$. Table 12 shows the results of the efficiency level assessment for the different mailing conditions.

Table 12 Efficiency levels by message appeals

Message Appeal	Efficiency Level		
	n	*M*	*SD*
Info only	155	2.39	1.63
Social normative	1,076	2.35	1.55
Self-benefit	298	2.11	1.52

Note: Efficiency level was assessed by BEN Energy AG based on a the characteristics further detailed in Section 3.4.1; Results range from 1 (high efficiency) to 7 (low efficiency)

As revealed by a TukeyHSD *post hoc* test, the *self-benefit* appeal attracted significantly more people with higher energy efficiency ($M = 2.11$, $SD = 1.52$), compared to the condition were the *social normative* appeal was added ($M = 2.35$, $SD = 1.55$); $p = 0.05$, and not significantly but in the same direction when the *info only* appeal was used ($M = 2.39$, $SD = 1.63$); $p = .17$. The effects are, however, quite small. Results of efficiency levels after message appeal are displayed in *Figure 28*. Depending on the mailing variant, participants have different saving potentials. However, the effects are contrary to our assumptions that *self-benefit* appeals attract households with larger saving potentials, at least for a financial savings the opposite is the case. We could not find any differences in the efficiency level of households attracted by the information only, and *social normative* appeal, respectively; $p = .95$.

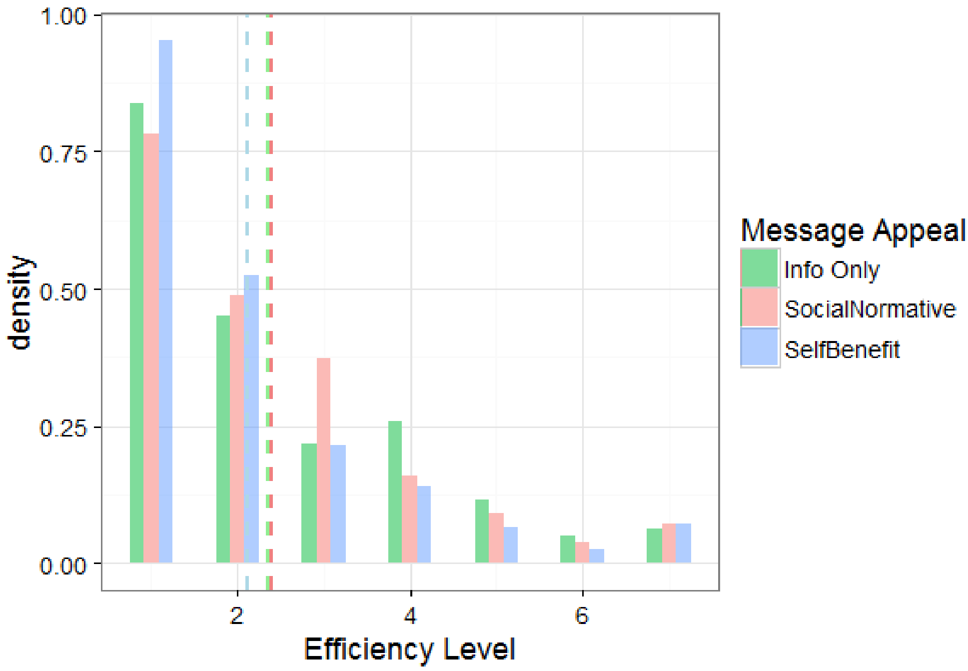

Figure 28 Energy efficiency levels by message appeals; Self-benefit appeals motivate households with a higher efficiency level

4.4.2 Effect of Appeal Type on Electricity Consumption

As proposed by hypothesis 4, households' energy savings depend on the type of initial message appeals. To test for the effect of message appeal on the households' electricity consumption the analysis has to control for the selection effects described above. Thus, a two-factor ANOVA was conducted to compare the main effects of message appeal and efficiency level of households and the interaction of both on households' changes in electricity consumption before and after signup. Message appeal included the three appeals used to motivate participation (*info only*, *social normative*, and *self-benefit*) and efficiency level consisted of two levels (coded Low/ High after median split). Table 13 provides an overview of the descriptive statistics of the electricity consumption for the different groups.

Table 13 Descriptive statistics of electricity consumption

Message Appeal			Consumption before		Difference	
	Efficiency	n	*M*	*SD*	*M*	*SD*
Info Only	High	53	1,945	1,134	-49	318
	Low	77	3,314	1,737	-95	425
Social Normative	High	327	1,871	846	-12	378
	Low	533	3,272	1,473	-109	441
Self-benefit	High	108	1,839	793	172	1,229
	Low	132	3,104	1,383	-32	772

Note: Consumption before shows mean yearly consumption of households before signup. Difference mean values show changes in kWh per year, comparing consumption before and after signup on smartsteps; Statistics are displayed for different message appeals; A control group of households not contacted during the course of the project could not be considered as for those households no information on energy efficiency was available.

All effects were statistically significant at the .01 significance level except for the interaction. The main effect of message appeal yielded an *F* ratio of $F(2,1224) = 5.08$, $p < .01$, indicating a significant difference for message appeals. A post hoc test using Tukey HSD revealed that *self-benefit* appeals motivated an significant increase in consumption ($M = 59.86$ kWh, $SE = 64.98$), compared to a decrease in consumption for the *social normative* appeal ($M = -72.01$ kWh, $SE = 14.34$) and the *info only* appeal ($M = -76.56$ kWh, $SE = 66.74$), $p = .005$, and $p = .077$, respectively. In terms of a difference in difference approach households receiving a *self-benefit* appeal increased their consumption by 3.67 % and 4.70 % compared to households receiving the *social normative* and the *info only* message appeal, respectively. The main effect for a households efficiency level yielded an *F* ratio of $F(1,1224) = 11.32$, $p<.0001$, indicating a significant difference between changes in consumption for households with a high and low efficiency upon signup. Compared to a slight increase in consumption for households with a high efficiency ($M = 24.92$ kWh, $SE = 30.18$) households with low efficiency slightly reduced their consumption ($M = -93.10$ kWh, $SE = 18.88$). The interaction effect was not significant, $F(2,1224) = 1.02$. $p = .36$. A post hoc test using Tukey HSD revealed that households with a high efficiency receiving the *self-benefit* message appeal significantly increased their consumption ($M = 172.04$ kWh, $SE = 118.27$) compared to highly efficient households receiving a *social normative* message appeal ($M = -11.64$ kWh, $SE = 20.87$), $p < .05$. The difference in the trends of consumption correspond to a difference of 5.37 %.

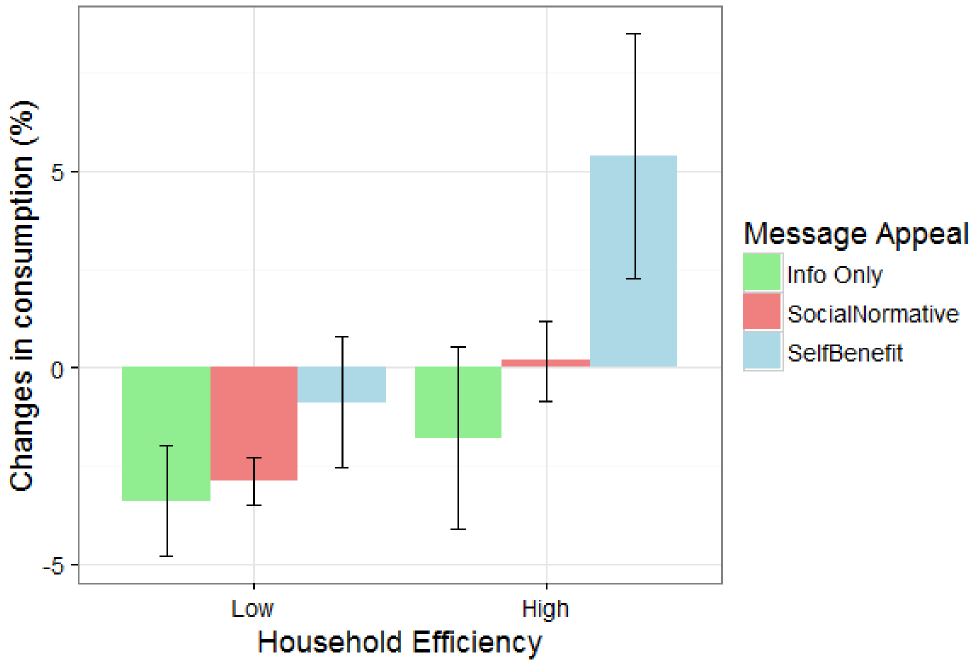

Figure 29 Changes in consumption trends for different message appeals and efficiency levels upon signup; error bars indicate SE of the mean.

4.5 Discussion

The field experiment suggest that for programs to curb residential energy consumption marketing strategies emphasizing the self-benefit over altruistic motives or social normative concerns decrease participation rates in these programs. Compared to emphasizing social normative concerns or simply providing information that do not rule out altruistic messages, participation rates nearly halved when emphasizing monetary reason as a motive appealing to the self-benefit of consumers from 13.50 % and 14.57 %, respectively, to 8.27 %. The effectiveness of appeal type also depends on characteristics of the consumers. Social normative appeals motivate more consumers with a high electricity consumption to sign up for the program, even though generally more households with a high consumption join in.

By contrast, providing a monetary feedback on potential savings did not increase sign ups amongst consumers with a high consumption compared to providing only information on individual consumption even though the amount of savings for high consumers is higher. Furthermore, different message appeals attract different segments of customers which can potentially affect outcomes such as energy savings. Specifically, self-benefit appeals attracted households that were already more energy efficient compared to households attracted by a social normative appeal. Generally, households with a lower energy efficiency at signup significantly reduced their electricity consumption compared to households with a higher energy efficiency ($p = < .0001$). Finally, self-benefit appeals had the counter intended effect to motivate consumers to increase their energy consumption: Compared to households contacted by means of a social normative message appeal and a message appeal solely providing consumption information households receiving a self-benefit mailing significantly increased their electricity consumption by 3.67 % and 4.70 % ($p = .005$ and $p = .077$), respectively.

4.5.1 Implications for Theory and Practice

The present study adds to existing literature by showing that self-benefit appeals are less effective than social normative and appeals solely providing information in motivating consumers to join programs to curb their energy consumption. Furthermore, households with higher consumptions are more likely to participate and social normative appeals can amplify this effect. This is in line with existing literature showing that altruism and general environmental concern, together with household properties such as higher income and size are the main drivers to participate (Clark et al., 2003). However, results show that emphasizing one motive may alter another.

Saving energy always affects altruistic motives, as well as social normative concerns, and holds the benefit of saving money. As D. Schwartz et al. (2015) showed, environmental reason can be weakened when emphasizing monetary benefits without the converse being true. Importantly, the authors point to the fact that their results are not consistent with the overjustification effect in which people attribute their behavior to monetary motives instead of intrinsic ones only in the case of giving extrinsic incentives. The results obtained in this study emphasize that the attention to environmental or altruistic reason is in fact malleable. Adding information on potential monetary savings to a neutral variant displaying a households last years' electricity consumption decreased the overall rate of participating households. Furthermore, sign-up rates did not increase with the amount of potential savings compared to when they not explicitly emphasized. Thus, self-benefit information negatively impacted the importance of intrinsic motives to join the program. Addition of social normative information on the other hand increased participation rates amongst high consumption households with no effect for low consumption households and thus, no evidence for a boomerang effect. Furthermore the results show that appeals attract segments of consumers with higher energy efficiency that amplify negative consequences beyond the observed weakening of motives to the actual potential of benefiting from the program. Accordingly, emphasizing monetary benefits not only weakens environmental motives and thereby gives less reason to participate at all but also attracts consumers that already exploit more saving potentials.

Finally, in the present study, appealing to the self-benefit of consumers by showing potential monetary savings leads to an increase in electricity consumption compared to providing social normative comparisons and information on past consumption. Again, a weakening of altruistic motives and a shift of reference frame by paying attention to the financial consequences of energy relevant behavior can explain this observation. In line with (Gneezy & Rustichini, 2000) by quantifying potential energy saving in terms of money, consumers showed an increase in consumption. The fine of consuming more electricity thus comes with a price that, in the field of electricity, is quite reasonable and affordable for a vast majority of Swiss households.

In practice, the established status quo of emphasizing all associated benefits in marketing programs to curb residential energy consumption needs revision as it comes at a cost on different levels: the adoption rate, the properties of participating households, and the overall impact on energy consumption. Thus, practitioners need to revise the status quo. Emphasizing non-monetary benefits such as normative concerns or altruistic motives seems like a promising approach. Monetary motives most likely speak for themselves.

4.5.2 Limitations and Future Research

Due to the real-world setup the present study has several shortcomings: First, monetary savings were given as an estimate derived from the real price consumers pay for electricity. Consumers might respond differently if confronted with higher monetary savings due to higher overall electricity consumption. This could for example be the case in rural areas containing more single-family homes with bigger living space and areas with a bigger share of electric heating. Second, in liberalized markets, different utility companies might attract different segments of consumers and may observe different effects of different motives in engaging their customers.

Message contents were adapted following White & Simpson (2013). However, generalizability of message content cannot be proclaimed and future studies should further disentangle self-benefit aspects (e.g., saving money vs. acting egoistically). Framing monetary benefits differently (e.g., as opportunity to further increase efficiency) or applying it at different levels of construal might alter behavioral outcomes.

One promising approach is to selectively contact customers with a high probability to sign-up. Based on available customer data and using a machine learning approach Sodenkamp et al. (2015) could successfully increase the success of a mailing campaign. This approach could be extended by adding a dimension of different marketing appeals suited differently well for different customers and select customers based on the likelihood for each appeal. Thus, the overall likelihood of sign-ups is likely to be increased as different segments of the target population respond differently to available appeals.

Furthermore, the present study focuses on the most common appeals used to motivate program participation. Future research can include other motives underlying energy savings, such as self-sufficiency for prosumers or health related messages. Especially health-related messages seem to be promising appeals as they have proven to induce substantial energy savings (Asensio & Delmas, 2015).

5 Incentives to go Green

An Empirical Investigation of Monetary and Symbolic Rewards to Motivate Energy Savings

5.1 Introduction

Besides software engineering and technology acceptance, incentive alignment is considered to be the third dimension in the design and evaluation of IS (Ba et al., 2001). Regarding sustainable behavior by individual consumers such as reducing their energy consumption, the aspect of incentive alignment becomes directly visible, as it is associated with financial and ecological benefits/ incentives for the consumer (Wunderlich, Kranz, Totzek, Veit, & Picot, 2013). In the context of the theoretical foundation of human motivation, a significant body of research in the behavioral sciences has studied incentives to promote target behaviors. Yet, with rather inconsistent findings in the domain of energy, the implementation of incentive schemes seems to be a useful approach to establish good habits (Gneezy et al., 2011). However, the literature also points to potential unwanted effects of using external incentives in the long term, and after the intervention has ended, leading to below baseline frequency of the targeted behavior (Deci, Koestner, & Ryan, 1999). One explanation is that the external incentives undermine the intrinsic motivation to voluntarily perform the incentivized behavior. Deci and Ryan (Deci & Ryan, 1988) explain this undermining on the basis of cognitive evaluation theory (CET) with the desired need for autonomy that is threatened ones external incentives control the behavior (Deci & Ryan, 1988). Potentially, the undermining strongly depends on the type of incentive (e.g., monetary vs. non-monetary) as it frames the outcome of the target behavior as either a monetary trade or a social event and the respective height of the incentives in place (Heyman & Ariely, 2004).

The paper at hand empirically investigates the effect of different incentive types on the usage behavior of an IS-based program to curb residential energy consumption and the effect of system usage on actual electricity consumption. For this purpose, we developed the smartsteps web portal and conducted a large-scale field-experiment that involved 2,355 participants over the course of six months. Following a manipulation check, we analyzed the effect of incentive type and size on system usage and finally the participant's energy consumption. Our research contributes to the research in IS, psychology, and the design of demand response programs to control domestic energy consumption.

5.2 Previous Research on Incentive Alignment: Hypothesis Development

5.2.1 Motivation and Incentive Alignment in IS Research

Ba et al. (2001) introduced the concept of incentive alignment as a third dimension in the design and evaluation of IS, besides software engineering and technology acceptance. The authors define incentive alignment as supporting organizational goals by reinforcing to "[...] employ the system in a manner consistent with the design objective [...]" (Ba et al. 2001, p.226). Concretely, incentives influence the user's behavior and interaction with the system in a goal directed manner.

In IS research on gamification, incentives have been used to "gamify" a system and show their potential to effectively engage users with application content, or increase productivity (see Schlagenhaufer & Amberg, 2015, for review). Incentives are most commonly operationalized in form of bonus points to steer the users' interaction towards the design objective of the system and, by showing progress and intermediate goals, motivate further interactions. In the context of gamification, intermediate goals and rewards are commonly represented as badges (Hamari, 2015). Badges offer users an informational component of why a certain behavior can be beneficial and are commonly designed as optional rewards outside of the core functionalities of an IS. They can influence psychological as well as behavioral outcomes. However, only a few studies have so far shown the effectiveness of bonus point systems and badges in increasing intended user interactions, but first results are promising. Using game elements like bonus points, Barata, Gama, Jorge, and Gonçalves (2013), for example, could show an increase in the attention to reference materials, online participation and proactivity in an educational course, and Costa, Wehbe, Robb, and Nacke

(2013) could increase punctuality in the workspace. Hamari (2015) could show an increase in various use-related metrics by gamifying a utilitarian trading system by the implementation of badges. Therefore, we propose that for users incentivized with bonus points the activity, and more specifically the goal directed interaction with the application content the points are given for, will be higher compared to when no bonus points are in place.

Hypothesis 1: Bonus points increase the users' interaction with the application content

In the case of green information systems that help individuals to reduce their energy consumption, the consequences of using these systems are twofold. On one hand, a reduction of consumption or consumption in off-peak times offers a financial incentive in form of direct monetary benefits: People save money. Moreover, following policy regulations, incentives are becoming a mean to additionally motivate energy savings (e.g., an energy saving bonus deployed by a utility). On the other hand, by saving energy people contribute to environmental sustainability, and thereby potentially pursue their intrinsic need to act upon a problem they are increasingly aware of. Thus, inherent motivations to use systems that encourage consumers to save energy are not solely captured by external incentives but strongly depend on internal motives of the consumers. Furthermore, external incentives and internal motives are not only conceptually different but likely to interact.

Behavioral concepts from social psychology and behavioral economics draw a more complex and accurate picture of the motivational processes of technology adoption and usage, as increasingly recognized by IS scholars (Venkatesh, Morris, Davis, & Davis, 2003; Wunderlich et al., 2013). One concept that has drawn much attention in the field of IS, is that of intrinsic and extrinsic motivation. Intrinsically motivated behavior is performed by itself, in order to experience pleasure and satisfaction inherent in the activity (Deci & Ryan, 1988; Vallerand, 1997). Contrastingly, extrinsic motivation refers to performing a behavior due to a separable outcome (Ryan & Deci, 2000). IS research commonly operationalizes intrinsic motivation as perceived enjoyment or playfulness and extrinsic motivation as perceived usefulness (Gerow, Ayyagari, Thatcher, & Roth, 2013). Davis, Bagozzi, & Warshaw (1992) emphasizes the need for more research in order to understand the mutually reinforcing or countervailing effects of extrinsic and intrinsic incentives. However, the sources of and interplay between intrinsic and extrinsic motivation has yet not been a particular focus of research in IS (Gerow et al., 2013). Game mechanics, such as badges, can enforce not only extrinsic but as well as intrinsic motives, depending whether obtaining a badge involves challenges and informational elements (Malone, 1981). Behavioral research further suggests that the type of the reward associated with obtaining a badge also strongly determines whether it enforces extrinsic or intrinsic motives (Heyman & Ariely, 2004). Therefore, recalling Melvilles (2010) call to investigate what design approaches are effective for developing information systems that influence human actions about the natural environment and focusing on the dimension of incentive alignment, an understanding of the role of incentives in influencing user behavior is crucial.

5.2.2 Motivation and Incentive Alignment in Behavioral Research

In general, incentives have two kinds of effects: The rational change of the outcome of incentivized behavior, and somewhat irrational, psychological effects as for example on intrinsic motivation. The literature provides rather unstable results of interventions utilizing incentives to motivate sustainable behavior and often points to the temporal dependency of effects (Abrahamse et al., 2007). Dietz (2010) describes the ineffectiveness of financial incentives to motivate cost-minimizing behavior as the energy efficiency gap. In the field of energy, most interventions incentivize actual energy savings rather than concrete actions and decisions that directly or indirectly contribute to the superior goal of saving energy.

Other domains implemented incentive schemes yielding stronger positive effects over time. Incentives seem to be a potentially effective instrument to motivate people to exercise more frequently (Charness & Gneezy, 2009), to support compliance in psychotherapeutic interventions (Budney et al., 2006; Volpp et al., 2009), and, in general, to establish good habits (Gneezy et al., 2011). However, the success of interventions, and even the direction of effects thereby depends on the consideration of several psychological factors. Before engaging in a behavior, incentives can change the individual's perception of the task as either intrinsically or extrinsically motivated (Deci et al., 1999). Engaging in a behavior, incentives can change the amount of effort we spend (Heyman & Ariely, 2004). Finally, incentives, especially when removed, can influence the likelihood to continuously engage in the incentivized behavior (Deci et al., 1999). Thereby, effects seem to strongly depend on the type and size of incentives (Heyman & Ariely, 2004). Recent findings in the field of IS support these findings (Lounis et al., 2014).

Incentives can be monetary or non-monetary (e.g., symbolic) (Deci et al., 1999) and substantially vary in height. Following Heyman and Ariely (2004), the effort to reach monetary goals linearly depend on the height of the incentive provided. Thus, with monetary incentives in place, activity of users will depend on the height of incentives. In the context of green IS, non-monetary or intrinsic goals, such as the achievement to become more sustainable, can be represented more clearly by design and richness of information. As for example the achievement of mastering a level in a game can be perceived as differently valuable, we argue that effort to pursue the goals of the system as well increase with the perceived height of the incentive.

Hypothesis 2: The activity of users will increase with the height of incentives

As a core proposition of Goal Contents Theory (GCT) of SDT, Vansteenkiste, Lens, and Deci (2006) point to the dependence of incentives type on the kind of motivation underlying the goal of engaging in a task. Monetary oriented goals can be classified as extrinsic goals leading to extrinsic motivation. Achievement to learn or succeed can be classified as intrinsic goals leading to intrinsic motivation. As extrinsic motivation is known to crowd out intrinsic motivation (Deci et al., 1999) we argue that non-monetary incentives can be as effective in increasing the usage of an personal IS, as the interaction with the application content (activity) is usually characterized by multiple interactions over time. Based on the combined view of research in IS and psychology, we propose the following hypothesis:

Hypothesis 3: The positive effect of financial incentives on the user activity can be reached with virtual incentives

Generally, we expect the user activity do decrease over time, as this is a common observation in the field of IS (Loock et al., 2013). Furthermore, as monetary incentives are known to crowd out intrinsic motivation, we expect a steeper decrease of activity over time for financial incentives compared to when no incentives are given. As non-monetary incentives represent achievement goals we do not expected them to have the same effect but a decrease of activity similar to when no incentives are given. Thus, we propose the following hypothesis:

Hypothesis 4: For financial incentives, the user activity shows a steeper decline compared to when no incentives are given.

Following the overall design objective of the system, we further argue that there is a relationship between the active use of the IS and the target outcome that is energy savings.

Hypothesis 5: Energy savings increase with the users' activity on the portal

However, building on GCT, the positive effect of user activity on energy savings is likely to be moderated by type of incentives. Detrimental effects of monetary incentives compared to non-monetary incentives on intrinsic motivation to achieve actual energy savings are expected. Especially, because the possible consequence of saving energy is not incentivized. Thus, we propose the following hypothesis:

Hypothesis 6: In general, financial incentives undermine energy savings by the users.

5.3 Field Experiment

5.3.1 Subjects and Design

Two thousand three hundred and fifty five real energy customers of the partner utility ewz participated in this field study. The study contained a 2x2 factorial between subject design (bonus type x bonus height), and a control group with no treatment. Participants in the treatment groups could collect bonus points for activity on the portal, participants in the control group received no bonus points at all. The points indicated the effect of the users' choices (Zichermann & Cunningham, 2011). Depending on the experimental variation of the bonus type, the bonus points had a different purpose. The experiment manipulated the bonus type and either used a monetary or virtual bonus to incentivize system usage. Participants in the monetary bonus group could redeem their bonus points for a credit on their invoice by their utility company. Participants in the virtual bonus group ascended levels to display progression and received badges as visual representation for the accomplishment for each level (Lounis et al., 2014). To manipulate bonus height, the experiment implemented two levels for each bonus type. The financial bonus was implemented in a maximum of 25 CHF (23 € or USD 25), and 75 CHF (69 € or USD 75) to be earned within the six month of activity, respectively. The height of the virtual bonus was varied by making the visual representation of accomplishments tangible: Users could print "efficiency certificates" for each level. The participants were randomly assigned to one of the experiment groups at time of registration. The probability to be assigned to control group was set to one third of all the other groups as the utility requested more participants to be in one of the groups with incentives in place. Table 14 shows the experimental design and number of participants for each experimental group. In the user group 34 % of the subjects were females.

Table 14 Experimental design and number of participants

	Incentive height	
Incentive type	*Low*	*High*
Virtual	516 (Fig. 2a)	538 (Fig. 2b)
Financial	549 (Fig. 2c)	555 (Fig. 2d)
Control	197	
n	**2,355**	

5.3.2 Experimental Procedure

In order to test our hypothesis, we developed the energy platform smartsteps in corporation with the Swiss utility company ewz as detailed in Chapter 3. At the time of the experiment ewz had around 225,000 residential energy customers. The underlying rationale for building the system was to create a behavioral intervention that uses IS to cost-effectively address a large number of people and that is capable of providing users with different kinds of incentives to rigorously evaluate their effectiveness on system usage.

The web portal was designed to motivate users to save energy by providing energy consumption feedback on the users' electricity consumption, information on in-home energy consumption in German language (energy quizzes, knowledge sharing), and energy saving tips. smartsteps served as the basis for an energy efficiency campaign that aimed at raising awareness about energy consumption and at preparing customers for the introduction of smart meters. The platform was based on the design of platforms successfully used to conduct large scale field-experiments (Loock et al., 2011, 2013). The experience chain of the experiment is depicted in Figure 30.

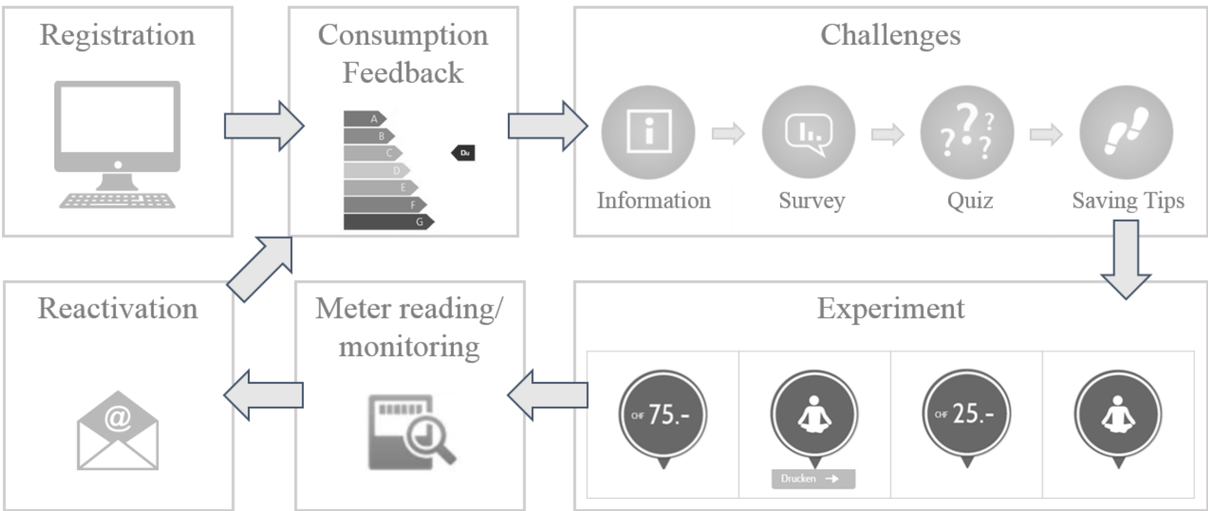

Figure 30 Experience chain of the smartsteps experiment

smartsteps enables users to check their households' energy efficiency, on the basis of self-entered household details and their yearly electricity consumption which is stored in the backend of the system. Additionally, users can monitor their electricity consumption by entering their meter information, and engage in challenges that contained information and saving tips to decrease their in-home energy consumption. After registration, users could enter their household details and received an injunctive (in form of a rating on an energy efficiency scale) consumption feedback that was calculated based on their electricity consumption (Loock et al., 2011). Afterwards, users were guided to take their first challenge. Challenges are blocks of content elements and consisted of information elements, surveys, quiz questions, and saving tips. The information gave a reference frame to each challenge and set general goals for the user (Passos, Medeiros, Neto, & Clua, 2011). Surveys and quizzes were used to assess household characteristics, and knowledge levels, respectively. The information was used to select useful saving tips for each user. Six new challenges became available over the time course of six month. All participants of the study had equal access to the content and were presented the same content elements.

The content elements of the platform were designed to be challenging for users. Past research showed, that entering a meter reading on the platform and the execution of saving tips is no behavior voluntarily done by a large portion of the population. Thus, incentives are effective means to increase activity, as activity is generally low (Graml et al., 2011). For all content elements, users could collect bonus points. Participants in the control group could not collect any bonus points. The incentive scheme is listed in Table 15.

Table 15 Incentive scheme

Bonus Group	Availability/ Month	Bonus Points
Injunctive consumption feedback	Once	20
Normative consumption feedback	Once	20
Correctly answered quiz question	4	3
Co-creation	1	10
Saving tip (promised/ done or comment)	3	20
Meter reading	4	10
Meter reading reminder	Once	20
Load disaggregation tool	Once	20

Upon registration, participants were randomly assigned to different groups. Based on the group participants either received a high financial, a high virtual, a low financial, or a low virtual bonus they could redeem/ received for their points, or no bonus at all (control group). Participants could enter their own meter readings to monitor their electricity consumption and collect bonus points on a weekly basis, and set an email reminder. Each time new content became available that also provided the opportunity to collect bonus points, users received a notification via email. At the second login, users could receive a social normative consumption feedback comparing their electricity consumption to that of their neighbors.

To maintain control over the online portal, members of the research project team programmed the entire system as detailed in Chapter 3. One day after signing up on the portal, participants were invited to take a short survey to assess the perceived height of the incentive. The activity of the participants was defined as the interaction with incentivized content elements. As the goal of the portal was to motivate a large number of participants to be as active as possible, the activity was assessed as the logarithm of bonus points collected to account for few extremely active users and the associated right-skewed distribution. To track the participants' change in the trend of their electricity consumption after signup on the portal we received consumption data by the utility partner ewz and collected self-entered meter readings by the participants.

5.3.3 Intervention

The goal of the content items provided was to increase the energy awareness of the participants and motivate an individual reduction of energy consumption. Bonus points and the associated incentives aimed to influence the behavior of the participants towards this goal (Ba et al., 2001). Concretely the incentives were designed to reinforce the interaction with the content elements and thereby increase the overall activity of the participants. Bonus points were shown on each content item to indicate the value of the interaction with this item. The collected bonus points were displayed on a separate page. The control group could not see either the points on the content items or the separate page. The bonus points accumulated over time and “unlocked” the respective bonus.

Each group had to collect 100 points per bonus stage (e.g., 100 points for a credit of 15 Swiss francs (equal to 13 € or USD 15) for the bonus group financial high). The last stage of bonus points was reached at 500 points. The risk of participants manipulating the system was prevented by the limited amount of points one could collect. As listed in Table 2, participants at least had to be active for 3 month to reach the last bonus level but could reach the first level within the first experience chain. The experimental stimuli used to represent the respective incentives are displayed in Figure 31.

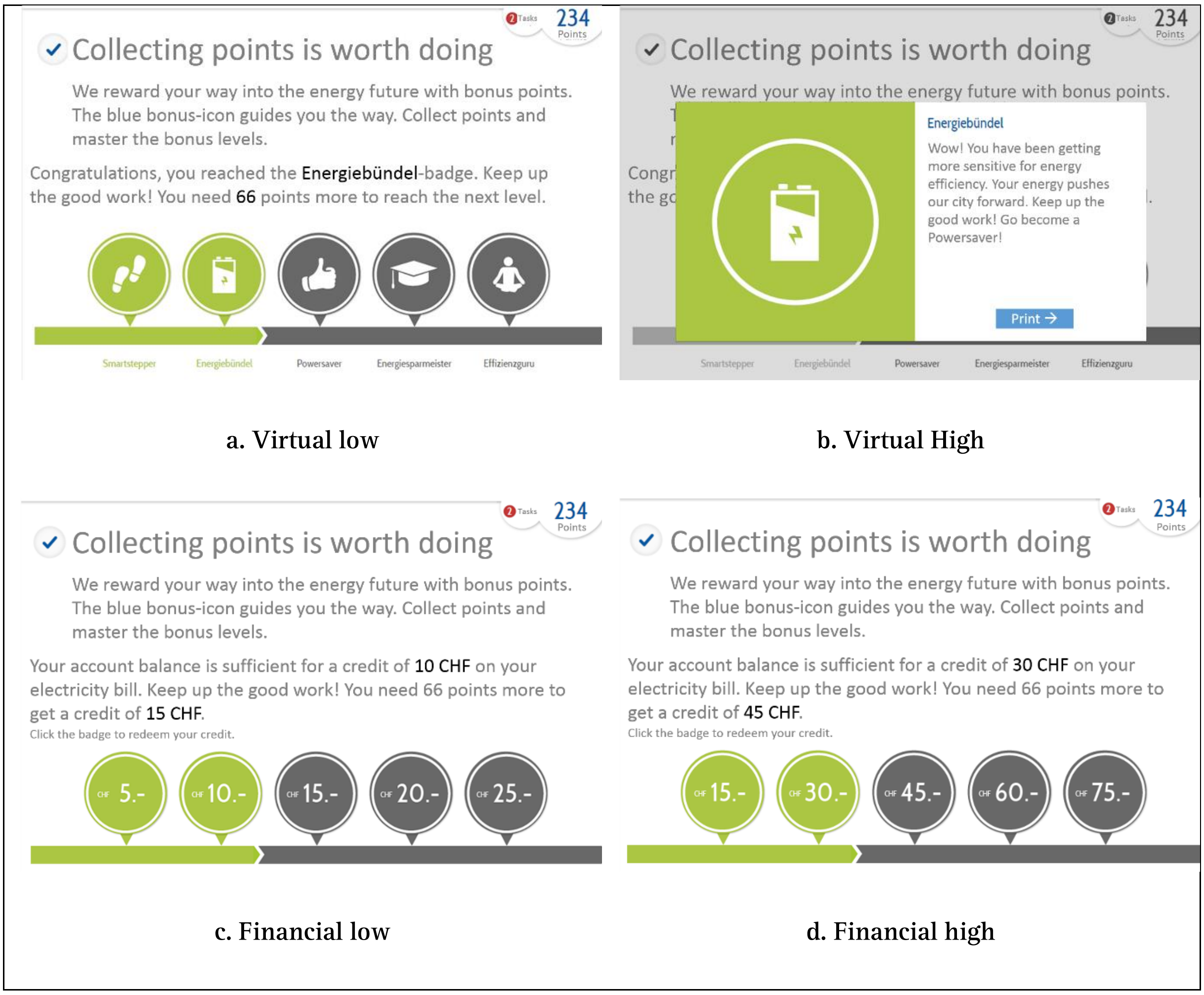

Figure 31 Experimental stimuli displaying the different incentive types and heights

5.4 Analysis and Results

To assess whether the different incentive types and heights were, besides their objective difference, perceived differently, we measured the perceived value of the separate incentives following the methodology proposed by Okada (2005). Table 16shows the questions to assess the perceived value and the descriptive statistics. The perceived value of the bonus as a function of bonus group is displayed in Figure 32.

Table 16 Perceived value of the bonus

Bonus Group		Questions		
	n	What is the value of the bonus points?	How well off are you with the bonus points?	How happy are you with the bonus points?
Virtual High	17	2.41 (*1.28*)	2.59 (*0.87*)	2.76 (*0.97*)
Financial High	20	2.89 (*1.15*)	3.05 (*0.83*)	3.20 (*1.06*)
Virtual Low	20	1.95 (*0.76)*	2.25 (*0.64*)	2.25 (*0.72*)
Financial Low	26	2.69 (*1.19*)	2.77 (*1.11*)	2.88 (*1.28*)

Note: Measure on five point Likert scale: (1) Not at all valuable/ Not at all well off/ I do not care about it at all, (5) Extremely valuable / Extremely well of / I am very happy; Values show mean answers; SD in parentheses; alpha = .91; Users were invited to participate in a survey three days after signup. Low participation rates may point to selection effects and results have to be considered carefully.

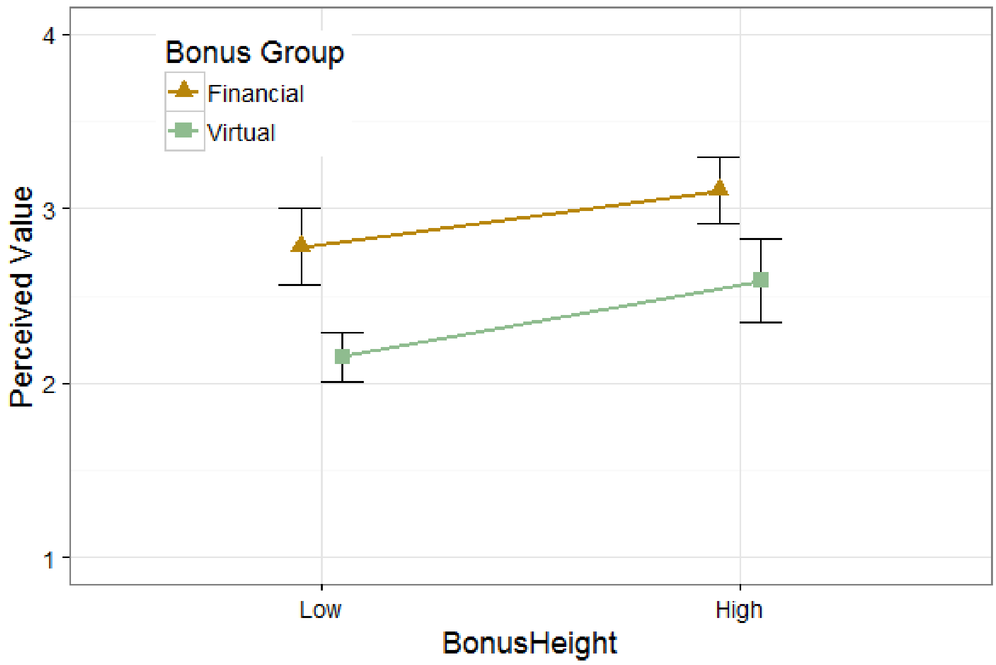

Figure 32 Perceived value of the incentives by bonus group; error bars indicate SE of the mean

An ANOVA shows that there is a highly significant effect of bonus type on the perceived value; $F(4,82) = 6.85$, $p < .01$, $\eta^2 = .10$, and a weakly significant effect of bonus height on the perceived bonus value; $F(4,82) = 2.53$, $p < .10$. The interaction of incentive height and type showed not to be significant; $F(4,82) = 0.07$, $p = 0.78$, $\eta^2 = .04$. Thus, the manipulation of incentive height and type also had an effect on the perceived value. The direction of the effect is – as expected – in direction of the intended manipulation, which is therefore successful.

As shown in Figure 33, the results supported not all assumptions stated in hypothesis 1 to 3 but revealed rather counter-intuitive effects. As predicted in hypothesis 1, incentives increased the users' activity on the portal, compared to when no incentives were in place ($F(4,2350) = 4.36$, $p < .01$, $\eta^2 = .007$). For further analysis of single group differences, all analyses were carried out as planned contrasts within analysis of variance, as standard factorial design was not used. Hypothesis 2 was not supported for financial incentives, as the activity of the high financial and the low financial bonus group did not significantly differ ($t(4,2349) = 0.424$, $p > .6$, $d = .02$), even though the perceived value increased with incentive height. However, as predicted in hypothesis 2, the activity of the participants given the virtual incentive increased when the bonus height increased from low to high ($t(4,2350) = 1.715$, $p < .1$, $d = .11$), in line with the perceived value of the incentive. Therefore, results indicate that the relationship between bonus height and activity is not equal for incentive types (at least in the height under investigation) but interacts. Hypothesis 3 is supported as the high virtual incentive increased activity to a level that it does not significantly differ to that of both financial incentive groups ($t(4,2350) = 1.502$, $p > .1$). However, differences may occur at bigger sample sizes.

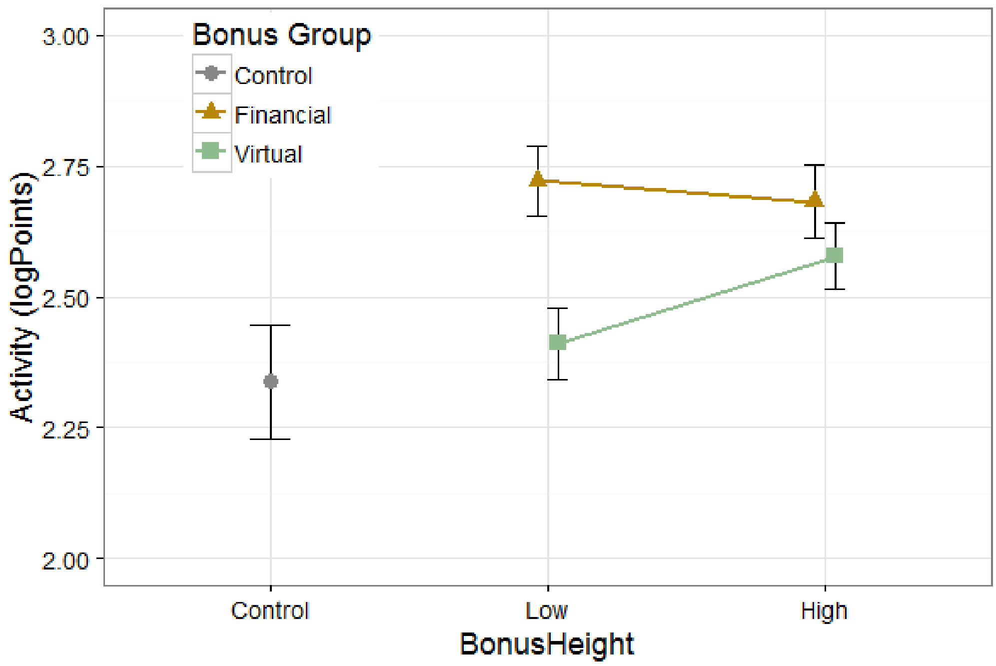

Figure 33 Average activity as a function of incentive type and height; error bars indicate SE of the mean.

Table 17 Activity by bonus group

Bonus Type	Bonus Height	Activity (LogPoints)		
		n	*M*	*SD*
Virtual	High	490	2.55	1.48
	Low	462	2.42	1.54
Financial	High	506	2.68	1.68
	Low	502	2.75	1.56
Control		184	2.32	1.49

To test hypothesis 4, we collected data for each occasion participants collected points over time, which results in a repeated measurement structure of the data. We apply a linear mixed-effect model by means of the lmer()-function that is offered in the lme4 package of the R statistical software. Table 18 presents results from the hierarchical linear model that estimates the relationship of Bonus Experiment groups in interaction with time on user activity; unstandardized variable coefficents are reported. The five experimental conditions were dummy coded with the control group acting as the reference category. Time was subsumed in three phases, containing intervals of two month each. Random effects are added as singles users.

Table 18 Multilevel estimates predicting activity

	Model 1	***Model 2***
	Est. (*SE*)	Est. (*SE*)
Intercept	3.40 (0.35)***	3.08 (0.15)***
Time	-1.27 (0.02)***	-1.15 (0.06)***
Bonus Group		
Virtual High		0.30 (0.18) .
Financial High		0.44 (0.18) *
Virtual Low		0.11 (0.18)
Financial Low		0.54 (0.18)**
Cross level interactions		
Virtual High * Time		-0.11 (0.07)
Financial High * Time		-0.16 (0.07)*
Virtual Low * Time		-0.04 (0.07)
Financial Low * Time		-0.20 (0.07)**
R^2	.49	.75
AIC	19,094	18,306

Note: AIC = Akaike's Information Criterion.

. p > .10, *p > .05, **p > .01, *''p > .001

Results confirm that financial incentives in both height variants and the high virtual bonus significantly increase activity on the portal. Generally, all participants show a rapid decline in activity over time (b = -1.15, p < .001). However, results support hypothesis 4: for the high and low financial bonus, activity decreases significantly steeper, compared to the control group, as shown in the significant interaction with time (b = -.16, p < .05, and b= -.20, p < .01). This is not the case for the virtual bonus group.

Finally, to test hypothesis 5 and 6, it was checked whether the activity on the portal has a positive effect on electricity consumption that is a reduction of consumption and if this effect is moderated by experimental group. Table 19 shows the descriptive statistics for the participants' electricity consumption before and the difference to after intervention start (defined as day of signup) for each experimental group. Data was assessed on basis of yearly meter readings and self-entered readings by participants. To calculate the consumption before the signup, at least two meter readings are necessary. It was not possible to determine whether the reduction came from the signup or other influences due to the following factors:

- The temperature as the one of the largest influences on energy consumption was different in the years before and after the campaign.
- The consumption of portal participants differs strongly from that of the customers who did not opt-in. The magnitude of consumption and therefore also the savings are much higher for the participants.
- The (yearly) meter reading of all customers happen at different points during the year. The selection bias is alleviated by considering the meter readings for at least a year before and after the campaign start.

Table 19 Mean electricity consumption of participants before and after signup.

Bonus Group		**Consumption before**		**Difference**	
	n	*M*	*SD*	*M*	*SD*
Virtual High	430	2,667	1,488	-50	393
Financial High	453	2,694	1,454	-51	371
Virtual Low	407	2,609	1,315	-53	341
Financial Low	436	2,605	1,463	-43	341
Control Group	161	2,656	1,305	-75	376

Note: Mean electricity consumption of participants before and difference to after signup. Consumption is displayed as average consumption in kWh per year. Data was available only for a subset of 1,886 participants.

Hypothesis 5 is supported as the activity on the portal is associated with the reduction of participant's electricity consumption as shown in the results of the ANOVA in Table 20, $F(1,1877) = 3.05$, $p = .08$. However, effects are quite small. For users, the mean difference that is described by activity is -2.19 %. That is the users collected 2.6 LogPoints on average leading to a reduction of 2.19 % based on the model and an average reduction of 34 kWh/ year. Hypothesis 6 is not supported as the change in electricity consumption does not depend on the experimental group, $F(4,1877) = 0.3$, $p = .88$.

Table 20 Effect of activity and experiment group on changes in electricity consumption

	d.f.	*F*	*p*	η_p^2
Activity(LogPoints)	1	3.05	.08 .	.002
Experiment Group	4	0.30	.88	.000
Activity(LogPoints)* Experiment Group	4	0.30	.88	.000

Note: Signif. codes: '' 0.05 '.' 0.1, Results of an ANOVA applying a difference-in-difference approach*

5.5 Discussion

5.5.1 Key findings

This chapter describes the concept and implementation of an incentive system to increase usage and positive effects of an information system to motivate sustainable behavior in end consumers. Specifically, this chapter investigates incentive systems implemented in the smartsteps web-portal. The smartsteps portal aims to curb energy consumption of customers of the utility company ewz by providing household-specific information on consumption, context information like social normative feedback and personalized support in making sustainable decisions and change existing habits. 2,355 users of the portal participated in the present field experiment. The platform was used to test the effect of different incentives on activity on the portal and energy savings. Therefore, participants were randomly assigned to an experiment group upon signup that varied the type (monetary vs. non-monetary) and height (high vs. low) of the incentives and a control group that did not receive any incentive, respectively. The experiment showed that incentives increased the activity of participants on the portal, but that effects depend on incentive type and height. Surprisingly, the activity did not increase with the height of the financial incentive but with the height of the non-monetary virtual incentive. High virtual incentives (with which no costs were associated) showed to be equally effective in increasing activity compared to both high and low financial incentives. Additionally, participants given the financial incentives show a higher decrease in their activity compared to the control group. This is not the case for participants receiving the virtual bonus. As hypothesized, a portion of the reduction of participants' energy consumption after intervention start was explained by the activity on the portal. However, the type of incentive did not show to significantly influence participants energy consumption.

5.5.2 Implications for Theory and Practice

The results are valuable for both, practitioners and researchers. The field experiment comprised a sample of real energy customers that used a service portal provided by their utility, enabling us to yield results with high external validity. Results show that incentives increase the activity on a web portal to motivate sustainable behavior but that the effectiveness of monetary incentives is not necessarily superior to non-monetary or virtual incentives. Furthermore, participants given the financial incentive show a steeper decline in activity, compared to a control group. Therefore, the assumption of a user's behavior to be linearly dependent on the expected outcome of his actions does not hold up. Solely providing users of green information systems with higher monetary incentives does not necessarily increase their activity and thereby associated positive outcomes. Furthermore, designing incentives that appeal to the intrinsic motives of the user and at the same time being perceived as valuable, can increase user activity to the same effect as financial incentives – with no associated monetary costs for the provider or potentially harmful effects like the crowding out of intrinsic motivation.

Besides fulfilling intrinsically motivated goals, saving energy always holds financial benefits, as households save money. However, as pointed out by CET, externally given incentives are distinct from those inherent in a behavior and are likely to be perceived as more controlling and can crowd out intrinsic motivation (Ryan & Deci, 2000). The field experiment showed that green IS targeting individual households can benefit from implementing other extrinsic motivators than monetary incentives. This is in accordance with latest findings emphasizing the opportunity of virtual rewards or badges to appeal to intrinsic motives that have shown to be more powerful predictors to engage in an activity, especially long-term (Hamari, 2015; Malone, 1981), and research investigating non-price incentives and energy conservation (Asensio & Delmas, 2015).

Contrasting established theory, the activity of participants did not increase with the height of financial incentives but with the height of virtual rewards (Heyman & Ariely, 2004). This is likely due to the different properties of the high and low virtual rewards in place. As low rewards simply signal progress and a level of achievement, high virtual rewards inherent a higher informational component and come from an official and trusted sender, both known factors in increasing intrinsic motivation and the participation in programs to reduce energy consumption in general (Deci et al., 1999; Hoicka et al., 2014). Thus, in the context of IS, established theory might not hold and needs to be adjusted. The outcome of a green IS targeting households (e.g., energy savings) has shown to depend on the active usage of the system over time. Intrinsic motives thus play an important role as they better predict long-term behaviors, than external incentives, which also in turn negatively affect intrinsic motives.

Financial incentives lead to a stronger decline in activity, compared to the decline of the control group. This points to the potential negative effect of financial incentives on intrinsic motives of the participants even though they were not removed during the time considered in the analysis. However, as bonus points could only be collected with reasonable delay, this delay might be sufficient for a crowding out effect.

Additionally, the activity of the participants on the portal showed to be associated with the change of participant's electricity consumption after signing up. The mean difference in electricity consumption that is described by activity is -2.19 %, which shows that active users have a higher reduction in energy consumption. For the field of green IS, this emphasizes the need for interventions targeting everyday behaviors and habits of single individuals to maximize interaction points with the system provided.

5.5.3 Limitations and Future Research

In the present study, the effect of monetary incentives on the activity of the participants is solely accountable in the heights under investigation. The incentive of 75 CHF (69 € or USD 75) was not sufficient to further increase activity compared to 25 CHF (23 € or USD 25), but higher incentives may be.

The design required an opt-in by participants: After being contacted, participants had to go on the web portal and sign up for participation. The response rate of users in our campaign was reasonably high, however a system with an opt-out design could obviously further increase the reach of the system (e.g., monetary bonus for energy savings). In this context, the alignment of incentives and particularly the type of incentives may, even to a larger degree than in an opt-in setting, influence user behavior, as people do not voluntarily choose to pursue the incentives.

Further research could investigate the effects of incentive type and size on constructs determining the adaption and continuous usage of technology, such as those reflected in the technology acceptance model (Venkatesh et al., 2003) and the internal and external perceived locus of causality (Wunderlich et al., 2013). This would allow for a deeper understanding of the processes elicited by different types and heights of incentives. Finally, the investigation of design-dimensions of the perceived value of incentives could allow practitioners to optimize incentive alignment for the purpose of the system.

6 General Discussion and Implications

Results add to existing work in the field of information systems, Green IS, behavioral economics, and offer insights for the successful design and implementation of energy conservation programs

This chapter provides a general discussion of the results obtained in this thesis. Following a recap of the background of this thesis in Section 6.1, Section 6.2 summarizes key findings and discusses implications for research and practice. Section 6.3 closes with the limitations of the present work and provides an outlook for future research.

6.1 Background of this Thesis

Climate change and technological trends lead to a transformation from centralized to decentralized power markets and significantly threatens existing business models of utility companies. In the residential market, however, disruption opens up new opportunities for utilities to grow as service partners. Utilities can (initially) position as a service provider in the energy efficiency market as it serves both, the purpose of fulfilling governmental regulations and concrete customer needs. In the field of energy efficiency, access to consumption data uniquely positions utility companies to offer meaningful services. Moreover, residential consumers can make a difference, as they account for around 25 % of primary energy consumption in western countries. In order to establish new services, utilities need to drastically transform existing customer interaction and build up customer knowledge. In this context, information systems (IS) provide a unique opportunity to capture multiple benefits with single applications to engage individuals. First, IS can effectively curb residential energy consumption at scale by closing the gap between reach and relevance of impactful instruments to stimulate energy savings. Second, IS can open a bidirectional flow of information to obtain relevant information and allowing for targeted interaction. Third, IS can aim to shape public perception of utilities as innovative and consumer-focused. The value of customer engagement around the topic of energy efficiency depends on the share of households participating, the optional value of engagement for utilities, and the capability to curb energy consumption. Thus, value is determined by different behaviors of single consumers: the initial willingness to voluntarily use the IS, the depth of interaction with the system over time, and the individual reduction in energy consumption. However, to date, research commonly focusses on the effectiveness of single instruments and associated design decisions. Therefore, an IS needs to capture all phases of the action process and maximize value at each stage.

Consumers do not always act to maximize moral and financial utility, as evident in the energy efficiency gap. Misperceptions, bounded rationality, and cognitive biases lead people to fail to live up to their own intentions. Thus, conventional solutions often lack effectiveness as they treat consumers as agents solely driven by an economic rational (Delmas et al., 2013). Various interventions could show that positive treatment effects depended on paying respect to the individual as driven by the complex interplay of intrinsic and extrinsic motives and situational constraints (see e.g., Abrahamse et al. (2005), for review). Even though first lab-based evidence points to detrimental effects of emphasizing positive pecuniary consequences of engaging in energy efficiency programs, practitioners usually appeal to this motive. However, evidence in the field, as well as an investigation of potential negative effects on outcome related variables, is missing. After initially joining programs, activity of users commonly shows a rapid decline. This decline seems to be negatively associated with energy savings and decreases the value for the utility as the system collects less information over time. Thus, mechanisms to enforce interaction with IS seem promising. In other domains, incentive mechanisms have shown to effectively motivate target behaviors and establish good habits (Gneezy et al., 2011). In the IS context, incentives can serve as extrinsic motivators to motivate goal-directed interaction. However, depending on incentive type (e.g., monetary vs. non-monetary) and height, interaction is framed differently and can potentially negatively affect intrinsic motivation.

In summary, the thesis contributes to existing research by a) designing an IS to maximize positive outcomes through focusing on motives at every stage of the decision process, b) empirically investigating the effectiveness of different motivational appeals to initially promote programs in the field, and c) an investigation of monetary and non-monetary incentives to motivate interaction with the system and contribute to positive outcomes.

6.2 Key Findings

This thesis further developed an IS that allows users to get personal assistance on how to save energy, enables utilities to engage with their residential customers, and implementation of large-scale field experiments in real-world settings. By means of strictly controlled marketing efforts, the IS motivated 3,980 users to participate. Data obtained gives insights to successfully promote related programs. Careful selection of appeals to market programs to curb residential energy consumption can increase voluntary participation by 78 %. By applying knowledge of whom the program appealed to (e.g., baseline consumption, zip code, etc.) the success of future marketing efforts can be further increased. Importantly, positive outcomes of programs (e.g., energy savings) show to be affected by initial marketing appeals. Emphasizing monetary motives showed to increase consumption by 3.7 % and 4.7 % compared to messages appealing to social normative concerns and solely providing information on past consumption, respectively. User activity can be increased by means of incentives implemented in a gamified approach. However, effects depend on the type and height of incentives. Using non-monetary incentives can be as effective as using monetary incentives. Though, non-monetary incentives do not come with any associated costs or detrimental effects on intrinsic motivations to use the system. Energy savings depend on the usage pattern of participants. Compared to households not contacted during the course of the project, users of the monitoring functionalities of the IS save a modest 1.22 % in their electricity consumption. Users of the engagement features of the IS did not show to significantly save energy. The present section discusses the key findings and implications of the dissertation.

IS promotion The field experiment in Chapter 4 showed that emphasizing monetary motives can drastically reduce actual participation rates in programs to curb residential energy consumption. Furthermore, monetary appeals lead to selection effects limiting potential savings for the group of participating households and even motivate an increase in consumption.

For the 20,000 mailings sent to motivate participation, sign-up rates strongly depended on what motives messages appeal to. Compared to appeals emphasizing social normative motives or solely providing information on past consumption not covering a generally altruistic purpose, monetary motives reduced sign-up rates by around 40 % with an overall rate of 8.3 %. The appeal to only provide information and giving the opportunity of altruistically contributing to environmental sustainability motivated 13.5 % of households to join. Adding a social normative message in form of a comparison of consumption to median consumption motivated 14.6 % of households. In line with other recent findings, results support the assumption that monetary motives diminish environmental motives without the reverse being true and, thus, overall willingness to participate (D. Schwartz et al., 2015). Therefore, attention to altruistic or environmental reason is malleable in contrast to attention to money, even though both are inseparable consequences of saving energy. Thus, to maximize participation in energy conservation programs, advertisement campaigns should avoid any information appealing to monetary motives as monetary motives presumably speak for themselves.

In the context of smart metering, programs giving individual feedback on energy consumption and personalized recommendations to conserve energy are increasingly offered by utility companies (Gangale et al., 2013). Results of the field experiment show that interest in these programs is higher amongst households' with higher energy consumption. This might be due to factors known to correlate with absolute consumption such as income, education level, and number of household members. Participation rates for high consumers further increase when adding social normative feedback as a motivational appeal. This is in line with findings showing the influence of social normative feedback on energy consumption (Allcott, 2011b). However, emphasizing monetary motives does not increase sign-ups amongst high consumers even though actual monetary benefits increase. Again, this can be due to the aforementioned demographic parameters that characterize high consumers.

Advertisements emphasizing monetary motives attract more households characterized by an efficient use of energy, compared to when social normative appeals are used. Concretely, households attracted by monetary appeals have a rather moderate electricity consumption relative to the households dwelling type, primary heating, warm water heating, number of electrical appliances, living space, and number of inhabitants. Effectively, this results in a lower potential for the actual program to cause effects. As overall participation rates for monetary appeals are lower, fewer energy inefficient households can be motivated by means of monetary savings. Effects are likely due to diminishing influences of monetary- on environmental motives that are probable to be less developed for households with a low energy efficiency. This is contrary to the widely spread assumption of practitioners to emphasize monetary savings in order to successfully motivate households that care less for the environment – with the converse being true.

As a consequence of emphasizing monetary benefits, consumers who enrolled for the advertised program increased their consumption by 3.7 % and 4.7 % compared to when appealing to social normative motives and solely providing information on past consumption, respectively. Thus, emphasizing monetary motives is a suitable means not to motivate conservation, but additional consumption. This is in line with other experimental findings showing harmful effects of emphasizing monetary savings (Asensio & Delmas, 2015; Delmas et al., 2013). Shifting the focus on monetary motives can result in neglecting prosocial aspects of behavior and crowd out image motivation (Gneezy et al., 2011). If saving energy is no longer perceived as a potential mean to contribute to society and do something *good* rational economic decisions are likely to determine behavior. As electricity prices are still considerable low, moderate increases in consumption can be handled by households. Ruling out image motivation likely enhances this effect, as it is an important driver for prosocial behavior. When individuals are prompted away from "doing something good" to "doing something well", image is no longer a concern as gaining less money from a certain behavior is likely not to be perceived as negative by others.

IS usage Bonus Points as an element of gamification can motivate an active usage of the IS. Effects, however, depend on type and height of the respective incentive. Results of the field experiment in Chapter 5 suggest that core motivation for continuous usage is intrinsic. Monetary incentives in the investigated height have moderate effects. Rather emphasizing achievements of users by using the system (e.g., badges with detailed feedback) can increase interaction with instruments to curb in-home energy use.

Perceived bonus height can be manipulated by means of implementation. For monetary incentives, this can be achieved by varying the amount in line with the economic rationale. For symbolic incentives, such as virtual badges perceived bonus height can be increased by tangibilizing the reward. In the present project this was achieved by generating printable "certificates".

Monetary incentives increase an active use of the IS. Especially in early phases of interaction incentives show a considerable efficacy. Compared to a control group, activity of users given a financial bonus was increased by around 17 %, $p < .01$. However, the increase in activity did not significantly differ compared to a group given tangibilized symbolic reward, $p > .1$. Surprisingly, the *high* monetary incentive under investigation did not increase activity compared to the low monetary incentive even though it was perceived as more valuable, $p > .6$. This can be explained by the observation that monetary incentives convey information. Higher monetary incentives implicitly signal more effortful tasks and can thereby undermine activity. Within the first six month of IS usage, activity of users shows a steep decrease over time, $p < .0001$. For users not incentivized by external rewards, the decrease in activity shows to be less steep as for users receiving a monetary incentive to use the IS, all p's $< .05$. For symbolic rewards, this effect is not found. This result is consistent with the overjustification effect in which users attribute their activity to monetary motives rather than intrinsic ones. User activity has an effect on their energy consumption. Users with a high activity have a higher reduction in energy consumption, $p = .08$. The mean difference in electricity consumption that is described by activity is -2.2 % and is thus rather small.

Generally, the IS motivates energy savings solely for users that are using the monitoring functionalities of the portal. This subgroup reduces electricity consumption by 1.22 % compared to a control group not contacted within the course of the implementation project, $p < .05$. Compared to first smart metering pilot projects these savings are in the lower bound. However, for households in Switzerland, electricity consumption only captures about 30 % of total primary energy consumption. As the most effective areas for households to curb consumption, water and space heating are to a large portion powered by fossil fuels. Furthermore, in the City of Zurich, about 90 % of households are tenants and, thus, have limited control over their appliance stock or weatherization measures.

Few actions to curb residential energy consumption (ACREs) realize a large share of the potential energy savings. The effectiveness of ACREs largely differs between single measures and the acceptance by the target population. The most effective ACREs aim to reduce energy used for space heating and warm water. However, most ACREs deal with small electric appliances. For small electric appliances most savings depend on investment decisions. Therefore, general selection mechanisms for the purchase process can realize most of the potential savings. Importantly, misperceptions by consumers can keep consumers from taking action in the most effective areas, foremost space heating. Thus, besides selecting the most relevant ACREs for consumers, information on the effectiveness of underestimated appliances seems promising.

To summarize, IS can benefit from implementing incentive systems as a means to increase user activity in a direction as intended by design. In the given context and height under investigation, monetary rewards did not show to be superior to symbolic rewards. As symbolic rewards do not come with any associated monetary costs and do not show to produce harmful effects on the intrinsic motivation of users they can be considered superior for the present purpose. Practitioners can further maximize effects of symbolic rewards by assessing their perceived value in the implementation process.

Data Set The architecture of smartsteps allows for a simple implementation of experimental designs by displaying different versions of the IS to the users of the respective experimental groups. User behavior is thereby measured in a real-world context. Users experience the portal as a service offered by their utility and not as a tool for research. Results are therefore high in external validity. Moreover, digital channels to the customers offer the opportunity to efficiently implement surveys. Most research in the field of energy conservation either pursues an approach driven by analysis of consumption as a behavioral outcome or on survey based research to identify psychological mechanisms explaining behavioral intentions the present system offers the opportunity to pursue both.

In the course of the implementation project a mailing was developed that motivates 14.6 % of households and up to 19.1 % of selected households (high consumers) to sign-up for the program. Despite the strictly limited marketing efforts, 3,980 users registered on the portal. Thus, the group of portal users represents a significant share of the overall population. Out of these groups of households, 70.8 %[23] enter detailed information on household characteristics with respect to in-home energy consumption and energy relevant behavior in order to receive consumption feedback. Combined with data available for all customers of a utility (e.g., address data and consumption information) the data obtained by the IS can serve as a ground truth. Based on the ground truth machine learning algorithms can infer both, individual household characteristics (e.g., heating type) and observed behavior (e.g., decision to join the program) for the whole population (Beckel, Sadamori, et al., 2014; Sodenkamp et al., 2015). Data can then support various purposes: 1) increase of the reach of energy conservation and retrofitting programs, 2) identification of the best available measures for individual households to effectively curb consumption, and 3) support of sales related targets for the utility.

To increase the reach of energy conservation programs the ground truth obtained by means of consumer behavior following the mailings sent during the course of the implementation project can identify probabilities for the response of single consumers not contacted during the course of the implementation project. Given a limited budget, marketing efforts can thereby dramatically increase program reach as the signup rates for selected households can more than double (Sodenkamp et al., 2015).

Energy conservation programs can benefit from identifying households with higher potentials to save and explicitly target those households. Furthermore, a priori identification of the best available concrete measures for single households and thereby allowing for

[23] For users responding to the second mailing after implementation usability improvements introduced in Section 3.4.3

individual tailoring programs can further increase effectiveness. Utility companies usually hold incomplete information to derive a households' energy efficiency, as consumption information is available, but relevant characteristics are missing. The data obtained to determine a households' energy efficiency can serve as a ground truth to estimate characteristics for the whole customer group of a utility. Features can be estimated with an accuracy over 70 % for relevant characteristics (Beckel, Sadamori, et al., 2014). Combined with individual consumption information characteristics enable determining efficiency levels for single households. Practitioners can tailor campaigns accordingly to maximize effectiveness (Abrahamse et al., 2005).

The dataset obtained by the IS can directly and indirectly support sales targets of a utility. The functions can be subsumed in increasing *customer readiness* for the utility, as introduced in Section 1.1.3. First, data obtained provide consistent customer level information on relevant household features for energy consumption. The information obtained can support product development and sales with segmentations based on customer level properties. Furthermore, the IS provides a direct channel to residential customers allowing for promotion of events and services. Direct channels can also be used as "test-labs" to promote innovations and evaluate customer response, as customer reactions, as well as e-mail open rates are reliably tracked. For the utility, the IS provides a new way to engage their residential customers. Ultimately, the IS aims to strengthen customer loyalty by increasing customer satisfaction and creating an offer that increases switching costs. Besides satisfaction, this introduces another important factor of *customer readiness*: customer advocacy. Given the strictly limited efforts to promote the portal, 10.6 % of the users registered on the portal were not contacted by means of any promotion. Thus, those users were advocated by peers.

In the near future, the system is planned to be deeper integrated into the processes of the implementation partner and available for future research. Furthermore, two more instances of the engagement portal that are based on the same architectural components and basic user experience are implemented in Germany allowing for future investigation of cross-cultural differences.

6.3 Limitations and Outlook

This thesis adds to the literature by developing and evaluating design principles for IS by utility companies to curb residential energy consumption at scale and increase customer readiness for the utility. The business environment was assessed based on current trends and disruptions of the European residential utility market. However, implementation was strongly affected by the current situation and strategy of the implementation partner ewz. Also, the given situation of technical infrastructure did not allow for an integration of smart meter data. Smart meter allow to automatically deliver feedback information for which users had to manually input meter readings in the present project. Results emphasize the importance of feedback information in order to curb residential energy consumption. Thus, an integration of technical infrastructure to automatically deliver feedback in the designed format is a promising approach and a concrete target to further develop the IS in cooperation with the implementation partner.

Furthermore, the system was implemented in the area of the City of Zurich, an area characterized by a high portion of tenants and a low absolute energy consumption due to relatively small living areas per household. Thus, validation of design guidelines and measures to curb a households' energy consumption is limited to the given context of implementation. The implementation of other instances in two different regions in Germany will allow for a validation of design principles and consideration of cultural influences.

Situational constraints such as current price for electricity, consumption levels in the city of Zurich, and the current media attention to energy relevant topics are likely to impact the decision to use the IS. The results obtained in Chapter 4 present the outcome of a promotional campaign with respect to the current situational constraints. Although difficult to empirically investigate in the field, practitioners would benefit from a clear understanding of the influence of important contextual events (e.g., the nuclear disaster in Fukushima) on participation rates in programs to curb residential energy consumption. Concretely, mechanisms to timely detect positive contextual factors could increase the reach of programs.

With respect to incentives in order to motivate system usage, a surprising finding of the field experiment in Chapter 5 was that the positive effects of the monetary incentive did not increase with the respective height. This finding should be evaluated more closely and with respect to the underlying psychological mechanisms. In general, detailed survey data on motivational precedents, capturing processes relevant for adoption and continuous usage of the system, can benefit the overall research approach. However, as evident in Chapter 5, only a fraction of about 10 % of users was willing to participate in surveys. This is due to the fact that participants used the IS as a real service provided by their utility.

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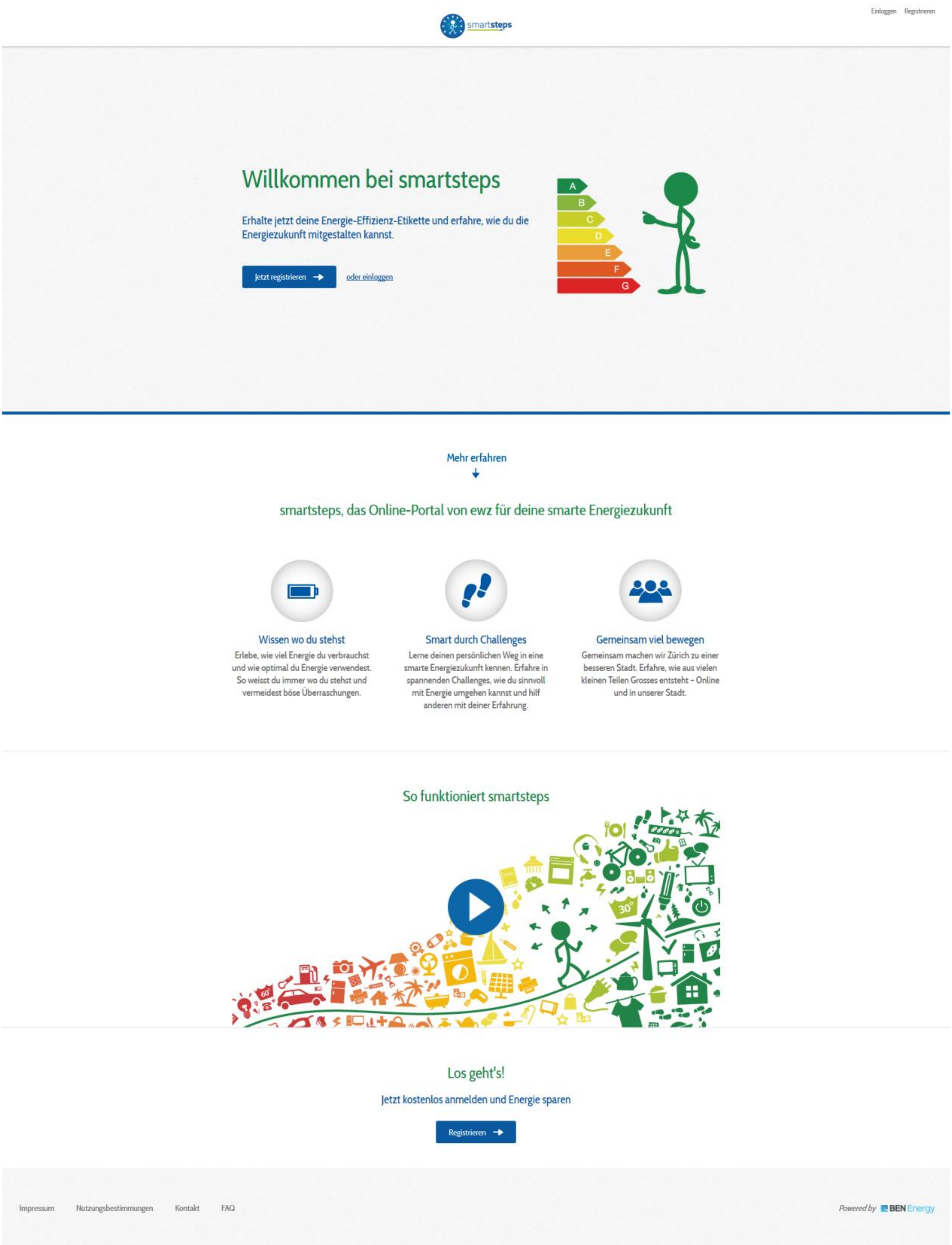
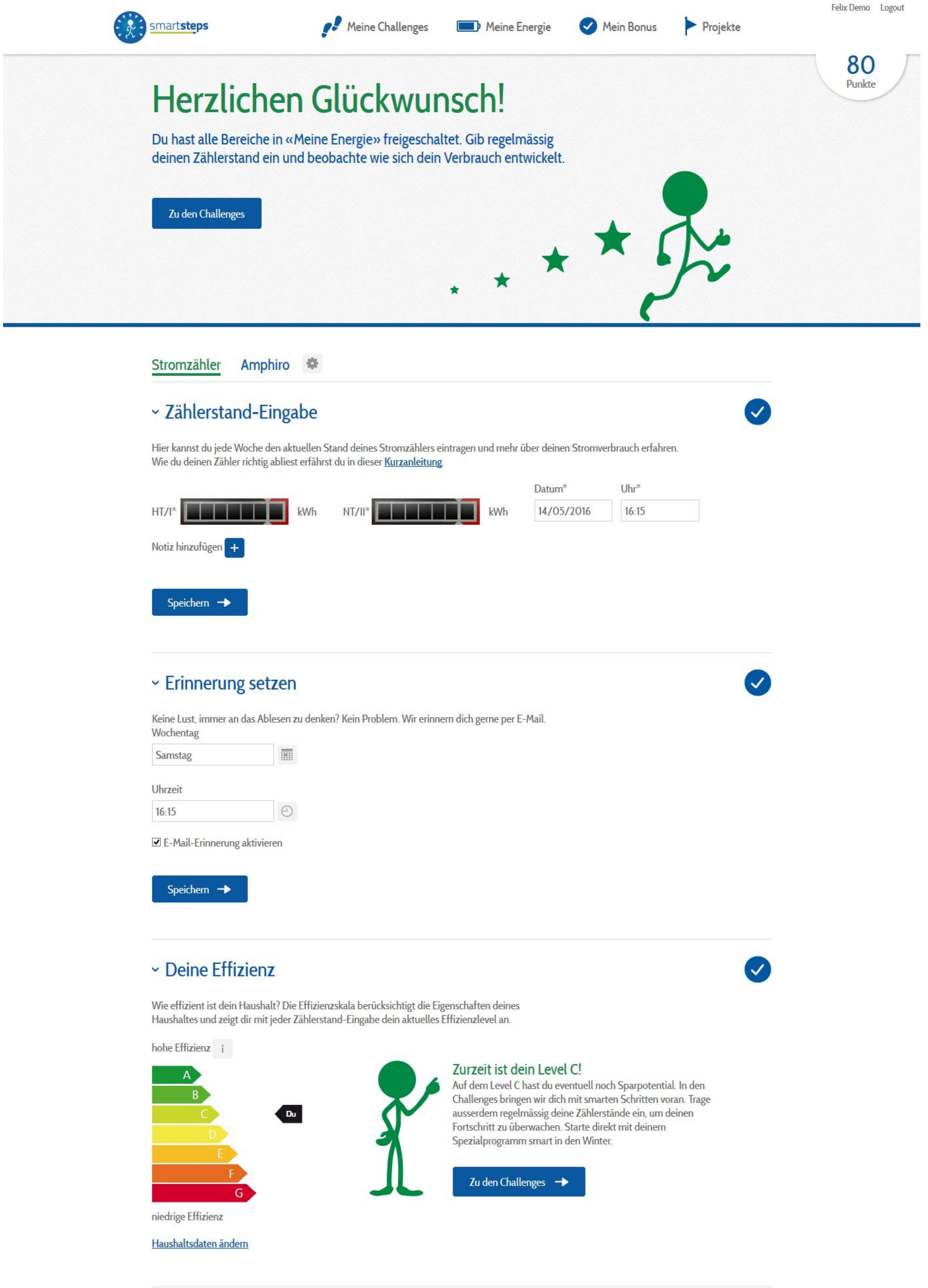
Appendix

I. APPENDIX smartsteps landing page



II. APPENDIX smartsteps My Energy page



Vergleich mit deinen Nachbarn

Dein wöchentlicher Stromverbrauch im Vergleich zu dem deiner Wohngegend.

Dein aktueller Verbrauch

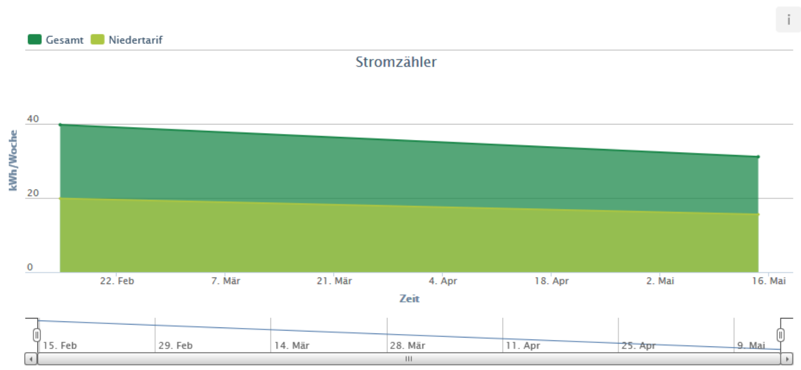
kWh/Woche

Adresse ändern

Durchschnitt in der Wohngegend

kWh/Woche

Historischer Verbrauch



Deine Zählerstandseingaben

Datum	Zeit	Stand HT	Stand NT	Gesamt	Woche Ø	Level	Notiz	
14.05.16	16:15	300,0	300,0	400,0	31,1 kWh	C		
14.02.16	16:13	100,0	100,0	176,0	39,7 kWh	C		
14.01.16	16:12	12,0	12,0	-	- kWh	-		

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Deinen Fortschritt beim Energiesparen kannst du mit wöchentlichen Zählerstandseingaben beobachten.
Wie einfach Energiesparen sein kann erfährst du im Bereich Meine Challenges.

Weiter zu den Challenges →

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III. APPENDIX

Longlist of energy saving advice as provided on smartsteps

#	Energiespar-massnahme	Verwendungs-zweck	Art der Ener	Max. Einsparu	*Portaleintrag*		
				kWh/ Jahr	Titel	Handlung	Rebound-Spezifikation
1	Abluft des Kühlschranks frei machen	Kühlen und Gefrieren	Eff.	60	Abluft vom Kühlschrank frei	Ich überprüfe, ob die Abluft des Kühlschranks frei entweichen kann und nicht versperrt ist.	
2	Abschalthilfen installieren	Elektronik	Invest.	400	Abschalthilfe kaufen	Ich kaufe eine Abschalthilfe (Steckerleiste / Stromsparmaus) um das Abschalten der Geräte mit Stand-By Verbrauch zu erleichtern.	
3	Auf das Vorheizen verzichten	Küche	Verh.	40	Backofen nicht Vorheizen	Will ich etwas im Ofen zubereiten, schiebe ich es direkt und ohne Vorheizen in den Ofen	
4	Auf den Raumluftbefeuchter verzichten	Heizen	Verh.	300	Keinen Luftbefeuchter	Wenn es mir in der Wohnung zu trocken ist, verzichte ich auf den elektrischen Luftbefeuchter und suche eine energielose Alternative.	.... Und wenn ich andere Feuchtigkeitsquellen habe, vergesse ich das Lüften nicht.
5	Auf den Tumbler verzichten	Waschen und Trocknen	Verh.	300	Feuchte Wäsche aufhängen	Wenn ich die Wäsche aus der Waschmaschine nehme, hänge ich die Wäsche draussen auf der Leine auf und verzichte auf maschinelles Trocknen. Kleine Mengen kann ich auch in der Wohnung trocknen, wenn ich kein ständiges Feuchtigkeitsproblem habe.	Wenn Du ganze Waschmaschinenladungen auf den Wäscheständer in Deiner Wohnung aufhängst, sei Dir des Risikos von Feuchteschäden oder Schimmelbefall bewusst. Als Mieter kannst Du für solche Schäden haftbar gemacht werden
6	Bei niedriger Temperatur duschen	Warmwasser	Verh.	400	Nicht so warm duschen	Wenn ich in der Dusche stehe und das Wasser aufdrehe, stelle ich die Temperatur niedriger ein als sonst.	
7	Bei niedrigeren Temperaturen waschen 30’C statt 40’C/60‘C	Waschen und Trocknen	Verh.	50	Mit niedrigen Temperaturen Waschen	Immer wenn ich das Waschmittel in die volle Maschine einfülle, wähle ich eine Temperaturstufe niedriger als auf der Wäsche angegeben.	Mit speziellen Waschmitteln kannst Du normal verschmutzte Wäsche sogar mit 20° sauber bekommen, dadurch sparst Du bis zu 60 Prozent des Stroms.

8	Beim Einseifen das Wasser abstellen	Warmwasser	Verh.	100	Seife drauf, Wasser aus	Immer wenn ich das Duschgel oder das Shampoo in die Hand nehme, stelle ich das Wasser in der Dusche ab. Trotzdem verlängere ich meine Duschzeit nicht.	
9	Lüftungsverhalten optimieren	Heizen	Verh.	1200	Richtig die Wohnung lüften	Nach dem Aufstehen, nach dem Heimkommen und vor dem Zubettgehen stelle ich die Heizkörper ab und lüfte danach meine Wohnung stoss.	Lüfte 3-4 Mal täglich kurz durch (ca. 5 Minuten). Dabei drehst Du die Thermostatventile, der in der Nähe stehenden Radiatoren zu und nach dem Lüften wieder auf die gewünschte Stufe auf. Fünf bis zehn Minuten vor dem Lüften müssen die Heizventile zurückgedreht werden.
10	Boiler auf 60° C stellen	Warmwasser	Eff.	360	Warmwasser auf maximal 60° C	Ich stelle meinen Boiler auf maximal 60° C!	
11	Duschsparbrause installieren	Warmwasser	Invest.	600	Sparsame Duschbrause kaufen	Ich installiere eine wassersparende und energiesparende Duschbrause!	... Und dusche dennoch nicht länger.
12	Fenster abdichten	Heizen	Eff.	800			
13	Freie Abluft für den Tumbler	Waschen und Trocknen	Eff.	50			
14	Gefrierfach abtauen	Kühlen und Gefrieren	Eff.	100	Gefrierfach abtauen	Ich taue meine Gefrierfächer ab, sobald sich übermässig Eis bildet (mehr als fingerbreite Eisschicht) und die Tür nicht mehr dicht schliesst.	
15	Geschirrspüler an Warmwasseranschluss	Küche	Eff.	125	Geschirrspüler an Warmwasseranschluss	Ich schliesse den neuen Geschirrspüler ans Warmwasser an.	Nur sinnvoll, wenn Dein Warmwasser nicht mit einem Durchlauferhitzer oder Boiler erwärmt wird. Am besten regenerative Quellen verwenden.
16	Hände mit kaltem Wasser waschen	Warmwasser	Verh.	230	Kaltes Wasser auf die Hände	Immer wenn ich mir die Hände wasche, seife ich sie mir vorher ein und stelle dann den Hahnen nur auf kaltes Wasser.	
17	Heizkörper auf Frostschutzmodus	Heizen	Eff.	200	Heizung in den Frostschutzmodus	Ich fahre/bin bald im Urlaub/abwesend. Vorher stelle ich die Heizkörper auf den Frostschutzmodus.	
18	Heizkörper entlüften/ Wasserstand kontrollieren	Heizen	Eff.	1000	Heizkörper entlüften/ Wasserstand kontrollieren	Ich entlüfte meine Heizkörper/ Ich kontrolliere den Wasserstand meiner Heizungsanlage	Wenn Dein Heizkörper unregelmässig warm ist oder gluckernde Geräusche macht, kannst Du den Heizkörper mit einem Spezialschlüssel entlüften bis nur noch Wasser herauskommt. Näheres im Handbuch oder bei Deinem Heizungsmonteur.

19	Heizungsrohre dämmen	Heizen	Invest.	1500	Heizungsrohre dämmen	Ich lasse ungedämmte Heizungs- und Warmwasserleitungen in unbeheizten Kellerräumen dämmen.	
20	Im Kühlschrank auftauen	Küche	Verh.	25	Im Kühlschrank auftauen	Hole ich Tiefkühlprodukte aus dem Gefrierfach, lege ich sie zum Auftauen direkt in den Kühlschrank.	Fleisch und Fisch muss nach dem Auftauen verarbeitet werden, sonst entstehen möglicherweise krankheitserregende Keime.
21	Im Sommer die Umwälzpumpe ausstellen	Heizen	Eff.	80	Im Sommer Umwälzpumpe aus	Ich schalte im Sommer die Umwälzpumpe aus, wenn laut Hersteller meiner Umwälzpumpe keine Probleme durch das Abschalten zu erwarten sind.	Setze Dir rechtzeitig eine Erinnerung, dass Du die Pumpe wieder anstellen musst.
22	Isolierpfanne nutzen	Küche	Verh.	130	Schneller kochen mit der Isolierpfanne!	Ich verwende zwei Wochen lang anstatt eines Kochtopfes je nach Aufgabe entweder den Dampfkochtopf oder die Isolierpfanne.	...und lass mich von der Grösse des Dampfkochtopfes nicht verwirren. Portionen wirken immer kleiner in grossen Pfannen.
23	Kaffeemaschine ausstellen	Küche	Verh.	100	Kaffeemaschine komplett ausschalten	Immer wenn ich mir Kaffee gemacht habe, schalte ich die Kaffeemaschine komplett aus und stelle den Milchbehälter in den Kühlschrank.	Mit einer Steckerleiste oder eine Stromsparmaus kannst Du einfach die Maschine ausstellen ohne lange immer den Schalter suchen zu müssen. Einige Maschinen bieten eine einstellbare Abschaltautomatik.
24	Keine warmen Speisen in den Kühlschrank	Kühlen und Gefrieren	Verh.	60	Nichts Warmes in den Kühlschrank	Habe ich noch etwas von meiner warmen Mahlzeit übrig, lasse ich diese zuerst auskühlen und stelle sie dann erst in den Kühlschrank.	
25	Kochwäsche bei 60° C	Waschen und Trocknen	Verh.	110	Niedrigere Temperaturen bei der Kochwäsche	Wenn ich das Waschmittel für meine Kochwäsche einfülle, wähle ich statt der 90° C die 60° C.	
26	Kühlschrank nur kurz öffnen	Kühlen und Gefrieren	Verh.	15	Erst überlegen, dann den Kühlschrank öffnen	Immer wenn ich vor dem Kühlschrank stehe und die Hand am Griff habe, überlege ich mir, was ich aus dem Kühlschrank nehmen möchte und öffne dann die Tür.	
27	Kürzer Duschen	Warmwasser	Verh.	570	Kürzer in die Dusche	Immer wenn ich unter der Dusche stehe und das Wasser aufdrehe, setze ich mir ein Zeitlimite von fünf Minuten.	... aber ich erhöhe nicht die Temperatur oder meine Duschhäufigkeit.
28	Licht konsequent ausschalten	Beleuchtung	Verh.	120	Durch die Tür und Licht aus	Gehe ich durch die Tür greife ich nach dem Lichtschalter, der neben der Tür ist und schalte das Licht hinter mir aus.	Du kannst im ganzen Haus Bewegungsmelder installieren, die automatisch das Licht ausschalten, wenn keine Aktivität mehr im Raum ist.

29	Lüftungsschlitze am Kühlschrank reinigen	Kühlen und Gefrieren	Eff.	30	Lüftungsschlitze reinigen	Ich putze die Lüftungsschlitze meines Einbaukühlschrankes.	
30	Luftzirkulation vor den Heizkörpern gewährleisten	Heizen	Eff.	800	Platz vor Heizkörpern schaffen	Ich stelle die Möbel vor Heizkörpern ein Stück weit weg, damit die Raumluft zirkulieren kann.	Wenn Du in einem Raum eine Bodenheizung hast, brauchst Du in dem Raum keine Möbel verrücken.
31	Mit Deckel kochen	Küche	Verh.	80	Jedes Mal den Deckel drauf!	Immer wenn ich die Pfanne zum Kochen hervorhole, greife ich gleich nach dem passenden Deckel zum Aufsetzen.	
32	Mit wenig Wasser kochen	Küche	Verh.	30	Nicht so viel Wasser beim Kochen verwenden	Immer wenn ich die Pfanne am Hahnen mit Wasser fülle, achte ich darauf, möglichst wenig Wasser einzufüllen.	
33	Modem abstellen	Elektronik	Verh.	100	Modem komplett ausstellen	Auf meinem Weg ins Bett oder aus dem Haus, schalte ich das Internetmodem immer ganz aus.	Mit einer Zeitschaltuhr kannst Du dies ganz einfach umsetzten. Auch eine Steckerleiste mit Schalter oder die Energiemaus vereinfacht das manuelle Abschalten durch einfach erreichbare Schalter.
34	Neue Kaffeemaschine	Küche	Invest.	100	Neue Kaffeemaschine kaufen.	Ich tausche meine ineffiziente Kaffeemaschine gegen eine energieeffiziente Kaffeemaschine aus.	..und entsorge die alte Kaffeemaschine im Entsorgungstram von ERZ oder auf einem Recyclinghof.
35	Neue LED Lampen installieren	Beleuchtung	Invest.	360	LED-Lampen installieren	Ich ersetze meine alten Glühbirnen und Halogenleuchtmittel durch LED-Lampen.	...und vergesse nicht, beim Verlassen des Raumes das Licht zu löschen.
36	Neue Umwälzpumpe	Heizen	Invest.	250	Neue Umwälzpumpe	Ich kaufe eine neue Umwälzpumpe	
37	Neue Waschmaschine	Waschen und Trocknen	Invest.	80	Neue Waschmaschine anschaffen	Ich ersetze meine ineffiziente Waschmaschine gegen eine neue A+++.	...und entsorge die alte fachgerecht im Recyclinghof oder im E-Tram von ERZ.
38	Neuen Kühlschrank anschaffen	Kühlen und Gefrieren	Invest.	170	Neuen Kühlschrank anschaffen	Ich tausche meinen ineffizienten Kühlschrank/Gefrierschrank gegen ein energieeffizientes Gerät aus.	...und entsorge mein altes Gerät fachgerecht beim Entsorgungstram von ERZ oder bei einem Recyclinghof. Für die Grösse Deines neuen Kühlschranks kannst Du Dich an folgende Richtwerte halten: Kühlschränke mit bis zu 140 Liter sind angemessen für 1-2 Personen-Haushalte. Kühlschränke mit 200-250 Liter sind für 3-4 Personen-Haushalte ideal.
39	Neuen Wärmepumpen-Tumbler	Waschen und Trocknen	Invest.	200	Neuen Wärmepumpen-Tumbler anschaffen	Ich kaufe einen neuen Wärmepumpen-Tumbler.	...und benütze diesen vorwiegend im Winter, da ich im Sommer die Wäsche draussen umsonst trocknen lassen kann.

40	Neuen Wärmepumpenboile r anschaffen	Warmwasser	Invest	2300	Neuen Wärmepumpenboi ler installieren	Ich installiere einen energieeffizienten Wärmepumpenboiler!	Den alten Elektroboiler entsorge ich beim Fachhändler oder am Recyclinghof. Ich lasse Bauteile gegen beheizte Räume dämmen (ansonsten wird diesen Räumen Wärme entzogen)! Bei ewz bekommst Du eine Vorgehensberatung.
41	Neuer Geschirrspüler	Küche	Invest	100	Neuen Geschirrspüler anschaffen	Ich kaufe einen effizienten Geschirrspüler.	...und entsorge mein altes Gerät fachgerecht beim Entsorgungstram von ERZ oder bei einem Recyclinghof.
42	Nicht baden, sondern duschen	Warmwasser	Verh.	400	Duschen statt Baden	Ich vermeide es zwei Wochen lang zu baden und dusche stattdessen!	
43	Nur volle Waschmaschinen starten	Waschen und Trocknen	Verh.	100	Nur volle Waschmaschinen starten	Nur wenn die Waschmaschine voll ist und die Überlastanzeige nicht leuchtet, drücke ich auf Start.	Du kannst die Beladungsanzeige nutzen, die einige Maschinen besitzten. Die Maschine nicht überladen und entsprechend der Wäschemenge das Waschmittel richtig dosieren.
44	Nur volle Geschirrspüler starten	Küche	Verh.	100	Nur volle Geschirrspüler starten	Ich nutze jeden Platz in der Geschirrspülmaschine aus, bevor ich das Sparprogramm starte.	
45	Programmierbare Thermostatventile installieren	Heizen	Invest	1300	Programmierbare Thermostatventile installieren	Ich installiere programmierbare Thermostatventile an die Heizkörper! Du kannst für jeden Raum die passende Temperatur einstellen. Ca. 18° im Schlafzimmer und in der Toilette, Ca. 21 ° im Wohnzimmer und in Aufenthaltsräumen, Ca. 22° im Kinderzimmer und Badezimmer.	..und achte darauf, nicht länger als notwendig zu lüften.
46	Raumtemperaturen effizient einstellen	Heizen	Eff.	3000	Auf die Raumtemperature n achten	Immer wenn ich nach Hause komme, überprüfe ich, ob meine Räume die richtige, energieeffiziente Temperatur haben.	Wir empfehlen Dir folgende Temperaturen: Ca. 18° im Schlafzimmer und in der Toilette, Ca. 21 ° im Wohnzimmer und in Aufenthaltsräumen, Ca. 22° im Kinderzimmer und Badezimmer, wenn Du diese Temperaturen getrennt einstellen kannst.
47	Restwärme der Herdplatte nutzen	Küche	Verh.	50	Restwärme nutzen	Immer wenn ich schon für das Essen eindecke, schalte ich die Herdplatten aus und nutze die Restwärme.	Bei Guss- und Keramikplatten kannst Du schon fünf Minuten vor dem Ende die Platte abstellen. Bei längerer Garzeit (über 30min) bereits zehn Minuten eher. Du kannst Dir hierfür auch einen Timer stellen.
48	Richtige Grösse der Herdplatte	Küche	Verh.	100	Topf und Herd immer gleich gross!	Bevor ich den Schalter für die Herdplatte umdrehe, schaue ich kurz, ob Platte und Pfanne zusammenpassen.	

49	Sonnenkollektoren installieren	Warmwasser	Invest	2800	Sonnenkollektore n installieren	Ich installiere Sonnenkollektoren und einen Warmwasserspeicher.	...nutze aber dennoch nicht mehr Warmwasser als nötig. Für einen ersten Ansatz kannst Du eine Vorgehensberatung bei ewz machen.
50	Durchflussbegrenze r installieren	Warmwasser	Invest	300	Sparaufsätze installieren.	Ich installiere an alten Armaturen Sparaufsätze auf den Wasserhähnen!	Für Wasserhähne, an denen Du regelmässig schnell grosse Mengen an Wasser entnimmst (bspw. im Garten), sind Sparaufsätze nicht geeignet. Ebenso wenig bei neuen Armaturen mit Effizienzlabel.
51	Sparprogramm Geschirrspüler	Küche	Verh.	80	Geschirrspülen mit Sparprogramm	Immer wenn ich den Geschirrspüler starten will, schalte ich das Sparprogramm ein.	Am besten spülst Du stark verschmutztes Geschirr mit kaltem Wasser vor - so wird garantiert alles sauber!
52	Stand-by vermeiden (daheim)	Elektronik	Verh.	200	Unterhaltungselek tronik komplett ausschalten.	Nachdem ich mit der Fernbedienung meine Unterhaltungselektronik auf Stand-by gestellt habe, trenne ich alle Geräte vom Stromnetz - am besten mit einer Steckerleiste.	Du kannst ganz einfach mehrere Geräte über eine Steckerleiste mit Schalter an und Ausschalten. Mit einer Energiemaus kannst Du mit einer Fernbedienung Geräte an oder abschalten.
53	Stand-by vermeiden (im Büro)	Elektronik	Verh.	200	Büroelektronik komplett ausschalten.	Ich schalte elektronische Geräte im Büro immer komplett aus.	
54	Stark dreckiges Geschirr kalt überspülen und dann im Sparprogramm waschen	Küche	Verh.	0	Verschmutztes Geschirr kurz per Hand abspülen	Komme ich mit stark verschmutzten Geschirr zurück in die Küche, spüle ich es kurz mit kaltem Wasser ab, bevor ich es in den Geschirrspüler stelle und das Sparprogramm laufen lasse.	
55	Temperatur des Gefrierfaches auf -18‘C	Kühlen und Gefrieren	Eff.	50	Tiefkühler auf -18° C stellen	Ich stelle die Temperatur bei meinem Tiefkühlgerät auf -18° Celsius.	
56	Temperatur des Kühlschranks auf 7‘C	Kühlen und Gefrieren	Eff.	40	Kühlschrank auf 7° C stellen	Ich stelle die Temperatur in meinem Kühlschrank auf 7° Celsius.	
57	Temperatur und Luftfeuchtigkeit überwachen	Heizen	Verh.	0	Raumtemperatur bestimmen	Ich bestimme die Raumtemperatur in allen Räumen.	Für das Messen kannst Du das Thermometer in die Mitte des Raumes stellen und ein wenig Zeit vergehen lassen.
58	Vorhänge und Storen wenn möglich schliessen	Heizen	Verh.	2000			

59	Vorwaschen der Wäsche weglassen	Waschen und Trocknen	Verh.	20	Vorwaschen der Wäsche weglassen.	Wenn ich die Waschmaschine anschalte, deaktiviere ich das Vorwaschen meiner Wäsche.	… und wasche danach auf einer niedrigen Temperatur.
60	Warmwasser an die Waschmaschine anschliessen	Waschen und Trocknen	Eff.	120	Waschmaschine ans Warmwasser anschliessen	Ich schliesse die Waschmaschine an die Warmwasserleitung an. Bei Fragen wende ich mich an ewz.	... Kaufe mir aber nicht vorzeitig ein neues Gerät, wenn mein altes bereits sehr effizient ist.
61	Wasser im Wasserkocher vorkochen	Küche	Verh.	60	Wasser im Wasserkocher aufkochen	Hole ich die Pfanne zum Kochen hervor, greife ich zum Aufkochen des Wassers anschliessend zum Wasserkocher.	
62	Wasserkocher mit Temperatureinstellu ng	Küche	Invest	10			

IV. APPENDIX

Assumptions and sources for the calculation of max. savings for the energy advice provided on smartsteps

#	Hinweise zu Einsparungen und Annahmen	Quelle
1	Durch Hitzestau ca. 6 % mehr Verbrauch pro 1°C mehr. Hier 3°C	(energieschweiz, 2014a)
2	Öffentliche Energieberatung Bern-Mittelland (2013) nennt 400 kWh	(Grazer Energie Agentur, 2011; Öffentliche Energieberatung Bern-Mittelland, 2013)
3		(energieschweiz, 2013a)
4	Jahresverbrauch des Gerätes	(energieschweiz, 2014a)
5	Annahme: 2/3 der Wäsche werden an der Luft anstatt im Tumbler getrocknet. Vorheriger Verbrauch Tumbler 450 kWh.	(Nipkow, 2013)
6	Ergebnisse angepasst auf 4 Personen	(Bundesministerium für Umwelt, 2014; Tiefenbeck et al., 2013)
7	Mittelwert aus den genannten Einspareffekten von 20-60 %	(Bundesministerium für Umwelt, 2014; CKW, 2012; energieschweiz, 2014a)
8	Annahme: 30s Pause bringen 0.2 kWh Einsparung. 500x im Jahr	(Tiefenbeck et al., 2013)
9	10 % Verluste beim Lüften. Annahme 2/3 kann vermieden werden	(energieschweiz, 2014b; Grazer Energie Agentur, 2011)
10	10 % Einspareffekt	(Bundesministeruium für Umwelt, 2013)
11	50 % Einspareffekt	(Bundesministeruium für Umwelt, 2013; energieschweiz, 2013a)
12		(Bundesministerium für Umwelt, 2014)
13	Annahme: Hitzestau wie bei ESM 1. 450 kWh Jahresverbrauch	
14	50 % Einspareffekt	(Grazer Energie Agentur, 2011)
15		(Grazer Energie Agentur, 2011)
16		(Bundesministeruium für Umwelt, 2013)
17	Annahme: Zwei Wochen im Winter	(energieschweiz, 2013a, 2014b)
18	10 % Einspareffekt	(Bundesministerium für Umwelt, 2014; Grazer Energie Agentur, 2011)
19		(Bundesministerium für Umwelt, 2014)
20	Annahme: 10 % Einspareffekt bei grosser Kühl-Gefrierkombination	(Grazer Energie Agentur, 2011)
21	Annahme: 20 % weniger Betriebsstunden bei 400 kWh/Jahr	(energieschweiz, 2013b, 2014b)
22	Mit 50 % Einsparung bei 260 kWh im Jahr für Kochen ohne Deckel	(Bürger, 2009; Nipkow, 2013)
23	50 % Einspareffekt	(Nipkow, 2013; TopTen International, 2012)
24		(Grazer Energie Agentur, 2011)
25		(Bundesministeruium für Umwelt, 2013; CKW, 2012)
26	Geschätzt: 5 % Einspareffekt	(Grazer Energie Agentur, 2011; TopTen International, 2014)

27		(Bundesministerium für Umwelt, 2014; Tiefenbeck et al., 2013)
28		(Bürger, 2009; energieschweiz, 2014a)
29	Annahme: Reduziert den Hitzestau (vgl. ESM 1) um 1.5°C	(Grazer Energie Agentur, 2011)
30		(Bundesministerium für Umwelt, 2014; energieschweiz, 2013a; Grazer Energie Agentur, 2011)
31	30 % Einspareffekt bzw. 30 CHF = 150 kWh (1 CHF = 5 kWh)	(CKW, 2012; Öffentliche Energieberatung Bern-Mittelland, 2013)
32	Annahme: 50 % weniger Wasser. Spart 0.1 kWh/l bei 5 die Woche	(energieschweiz, 2014a)
33		(Bundesministerium für Umwelt, 2014; Grazer Energie Agentur, 2011)
34	Differenz von Durschnitt zu Toprunner, Portionskaffeemaschinen	(TopTen International, 2014)
35	15 Lampen	(Bundesministerium für Umwelt, 2014; Bundesministeruium für Umwelt, 2013; CKW, 2012; Nipkow, 2013)
36	50 CHF Einsparpotenzial (1 CHF = 5 kWh)	(energieschweiz, 2013b; Öffentliche Energieberatung Bern-Mittelland, 2013)
37	Differenz von Durschnitt zu Toprunner	(TopTen International, 2014)
38	Differenz von Durschnitt zu Toprunner	(TopTen International, 2014)
39	Differenz von Durschnitt zu Toprunner	(TopTen International, 2014)
40	Differenz von Durschnitt zu Toprunner	(TopTen International, 2014)
41	Differenz von Durschnitt zu Toprunner	(TopTen International, 2014)
42	Mittelwert aus beiden Quellen für 5 Bäder / Woche	(Bundesministerium für Umwelt, 2014; CKW, 2012)
43	Annahme: Jedes Mal 50 % gefüllt	(CKW, 2012; Grazer Energie Agentur, 2011)
44		(Grazer Energie Agentur, 2011)
45	20 % Einspareffekt	(Bundesministerium für Umwelt, 2014; energieschweiz, 2013a)
46	Annahme: 3°C, pro Grad Celsius 6 % Einsparung. 2-3°C Reduktion	(energieschweiz, 2014b; Grazer Energie Agentur, 2011)
47		(Öffentliche Energieberatung Bern-Mittelland, 2013)
48	20-30 % Einspareffekt	(CKW, 2012; Grazer Energie Agentur, 2011; Öffentliche Energieberatung Bern-Mittelland, 2013)
49	30 % Einspareffekt	(Bundesministerium für Umwelt, 2014; Bundesministeruium für Umwelt, 2013)
50	Ohne Duschsparbrause	(Öffentliche Energieberatung Bern-Mittelland, 2013)
51		(Bundesministeruium für Umwelt, 2013; Grazer Energie Agentur, 2011)
52		(Bundesministeruium für Umwelt, 2013; Grazer Energie Agentur, 2011)
53	Auch unter keiner Annahme quantifizierbar	(Grazer Energie Agentur, 2011)
54	15 % Einspareffekt	(Grazer Energie Agentur, 2011)
55	15 % Einspareffekt bei 300 kWh Jahresverbrauch	(energieschweiz, 2014a; Grazer Energie Agentur, 2011)
56	Auch unter keiner Annahme quantifizierbar	(Grazer Energie Agentur, 2011)
57	15 % Einspareffekt	(energieschweiz, 2013a; Grazer Energie Agentur, 2011)
58	10-20 % Einspareffekt	(CKW, 2012; Grazer Energie Agentur, 2011)
59	30-50 % Einspareffekt	(CKW, 2012; Grazer Energie Agentur, 2011)
60		(CKW, 2012; Grazer Energie Agentur, 2011)
61	Annahme: Jeden tag 1.5l Wasser bei 85°C	
62	Annahme: Wie Heizkörper entlüften	

V. APPENDIX Mailing variants

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Zürich, 3. November 2014

Ihr persönliches Energie-Portal

[redacted]

Gerne möchten wir Ihnen zu Ihrem Stromverbrauch mehr Informationen liefern und **Sie beim Energiesparen unterstützen**. Wir haben auf **smart-steps.ch** für Sie Ihren Energieverbrauch berechnet und wie sich ein effizienter Umgang mit Energie für Sie lohnen kann:

Denken Sie an Ihre persönlichen Vorteile, wenn Sie Energie effizienter verwenden. Bei einer Reduktion des Verbrauchs um 10% könnten Sie jährlich rund 99 CHF* sparen.

Das Einsparpotenzial berücksichtigt jedoch nicht Ihre individuellen Wohngegebenheiten. Finden Sie auf **smart-steps.ch** in 30 Sekunden heraus, wie effizient Ihr Haushalt wirklich mit Strom umgeht. Erfahren Sie ausserdem **kostenlos**, wie Sie Ihren **Energieverbrauch einfach kontrollieren und senken** können und wie sich ein effizienter Umgang mit Energie so für Sie lohnen kann.

Auf der nächsten Seite erhalten Sie die **Zugangsdaten** für Ihr persönliches Energie-Portal.

* Als Berechnungsgrundlage für mögliche finanzielle Einsparungen wurden ein Durchschnittspreis von 19.22 Rp/kWh des Standardtarifs ewz.naturpower und Ihr Stromverbrauch im Jahr 2013 verwendet.

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Zürich, 3. November 2014

Ihr persönliches Energie-Portal

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Gerne möchten wir Ihnen zu Ihrem Stromverbrauch mehr Informationen liefern und **Sie beim Energiesparen unterstützen**. Wir haben auf **smart-steps.ch** für Sie Ihren Energieverbrauch berechnet und hier für Sie dargestellt:

Im Jahr 2013 hatten Sie einen Stromverbrauch von 1'120 kWh.

Die Höhe Ihres Verbrauchs zeigt Ihnen jedoch noch nicht **Ihr** Einsparpotenzial auf. Finden Sie auf **smart-steps.ch** in 30 Sekunden heraus, wie effizient Ihr Haushalt mit Strom umgeht. Erfahren Sie ausserdem **kostenlos**, wie Sie Ihren **Energieverbrauch einfach kontrollieren und senken** können.

Auf der nächsten Seite erhalten Sie die **Zugangsdaten** für Ihr persönliches Energie-Portal.

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Ihr persönliches Energie-Portal

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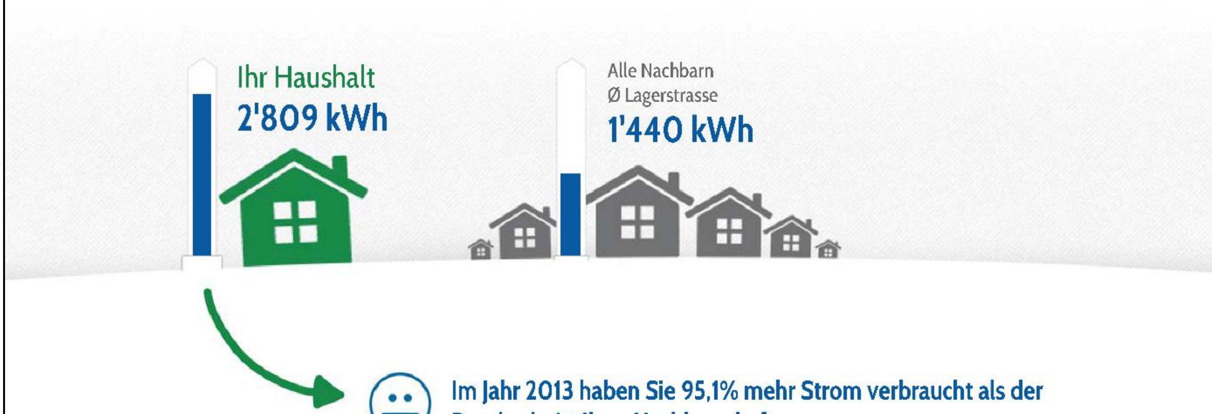
Gerne möchten wir Ihnen zu Ihrem Stromverbrauch mehr Informationen liefern und **Sie beim Energiesparen unterstützen**. Wir haben auf **smart-steps.ch** für Sie Ihren Energieverbrauch berechnet und mit Ihrer Nachbarschaft verglichen:



Im Jahr 2013 haben Sie 95,1% mehr Strom verbraucht als der Durchschnitt Ihrer Nachbarschaft.

Die Einordnung berücksichtigt jedoch nicht Ihre individuellen Wohngegebenheiten. Finden Sie auf **smart-steps.ch** in 30 Sekunden heraus, wie gut Ihr Haushalt wirklich mit Strom umgeht. Erfahren Sie ausserdem **kostenlos**, wie Sie Ihren **Energieverbrauch einfach kontrollieren und senken** können.

Auf der nächsten Seite erhalten Sie die **Zugangsdaten** für Ihr persönliches Energie-Portal.

smart-steps.ch ist das neue Online-Portal von ewz rund um den richtigen Umgang mit Energie. Im Rahmen der Energieforschung Stadt Zürich möchten wir neue Wege in eine smarte Energiezukunft finden. **Tragen auch Sie Ihren Teil dazu bei.** Registrieren Sie sich jetzt online.

Gehen Sie online auf www.smart-steps.ch

Geben Sie Ihren persönlichen Code [redacted] ein und melden Sie sich kostenlos an.

Mit Eingabe Ihrer Kundennummer [redacted] finden Sie heraus wie gut Ihr Haushalt wirklich ist.

Los geht's, wir wünschen Ihnen viel Spass!

smartsteps
Mit ewz in die Energiezukunft

Freundliche Grüsse

Romeo Deplazes
Leiter Markt und Kunden

Stéphanie Engels
Leiterin Nachhaltigkeit

ewz Die Energie

Ein Unternehmen der Stadt Zürich

ENERGIEFORSCHUNG STADT ZÜRICH
EIN ewz-BEITRAG ZUR 2000-WATT-GESELLSCHAFT

Curriculum Vitae

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