



Interim report dated 30 September 2020

Motivations for Investment in Smart Technologies and Energy Efficiency

The Case of Residential Buildings

	Option 1	Option 2
	Instandsetzung der Heizung 	Bezug von Ökostrom 
Kosten	20 CHF pro Monat	3 CHF pro Monat
Nutzen / Energieeinsparungen	30%	40%
Finanzierung	Ihr Vermieter	Energieversorger
Batteriespeicher	Ohne	Ohne

Ihre Wahl:

Option 1 Option 2 Keine der beiden

Source: ©MISTEE 2020



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TEP

Date: 30 September 2020

Location: Bern

Publisher:

Swiss Federal Office of Energy SFOE
Energy Research and Cleantech
CH-3003 Bern
www.bfe.admin.ch

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SFOE contract number: SI/501966-01

The authors bear the entire responsibility for the content of this report and for the conclusions drawn therefrom.



Zusammenfassung

Zusätzlich zu Innovationen und damit verbundenen neuen Geschäftsmodellen im Energiebereich kommt es möglicherweise zu einem Paradigmenwechsel der Haushalte bei Investitionen in Energieeffizienz von Gebäuden und intelligente Technologien. Wir argumentieren, dass dieser Wandel in der Schweizer Energiepolitik angemessen berücksichtigt werden muss. Verschiedene Investitionsmöglichkeiten, insbesondere in erneuerbare Energien, die sowohl Eigentümern als auch Mietern zur Verfügung stehen, führen zu weiterem Abstimmungsbedarf bei Investitionsentscheidungen. Neue Investitionsmöglichkeiten erfordern eine angepasste Politik, weshalb es notwendig ist, die individuellen Investitionsmotive und -barrieren zu verstehen. Deshalb schlagen wir zwei Mikrobefragungen vor, um die Entscheidungsmechanismen und Motivationen für Haushaltsinvestitionen sowohl für Gebäudeeigentümer als auch für Mieter von Wohngebäuden zu untersuchen. Insbesondere untersuchen wir die Auswirkungen verschiedener Interessensabwägungen auf das Investitionsverhalten mehrerer Haushaltsgruppen. Wir wenden eine ‚stated-preferences-Methode‘ auf eine Stichprobe von Haushalten einschliesslich der Mieter an. Darüber hinaus verwenden wir den ‚revealed-preferences-Ansatz‘ für eine Stichprobe von Eigentümern, die von bestehenden Subventionen profitierten.

Résumé

Parallèlement aux innovations énergétiques et aux modèles commerciaux associés, un changement de paradigme pourrait se produire au niveau de l'investissement des ménages dans l'efficacité énergétique des bâtiments et dans les technologies intelligentes. Nous considérons que ce changement doit être pris en compte de manière adéquate dans la politique énergétique suisse. Diverses possibilités d'investissement, en particulier dans les sources d'énergie renouvelables, sont désormais accessibles non seulement aux propriétaires mais également aux locataires. Les nouvelles possibilités d'investissement exigent des politiques adaptées, d'où la nécessité de comprendre les motivations et les obstacles individuels à l'investissement. Ainsi, nous proposons deux enquêtes au niveau individuels afin d'étudier les mécanismes de décision et les motivations à investir pour les propriétaires d'immeubles ainsi que pour les locataires de bâtiments résidentiels. En particulier, nous étudions l'impact de divers arbitrages sur le comportement d'investissement de plusieurs groupes de ménages. Nous appliquons une méthode de préférences déclarées à un échantillon de ménages comprenant des locataires et des propriétaires. De plus, nous utilisons l'approche des préférences révélées pour un échantillon de propriétaires ayant bénéficié de subventions existantes.

Summary

Along with energy innovations and related business models, there arises possibly a paradigm shift in households' investment in building energy efficiency and smart technologies. We argue that this shift needs to be adequately addressed in Switzerland's energy policy. Various investment opportunities especially in renewable energy sources, now available to both owners and tenants, bring about new trade-offs with previously available investment options. New investment opportunities call for adapted policies, hence a need for understanding individual investment motivations and barriers. Thus, we propose two micro-level surveys to study the decision mechanisms and motivations for household investments for building owners as well as tenants of residential buildings. In particular, we study the impact of various trade-offs on investment behaviour across several groups of households. We apply a stated-preferences method to a sample of households including tenants. Moreover, we use the revealed-preferences approach for a sample of owners that benefited from existing subsidies.



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Abbreviations

- CREST Competence Center for Research in Energy, Society and Transition
- DCE discrete choice experiment
- DSM demand side management
- EE energy-efficiency
- KEV Kostendeckende Einspeisevergütung
- LEN local electricity networks
- MISTEE Motivations for Investment in Smart Technologies and Energy Efficiency
- MuKE n Mustervorschriften der Kantone
- NEM net energy metering
- PV photovoltaics
- R&D Research and Development
- RES renewable energy sources
- RQ Research question
- SCC self-consumption collectives
- SCCER Swiss Competence Centers for Energy Research
- SFOE Swiss Federal Office of Energy
- SHEDS Swiss Household Energy Demand Survey
- ST smart technologies
- TEP Technology Economics Policy
- WTI willingness to invest
- WTP willingness to pay



1 Introduction

1.1 Background information and current situation

The advent of technological and business innovations might bring a paradigm shift in energy-related investments in residential buildings. The increasing availability of renewable solutions at relatively low cost provides building owners with low-investment alternative for otherwise often costly energy-efficiency (EE) investments, such as insulation of the building envelope. Investment in renewable energy sources (RES) is also subject to policy developments. Feed-in tariffs will be replaced by one-time upfront subsidies and net energy metering (NEM) possibilities offered by utilities. Moreover, community initiatives such as local electricity networks (LEN) and sharing business models could unleash a large pool of potential funds from owners and tenants, who benefit from the economies of scale.

These developments could appeal to an increasing number of 'prosumers', i.e. households who do not only consume but also produce their own energy. Yet, it is likely, as pointed out by Sioshansi (2017), that the majority of households will remain mere consumers, although there is a significant EE potential. This potential could be realized by investing in energy efficiency measures like retrofits, but also in optimization and storage devices. The latter investments could be especially appealing today, when smart technologies (ST) are improving and new possibilities for demand side management (DSM) come up. Such possibilities can be for instance dynamic pricing, sector coupling, own production, optimizing own-production and consumption, possibly with stationary batteries.

Whilst energy-efficiency and renewable energy investment possibilities are available to almost all households, constraints and incentives can vary for different groups. So far, literature had mostly a single focus, e.g. owners' willingness to invest in energy-efficiency retrofits (Banfi et al. 2012), building integrated photovoltaics (PV) (Hille et al. 2018), solar or flexible prosumers (Kubli et al. 2018a, b) or tenants' willingness to pay for a rent premium (Reichardt 2014; Farsi 2010). Petrovich et al. (2018) compared PV adoption as compared to energy-efficiency roof retrofits, thus considering two dimensions. In contrast, we propose a unique comprehensive decision framework with tailored investment opportunities. More so, we consider a broader decision scope encompassing EE and RES investments, as well as private investments and household expenses. This allows us to identify the motivations to invest for all households including tenants. Tenants are particularly relevant due to their high proportion among Swiss households. They play an important role for energy savings and RES potentials, which can be unleashed by designing adapted policy measures (e.g. Inderberg et al. 2018).

1.2 Purpose of the project

The investment decisions of both owners and tenants of residential buildings and the corresponding determinants are not sufficiently analyzed. Insights are of interest for researches, energy providers and very important for policymakers, especially in times of fundamental changes and when ambitious and important goals have to be fulfilled. Prosumer and consumer preferences might be induced by different motivations. Hence, they should be addressed by different policies. Therefore, policymakers have to be informed about the decision mechanisms and decisive factors of residents' EE and RES investment decisions and related trade-offs. We propose a comprehensive analysis with revealed- and stated-preference approaches to study these investment behaviors.

In particular, we focus on the impact of different policies like different forms of subsidies (up-front or annual), pricing (feed-in tariffs, net metering, CO₂-tax) and tax incentives. Effects of information nudges on investment decisions are also examined. We analyze the effectiveness of these instruments and the underlying motivations of individuals for various investments. We use econometric models that account for unobserved heterogeneity and latent categories of households.



1.3 Objectives

Both on the federal and on the cantonal level, Switzerland has been implementing several regulatory changes and energy policy measures of various forms to foster EE and RES investments. Examples are building retrofit subsidy programs (some hundred millions Swiss francs per year), tax incentives, and feed-in tariffs for RES (KEV fund). More recently and currently being introduced are the obligation to use at least 10% of renewable energy for heating and hot water in case of retrofits (also known as “Kleine Sanierungspflicht”) of the Energy related Model Code of the Cantons (MuKE), the possibility to create self-consumption collectives (SCC, “Eigenverbrauchsgemeinschaften”), the switch from feed-in tariffs to upfront subsidies or net electricity metering offers from utilities. Moreover, there are R&D initiatives, also supported by the SFOE, to bring down upfront investment costs, based on the working hypothesis that this would trigger a higher EE and RES investment rate.

Yet the impact of these approaches on building owners’ investment decisions remains unknown. Moreover, with respect to a massive scale-up, some of these measures might be adjusted in the future, for instance in terms of the concrete economic incentives. Last but not least some goals of the Swiss Energy Strategy are not yet endowed with policy instruments, or need regulatory adjustments, particularly regarding incentives to hourly load management and storage. Thus, more evidence about the responsiveness of building owners and about the sensitivity of the incentives of these instruments is required for the development of well-defined policy measures and their implementation.

While some policies address part of the ongoing developments, disruptive innovations that could boost prosumer behavior (Inderberg et al. 2018) are not sufficiently addressed. For instance, smart technologies (e.g. smart metering, optimization and storage) and business innovations (such as crowdfunding or collective self-consumption) allow tenants a range of investment possibilities. Or, as feed-in tariffs are being discontinued, to be economically viable, individual solar projects could join community or utility-scale solar projects in order to ensure a significant self-consumption share. These instances could present important policy opportunities for energy saving.

The main objective of this project is to identify motivations, barriers and the principal trade-offs in households’ EE investment decisions. We also aim at identifying the relative effectiveness of existing policies as well as new alternatives. We specifically aim at identifying the additive effects of material and psychological levers (crowding out) as well as “free-riding” behavior (infra-marginal consumers).

The project is about the various trade-offs impacting the household’s investment decisions across different population segments. We focus on trade-offs between EE and RE investments in buildings, between energy-related investments and other expenditure priorities and also between individual investment and collective actions. More, also aspects as crowdfunding or investment shares versus own upfront investments are examined. The working hypothesis is that households have a willingness to pay for attributes such as “from-my-backyard”, for instance if renewable energy is generated through SCC, roof-top-systems and LEN that provide higher convenience compared to own investments. More so, the relative effectiveness of various policy schemes as well as psychological levers on households’ investments should be analyzed, while considering the heterogeneity of responses in different groups.

Particularly the objective is to answer the following four research questions (RQ):

- RQ1 focuses on the effect of past regulation, subsidy programs and other instruments, which have been implemented since 2005, on the investment behaviour of building owners. The working hypothesis is that the annual retrofit rate / adoption probability should show a gradual change along with various promotion policies that varied over time and across Cantons. It is particularly interesting to examine the trend variations across cantons and to identify cantons that have shown declining renovation rates and to identify the main triggering factors and whether new instruments, technological options, and heating systems changed the envelope retrofit investment behaviour.



- RQ2 is on experience and complexity effects the owners' investment behaviour as well as the moderating effect of upfront costs and stringent policy rules in the trade-offs between EE and RES investments as well other investments.
- RQ3 is regarding the various trade-offs impacting the household's investment decisions (both tenants and owners) across different population segments. We focus on two main trade-offs: between EE and RE investments in buildings, and between individual investment and collective actions,
- RQ4 focuses on the relative effectiveness of various policy schemes as well as psychological levers on households' investments, while considering the heterogeneity of responses in different groups. This includes various moderating effects such as income, risk attitude and environmental concerns.

2 Description of facility

The choice experiment (see section 3 below) will be integrated in the Swiss Household Energy Demand Survey (SHEDS), an online survey designed and implemented by researchers from SCCER CREST. It is fielded in collaboration with the survey company Intervista, mandated to conduct the sampling; namely, contacting potential respondents and offering them an incentive (bonus points) for answering the survey. Respondents are invited until a sample size of 5,000 is reached every year. Only respondents who report being involved (at least partly) in their household's expenses qualify for the survey. The final sample is constructed to be representative of the Swiss population (excluding Ticino) according to the following pre-selected characteristics and quotas:

- Age: 18-34 = 30%, 35-54 = 40%, 55+ = 30%;
- Gender: male = 49%, female = 51%;
- Region: French-speaking = 25%, German-speaking = 75%;
- Living situation: tenants = 62.5%, owners = 37.5%.

SHEDS is designed as a series of modules: core modules intended to collect longitudinal data, as well as additional modules dedicated to one-time experiments. The core modules represent a major part of the survey (more than two thirds of the survey). The questions therein are based on the multidisciplinary framework developed by the research group (Burger et al., 2015), and are drawn from the established and cutting-edge research literature of their respective fields. The core modules are dedicated to eliciting energy-related, psychological, social context, and socio-economic information. The energy-related modules collect information about equipment and usage in three energy domains: electricity, heating, and mobility.

Most of the core modules are repeated in every wave of SHEDS and for all respondents, in order to collect information from the same individuals and concerning identical topics over time (e.g., annual energy expenditures). Time-invariant characteristics, however, are naturally collected only once for each respondent, at the time of first entrance in SHEDS (e.g., gender). In addition, regarding elements which are unlikely to change on a yearly basis (e.g., cars or living situation), respondents are only asked to answer again if they experienced changes compared to what they stated in the previous wave. Finally, some of the core modules are rotated in further waves of the survey and are asked on a less frequent basis (every 2-3 years or during the first and last planned wave of the survey) since they do not need to be collected on a yearly basis due to their relatively stable nature (e.g., values). The duration of core modules is thus shorter for the returning respondents, freeing up valuable survey time which can be dedicated to additional modules.

Next to core modules, each wave (except the first) of SHEDS encompasses a series of additional modules in which various types of choice experiments are implemented. Only returning respondents are



eligible for the additional modules, and each respondent is randomly allocated to only one of the choice experiments. Total survey duration is intended to be similar (25-30 minutes) for new and returning respondents. The discrete choice experiment designed in MISTEE is part of the additional core modules in wave 2020 of SHEDS.

3 Procedures and methodology

A discrete choice experiment (DCE) is implemented to extend the analysis to all the households including tenants as well as owners. The scope of this analysis is limited to buildings and dwellings occupied by the respondents. Our main objective is to understand energy-related investment decisions, corresponding trade-offs, as well as the relative effectiveness of various policy schemes and additive effects like crowding-out of material and psychological levers in form of information nudges in each hypothesis. Obviously, the choice tasks are tailored to the population segment, since investment possibilities differ for owners and tenants, detached and semi-detached buildings, new and old buildings.

To examine all trade-offs and influential factors, heterogeneity in preferences and motivations across different population segments is allowed. In particular, different clusters of households with different propensities for energy investments will be identified. Basis is a bounded-rationality framework, in which the investment decisions are impacted by costs, benefits and involve technological and financial risks, but also environmental attitudes and emotional factors. The research design and the adopted econometric framework will allow quantifying a variety of moderating effects on investment behavior.

The analysis considers determinants such as income, risk attitudes and environmental concerns. Multiple treatment groups are also created in order to identify the effects of various policy or information treatments on investment behavior: CO₂-tax increase, CO₂-cap information nudges, subsidies, and electricity tariff system. This allows us to identify the crowding-out and as well as free-riding behavior. Our focus will be on willingness to invest (WTI) in solar systems and smart technologies like optimization and storage devices. In particular, the focus lies on three aspects: (1) How does the WTI in solar systems change under each policy scheme, in particular with SCC and with NEM? (2) Which schemes are appropriate to incentivize storage devices (with or without RES)? And (3) How does the WTI in grid-service devices (e.g. DSM of appliances, local batteries) differ between (i) an abstract tariff system (such as time of use tariffs or utility controls of appliances or batteries) and (ii) optimizing self-consumption of self-produced electricity? We will address these research questions with several data sets. Whenever possible, we will make use of a triangulation approach to assess the robustness of results across various methods and available data.

Data connection on an individual level allows for combining a revealed and stated preference approach to “anchor” the evidence from the stated preferences. We follow Fehr et al. (2003) to combine experimental preference elicitation methods with revealed preferences. Our experimental approach also extends on Oberst and Madlener (2015) who studied prosumer preferences in Germany. The experiment design is tailored to the respondents and will be complemented by follow-up questions about the importance of various attributes in the adopted decisions.

4 Activities and results

In the first year of the project, the choice experiment has been designed and refined over some weeks and implemented as an additional module in wave 2020 of SHEDS. The survey was distributed to a sub-sample of SHEDS in May-June 2020 and to a sample of SFH owners in selected Cantons.

Data collection was successful despite unusual complications related to the outbreak of the recent Covid-19 pandemic.



The descriptive analyses of the DCE data already conducted indicate that respondents faced various trade-offs, as intended, when it comes to selecting investment and spending options. There seems to be a tendency towards in favor of renewable energy options (as compared to energy-efficiency), both for owners and tenants.

Preliminary findings indicate that the initial assumptions and the research questions are adequate and that there are different levels which play a role in the decision process of respondents. Further sophisticated econometric analyses have to be carried out to confirm the preliminary findings and investigate additional hypotheses, which will allow answering the research questions.

Moreover, descriptive analyses were conducted to elicit annual rates of retrofits of different building elements (windows, façade, roof, basement ceiling). Preliminary results indicate that retrofit rates of opaque elements in most Cantons and building types are about one percent per year and those of window somewhat higher. There are some indications that retrofit rates in some Cantons are higher than in others. (see Jakob et al. 2020 for details). Underlying reasons for such differences need to be identified by adopting more sophisticated econometric methods.

5 Evaluation of results to date

Up to this point, the research project is running as expected. Despite the difficult situation caused by COVID-19, implementation of the DCE and data collection were successfully conducted, with only a minor delay compared to original plans. The data set is larger than anticipated and will allow robust analyses. The descriptive analysis indicates that the DCE was meaningfully drafted, in the sense that respondents were actually forced to face multiple trade-offs when making their (hypothetical) investment decisions. These results still have to be confirmed by more sophisticated econometric approaches. The results of such analyses will allow us to answer all the research questions. Based on our findings, we expect that it will be possible to formulate important policy implications.

6 Next steps

The econometric analyses of the DCE will be implemented during the next few months. These will serve as the basis for two working papers (one focusing on owners and one focusing on tenants), which are part of the dissertation of the PhD student. The two papers will be available in 2021.

The preparation of a second discrete choice experiment, which will be conducted in 2021, will start in October 2020. This DCE's objective is to determine the effect of past regulation, subsidy programs and other instruments, which have been implemented since 2005, on the investment behavior of building owners. To this end, it will focus on owners of buildings with and without PV installations, and among owners with PV we will also distinguish between those who benefitted of subsidies for their installations and those who did not. We have already been in contact with Intervista regarding this DCE, and they can guarantee a sample matching these characteristics. The choice experiment will be implemented before summer 2021, so that data can be collected before school holidays, while the analysis and the corresponding paper should follow at the end of 2021 and beginning of 2022.

7 National and international cooperation

The MISTEE choice experiment was undertaken as a part of the Swiss Household Energy Demand Survey (SHEDS) which is the result of an intensive national cooperation. Moreover, the MISTEE project was implemented in close collaboration with the project "Kantonale Energiekennzahlen und



CO₂-Emissionen im Gebäudebereich – Zwischenbericht” which allowed to increase the sample size for the DCE and to elicit energy retrofit rates.

8 Communication

In the first year of the project no dedicated communication activities have been conducted except for:

- internal communication within the project «Kantonale Energiekennzahlen und CO₂-Emissionen im Gebäudebereich»
- communication with energy utilities to raise their interest in participating in the next phase of the project MISTEE

9 Publications

Publications will be made in the beginning of 2021, as soon as the data is analyzed and implications are derived. The writing process will start soon.

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