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Analysis of investment decisions based on homeowners' stated preferences: Policy measures, smart technologies and financing options

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Abstract

Various energy investments are possible in residential buildings. Owners' opportunities are moreover extending with smart technologies and optimisation options, as well as with the rise of collective investment projects. In this context, we investigate owners' investment decisions by conducting a discrete choice experiment that includes all these elements. Our experiment allows evaluating the willingness-to-pay (WTP) for investing in energy efficiency and for purchasing renewable energy. The effect of several energy policies is also investigated using treatment information messages displayed to randomly selected respondents. The results based on our sample of 1,451 Swiss homeowners suggest that WTP for energy investments is positive but marginally decreasing, so that it may be insufficient for very sophisticated and expensive investments. A general paradigm shift is not evident from our results, as the respondents prefer investing alone rather than collectively. Also, load management and storage appear to be valued only in combination but not separately. Amongst all policies, only for a binding CO_2 cap per square meter of the accommodation a significant effect can be detected.

JEL Classification: D12, L94, Q41.

Keywords: Energy efficiency, Renewable energy, Choice experiment, Conditional logit models.

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1 Introduction

Residential energy investments play an important role in the transition towards more sustainable energy consumption (Burger et al., 2019; Gerarden et al., 2017). An increasing array of energy investments can be implemented to conserve energy or to produce renewable energy, thereby reducing the environmental burden of buildings (Kasperson and Ram, 2013). Lately, new opportunities emerged. Efficiency can be increased by batteries or external optimization. Collective investment projects open up uncomplicated and inexpensive ways to profit from energy investments (Moret and Pinson, 2018; Bonzanini et al., 2016). Purchasing renewable energy from utilities can also contribute to more sustainable energy usage (Tabi et al., 2014)[1]. These developments can lead to a paradigm shift in energy investments. This, together with the still low investment rates in residential buildings, may make it necessary to adapt policies in order to achieve environmental goals (Inderberg et al., 2018; Hertig and Teufel, 2016).

Anyhow, there is still uncertainty with respect to motivations, barriers and trade-offs affecting energy investments for residential buildings. A comprehensive picture is lacking (Inderberg et al., 2018; Heiskanen and Matschoss, 2017). Most studies focus on certain kind of investments or aspects. But since different investments can be expedient and various aspects can have an influence, not only economic feasibility, and also other decisions play a role, (Golove and Eto, 1996; Geller and Attali, 2005) we want to gain a more profound understanding of the decision-making process. Therefore, we examine the importance of investment specific aspects for a wide range of energy investments. In this context, we take into account recent developments in the relevant technologies and investment opportunities. We also aim to find out whether decision-making depends on investment-specific aspects, or whether there are clear preferences and aversions. In addition, we examine the effect that developing opportunities in this area have on investment decisions. Due to the changing opportunities and untapped investment potential despite

[1]Even though such purchasing options are not really investments, we will for convenience refer to the whole range of energy-related investment and purchasing options as “energy investments” in the remainder of the paper

the availability of promoting policies, we also investigate the influence of different policies on investment decisions. Finally, we calculate the willingness-to-pay (WTP) or invest (WTI)[2] and draw policy implications from our findings.

Therefore, we conducted a discrete choice experiment (DCE), in which 1,451 Swiss homeowners chose between different energy investments and alternatives. All investment options are characterised by a number of attributes. Furthermore, we introduce policy treatments after the first two choice tasks to see how this affects decision-making. As a result, our experiment comes with between and within variation (see Charness et al., 2012). Conditional logit models are used for the econometric analysis.

The analysis shows that homeowners appreciate energy investments, and we find indications for a prosumer tendency. Purchasing renewable energy is regularly chosen. We find a positive but diminishing willingness-to-invest and willingness-to-pay for energy investments. Despite potential advantages of collective investments, respondents show an aversion to such projects and prefer to make their own investments in the residential building. Batteries for storing renewable energy show no significant effect, whereas load-management has a negative effect on selection probability. As the negative WTP for this attribute shows, respondents would demand compensation for loss of control. Only the combination of storage and load-management shows a positive effect, which can be explained by the fact that the advantages of both optimisations can be combined in this way. Among treatments, SFH owners show a response to a strict CO_2 cap per square metre of living space, whereas flat owners respond to increased CO_2 taxes. Yet, the effects are not strong and further research may be required to provide further evidence and draw policy conclusions.

Our findings add to the existing literature because most studies focus on specific investment types or influential factors. Banfi et al. (2012) focus on energy-efficiency retrofits,

[2] In this paper, we talk about WTI if it is a real investment in the truest sense of the word (as for instance, insulation or PV). WTP is used for the purchasing options (buying renewable heat or electricity). This is done to clarify that these are different types of expenses. However, there is often no such differentiation in the literature, also because most studies do not consider such a wide range of both energy investments and purchasing options. This is why the literature usually refers only to WTP, even when referring to investments. WTP in these cases is equivalent to WTI in our paper.

Hille et al. (2018) examine PV adoption and Lang et al. (2021) investigate switching behaviour from conventional to renewable heating systems. Yet, more comprehensive studies are rare. One exception is presented by Ameli and Brandt (2015) who consider a wide range of potential investment options. Whilst their study focuses on effects of personal characteristics on investment decisions, our paper goes in another direction by not only investigating the effect of characteristics but primarily analysing the effects of investment-specific attributes. Furthermore, we consider an even wider range of potential investments and disruptive innovations, which bear potential to lead to a paradigm shift.

This paper is structured as follows. Section 2 reviews the relevant literature, and Section 3 describes the methodology and the experiment. Section 4 explains the econometric analysis, and Section 5 presents the results. Section 6 concludes and discusses policy implications.

2 Literature review

Discrete choice experiments have already used to analyse energy investment behaviour. For instance, Scarpa and Willis (2010) focus on residential renewable energy production and use both conditional and mixed logit models to calculate the households' WTP for different renewable energy production installations. They find a positive WTP for micro-generation technologies like PV or heat pumps. Yet, for most households, this WTP is insufficient to cover realistic installation expenses.

Similar studies estimate the WTP for energy efficiency measures in residential buildings. Banfi et al. (2008) find a positive WTP for energy-efficiency measures such as insulation on residential buildings in Switzerland. They find that residents value not only the efficiency gains and environmental benefits, but also increased comfort. Lang et al. (2021) conduct a discrete choice experiment focused on heating-related investment decisions. Their findings show a positive WTP for renewable heating systems, even though the respective WTP is for some groups insufficiently high to induce switches towards such heating systems.

The WTP to purchase sustainable energy (without investing in the installation) is a related topic that has been examined, for instance, by Borchers et al. (2007) who conduct a choice experiment to analyse consumer preferences regarding renewable electricity from different sources. Their analysis indicates that solar energy is particularly valued. Furthermore, they find a willingness to pay a premium for such green electricity. Hansla et al. (2008) conduct a survey in Sweden and therein consumers state their willingness to purchase renewable electricity. The respective WTP depends on factors like electricity prices and environmental attitudes.

Few studies have taken into account a wide range of potential energy investments, rather than only specific energy efficiency or renewable energy options. One exception is Ameli and Brandt (2015) who consider a wide range of energy investments. They find that ownership, income and environmental attitude affect energy investment decisions. Yet, their analysis concentrates only on effects of personal characteristics on investment behaviour. Because this does not answer which investment specific attributes affect choices and how, we go one step further by conducting a discrete choice experiment to close this research gap, also taking into account recent innovations, not only from a technological but also from a business side. Thereby, we get the current image of what affects homeowners' energy investment decisions and their respective WTI and WTP.

3 Method and data collection

In order to investigate energy investment decisions in the current context where owners' opportunities are extending, we design a discrete choice experiment (DCE) that encompasses a number of energy investments and also non-energy-related alternatives to be able to identify preferences and trade-offs.

Compared to revealed preferences, the stated preference approach offers the opportunity to investigate behaviour of owners who have not invested so far. This is a decisive aspect, since non-investors precisely constitute the group that should be targeted in priority by policy measures in order to achieve climate goals.[3]

3.1 Discrete choice experiment

Choice behaviour in DCEs gives an indication about personal preferences. It can be assumed that respondents choose their favoured option from the available alternatives, taking into account the respective attributes and corresponding level in their decision (Bessette and Arvai, 2018). As a result, choices illustrate the decision-making process and give indications about preferences and trade-offs. These can be identified by analysing selection behaviour of multiple choice tasks (Chau et al., 2010).

Our approach is based on the random utility theory (McFadden, 1974). Respondents are assumed to maximise their utility by choosing the most beneficial option for themselves (Louviere et al., 2010). The respondents' utility depends on different observable and unobservable attributes of the offered choice set (Alriksson and Öberg, 2008). Because several attributes can influence the respondent's choice, they can face trade-offs not only between alternatives but also the corresponding attributes.

DCEs with realistic options allow getting a better understanding of homeowners' diverse preferences (Rudolf et al., 2014). By not only considering certain energy investments but also different attributes and levels, it is possible to get a more precise and comprehensive picture (Bessette and Arvai, 2018; Bidwell, 2013).

[3] A criticism addressed to stated preference approaches is that they might not reflect actual behaviour. To mitigate that risk, we mentioned to respondents that our research project was relevant for shaping future policies and therefore highlighted the importance for themselves to answer in accordance with their true preferences, and we therefore expect the stated answers to represent the real preferences of the participants (Vossler et al., 2012; Newell and Siikamäki, 2014). Moreover, each respondent is exposed to a number of choice tasks, which makes it possible to elicit preferences based on trade-offs. WTIs and WTPs are based on such trade-offs, not on simple numbers stated by the respondents.

Our experiment has both within and between variation (see Charness et al., 2012). Within variation is created by including two blocks of choice tasks with a treatment in between these blocks. Between variation exists because participants are allocated in the control and seven treatment groups. Furthermore, they receive tailored investment options based upon their accommodation to ensure that only relevant alternatives are considered, and the results are not biased. A similar approach is chosen by Lang et al. (2021) in the context of heating investments. More so, within variation approaches are applied by other researchers like Allcott and Knittel (2019); Allcott and Taubinsky (2015)[4]

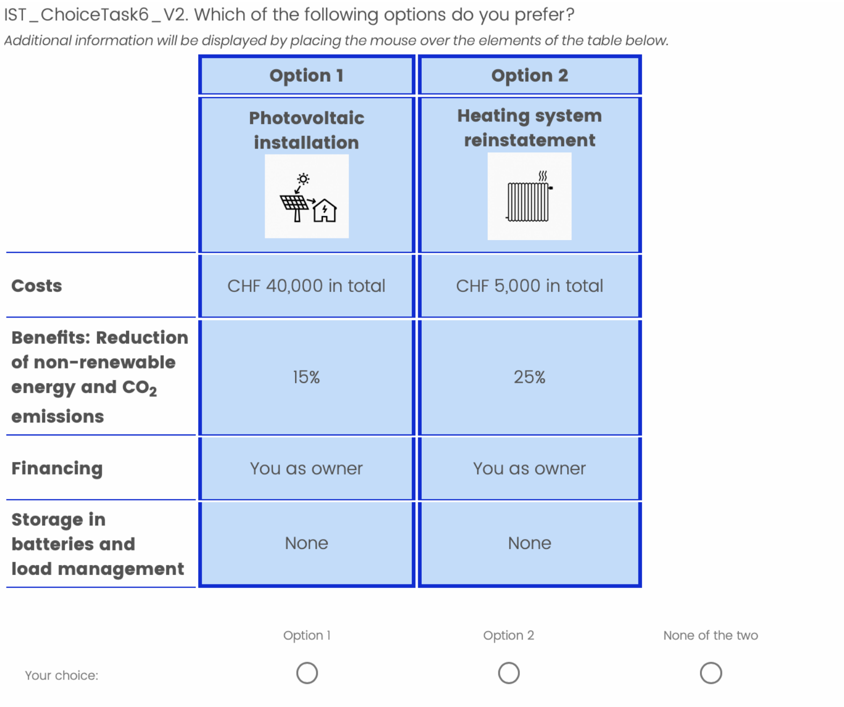
3.2 Set-up

Before the actual choice experiment starts, respondents receive further information and are asked to answer questions regarding their housing situation for an efficient selection of relevant investment options. Participants are requested to choose according to their preferences, taking costs and their financial limits into consideration to receive meaningful results (see Johnston et al., 2017).[5]

[4]Within experiment treatment can lead to spurious results as people may act accordingly with what they think is expected from them (Charness et al., 2012). This may be especially relevant if the participants are told about the necessity and benefits of energy investments. We acknowledge this issue and tried to limit the effect by applying methods for truthful revelation according to their preferences.

[5]The specific wording of the budget reminder was: "In particular, some of the following questions will involve costs to your own household; please give careful consideration to how these costs would affect your financial budget."

Figure 1: Example choice task


IST_ChoiceTask6_V2. Which of the following options do you prefer?

Additional information will be displayed by placing the mouse over the elements of the table below.

	Option 1	Option 2
	Photovoltaic installation	Heating system reinstatement
Costs	CHF 40,000 in total	CHF 5,000 in total
Benefits: Reduction of non-renewable energy and CO_2 emissions	15%	25%
Financing	You as owner	You as owner
Storage in batteries and load management	None	None

	Option 1	Option 2	None of the two
Your choice:	○	○	○

The experiment contains six choice tasks such as the one displayed in Figure 1[6] and can be divided in four parts: (i) two baseline choice tasks, (ii) the treatment for all respondents who do not belong to the control group, (iii) two choice tasks similar to the baseline choice tasks and finally (iv) two additional choice tasks which may feature smart technology and load-management attributes.[7]

Respondents are asked to choose between two unlabelled energy investments (option 1 & 2) and the third alternative, which was "none of the two" (status quo or short SQ in the following), giving respondents the choice to select non-energy spending or saving options (Alriksson and Öberg, 2008). The investment options are accompanied by pictograms of the specific investment options to make it even clearer, as it also can be seen in Figure 1. All potential investment options are displayed in Table 1. In addition, we specify abbreviations (column 2) and assign them to different categories (column 3), which will be referred to in the later sections of this paper.

[6]All have an identical design and only differ with respect to the displayed investment options and their attributes.

[7]The choice experiment was available in German, French and English. Most respondents chose German and French.

Table 1: Energy investments

Investment	Abbrev.	Category	Description
Status quo	SQ	NE	Non-energy-related option, for which respondents could choose an alternative usage of the money, for instance saving it or spending it for other purposes
Envelope reinstatement	ER	NE	Reinstatement of the facade without energy efficiency gains (e.g. painting)
Heating system reinstatement	HS	EE	Reinstatement of the existing fossil fuel powered heating system
Renewable heating	RH	RE	Switch from a fossil fuel powered to a renewable heating system, such as a heat pump, a wood heating system
Photovoltaic installation	PV	RE	Photovoltaic installation that converts solar power into electricity
Insulation	EI	EE	Renovation of the building's envelope with energy-efficiency gains (e.g. replacement of windows and/or insulation of façade, attic or roof)
Purchasing renewable heat	BH	RE	Purchase of renewable heat from the provider (e.g. district heating)
Purchasing renewable electricity	BE	RE	Purchase of renewable electricity from the utility

PV and insulation come in some cases in combination with heating-related investments

For the analysis, we group certain investment options, as it can also be seen in Table 1, because some investments are more dominant compared to others with respect to the respective costs, effort and associated circumstances. So is insulation a dominant investment, not only because of the costs but also the hassle and stress coming along with it. As a result, replacement or overhaul of the heating system is not that crucial anymore, if the facade and roof are simultaneously insulated. Replacing the heating system or at least getting it to reconditioned from time to time is inevitable. As a result, a heating overhaul decision is not as incisive as the decision to insulate. Furthermore, the effect of some investments can be comparable because these measures help to use energy more efficiently, and they can be partially substitutes for each other with respect to certain policy requirements, as for instance a CO_2 cap. Therefore, the investments are divided into three categories: non-energy use (NE), energy efficiency (EE) and renewable energy (RE) investments. Investments that are in the same category lead to similar benefits, at least in part.

Attributes and levels can be seen in Table 2. They are realistically chosen and comparable to actual policies, market prices and the outcomes of the specific investments. Energy investment options come with five different attributes: (i) the specific kind of investment; (ii) corresponding costs, which are either investment costs, yearly costs for district heating or the premium that has to be paid on top of the usual electricity bill for consuming renewable instead of conventionally produced electricity; (iii) the benefits in form of reduction of non-renewable energy and CO_2 emissions; (iv) financing possibilities and finally (v) whether the investment includes storage for renewable electricity in batteries or load-management.

Decisive factors for investing or purchasing renewable energy are costs and resulting benefits. Therefore, the different options came with a range of benefits and costs, which can be seen in Table 3.

Table 2: Attributes and levels of the choice experiment

Attributes	Description	Levels
Costs	The costs of buying or investing in a certain measure	Depending on the specific investment option between 4.000 - 120.000 CHF
Benefits	Reduction of non-renewable energy and CO2 emissions	Depending on the specific investment option between 0 and 100% energy saved / energy produced or consumed from renewable energy sources
Financing	The costs can either be incurred by the owner alone or shared between several investors	For flat owners: (1) investing with other owners, (2) self-consumption community with neighbours, (3) crowd-investment (4) purchasing renewable heat from the utility and (5) purchasing renewable electricity from the provider
		For SFH owners: (1) investing alone, (2) with 2-3 neighbours (3) self-consumption community with multiple neighbours, (4) purchasing renewable heat from the utility and (5) purchasing renewable electricity from the provider
Storage and load management	Renewable energy investments can come with batteries for storing the produced energy or the investment can be accompanied by load management by the utility to consume energy most efficiently	For the first 4 choice tasks, only storage (yes/no) was available. For the last two choice tasks, different combinations of storage and load management were available

Table 3: Cost and benefit levels

Investment type	Costs	Benefits in %
Investment options (total costs for the lifetime of the investment (30 years))		
Envelope reinstatement	20,000; 25,000; 30,000; 35,000	0
Insulation	40,000; 60,000; 80,000; 100,000	15; 25; 40; 60
Heating replacement	4,000; 5,000; 6,000; 7,000	5; 10; 15; 25
Heating replacement and insulation	20,000; 50,000; 75,000; 100,000	15; 25; 40; 60
Renewable heating	30,000; 40,000; 50,000; 60,000	20; 40; 60; 100
Renewable heating and insulation	75,000; 100,000; 120,000; 150,000	20; 40; 60; 100
PV	15,000; 20,000; 30,000; 40,000	15; 25; 40; 60
- with storage	20,000; 27,000; 40,000; 55,000	20; 30; 50; 70
- with load management	20,000; 27,000; 40,000; 50,000	20; 30; 50; 70
- with storage and load management	27,000; 35,000; 50,000; 60,000	20; 40; 60; 80
Renewable heating and electricity	45,000; 60,000; 80,000; 100,000	20; 40; 70; 100
- with storage	50,000; 67,000; 90,000; 115,000	20; 40; 70; 100
- with load-management	50,000; 67,000; 90,000; 110,000	20; 40; 70; 100
- with storage and load-management	57,000; 75,000; 100,000; 120,000	20; 40; 70; 100
Purchasing options (yearly costs)		
Costs of district heating	1,000; 1,330; 1,670; 2,000	20; 40; 60; 100
Premium for renewable electricity	30; 80; 130; 180	15; 25; 40; 60

3.3 Treatments

After the first two choice tasks, the treatments are introduced, except for the control group. Grouping is randomly done, and all groups include the same number of respondents, except for the peer pressure group, which is equally split and each of them amounts to half of the other groups. Respondents are asked to answer all choice tasks after the treatment based on the information provided in the treatments.

All treatments, which can be seen in Table 4, represent realistic policies which already existed, are currently in place in Switzerland, or have been discussed.[8] As a result, respondents should be aware of such policies, belief in their credibility, and they should be able to understand potential implications. The informational screens are similar with respect to the length of the text, the design and complexity. An orange font was chosen to increase attention and memory (Dzulkifli and Mustafar, 2013). Because all treatments are very similar, only the content should affect choice behaviour. At the same time, the treatment does not influence the attributes of the options offered.

These treatments can have different effects on the respondents' choice behaviour. So would a further CO_2 tax increase come with rising costs if fossil fuels are used as energy sources. Higher taxes on CO_2 emission are based upon public good theory. CO_2 emissions do not face territorial limitations and affect everybody, whether they emit a lot or very little. Such a tax increase happened in Switzerland in 2022 due to the still high emission levels (BAFU, 2021). Higher costs can increase homeowners' willingness to invest in

Table 4: Treatments

Treatment	Implication
CO_2 tax increase	Leading to higher costs in case of fossil fuel powered heating system.
CO_2 cap per m^2	Makes it necessary to invest in renewable energy in the upcoming years.
Net electricity metering	People who invest in renewable energy only have to pay for their net electricity consumption.
Subsidy for PV	Increase of subsidies for PV.
Subsidy for insulation	Increase of subsidies for building insulation.
Peer pressure (high)	Compared to the Swiss average, many people in the neighbourhood invest in PV.
Peer pressure (low)	Compared to the Swiss average, few people in the neighbourhood invest in PV.

[8] The complete treatment texts and corresponding explanations can be found in Appendix A.3.

renewable energy production or to change to consumption of renewable energy. Yet, there is evidence that price elasticity is not high for energy prices (Labandeira et al., 2017; Filippini, 1999). Furthermore, energy costs are often only a small part of the expenditure, which keeps their significance low, especially for homeowners (). Accordingly, it is difficult to predict the effect of such a treatment.

Another treatment based upon the public good considerations that should decrease emission is a strict CO_2 cap per square-meter of the accommodation. It means an unavoidable restriction.The Swiss government agreed on introducing such a CO_2 cap from 2023 on. Residents of old buildings will be allowed to emit a maximum of 20 kilograms of CO_2 per square metre of energy reference area per year. This limit will be lowered every five years to achieve the net-zero CO_2 target of the Swiss government by 2050.[9] Exceeding the limit can only be prevented by switching to or consuming renewable energy. This makes such a policy effective and should increase the interest in renewable energy investments. Such a strict policy may be an opportunity to force homeowners to switch to renewable energy if other policies like taxes or incentives like subsidies fail to deliver the intended effect.

Feed-in tariffs have been in place in Switzerland for many years and were recently replaced by subsidies (BFE, 2021, 2019), which makes the respective treatments realistic and relevant. Both measures decrease costs and, thereby, lower one of the main barriers to energy investments (see e.g.,). Due to such policies, attractiveness of energy investments should be increased.

Finally, peer effects can play a role for energy investment decisions. Social pressure based on own observations of others' actions can change the own behaviour (Palm, 2017; Woersdorfer and Kaus, 2011). As results of peer pressure on energy investment decisions in the literature are mixed Mundaca and Samahita (2020); Palm (2017); Müller and Rode (2013), it is interesting to see how homeowners respond to hypothetical information about their neighbours' investment behaviour. Above average investment rates in the

[9]see https://www.parlament.ch/press-releases/Pages/mm-urek-s-2019-08-16.aspx

neighbourhood may motivate respondents to choose respective energy investments more often, whereas low investment rates may lead to the opposite decision behaviour.

3.4 Implementation

Ngene and Qualtrics are used to create the choice experiment. It was published as a part of the Swiss Household Energy Demand Survey (SHEDS) 2020 (see Weber et al. (2017)). Participants stem from a pool of subjects managed by the private survey company Intervista.[10] Furthermore, the DCE was also part of another survey conducted in multiple Swiss cantons (referred to as "Cantons' survey" in the following).

In total, the sample consists of 1,451 homeowners whereof 426 respondents come from our survey in SHEDS and 1,025 homeowners from the Cantons' survey. Thereof, 208 respondents are flat owners and 1,243 are single-family house (SFH) owners.

4 Econometric analysis

In the upcoming section, the econometric framework that we used for our analysis will be presented. It offers an explanation of how the DCE data is analysed, the WTI and WTP are calculated, and treatment effects are estimated.

4.1 Econometric strategy

To investigate owners' preferences, the econometric strategy is based upon the random utility theory of McFadden (1974, 1984). It is based on the assumption that the attributes and not only the product itself are decisive for appreciation. Thus, observations of the

[10]The panel holds over 100,000 subscribers in Switzerland at the time of the survey. Potential participants are contacted via e-mail and receive a small token for their participation. Of course, the sample is not completely random, as it consists of people subscribed to Intervista. Yet, Intervista guarantees that the sample is representative of the group of people of interest. More so, respondents were randomly assigned to the different treatment groups, which are as a result by design comparable.

selection behaviour indicate the valuation of the attributes and how they affect the respondents' utility. Thereby, it is possible to identify the attribute levels that led to their utility maximising choice behaviour.

Formally, it can be expressed that the obtained sample from our experiment consists of $N = 1451$ individuals who chose between $J = 3$ alternatives on $T = 6$ choice tasks. Individuals will choose according to maximise their own utility. Thus, in the random utility framework, individual n receives the utility U_{njt} from choosing alternative j in choice task t. The respective equation is:

$$U_{njt} = V_{njt} + \varepsilon_{njt} \quad \text{with} \quad n = 1, ..., N, \quad j = 1, 2, 3, \quad t = 1, ..., 6 \tag{1}$$

V_{njt} is the so-called representative utility, and ε_{njt} is a random term assumed to be an independently and identically distributed extreme value. V_{njt} is modelled as a linear function of observable explanatory variables:

$$V_{njt} = \beta_n' x_{njt} \tag{2}$$

Vector x_{njt} represents the set of attributes of alternative j and characteristics of owner n. Characteristics of owners are constant for an individual and, thus, have to be interacted with other variables for the econometric analysis. This model is estimated with a conditional logit model, which means that the parameters of interest are constant ($\beta_n = \beta$ $\forall$ n).

4.2 Willingness to invest

Finally, the marginal willingness to invest and marginal willingness to pay for different attributes of all alternatives can be calculated based upon the estimated results. As the coefficients of the very model indicate the marginal utility of the attributes, the WTI for attribute k can be computed as the ratio of the coefficient of this attribute to the cost coefficient. The corresponding formal expression is:

$$WTI_k = \frac{-\beta_k}{\beta_{cost}} \tag{3}$$

This indicates how much money an individual is ready to invest in an option with the respective attribute. We calculate how much homeowners are willing to spend on benefits in the form of energy savings or production and consumption of renewable energy.

Because the range of potential energy investments includes purchasing options, we also calculate the willingness to pay (WTP) for the purchase of renewable energy from the utility. This can be understood as the willingness to accept a surcharge for consuming renewable rather than conventional energy, and is in addition to the energy costs incurred anyway. The formal expression is the same as (3), but here not investment costs but rather purchasing costs are used for the calculation.

The WTI is calculated in CHF 1,000 and over the assumed lifetime period of 30 years. To make WTP and WTI more comparable, the WTP is also calculated for 30 years. Yet, for the investment costs, discount rates may play a role and, as a result, WTI and WTP estimates are likely to differ. This may also be true because energy investments on the building can increase its value.

5 Results

The results of our analysis are presented in this section. To start with, descriptive statistics are shown. Afterwards, estimation results are presented. We provide results that show the effects of the different investment options and other attributes on choice behaviour of the participants. Thereafter, WTI and WTP are discussed.

5.1 Descriptive Statistics

Ahead of the actual choice experiment, we posed a question, asking respondents how they would spend an unexpected tax refund in the amount of either CHF 5,000 or CHF 10,000. Available options ranged from saving or investing over spending for different purposes to using it for their home. Their responses give first indications of their preferences and also trade-offs between available options.

Table 5 shows the respective preferences of both flat and house owners. Flat owners have a preference for saving. Yet, a large share also indicate their willingness to invest it for their flat. The other options are chosen significantly less often. Whenever “other usage” was chosen, respondents mostly state they wanted to save it or spend it, for instance, for hobbies.

Table 5: Preferred usage of unexpected tax refund

	Flat owners	House owners
Invest on financial market	11.1	7.9
Save for retirement	30.3	22.5
Purchase new car	1.4	1.5
Spend for vacation	6.3	5.1
Energy-efficient appliances	9.6	8.9
Use it for my flat	24.5	0.0
Use it for my house	0.0	44.0
Other usage	16.8	10.2
Total	100	100

Shares in %

House owners primarily indicate that they want to use the money for their building. Saving is also often chosen. Investing on the financial market, energy-efficient appliances and other ways of spending it are less frequently chosen. This gives a first indication about the trade-offs respondents face. Especially, house owners are willing to use it for their property, but also energy related options. On the other hand, flat owners rather value saving. So the owner groups seem to have different attitudes.

Those who said they would spend the money on their flat or house then are asked what exactly they would spend the money on. Their responses can be seen in Table 6. Most of the flat owners state that they want to improve the inside of the flat. Only few want to make heavier investments, as for instance work on the façade. House owners also signal their preference for improvements in the building. Yet, more of them choose other investments like solar panels or work on the building envelope. So, whereas flat owners are more concerned with their living space, house owners seem to be interested in different energy investments on their buildings. Thus, they may also face trade-offs between spending to improve the inside of their building and other energy investments severe enough to have their choices altered depending on the respective attributes.

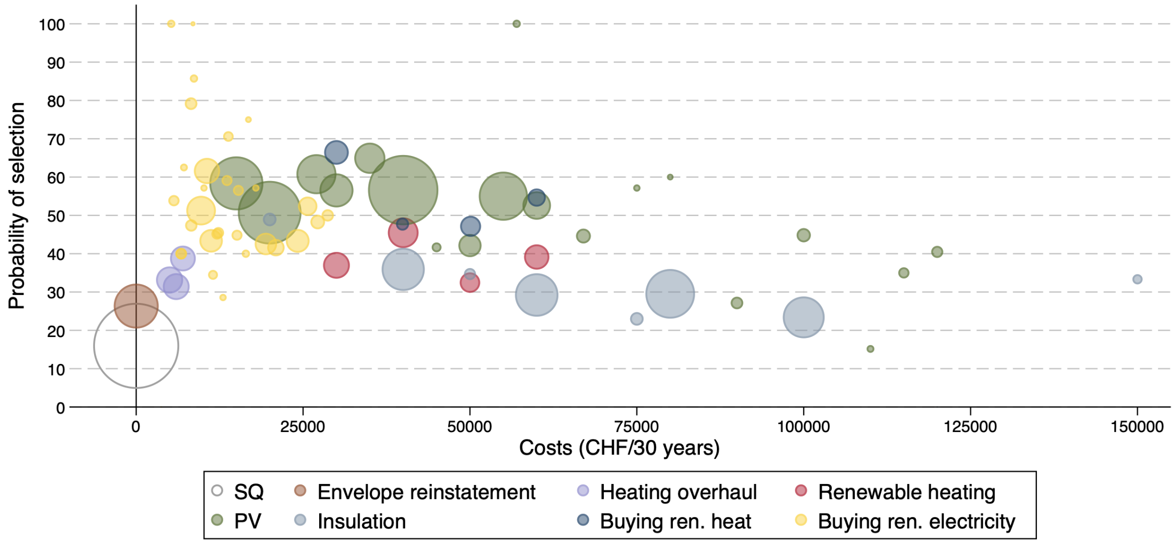
Table 6: Preferred usage for the own accommodation

	Flat owners	House owners
Repair of façade or roof	3.9	14.8
Inside addition or renovation	58.8	36.0
Heating system	13.7	15.9
Solar panel	7.8	19.2
Other usage	15.7	14.1
Total	100	100

Shares in %

A preference for renewable energy is mirrored in Figure 2 which shows the relative selection probability of the different energy investments by corresponding costs. The results indicate a general interest in energy investments. Especially PV and purchasing renewable energy are regularly chosen, which can be seen as an indication for a prosumer tendency (see e.g., Kesting et al., 2013). Contrarily, EE investments are not as often chosen, reflecting the low investment rates in recent years (Patel et al., 2021). It also becomes obvious that especially cheaper options are preferred. This is in line with the literature, showing that costs can be a decisive barrier to energy investments (Heiskanen et al., 2012).

Figure 2: Selection probability of energy investments by costs



Note: size of marker proportional to number of selected alternatives.

Whenever the SQ option is chosen, respondents are asked to indicate what they would spend the money on as an alternative. The main reason for not choosing energy investments is a preference for saving money, as it can be seen in Figure 3. [11]

Table 7 visualises which share of respondents always, never or sometimes chose the different available options. Some respondents have clear likes and dislikes. SQ is always chosen by 5% of the respondents. On the contrary, a large share of almost 67% never chose SQ, indicating their interest in energy investments.

47% of owners of old buildings never choose the insulation option whenever it is offered to them, although such EE investments are advantageous for such houses in particular (Weiss et al., 2012).

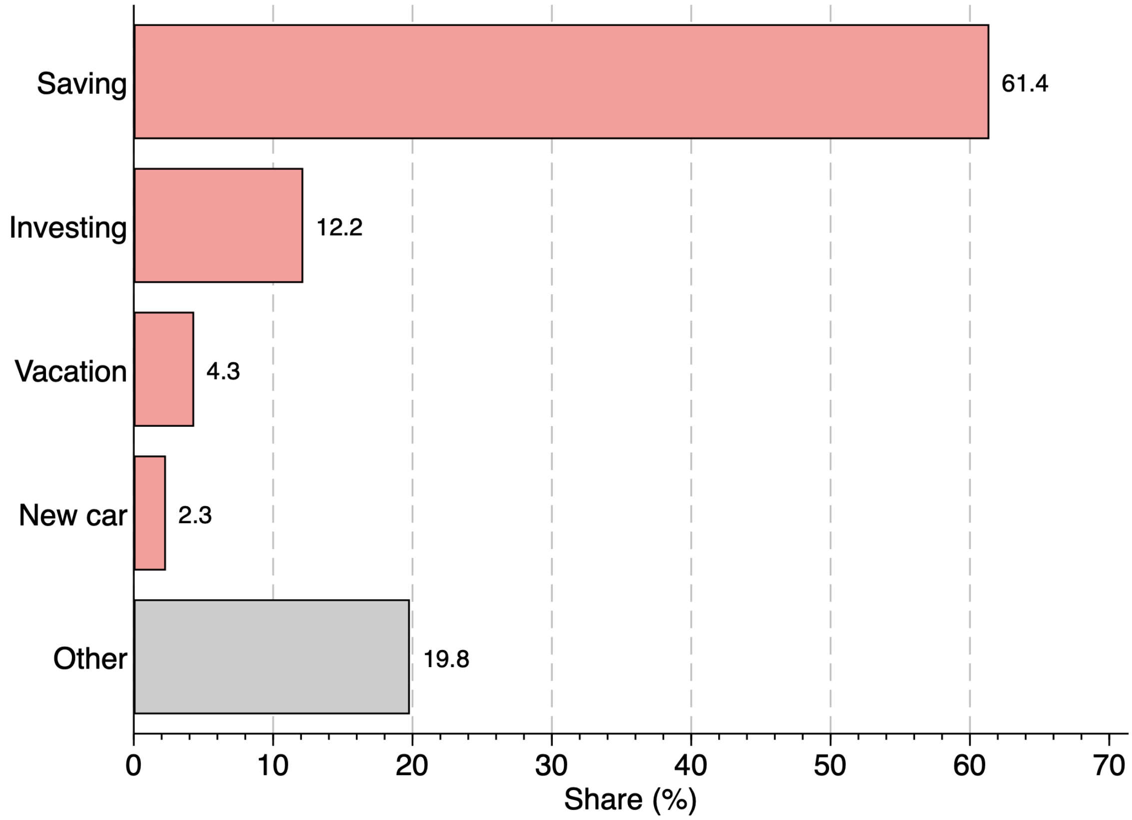
Table 7: Choice behaviour

	SQ	Envelope reinstatement	Heating overhaul	Ren. heating	PV	Insulation	Buying ren. heat	Buying ren. electricity
Never	66.6	67.6	38.4	40.2	22.8	46.7	36.4	45.9
Sometimes	28.1	10.6	50.5	33.8	49.8	43.0	14.2	11.4
Always	5.3	21.8	11.2	26.0	27.4	10.2	49.4	42.8
Respondents in total	1451	831	224	361	1449	1134	247	1022

Shares in %; respondents in total
Never: never chosen if available, sometimes: at least once but not all the time chosen if available, always: chosen whenever available
Investment options offered were tailored based on the respective housing situation

[11] Especially older people do not necessarily want to invest in their building but rather plan to save money for their retirement or the stay in a nursing home that may be necessary, as they regularly indicated whenever "other" was chosen.

Figure 3: Alternative usage of money



PV is selected in more than half of all cases when it is available. That RH is never chosen by 40 % of owners for whom this investment is relevant may point in the same direction as the finding of Lang et al. (2021) who discuss that people may not be willing to consider RH even if they make sense but rather stick with their fossil fuel powered heating systems.

Whilst some respondents face trade-offs pronounced enough to make them alter their choices between choice tasks, others stick with their choices. For them, trade-offs between options and their corresponding attributes are apparently not strong enough to affect their choice behaviour.

5.2 Estimation Results and Discussion

The main body of our work is the econometric analysis. Results of the conditional logit estimation are reported in Tables 8 and 9, which presents three different specifications. Model 1 is the basic model with a benefit coefficient and a coefficient for squared benefits, without considering investment specific benefit effects. In Model 2, the squared benefits are dropped, but investment specific benefits are considered to see what role the benefits play in the different investments. Finally, in the third model, investment specific benefits and squared benefits are included to calculate the WTI and WTP for all investment options, for which energy benefits play a role. [12] For each model, the column (1) shows the estimated coefficients, whilst the column (2) contains corresponding standard errors in parenthesises.

The coefficients show the extent to which the attributes affect selection of a particular option. The base category for energy investments is NE, which comes with no energy benefits. The results indicate that owners are indeed positive about energy investments. Most of them have significant and positive effects. One exemption is the heating system overhaul option, for which coefficients are not significant. When comparing the effect of insulation as energy efficiency option to the coefficients of renewable energy options, then it can be seen that all renewable energy investments show stronger effects in the first model. This can be an indication for a prosumer tendency, as already discussed by researchers like Kesting et al. (2013). This impression is reinforced by the descriptive statistics. Lower valuation of EE despite potential benefits can also be explained, for example, by high costs of such investments (Stieß and Dunkelberg, 2013), dirt and stress coming with such measures (Weiss and Dunkelberg, 2010) or a lack of civic involvement when it comes to EE (Weiss et al., 2012). Such a general trend is also what has been observed in the real world in recent years (IEA, 2020).

[12] This excludes heating overhaul, which seldom comes with relevant efficiency gains. Even if such benefits result, this is usually not the reason for a heating replacement, but rather the necessity to have it overhauled from time to time.

Both buying options have positive effects, which is especially strong for buying renewable heat, as for instance in the form of district heating. The results show that participants indeed have a positive valuation of energy investments, especially for renewable energy, either bought from the utility or produced by PV.[13] The strong effect of purchasing renewable heat and electricity from the utility can be explained by the low cost compared to the other options and the low additional cost of purchasing conventional energy in reality. Therefore, purchasing renewable energy is convenient and the hurdle to this can be assumed to be considerably lower compared to heavy investments as required for most energy efficiency measures. This can be also due to the fact that associated negative aspects such as required effort are usually lower with such purchases than with own investments (Tabi et al., 2014).

As mentioned before, costs play an important role and can act as a barrier, so that relatively low costs may be especially appealing to respondents (Balcombe et al., 2013). This is also mirrored in the findings, which show that purchasing and investment costs affect the investment decision negatively. The negative effect is more severe for the costs related to buying renewable energy compared to the cost coefficient for investing.

On the other hand, benefits affect selection positively. By including squared benefits, it is possible to see whether the positive effect of benefits decreases, which will also be discussed in Section 4.2. Squared benefits in Model 1 come with a significantly negative effect. In Model 2, investment specific benefits are significant and negative. Even though some coefficients are close, they do not offset the positive main benefit effect. Only few investment specific benefit and squared benefit effects in Model 3 are significant, and all of them are negative. These results show that even though benefits are important to respondents, the positive effect is decreasing, which may indicate that it is rather the "warm glow" of having done something good than the best possible efficiency that drives investment decisions (Ma and Burton, 2016).

[13]The strong effect of the "Buying renewable heat" option can be explained by the small sample that received that particular treatment, which means that this specific coefficient has to be interpreted cautiously. This also explains the non-significant WTP estimates. Yet, robustness checks underline the validity of the other coefficients, as can be seen in Appendix A.2.

Most of the treatments show no significant effect. The only exemption is the CO_2 cap treatment.[14]. Thus, only the strictest policy measure shows a significant effect. The lack of a significant effect of the CO_2 tax treatment can be explained by the limited importance of energy expenditures (Ürge-Vorsatz et al., 2007) or low price elasticity (see e.g., Zhu et al., 2018).

This may be due to the formulation of the treatment and the inevitability of such a measure. In case of a fixed cap, people have to accept it and act accordingly. A tax that would lead to higher costs is not necessarily reducing own consumption, especially if people are not really aware of how much they are paying for energy (Heiskanen et al., 2012). On the other hand, a strict cap limits the scope of actions and can force people to comply to avoid legal consequences. Thus, this measure has the most severe impact and such policies may be the way to ensure investment if other incentives do not lead to the intended outcome.

Choice experiments with a number of repeated similar questions can come with different time-variant factors like fatigue of the respondents or learning effects (see e.g. Day et al., 2012; Campbell et al., 2015). Such effects are not related to the actual information presented. Therefore, a trend variable is included in the regression to see whether respondents are more likely to choose the status quo option over the course of the experiment Yet, the results show the opposite. Because storage and load-management are only offered in the last two choice tasks, another indicator variable for these two choice tasks is included in the analysis to estimate the storage and load-management effects properly.

New business models and collective investment opportunities can lead to a paradigm change with respect to renewable energy investments. Less hassle, lower costs and increased flexibility can increase the attractiveness of such options and raise the willingness to participate (Moret and Pinson, 2018). Yet, our results show that respondents prefer investing alone to collective investment options in our experiment. In the results, there is no indication of a general trend towards collective investments, as both house and flat

[14]The CO_2 cap treatment effect is also significant for other specifications, indicating the validity of the findings

owners prefer investing alone or with co-owners compared to collective investment options. This may have different reasons. For instance, respondents may be not perfectly familiar with these options, or they are uncertain about them and how they work out, also because it can be assumed that very few of their peer have already made experiences with such projects. Also, the uncertainty and risk aversion may cause this outcome. In addition, in our research, we look at privately organised collective investments that are not backed by institutions. Compared to such institutional projects, the necessary commitment, cooperation and personal risk are higher for private group investments. Thus, interest in institutional collective investments and contributions may be greater, which can be explored in more detail in future research.

When it comes to storage, availability of a battery for storing produced renewable electricity has no significant effect on the selection of the respective option. On the contrary, load-management significantly decreases the selection chances. A combination of both a battery for storing renewable energy and load-management has a significant positive effect. This is also reflected in the WTP for batteries and load-management, which can be seen in Table 10. The fact that batteries do not have a significant effect may be due, among other things, to the fact that such investments have not really been profitable in Switzerland to date, although this could potentially change in the future (Swissolar, 2019). So, for now, it is reasonable that such devices do not really have an impact.

The negative effect for load management can be explained by control preferences, which have already been identified by other researchers (Fell et al., 2015). Distrust can also lead to disapprobation of external control of energy (Stenner et al., 2017), which explains why respondents rather ask for compensation than showing a positive WTP. That the WTP for the combination of a battery and load-management is positive makes also sense. A combination of battery and load-management can be attractive, as load-management optimises consumption, but residents stay in control due to their storage device. Furthermore, this allows buying energy whenever it is cheap and selling stored electricity when the prices are high. Finally, flexibility and control are increased by the battery so that the negative perception of load-management alone is more than offset.

Personal characteristics also play a role for energy investments. So are people in the retirement age (above 65 years) less likely to choose heavy energy investment options like insulation and PV, which is in line with findings, for instance, by Matschoss et al. (2013); Willis et al. (2011) who find that older residents are less likely to undertake such investments.[15]

[15] We also analyse the effect of education, also as a proxy for income because such data is not available for all individuals. Anyhow, there was no significant effect for education.

Table 8: Estimation results - part 1

	Model 1	Model 2	Model 3
Investments (base category: non-energy*:			
Heating overhaul	0.1338	−0.1201	−0.1158
	(0.1265)	(0.1749)	(0.1753)
Renewable Heating	0.3733***	0.4693***	0.2573
	(0.1385)	(0.1818)	(0.3693)
PV	0.8351***	1.1393***	0.8566***
	(0.1123)	(0.1052)	(0.1535)
Insulation	0.3356**	0.5005***	0.4422**
	(0.1324)	(0.1232)	(0.2015)
Purchasing renewable heat	1.5573***	2.0699***	2.3058***
	(0.2847)	(0.4501)	(0.6196)
Purchasing renewable electricity	0.4207***	0.5401***	0.3340
	(0.1242)	(0.1220)	(0.2526)
Costs (in 1000 CHF for period of 30 years):			
Investment costs	−0.0089***	−0.0094***	−0.0089***
	(0.0011)	(0.0011)	(0.0012)
Purchasing costs	−0.0251***	−0.0243***	−0.0240***
	(0.0060)	(0.0082)	(0.0082)
Benefits (in %):			
Benefits	0.0224***	0.0402***	0.0393***
	(0.0037)	(0.0086)	(0.0086)
Benefits × Benefits	−0.0001***		
	(0.0000)		
Investment specific benefits (in %):			
Renewable Heating		−0.0266***	−0.0185
		(0.0088)	(0.0154)
PV		−0.0306***	−0.0158
		(0.0087)	(0.0103)
Insulation		−0.0264***	−0.0237*
		(0.0088)	(0.0127)
Purchasing renewable heat		−0.0358***	−0.0456**
		(0.0091)	(0.0202)
Purchasing renewable electricity		−0.0266***	−0.0109
		(0.0091)	(0.0187)
Investment specific squared benefits (in %):			
Renewable Heating			−0.0001
			(0.0001)
PV			−0.0001**
			(0.0001)
Insulation			−0.0000
			(0.0001)
Purchasing renewable heat			0.0001
			(0.0001)
Purchasing renewable electricity			−0.0002
			(0.0002)

Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

* Non-energy in this context includes the status quo and envelope reinstatement options

Table 9: Estimation results - part 2

	Model 1	Model 2	Model 3
Treatment effect (base category: non-treated; interacted with benefits):			
CO_2 Tax	0.0010	0.0009	0.0007
	(0.0026)	(0.0026)	(0.0026)
CO_2 Cap	0.0073^{**}	0.0072^{**}	0.0070^{**}
	(0.0031)	(0.0031)	(0.0031)
Tariff and net-metering	−0.0016	−0.0016	−0.0017
	(0.0021)	(0.0021)	(0.0021)
Subsidies photovoltaics	0.0014	0.0013	0.0010
	(0.0031)	(0.0031)	(0.0031)
Subsidies retrofit	0.0027	0.0023	0.0020
	(0.0028)	(0.0028)	(0.0028)
Peer pressure (high)	−0.0030	−0.0030	−0.0033
	(0.0040)	(0.0040)	(0.0040)
Peer pressure (low)	0.0032	0.0029	0.0027
	(0.0038)	(0.0037)	(0.0037)
Financing (base: alone (SFH) with co-owners (Flat)):			
Collective investment (SFH)	-0.3346^{***}	-0.3555^{***}	-0.3445^{***}
	(0.0692)	(0.0701)	(0.0701)
Self-consumption community	-0.3207^{***}	-0.3116^{***}	-0.3234^{***}
	(0.0609)	(0.0606)	(0.0617)
Crowd investment (Flat)	-0.4727^{***}	-0.4584^{***}	-0.4701^{***}
	(0.1414)	(0.1408)	(0.1420)
Storage (base: no battery or load-management):			
Battery	0.0624	0.0967	0.0790
	(0.0616)	(0.0625)	(0.0631)
Load management	-0.2470^{**}	-0.2488^{**}	-0.2556^{**}
	(0.1185)	(0.1177)	(0.1181)
Battery and load management	0.2405^{**}	0.2920^{***}	0.2771^{***}
	(0.1012)	(0.1035)	(0.1032)
Characteristics:			
Respondent age 65+ × PV	-0.4794^{***}	-0.4759^{***}	-0.4781^{***}
	(0.1093)	(0.1091)	(0.1093)
Respondent age 65+ × Insulation	-0.2593^{*}	-0.2611^{*}	-0.2605^{*}
	(0.1351)	(0.1352)	(0.1353)

Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

* Non-energy in this context includes the status quo and envelope reinstatement options

Table 10: WTP for smart technologies and optimisation (in CHF)

	Storage (battery)	Load-management	Storage and load-management%
WTP	7,045	$-27{,}870^{*}$	$27{,}128^{**}$
	(6,769)	(14,590)	(10,673)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

5.3 Willingness to Invest and Pay

More so, the calculated the willingness to invest and pay for all three models. [16] For Model 1, the general WTI and WTP are calculated. For Model 2 the average willingness to invest and pay for 15 percentage points of benefits are estimated. Finally, for Model 3 the WTI and WTP for a fifteen percentage-point increase in resulting benefits at different levels are calculated. The estimates in CHF are presented in Tables 11 and 12, as well as in Figure 4.

In general, there is a positive willingness to invest, which is decreasing the higher the resulting benefits are. This indicates that respondents are happy to spend money in order to enjoy energy-related benefits, but this willingness is limited, which may be also an indication for the importance of the "warm glow" rather than achieving maximum efficiency or renewable energy production.

For example, the results based on Model 1 in Tables 11 show that the WTI decreases from almost CHF 38,000 for the first 15 percentage points of benefits to CHF 20,400 for the same amount of benefits at a level of 45%. The picture is similar for the WTP for purchasing renewable electricity, even though the amount is considerably lower.

Table 11: WTI and WTP for 15pp. of benefits (in CHF)

	0-15%	15-30%	30-45%	45-60%
WTI	37,853***	32,035***	26,218***	20,400***
	(7,749)	(5,912)	(4,233)	(2,992)
WTP	13,376***	11,320***	9,265***	7,209***
	(3,394)	(2,756)	(2,178)	(1,720)

Standard errors in parentheses.
Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Based on Model 2, the average WTI and WTP for 15 percentage points of benefits show that the average WTI for renewable heating and insulation is on a similar level around

[16] Even though the costs for the purchasing options were displayed as yearly costs in the choice experiment, the WTP is calculated for a 30-year period, which can be assumed to be the lifetime of typical energy investments, to make them comparable to the WTI figures in the tables.

CHF 22,000, CHF 15,000 for PV and the WTP for purchasing renewable electricity is with CHF 8,400 considerably lower. The result for buying renewable heat is not significant.

Table 12: Average WTI and WTP for 15pp. of benefits (in CHF)

	Renewable heating	PV	Insulation
WTI	21,748***	15,351***	22,064***
	(4,748)	(2,864)	(3,424)
	Buying ren. heat	Buying ren. electricity	
WTP	2,717	8,370***	
	(2,286)	(2,046)	

Standard errors in parentheses.
Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

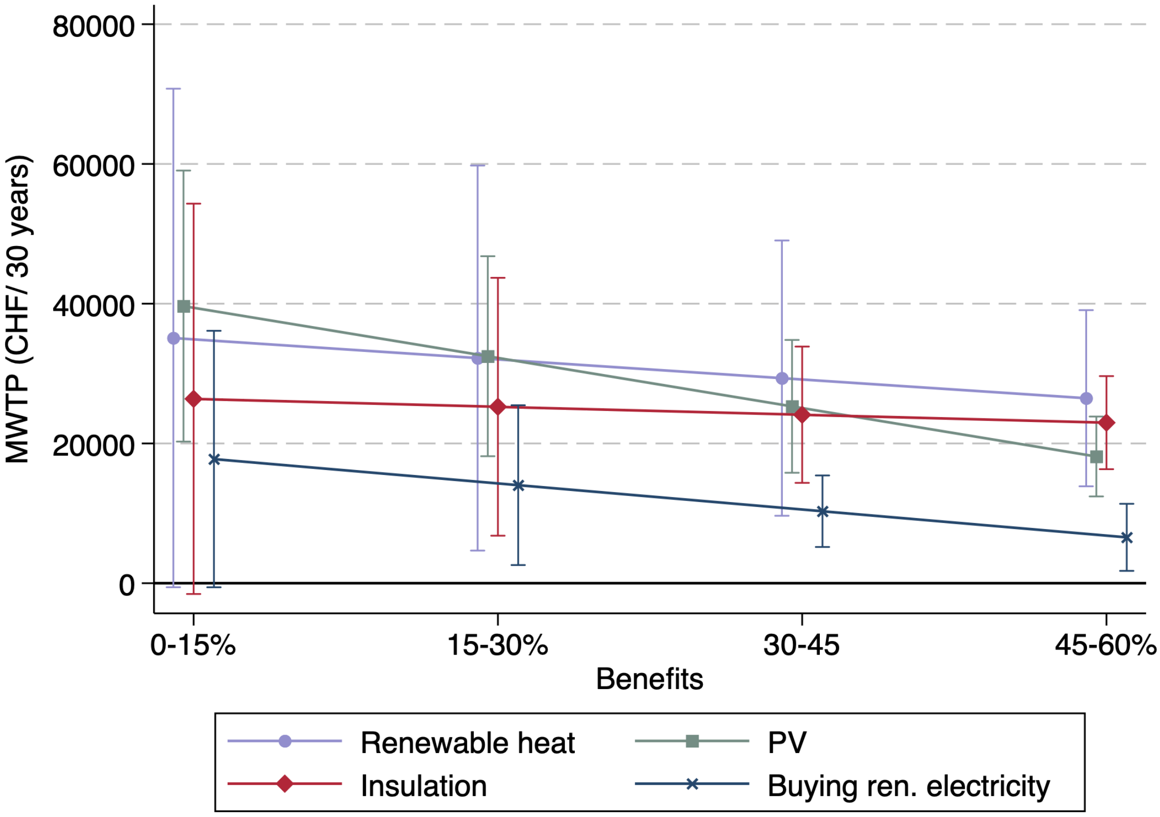
Finally, WTI and WTP for all investment and purchasing options are estimated based on Model 3 and can be seen in Figure 4. The general picture shows that the WTI and WTP are decreasing with increasing levels of benefits.[17]

The WTI and WTP estimates show what homeowners are indeed willing to spend money for energy investments. Yet, WTI and WTP are decreasing, which means that maximum efficiency and production levels are unlikely to be reached as especially achieving the last possible benefits is usually more expensive. The decreasing WTI and WTP can also mean that the willingness to pay is not high enough to actually carry out the investments, as it was already shown by Scarpa and Willis (2010) and Lang et al. (2021). Especially with energy efficiency measures, it is often the last steps to achieve maximum efficiency that are particularly costly.

When it comes to purchasing renewable electricity, our findings are in line with the positive willingness to pay a premium for consuming green electricity, as also found by Hansla et al. (2008); Borchers et al. (2007). Yet, the WTP for green energy is also quickly decreasing with the proportion of renewable energy in the overall energy mix. This is in line with findings from Farhar (1999), who found that the WTP for renewable energy is non-linear but rather decreasing with the amount. Similar findings were published

[17] Again, the results for buying renewable heat are not significant and, thus, are not displayed in Figure 4.

Figure 4: WTP



by (Ma and Burton, 2016) that many people only want to make the smallest possible contribution, which suggests that they only do this for the good feeling of having done something ("warm glow"). Low costs can be important to respondents (Balcombe et al., 2013), which can also explain why purchasing renewable heat is highly appreciated, but the willingness to pay is low or not significant at all. This shows that respondents are interested in purchasing renewable heat, yet, the price has to be low to be attractive. This has also important policy implications. If such investments are deemed important, policymakers may consider promoting them in order to foster uptake.

6 Conclusion

Engagement of residents by investing in energy measures for their residential buildings is important to reduce CO_2 emissions and achieve climate targets. Yet, investment rates are still low despite potential benefits and promoting policies. Therefore, we conduct a DCE to explore what actually affects energy investments for residential buildings in the changing energy investment environment. Observations from 1,451 Swiss homeowners are used to estimate how their decisions are affected by the investment type, corresponding attributes, smart technologies and information treatments. More so, we calculate their willingness to invest or pay.

In brief, our findings indicate that homeowners value energy investments. Even though we find indications for trade-offs between different investment types, the findings indicate a prosumer tendency. For some, trade-offs between different factors and investments make them alter their choices, whereas others show rather homogeneous preferences for certain investments. Coefficients in the econometric analysis underline the interest of renewable energy. Finally, homeowners prefer to invest alone or with co-owners and show no valuation of collective investment, even though such projects offer easy, flexible and often times relatively cheap alternatives to traditional investments.

Out of all introduced treatments, only the strong implications of a CO_2 cap per squaremeter significantly affect the choice behaviour. This can indicate that regulations rather than financial incentives may be the policy instrument to affect emissions of residential buildings. That the other policy treatments do not alter choice behaviour can be an indication that existing policies, which represented the starting point of the treatments, have to be adapted to reach the climate goals. Stringent rules such as CO2 caps can be the solution if the investment rates of the population that are considered necessary are not achieved despite other policies.

The willingness to invest and pay estimation indicates that homeowners are indeed willing to spend money for energy investments. Yet, the decreasing willingness shows that people are not willing to spend so much to reach the maximum levels. This can be an indication that it is primarily the warm glow rather than environmental issues that are driving such investment decisions.

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A Appendix

A.1 Estimation by owner group

Table 13: Estimation results - by owner group

	Flat owners	SFH owners
Respondents	208	1,243
Investments (base category: SQ & envelope reinstatement):		
Heating overhaul	0.3124	0.0883
	(0.2704)	(0.1449)
Ren. Heating	0.1240	0.3928***
	(0.3700)	(0.1509)
PV	0.5489*	0.7998***
	(0.3168)	(0.1287)
Insulation	0.0638	0.3627**
	(0.4346)	(0.1494)
Buying ren. heat	2.0574**	1.5015***
	(0.9266)	(0.3045)
Buying ren. electricity	0.3604	0.4191***
	(0.3124)	(0.1364)
Costs:		
Investment cost in 1000 CHF	−0.0048	−0.0096***
	(0.0031)	(0.0012)
Buying costs	−0.0289	−0.0256***
	(0.0195)	(0.0064)
Benefits (in %):		
Benefits	0.0239**	0.0232***
	(0.0099)	(0.0040)
Benefits × Benefits	−0.0001	−0.0001***
	(0.0001)	(0.0000)
Treatment effects (base category: not treated; interacted with benefits):		
CO_2 Tax	0.0150*	−0.0006
	(0.0085)	(0.0027)
CO_2 Cap	0.0027	0.0081**
	(0.0078)	(0.0035)
Tariff and net-metering	0.0036	−0.0024
	(0.0060)	(0.0023)
Subsidies photovoltaics	−0.0069	0.0027
	(0.0097)	(0.0033)
Subsidies retrofit	−0.0066	0.0042
	(0.0089)	(0.0030)
Peer pressure (high)	−0.0105	−0.0016
	(0.0087)	(0.0045)
Peer pressure (low)	−0.0038	0.0046
	(0.0105)	(0.0040)
Financing (base: investing alone (SFH) or with co-owners (Flat))):		
Collective investment (SFH)	0.0000	−0.3132***
	(.)	(0.0703)
Self-consumption community	−0.0221	−0.3950***
	(0.1647)	(0.0664)
Crowd investment	−0.5067***	0.0000
	(0.1524)	(.)
Optimisation (base: no battery or load-management):		
Battery	0.0627	0.0724
	(0.1692)	(0.0668)
Load management	0.0823	−0.3215**
	(0.2963)	(0.1303)
Battery and load management	0.3571	0.2034*
	(0.2794)	(0.1092)
Characteristics:		
Respondent age 65+ × PV	−0.2159	−0.4942***
	(0.3138)	(0.1181)
Respondent age 65+ × Insulation	−0.3426	−0.2356
	(0.4015)	(0.1441)

Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.
Standard errors in parentheses

Table 14: Respective WTP for flat owners

	0-15%	15-30%	30-45%	45-60%
WTI	74,719	68,773	62,826	56,879
	(58,285)	(50,246)	(43,118)	(37,426)
WTP	12,378	11,393	10,408	9,423
	(9,094)	(7,993)	(7,072)	(6,409)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 15: Respective WTP for SFH owners

	0-15%	15-30%	30-45%	45-60%
WTP	36,127***	29,879***	23,631***	17,383***
	(7,576)	(5,697)	(3,963)	(2,677)
WTP	13,586***	11,237***	8,887***	6,537***
	(3,570)	(2,847)	(2,182)	(1,644)

Standard errors in parentheses. Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.2 Robustness check

Here, we did the same regression after we deleted all observations where buying renewable heat was offered to make sure that availability did not affect other choices. But as the results in Table 16 below show, the other coefficients are on similar levels as in Table 8 and 9, which is an indication of the robustness of our results.

Table 16: Estimation results without renewable heating choice tasks

	Model 1		Model 2		Model 3	
Investments (base category: no energy investment (status quo and envelope reinstatement)):						
Heating overhaul	0.2570^{**}	(0.1261)	0.0259	(0.1732)	0.0101	(0.1736)
Renewable Heating	0.4210^{***}	(0.1414)	0.5545^{***}	(0.1816)	0.3629	(0.3687)
PV	0.9157^{***}	(0.1145)	1.2697^{***}	(0.1030)	0.8659^{***}	(0.1551)
Insulation	0.3572^{***}	(0.1384)	0.5873^{***}	(0.1236)	0.5230^{***}	(0.2008)
Buying renewable electricity	0.5284^{***}	(0.1399)	0.6357^{***}	(0.1397)	0.4197	(0.2602)
Costs (monthly in CHF):						
Investment costs	-0.0080^{***}	(0.0011)	-0.0085^{***}	(0.0011)	-0.0079^{***}	(0.0012)
Buying costs	-0.0274^{***}	(0.0082)	-0.0280	(0.0186)	-0.0291	(0.0186)
Benefits (in %):						
Benefits	0.0240^{***}	(0.0039)	0.0397^{***}	(0.0086)	0.0389^{***}	(0.0086)
Benefits^2	-0.0001^{***}	(0.0000)				
Investment specific benefits (in %):						
- Renewable Heating			-0.0259^{***}	(0.0088)	-0.0193	(0.0155)
- PV			-0.0302^{***}	(0.0087)	-0.0097	(0.0103)
- Insulation			-0.0262^{***}	(0.0087)	-0.0241^{*}	(0.0127)
- Buying renewable electricity			-0.0239^{**}	(0.0107)	-0.0070	(0.0196)
Investment specific benefits^2 (in %):						
- Renewable Heating					-0.0000	(0.0001)
- PV					-0.0002^{***}	(0.0001)
- Insulation					-0.0000	(0.0001)
- Buying renewable electricity					-0.0002	(0.0002)
Treatment effect (base category: non-treated; interacted with benefits):						
CO2 Tax	0.0007	(0.0026)	0.0005	(0.0026)	0.0003	(0.0026)
CO2 Cap	0.0062^{*}	(0.0032)	0.0060^{*}	(0.0032)	0.0057^{*}	(0.0032)
Tariff and net-metering	-0.0007	(0.0021)	-0.0007	(0.0021)	-0.0008	(0.0021)
Subsidies (PV)	0.0009	(0.0031)	0.0008	(0.0031)	0.0005	(0.0031)
Subsidies (Insulation)	0.0020	(0.0028)	0.0016	(0.0028)	0.0013	(0.0028)
Peer pressure (high)	-0.0043	(0.0040)	-0.0043	(0.0040)	-0.0046	(0.0040)
Peer pressure (low)	0.0023	(0.0037)	0.0018	(0.0037)	0.0015	(0.0037)
Trend (for choosing non-energy over the course of the choice experiment):						
Trend	-0.0601^{***}	(0.0170)	-0.0551^{***}	(0.0170)	-0.0582^{***}	(0.0171)
Financing (base: alone (SFH) with co-owners (Flat)):						
Collective investment (SFH)	-0.3160^{***}	(0.0695)	-0.3349^{***}	(0.0702)	-0.3230^{***}	(0.0701)
Self-consumption community	-0.3070^{***}	(0.0599)	-0.2907^{***}	(0.0599)	-0.3129^{***}	(0.0606)
Crowd investment (Flat)	-0.4315^{***}	(0.1425)	-0.4072^{***}	(0.1426)	-0.4313^{***}	(0.1436)
Storage (base: no battery or load management):						
Battery	0.0264	(0.0623)	0.0691	(0.0630)	0.0532	(0.0636)
Load management	-0.3992^{***}	(0.1226)	-0.3986^{***}	(0.1212)	-0.4031^{***}	(0.1218)
Battery and load management	0.1496	(0.1011)	0.2035^{**}	(0.1027)	0.1988^{*}	(0.1027)
Personal characteristics:						
Respondent age 65+ × PV	-0.4716^{***}	(0.1109)	-0.4689^{***}	(0.1107)	-0.4710^{***}	(0.1111)
Respondent age 65+ × Insulation	-0.2504^{*}	(0.1357)	-0.2547^{*}	(0.1357)	-0.2540^{*}	(0.1359)

Significance levels * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

A.3 Treatments

The exact treatment messages were:

Treatment 1: Policy – CO_2-tax increase

Today, heating fossil fuels are taxed at 96 CHF per ton of CO_2. According to the revised CO_2 law, this tax can be more than doubled to maximum CHF 210. This implies a price increase of 30 CHF per 100 liter of heating oil (+30%) and 2 cts/kWh for natural gas (+20%). Please respond to the following choice questions assuming that the new tax rate is in place.

Treatment 2: Policy - CO_2/m^2 cap

The revised CO_2 law stipulates a strict CO2 cap per square-meter of the building. Imagine that this policy is actually implemented. This makes it necessary to invest in renewable energy, at the latest when you need to retrofit your heating system. Please respond to the following choice questions assuming the strict limit is in place.

Treatment 3: Electricity tariff system – Net metering

Since 2018, house owners who install PV systems only need to pay for their net electricity consumption, i.e., the part they do not produce themselves. In addition, extra-production is rewarded by the local utility. Overall, this is very advantageous for house owners as this partially pays off their investment costs. Yet, many house owners are not aware of this important change. Please respond to the following choice questions considering that the electricity you produce is directly deducted from your bill.

Treatment 4: Policy – Subsidies for PV

To achieve the goals of the Swiss Energy Strategy 2050, subsidies for producing renewable electricity (PV) should be increased substantially. Currently, federal and cantonal contributions cover about 30% of investment costs. Imagine that these subsidies increase to 60%. Please respond to the following choice questions assuming that subsidies are actually 60%.

Treatment 5: Policy – Subsidies for buildings
To achieve the goals of the Swiss Energy Strategy 2050, subsidies for energy building retrofits should be increased substantially. Imagine that new federal and cantonal contributions will cover about 30% of investment costs. Please respond to the following choice questions assuming that subsidies are actually 30%.

Treatment 6A: Policy – Information nudge for diffusion (high)
It turns out that investment in photovoltaics (PV) has substantially increased recently. It is likely that the majority of your neighbours will invest in PV in the upcoming years.

Treatment 6B: Policy – Information nudge for diffusion (low)
It turns out that investment in photovoltaics (PV) has substantially decreased since 2018 as cost-covering feed-in tariffs were replaced by one-off subsidies. It is likely that very few of your neighbours will invest in PV in the upcoming years.

A.4 Choice patterns and corresponding follow-up question responses

A.4.1 Observed trade-offs

Choice patterns are analysed in more detail to find out more about trade-offs between and preferences for certain energy investments.

Some respondents face the whole range of offered options and thus may face trade-offs between the energy investment options and their attributes, but also non-energy-related options. Others, are more restricted in their choices and, thus, it is interesting to see their choice behaviour when it comes to the remaining options. For some respondents, trade-offs between different options are not severe enough to alter their choices, and thus we see some choosing always the same option. For others, trade-offs between the available options may be more severe, which makes them choose different options. Characteristics of respondents from the different groups can be seen and compared in Table 17. For this table, respondents who always chose status quo were excluded, which also explains the slightly deviating shares compared to the figures in Table 7.

What can be seen in the table is that the share of older people is higher amongst the respondents who always chose status quo. This is also in line with the written respondents to the follow-up questions. There, many older people indicated that they are not interested in energy investments, but also not in the other options, because such measures are not anymore of interest for them because they do not plan to stay in the building in the long run.

Contrarily, a large share of respondents never choose the SQ. But also other available options are never chosen by some respondent as presented in Table 7. These groups will be examined in the following part. The graphs always show how regularly the different options were chosen if they were available. So, these are conditional selection probabilities.[18]

[18]Further graphs and respective follow-up question responses can be seen in Appendix A.4

Table 17: Respondents' characteristics

	Always SQ	Never SQ	Never envelope reinstatement	Never heating overhaul	Never renewable heating	Never PV	Never insulation	Never buying heat	Never buying electricity	New building - no insulation	With renewable heating - no heating	No preference	Whole sample
Group:	-	1	-	-	2	3	4	5	6	7	8	9	-
Relative group size:	5.3%	66.6%	36.1%	5%	8.4%	17.6%	32.5%	5.2%	29.4%	20.8%	65.5%	12.6%	100%
Respondent age < 65	43	683	356	40	84	150	308	59	289	214	660	129	988
	(55.84)	(70.63)	(67.94)	(55.56)	(68.85)	(58.82)	(65.39)	(78.67)	(67.68)	(70.86)	(69.40)	(70.49)	(68.09)
Respondent age 65+	34	284	168	32	38	105	163	16	138	88	291	54	463
	(44.16)	(29.37)	(32.06)	(44.44)	(31.15)	(41.18)	(34.61)	(21.33)	(32.32)	(29.14)	(30.60)	(29.51)	(31.91)
Total	77	967	524	72	122	255	471	75	427	302	951	183	1451
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Building age <30 years	46	568	335	40	65	143	270	41	239	234	617	104	851
	(59.74)	(58.74)	(63.93)	(55.56)	(53.28)	(56.08)	(57.32)	(54.67)	(55.97)	(77.48)	(64.88)	(56.83)	(58.65)
Building age >30 years	31	399	189	32	57	112	201	34	188	68	334	79	600
	(40.26)	(41.26)	(36.07)	(44.44)	(46.72)	(43.92)	(42.68)	(45.33)	(44.03)	(22.52)	(35.12)	(43.17)	(41.35)
Total	77	967	524	72	122	255	471	75	427	302	951	183	1451
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Lower education	60	674	354	47	80	182	329	54	315	206	674	131	1023
	(77.92)	(69.70)	(67.56)	(65.28)	(65.57)	(71.37)	(69.85)	(72.00)	(73.77)	(68.21)	(70.87)	(71.58)	(70.50)
Graduate	17	293	170	25	42	73	142	21	112	96	277	52	428
	(22.08)	(30.30)	(32.44)	(34.72)	(34.43)	(28.63)	(30.15)	(28.00)	(26.23)	(31.79)	(29.13)	(28.42)	(29.50)
Total	77	967	524	72	122	255	471	75	427	302	951	183	1451
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
Maximum mean income	9	159	83	10	37	40	58	21	63	75	132	36	238
	(64.29)	(52.48)	(58.87)	(41.67)	(69.81)	(61.54)	(51.79)	(63.64)	(52.07)	(55.97)	(54.10)	(65.45)	(55.87)
More than mean income	5	144	58	14	16	25	54	12	58	59	112	19	188
	(35.71)	(47.52)	(41.13)	(58.33)	(30.19)	(38.46)	(48.21)	(36.36)	(47.93)	(44.03)	(45.90)	(34.55)	(44.13)
Total	14	303	141	24	53	65	112	33	121	134	244	55	426
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)
SHEDS sample	14	303	141	24	53	65	112	33	121	134	244	55	426
	(18.18)	(31.33)	(26.91)	(33.33)	(43.44)	(25.49)	(23.78)	(44.00)	(28.34)	(44.37)	(25.66)	(30.05)	(29.36)
Cantons' survey	63	664	383	48	69	190	359	42	306	168	707	128	1025
	(81.82)	(68.67)	(73.09)	(66.67)	(56.56)	(74.51)	(76.22)	(56.00)	(71.66)	(55.63)	(74.34)	(69.95)	(70.64)
Total	77	967	524	72	122	255	471	75	427	302	951	183	1451
	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Shares of the respective respondent group (in %)