

Decarbonising the rental housing market: An experimental analysis of tenants' preferences for clean energy features of residential buildings

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ARTICLE INFO

Keywords:

Renewable energy
Electric vehicles
Energy efficiency
Solar photovoltaics
Heat pumps
Citizen investment

ABSTRACT

End-use electrification has been identified as one of the most promising strategies for decarbonizing the building sector. While there is significant growth of distributed solar photovoltaics (PV), heat pumps and electric vehicles (EV) in many countries, the majority of this trend has been driven by high-income households, often owners of single-family homes. Further diffusion of clean energy technologies in buildings depends on addressing additional market segments, such as tenants who represent a large part of the population. We conducted a choice experiment with $N = 1'005$ Swiss tenants to investigate their preference for clean energy features when choosing an apartment. Inspired by the Theory-of-Planned-Behaviour, we tested the influence of Perceived Behavioral Control and Social Norms on respondents' preferences. We find that tenants express a positive willingness-to-pay for well-insulated apartments, and strongly prefer heat pumps over fossil heating. Furthermore, adding rooftop solar PV increases tenants' likelihood to choose an apartment, while an EV-charging-station is only preferred in combination with solar PV. 55.7% of tenants would also be willing to co-invest in rooftop PV. Our findings have important policy implications: Active involvement of tenants could be a key element of a just energy transition and opens opportunities for innovative business models.

1. Introduction

Decarbonizing the building sector is a key concern for energy policy (Leibowicz et al., 2018). This involves increased levels of energy efficiency through better insulation, but also the deployment of decentralized renewable energy sources for heating and power generation, such as heat pumps and solar photovoltaics. Sector coupling (Ramsebner et al., 2021) also involves the emergence of electric mobility as an important piece in the decarbonization puzzle. The co-adoption of building-related clean energy technologies can accelerate the trend towards smart end-use electrification, which is widely seen as a promising strategy to combat climate change (Jacobson, 2020; IRENA, 2022). And in fact, progress is being made on several fronts: Nine out of ten new cars in Norway are electric,¹ heat pumps are becoming increasingly popular in many European countries (Côté and Pons-Seres de Brauer, 2023) and global investment in solar PV is growing at unprecedented levels (IEA, 2024). One caveat in recent clean energy adoption trends,

however, lies in its unequal distribution among income groups. Investing in new technology requires sufficient financial means and can therefore be a challenge for low-to middle-income households. Furthermore, while owners of single-family houses have the power to decide on clean energy adoption, many people live in rental housing, where incentives for investment are split between landlords and tenants. To achieve a just and inclusive energy transition (Evans and Phelan, 2016; McCauley and Heffron, 2018), finding solutions to bring clean energy to the rental housing market, including low- and middle-income households, is key.

New business models have emerged to address these target groups.² Many energy providers are now offering green electricity (Hartmann and Apaolaza-Ibáñez, 2012; Tabi et al., 2014; Menges and Beyer, 2017) and some have also set a green tariff as the default option (Pichert and Katsikopoulos, 2008; Chassot et al., 2017). Furthermore, crowdfunding platforms, cooperatives and energy communities that are open to co-financing by several investors have been initiated all over Europe

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¹ <https://alternative-fuels-observatory.ec.europa.eu/general-information/news/norwegian-ev-market-surges-915-market-share-setting-sustainable-example>.

² Emerging solutions also include AI-related peer-to-peer trading for property owners with the goal of reducing electricity bills (Gunarathna et al., 2022; Khayyat and Slama, 2024). These business models could be adapted to suit tenants' needs.

(Salm et al., 2016; Bauwens et al., 2016; Reis et al., 2021; Kubli and Puranik, 2023).³ These options allow homeowners and tenants equal access to renewable electricity or monetary rewards. However, when it comes to heating systems or an energy-efficient renovation of the building structure, the influence of tenants is limited. If, on the other hand, tenants would increasingly consider energy-related features in choosing an apartment, this could indirectly drive landlords' investment decisions and thus contribute to decarbonization goals.

The aim of the present paper is to investigate the influence of clean energy-related features of rental buildings on tenants' likelihood to choose an apartment, as well as their willingness to pay (WTP) for such features. To do so, we conducted a large-scale survey of tenants in Switzerland (N = 1005), combining a choice experiment with a randomized informational treatment.

The remaining manuscript is structured as follows: Section 2 explores recent literature and establishes the study's underlying conceptual framework. Section 3 is dedicated to data and methods, whereas results of our empirical analysis are discussed in Section 4. Section 5 concludes the paper with policy implications and suggestions for further research.

2. Literature review and conceptual framework

2.1. Bringing the energy transition to the rental housing market

The decarbonization of buildings through energy retrofits is an integral part of reaching NetZero goals globally. In Europe, buildings, including residential and non-residential, make up one third of carbon emissions (Santamouris and Vasilakopoulou, 2021). Policies that target homeowners have been put in place, incentivizing investments in solar panels, heat pumps, battery storage and energy efficiency upgrades. However, in the context of the rental housing market, split incentives between landlords and tenants are a key challenge. The concept of split incentives is based on principal-agent theory (Åstmarsson et al., 2013; Ambrose, 2015), highlighting a misalignment of interests between tenants, who can save money from energy efficiency investments, and landlords, who might be reluctant to spend larger amounts on renovating the building due to an uncertain return on investment. If an investment is then made, these costs are typically passed on to the tenants through a rent increase, putting an additional financial strain on them.

The determinants that make consumers invest in energy efficiency have been investigated in a diverse set of studies. Partially, studies focus on the potential of installing energy-saving appliances in rental housing (Im et al., 2017), but also the willingness of landlords to invest in renovation (Hope and Booth, 2014). Just like in the case of investing in renewables, split incentives and risk-aversion (Farsi, 2010) are a key barrier to home improvements, while savings on energy (Havas et al., 2015), improved comfort and a "good feeling" are amongst the motivations to engage. It is noteworthy that research has found different results on tenants' willingness to pay for energy efficiency, in some cases measuring a rather small WTP or none at all (Banfi et al., 2008; Gabe and Rehm, 2014; März et al., 2022). Suggestions for solutions include mandatory building efficiency standards, tax incentives, but also investments in energy appliances in return for increased rent (Carroll et al., 2016; Wrigley and Crawford, 2017).

H1. Tenants are willing to pay for energy efficiency

When buildings get renovated, a change of heating system can have a substantial impact on tenants' energy bills. Streimikiene and Balezentis (2020) showed that high heating costs can be a driver to financially support a change of heating system. In a different approach, Lang and Lanz (2021) posed the question how information about an investment affects the willingness to pay for a more energy efficient heating system. They found that WTP increases with the information of energy bill

savings, while information on energy price volatility decreases the acceptance of a higher rent. A choice experiment surveying French homeowners and renters showed further that both household types express a distinct preference for renewable energy heating systems (heat pumps and wood) and are willing to pay more for it than natural gas or direct electric heating, when a replacement of the heating system is needed (Stolyarova et al., 2015).

When looking at subsidies to support the change of heating systems, a scenario study by Zwickl-Bernhard et al. (2022) showed that tenants should be considered as the receivers of subsidies to ease high spendings for the initial investment phase.

H2. Tenants are willing to pay for renewable heating (HP)

An abundance of studies investigated homeowners' willingness to pay for solar panels. While environmental attitudes or knowledge about the technology do not necessarily increase the likelihood of an uptake, the engagement in environmental organisations or higher education increase the propensity to invest (Ameli and Brandt, 2015; Mills and Schleich, 2012; Sardanou and Genoudi, 2013).

When it comes to rental apartments, existing literature does not yet paint a clear picture. Hammerle et al. (2023) analysed investor perspectives for solar for renters and found that property investors do not believe that tenants will accept higher rents for solar. Because of the landlord-tenant dilemma, property owners perceive the risk of not receiving an adequate profit from their investment as too high. In a prior study, Best et al. (2021) found that Australian renters pay more for energy if their housing has solar panels installed, suggesting that this cost increase needs to be considered in policy making. Domenig et al. (2024) find that if solar energy is used for collective self-consumption in multi-family apartments, both landlords and tenants can benefit, and hence a supportive policy framework can help overcome the split-incentives dilemma.

A study by Cook and Bird (2018) looked at the potential of solar communities and PV-installations for homeowners, but also low-to middle income tenants in the United States. The identified barriers included high up-front costs and the long-term nature of the investment. Suggestions for policy interventions included on-bill financing, loans, direct cash or tax incentives, but also crowdfunding (Cook and Bird, 2018, p. 27). The study further emphasized the role of multi-family building owners in the uptake of solar installations on rental buildings through capital refinancing or third-party leasing.

In addition to financial barriers, households oftentimes do not possess the adequate knowledge on their energy consumption or investments, thus an informed decision-making process cannot be expected. With a high loss- and risk-aversion towards investments with high initial costs (Mills and Schleich, 2012; Farsi, 2010), and no adequate options to access renewables in rental apartments, the barriers for tenants to engage in the energy transition are high.

One solution to circumvent these adoption barriers for renewables, without owning a home, are energy communities. These communities have sprung up all over the world to either secure energy supply or as a work-around to slow government policies (Bauwens, 2016; Bomberg and McEwen, 2012; Ebers Broughel and Hampl, 2018; Lowitzsch, 2019; Ruggiero et al., 2014; Van der Schoor et al., 2016; Yildiz, 2014). The most widely known energy communities are solar communities (Caramizaru et al., 2020). Here, investors either receive a monetary return on investment or they are directly remunerated with solar energy. The wide-spread adoption of these solar communities can thus be an indicator that there is a certain customer segment that is willing to invest

³ <https://www.rescoop.eu>.

in solar energy.⁴ This leads to the third hypothesis, namely:

H3. Tenants are willing to pay for PV

Electric mobility is an important player in the decarbonization of transport, but has mostly been driven by wealthy homeowners so far. A key bottleneck for tenants is access to charging infrastructure (Lopez-Behar et al., 2019). Homeowners can easily decide on the installation of charging infrastructure and might only face the installation costs as a barrier. Tenants on the other hand, are once again dependent on their landlord's willingness to invest in such features (Davis, 2019). In a field survey with potential EV buyers, Ramsebner et al. (2023) suggest that providing charging stations is an important factor when looking for an apartment and trying to change to an EV.

With regards to the willingness to pay for EV charging facilities, several studies found that tenants of office buildings are willing to pay a premium for charging stations (Freybote, 2023; Robinson et al., 2017). As more households adopt EVs, the combination of charging stations at home and at the office will be crucial to balance the electricity grid, but also to offer flexibility to the customers.

The environmental footprint of electric vehicles crucially depends on the source of electricity (Chen and Ma, 2024). If combined with renewable energy, EVs have significantly lower life-cycle emissions than internal combustion engine vehicles. Powering EVs with solar power generated on one's own roof also offers lower cost (Gudmunds et al., 2020). Therefore, climate-conscious homeowners have been found to increasingly co-adopt EVs and PV (Gahrens et al., 2021; Liang et al., 2022; Chakraborty et al., 2023; Hajhashemi et al., 2024; Sharda et al., 2024; Cha et al., 2024). While tenants are widely seen as the next frontier in EV adoption (Davis, 2019), little is known so far about their preferences for co-adoption, leading us to test a fourth hypothesis:

H4. Tenants are willing to pay for EV charging

2.2. Theory of planned behaviour

The Theory of Planned Behaviour is a useful framework to explore the drivers of human behaviour (Ajzen, 1985, 1987, 1991). The theory explains how behaviour is influenced by different determinants, namely an individual's intentions, attitudes, perceived behavioural control (PBC) and subjective (social) norms (Fig. 1). Attitudes are a reflection of a positive or negative evaluation of the final behaviour. With regards to the present study, the tenants' willingness to pay for energy efficiency, renewable heating, solar panels and EV charging is therefore determined by the individuals' positive or negative attitudes towards new technologies and an understanding of the advantages of energy efficiency (see hypotheses H1 to H4 above).

Subjective norms reflect societal pressures to perform in a certain way. They have been shown to be an influential component in explaining homeowners' adoption of solar panels (Baranzini et al., 2017; Bollinger and Gillingham, 2012; Sardianou and Genoudi, 2013). These norms can for example be built through the person's social environment, education, or their political affiliation. It has been shown that activating social norms, such as for example showing hotel guests information about their fellow guests' decision to reuse their towels, can increase the likelihood of pro-environmental consumer behaviour (Goldstein et al., 2008). In the present study, we were interested in finding out whether this effect would also occur in the context of clean energy features of rental housing, allowing us to test the following fifth hypothesis:

H5. Activating social norms increases tenants' likelihood to appreciate

⁴ In Switzerland, collective self-consumption communities (ZEV) have entered the market. Parties from one or more buildings join the community to produce and consume solar power. The electric utility can act as a service provider for billing purposes. <https://www.ewz.ch/en/business-customers/solar-energy/billing-solution/zev-self-consumption-association.html>.

clean energy features.

Lastly, perceived behavioural control (PBC) reflects whether an individual feels that actions underlie their control or that they possess the ability to exert a certain action. If individuals feel that they can choose what they want without restriction, and see that a different reality is possible, then they are more likely to perform a given behaviour. PBC has been widely shown to positively influence pro-environmental behaviours, including for example mobility choices or the decision to buy green electricity (Klößner, 2013; Litvine and Wüstenhagen, 2011; Nogueira et al., 2023). In this study, we wanted to find out whether this effect would also occur in the context of apartment choices, leading to the sixth hypothesis:

H6. Higher perceived behavioural control (PBC) increases tenants' likelihood to appreciate clean energy features.

Going one layer further, the three determinants are constructed by an individual's beliefs. These are beliefs about the consequences of the behaviour (influencing attitude), beliefs about what others would think of the behaviour (influencing subjective norms), and eventually, whether the person believes to possess the right resources sufficient to perform the said action (influencing PBC). It is worth noting that attitude, subjective norms and PBC additionally influence each other, which can make it difficult to clearly distinguish them.

3. Methods, data and sample

To investigate tenants' preferences for specific attributes of building-related clean energy innovation and to assess whether improving perceived behavioral control and activating social norms has an influence on their housing choice, we combined a choice experiment with a randomized informational treatment.

3.1. Sample

The final sample consists of $N = 1005$ tenants from the French and German-speaking parts of Switzerland (see Appendix, Table A1). Data was collected in July and August 2024. The stratified sample is largely representative of the Swiss population in terms of age, gender and income. Respondents were drawn from an online consumer sample of a professional market research agency. On average, it took respondents 22 min to complete the survey. The survey was only accessible to people who indicated that they rent an apartment or house, as homeowners were outside our scope. We also eliminated respondents who failed to correctly pass one of three attention checks ($N = 434$), as well as speeders taking less than 5 min to complete the survey and who provided implausible responses ($N = 150$).

3.2. Choice experiment

At the heart of our empirical survey is a choice experiment, in which respondents are asked to choose between hypothetical rental apartments. Choice experiments are a common research method in marketing and are also frequently used in energy and environmental economics (Hanley et al., 1998; Poortinga et al., 2003; Bergmann et al., 2006; Yoo et al., 2008; Chau et al., 2010; Heinze and Wüstenhagen, 2012; Michaud et al., 2013; Vuichard et al., 2022; Côté and Pons-Seres de Brauwier, 2023; Petrovich and Kubli, 2023) to elicit people's preferences when choosing between different alternatives. Also called choice-based conjoint analysis, the method is based on utility theory which states that consumers will choose the option that maximises their utility, which can in turn be expressed as the sum of part-worth utilities for different attribute levels (Lancaster, 1966; McFadden, 1974). The method's popularity in consumer research can be explained by the fact that it circumvents the social desirability bias of other stated preference methods.

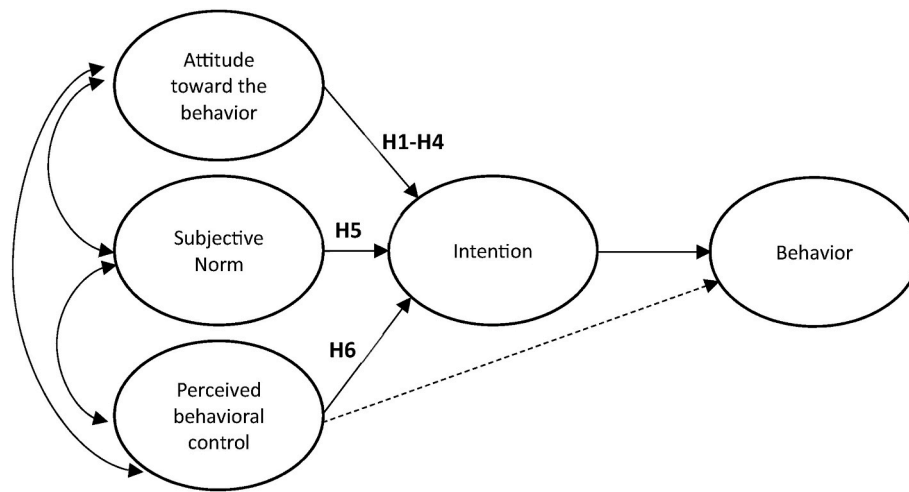


Fig. 1. Theory of planned behaviour (Ajzen, 1991) and hypotheses of this study.

Table 1
Attributes and levels in the choice experiment.

Attributes	Explanation	Levels
<i>Insulation</i>	How well is the apartment insulated?	(1) Very well (the temperature is just right at any time of year) (2) Well (the temperature is usually pleasant) (3) Poor (it is often too hot in summer, often too cold in winter) (4) Very poor (it is far too hot in summer, far too cold in winter)
<i>Heating system</i>	Which heating system does the apartment have?	(1) Heat pump (2) Electric heating (3) Gas (4) Oil
<i>Additional equipment</i>	Which additional equipment does the apartment have?	(1) Solar panels (2) EV charger (3) Solar panels and EV charger (4) E-bike charging point
<i>Monthly net rent</i>	How high is the rent?	(1) 10 CHF/m ² (2) 15 CHF/m ² (3) 20 CHF/m ² (4) 25 CHF/m ²

We used Sawtooth Software's Choice-Based Conjoint (CBC HB)⁵ package to design the choice experiment. Table 1 shows the four attributes with four levels each that were used to describe potential apartments. Respondents were presented with ten consecutive choice tasks, where they had to choose between three choice sets each. Choice tasks were randomized across participants, with each respondent seeing a unique choice set combination and each level shown a roughly equal number of times. Part-worth utilities were calculated using Hierarchical Bayes estimation, which combines individual-level and population-level data to measure respondents' preferences.

The attributes and levels were chosen to reflect realistic options on the Swiss rental housing market, while forcing respondents to make trade-offs between desirable and less desirable features (Table 1).

- The first attribute *insulation* aimed at understanding participants' preference for varying levels of energy efficiency of the building. Rather than confronting respondents with indicators that may be too

technical to be widely understood (such as liters of oil equivalent per square meter) or do not widely apply in Switzerland (such as the EU's energy performance rating⁶), we offered a qualitative description comprising four levels from "very poor" to "very good". In the table introducing the attributes and levels, we explained in simple terms how this corresponds to thermal comfort – where a building with "very good" insulation offers a pleasant indoor temperature throughout the seasons, while a building with "very poor" insulation heats up too much in the summer and feels uncomfortably cold in the winter.

- The second attribute *heating system* allowed the respondents to choose between living in a building characterized by fossil versus renewable heating systems. In the Swiss housing market, two thirds of households still heat with oil and gas, while heat pumps as a more climate-friendly option are the third-common heating system.⁷ We chose direct electric heating as the fourth level of this attribute, which is a less energy efficient option than heat pumps but still prevalent in 8% of the buildings.
- The third attribute *additional equipment* was chosen to reflect the emerging trend towards integrating clean energy features such as solar panels, charging points for electric cars, the combination of the two, as well as the possibility to charge one's e-bike. While those features are already very popular among owners of single-family houses, their diffusion in the rental market is still in its early stages. By including this attribute in our choice experiment, we can gain insights into tenants' appreciation of those features.
- The fourth attribute *net monthly rent* forces respondents to trade off any desirable features described in the other three attributes against the price of an apartment and will hence allow to express the relative preference for those attributes as a willingness-to-pay. In defining the levels, we decided to express them in terms of Swiss Francs per square meter to make sure the experiment works for respondents holding heterogeneous preferences in terms of apartment sizes. In the initial table of attributes and levels, we presented an example of how to convert this into the more common information of rent per month for an average apartment.

⁶ https://energy-efficient-products.ec.europa.eu/ecodesign-and-energy-label/understanding-energy-label_en.

⁷ 19% of Swiss buildings are equipped with heat pumps, however they are still more common in single-family houses (23%) than multi-family houses (12%), see <https://www.bfs.admin.ch/bfs/en/home/statistics/catalogues-data/bases.assetdetail.27905545.html>.

⁵ <https://sawtoothsoftware.com/advanced-analytical-tools/cbc-hierarchical-bayes>.

3.3. Experimental treatment

In addition to the choice experiment, we conducted a randomized informational treatment, dividing respondents into one control group (N = 333) and two treatment groups (N = 336 each). The first treatment aimed at testing the effect of activating social norms, in particular on the importance of clean-energy related features when choosing a new rental apartment. For this purpose, we first asked respondents to indicate in which of the 26 Swiss cantons they reside. In a next step, we provided an infographic that offered information about the result of a recent popular vote on a law that was designed to accelerate the deployment of renewable energies in Switzerland. In the June 9, 2024 national vote, the law had been accepted by a large majority of the population across Switzerland.⁸ By making this result salient, and additionally tailoring the information treatment to the relevant local circumstances by highlighting the result of the vote in the respondent's specific canton of residence (Fig. 2), we aimed at activating the social norm that renewable energy was widely supported.⁹

The second treatment aimed at increasing perceived behavioral control. There is a rich stream of literature about the landlord-tenant dilemma, basically stating that it is hard for tenants to influence energy-related decisions in rental buildings (Ástmarsson et al., 2013; Ambrose, 2015). These may lead tenants to perceive a lack of behavioral control, which could be an obstacle to getting actively involved in the energy transition. To counter this perception and increase perceived behavioral control, we presented respondents with an information treatment that explained the possibility to install shared solar PV on rooftops of multi-family residential houses. The description was based on a real example in Eastern Switzerland, which was presented on the website of a regional energy agency as a best practice example for using renewables in rental housing.¹⁰ The text explained how tenants could directly benefit from the shared solar installation by consuming locally produced renewable energy and saving on their electricity bill (see Fig. 3).

For both experimental treatments, we urged respondents to carefully read the information. In a follow-up question, we verified respondents' understanding. For respondents unable to answer the follow-up question, the survey was terminated.

3.4. Other variables

In the remaining parts of the questionnaire, we collected socio-demographic data and asked questions about attitudes, beliefs and knowledge on a range of energy- and climate-related issues. We also asked to what extent respondents would be willing to co-invest in a solar installation on the roof of their rental apartment building, using a five-point Likert scale. Furthermore, we posed questions related to respondents' political orientation and voting behaviour.

4. Results and discussion

In the next section, we will present the results of our empirical analysis in accordance with the hypotheses outlined above. First, section 4.1. examines the choice experiments' attribute importances and part-worth utilities of the attribute levels of the country-sample. This section represents hypotheses 1-4. Section 4.2. will explore the specificities of the treatments employed in the survey to test hypotheses 5 and 6. Finally, section 4.3 presents the results of an explorative analysis of the

influence of income and political orientation on tenants' preferences for clean energy features of buildings.

4.1. Choice experiment: attribute importances and part-worth utilities

Overall, the HB model had an average Root Likelihood (RLH) of 0.64, which indicates a good model fit.

4.1.1. Insulation

The attribute insulation was the most important of the four attributes (41.34%) included in the choice experiment (see Table 2 & Fig. 4). The effect is in the expected direction: tenants would prefer apartments with better insulation, even when they have to trade off this desired feature against sacrifices on other levels, such as a higher rent. While this is a rather obvious result, it must be noted that in the long-run, insulation will not only be important to save money on energy bills, but also be needed to stay cool in hot summers. As people increasingly feel the impact of hot weather during the summer months, tenants might increasingly choose flats that can provide a comfortable room temperature throughout the year.

4.1.2. Heating system

As for the attribute heating systems, which was the third-most important attribute (18.99%), respondents showed a clear preference for heat pumps. While heat pumps constitute only 18.5% of the heating stock in existing Swiss buildings,¹¹ their share has strongly increased in recent years: In 2023, 88% of the newly installed heating systems were using heat pumps and other sources renewable energy, compared to only 50% five years earlier.¹² As such, the technology is enjoying widespread familiarity in Switzerland. In contrast, fossil fuel heating systems show negative utility: gas is the second-least preferred, oil the least preferred level of this attribute. This is a clear indicator that the population is ready for new technology systems and may also reflect the success of government-funded awareness campaigns to promote renewable heating.¹³

4.1.3. Additional equipment

The attribute additional equipment was the least important attribute in the choice experiment, but still had an importance of 13.99%. Within the attribute, the most preferred level was the combination of having solar panels and an EV-charging station. Solar PV was the second most preferred, followed by the standalone EV-charging station and the e-bike charging option. Compared to the other attributes, these new clean energy features currently seem to play a less important role in explaining apartment choices. However, the positive result for solar and EV-charging indicates an openness and interest in these technologies among tenants. E-bike charging options create comparatively less excitement among tenants. While the market for e-bikes is booming and almost half of all newly sold bicycles in Switzerland are electric,¹⁴ tenants seem to take charging options for granted.

4.1.4. Net monthly rent

This attribute was the second most important attribute (26.32%). The effect is in the expected direction, a higher rent decreases the utility of an apartment. In the light of a tight housing market in Switzerland, tenants usually do not have much leverage when choosing their apartments and rent can be a decisive factor. Especially middle-to-low-income households are in competition with wealthier households to

⁸ <https://www.bk.admin.ch/ch/d/pore/va/20240609/can670.html>.

⁹ On average, a Swiss four-person household consumes 4500 kWh per year which corresponds to the electricity generated by 30m2 of solar panels. <https://www.iwb.ch/klimadreh/ratgeber/solaranlage/wie-viel-flaeche-benoetigt-t-meine-solaranlage>.

¹⁰ <https://energieagentur-sg.ch/referenzprojekt?referenzId=24>.

¹¹ <https://www.bfs.admin.ch/bfs/en/home/statistics/construction-housing/buildings/energy-sector.html>.

¹² <https://energiehub-gebaeude.ch/statistiken/>.

¹³ <https://erneuerbarheizen.ch>.

¹⁴ https://www.velosuisse.ch/wp-content/uploads/2024/03/Fahrrad-Neuve-rkaufe_2023.pdf.

Bitte lesen Sie diesen Text aufmerksam durch. Er ist für die Beantwortung der nachfolgenden Fragen **sehr wichtig**.

Wussten Sie schon...?

Die Versorgung der Schweiz mit einheimischen, erneuerbaren Energien erfreut sich grosser Zustimmung in der Bevölkerung. Auch in Ihrem Wohnkanton hat sich eine Mehrheit der Stimmbürgerinnen und Stimmbürger dafür ausgesprochen.

In der Volksabstimmung vom 9. Juni 2024 wurde das Bundesgesetz über eine sichere Stromversorgung mit erneuerbaren Energien im **Kanton Bern mit 70.83%** angenommen.



Quelle Abbildung: <https://www.admin.ch/gov/de/start/dokumentation/abstimmungen/20240609/bundesgesetz-ueber-eine-sichere-stromversorgung-mit-erneuerbaren-energien.html>

Fig. 2. Sample of information treatment to activate social norms. Translation in Appendix.

secure decent quality housing. This should be taken into account when interpreting the findings of our analysis. While respondents express preferences for clean energy features and better insulation, investments in new technologies usually come with an increase in monthly rent to make it profitable for landlords. While these rent increases are capped by law,¹⁵ they can pose a significant burden on tenants and sometimes force them to look for a cheaper apartment. It is therefore vital to ensure that the renovation of buildings pays attention to possible consequences for households.

The results of the choice experiment can be used to derive respondent's willingness-to-pay (WTP) for clean energy features, and thus

to test [hypotheses 1-4](#) (Fig. 5). To calculate WTP, we determined a monetary value for each utility point by dividing the difference between the highest and the lowest part-worth utility for the price attribute by the difference between the highest and the lowest level of the same attribute (Sammer and Wüstenhagen, 2006; Côté and Pons-Seres de Brauwer, 2023).¹⁶ As can be seen from Fig. 5, tenants' highest willingness-to-pay is linked to improving energy efficiency. This is particularly pronounced for substantial renovations: Moving, for example, from poor to good insulation would make tenants in our sample pay almost 21 CHF more per square meter and month, providing support for hypothesis 1. By comparison, a further improvement from

¹⁵ <https://renovabene.ch/fr/quels-couts-les-bailleurs-peuvent-ils-repercuter-sur-les-loyers-apres-un-assainissement/>.

¹⁶ cf. also <https://sawtoothsoftware.com/help/lighthouse-studio/manual/understanding-willingness-to-pay.html>.

Bitte lesen Sie diesen Text aufmerksam durch. Er ist für die Beantwortung der nachfolgenden Fragen **sehr wichtig**.

Wussten Sie schon...?

Auch Mieterinnen und Mieter können mitmachen, wenn es um die Nutzung erneuerbarer Energien geht. Am Beispiel dieses Mehrfamilienhauses in der Ostschweiz zeigen wir Ihnen, wie das funktioniert.



Sonnenstrom vom eigenen Dach

Die Solaranlage auf dem Dach dieses Mehrfamilienhauses erzeugt pro Jahr **83'300 Kilowattstunden** Strom. Das entspricht dem durchschnittlichen Stromverbrauch von etwa **18 Haushalten**.

Die Mieterinnen und Mieter können den Strom, der auf dem Dach produziert wird, direkt vor Ort konsumieren. Dafür bekommen Sie eine **Gutschrift auf Ihrer Stromrechnung**.

Wenn die Anlage gerade keinen Strom produziert (z.B. am Abend), beziehen die Mieterinnen und Mieter wie bis anhin Strom vom lokalen Elektrizitätswerk.

Die Solaranlagen entsprechen den kantonalen Empfehlungen aus dem Leitfaden «Solaranlagen – vom Guten zum Besten».

Quelle: energieagentur-sg.ch

Fig. 3. Information treatment to increase perceived behavioral control. Translation in Appendix.

good to very good insulation is only valued by tenants at about 4 CHF per square meter and month.

When it comes to hypothesis 2, Fig. 5 shows that tenants exhibit a clear willingness-to-pay for renewable heating. The difference is most pronounced when moving from oil heating to a heat pump. All else being equal, an apartment with a heat pump could be offered at a price premium of 8.71 CHF per square meter and month to provide the same utility to the tenant. Moving from gas to heat pump would still justify a monthly difference of more than 7 CHF/m², which is in support of our second hypothesis.

Looking at further clean energy features in the building, we find support for hypothesis 3 when looking at willingness-to-pay for solar PV on rental buildings. Compared to a building that does not have solar PV but a charging option for e-bikes as the only additional clean energy feature, tenants express a willingness-to-pay of 5.70 CHF per square

meter and month. This only slightly increases to 5.98 CHF if EV charging is added, suggesting that there is only marginal support for hypothesis 4.

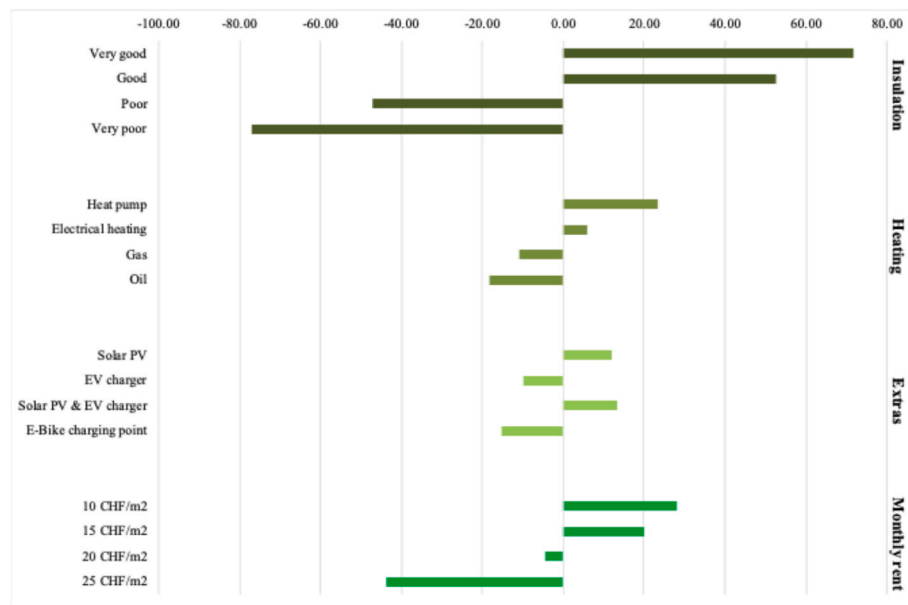
4.2. Experimental treatment

To test the effects of our experimental treatment, we explore peoples' response to the question "I am willing to co-invest in a solar PV installation on the roof of the rental building in which I live". On a five-point Likert scale from 1 (fully agree) to 5 (fully disagree), 55.7% of respondents in the overall sample said that they would fully agree (20.9%) or rather agree (34.8%). Table 1 shows how responses differ between the control group and the two experimental groups, demonstrating that especially increasing Perceived Behavioral Control (PBC) appears to have an effect on willingness to co-invest. While the share of respondents who say they fully agree is 19.6% in the control group, it

Table 2

Results of choice-based conjoint analysis (N = 1005).

Attributes	Levels	Average Zero Centered Utilities	Std. Deviation	Attribute Importance [%]
Insulation	Very good	71.63	45.52	41.34
	Good	52.62	33.58	
	Poor	-47.29	30.86	
	Very poor	-76.95	48.19	
Heating	Heat pump	23.32	33.95	18.99
	Electrical heating	6.05	26.37	
	Gas	-11.02	26.38	
	Oil	-18.35	31.06	
Extras	Solar PV	11.92	23.57	13.35
	EV charger	-9.79	20.89	
	Solar PV & EV charger	13.23	20.06	
	E-Bike charging point	-15.36	21.78	
Monthly rent	10 CHF/m2	28.11	47.54	26.32
	15 CHF/m2	20.10	22.66	
	20 CHF/m2	-4.57	26.40	
	25 CHF/m2	-43.64	41.27	

**Fig. 4.** Average part-worth utilities (N = 1005).

increases to 24.1% in the experimental group which received the informational treatment about a rooftop solar installation on a multi-family house. On the other end of the spectrum, the share of respondents who fully disagree with this statement, reflecting the lowest willingness to co-invest, decreases from 14.6% in the control group to only 8.9% in the PBC treatment group. As can be seen from Fig. 6, both experimental treatments increased willingness to co-invest, but only the effect in the Perceived Behavioural Control group is significant.

4.3. The effect of income and political orientation

When looking at the willingness to co-invest in solar panels across the different income levels of the respondents (Fig. 7), it becomes apparent that respondents with a higher income are more likely to state a willingness to invest. 73% of tenants in the highest income bracket and 72% of tenants in the second-highest income bracket agree or somewhat agree with the statement that they are willing to co-invest in solar panels, whereas this percentage is lower for respondents with lower income. But even in the lowest two income brackets, between 43 and 48% of respondents express a willingness to co-invest in solar panels on their rooftops (Fig. 7). This opens up new avenues for policymakers:

apart from building owners, also tenants could be promising target groups for incentivizing solar investment. If such incentives are tailored to the needs of different income classes, they can unlock contributions from both wealthy and less wealthy tenants. The spectrum of investors in renewables can be enlarged and thus the energy transition accelerated across all income levels, reaching a higher level of inclusion for the general population.

In another step of our empirical analysis, we explored the role of political orientation. Fig. 8 shows results of the choice experiment for two specific levels of the attribute “heating system”, namely oil vs. heat pumps, segmented by respondents’ stated identification with one of the six biggest political parties¹⁷ in Switzerland.¹⁸ Results show a

¹⁷ We focus on the six biggest parties because they represented 91.8% of the votes in the 2023 national parliamentary elections (<https://elezioni.admin.ch/en/ch/>). SP = Social Democratic Party, GLP = Green Liberal Party, Mitte = Center Party (formerly Christian Democrats), FDP = center-right liberal party, SVP = Swiss People’s Party.

¹⁸ Twelve respondents expressing a preference for another party and 273 respondents stating that none of the parties best represents their political views were excluded from this analysis.

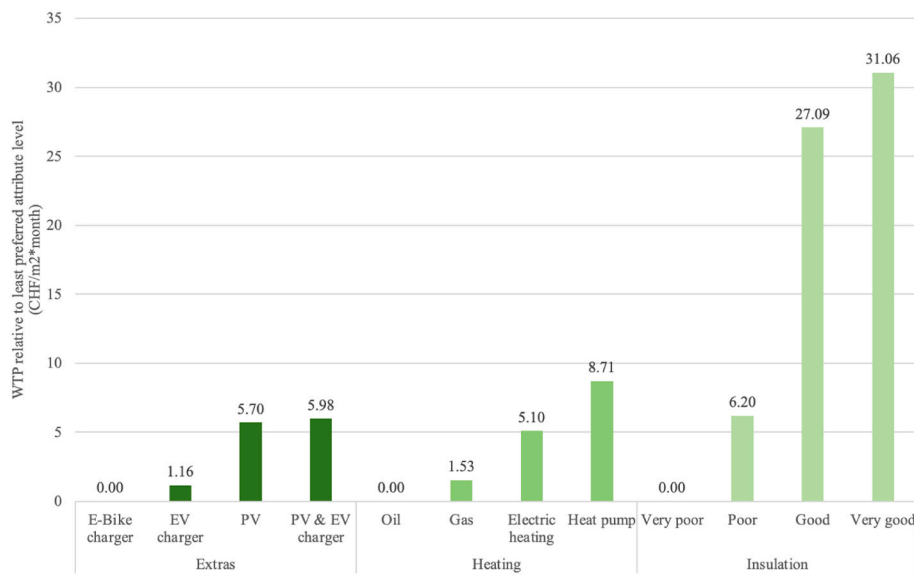


Fig. 5. Willingness-to-pay for clean energy features (N = 1005).

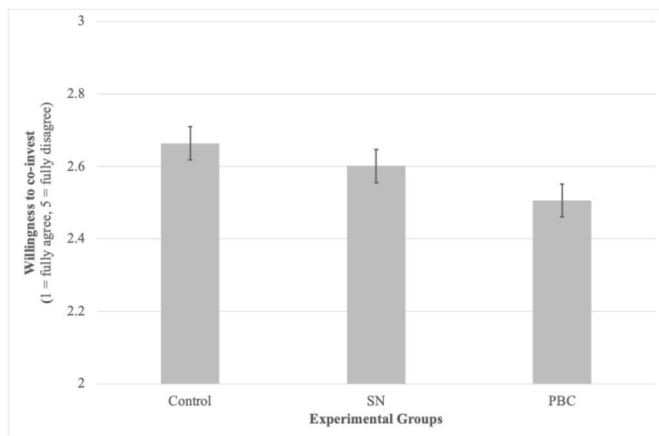


Fig. 6. Willingness to co-invest in solar PV across experimental groups (N = 1005).

consistently positive evaluation of heat pumps across the entire political spectrum. Negative evaluations of oil heatings are widespread, but fossil fuels appear to be relatively more politicized: there is a marked difference between strong opposition from left-party voters compared to a more mildly negative evaluation by liberal and conservative voters.

5. Conclusion and policy implications

This study investigated tenants' preferences on renewable and energy-efficient features of apartments. Surveying a sample of N = 1005 tenants in Switzerland, we have combined a choice experiment with a randomized informational treatment based on the theory of planned behaviour. Our empirical results show that tenants appreciate most of the building-related clean energy features, albeit to a different extent. The strongest preference is found for good insulation, which benefits tenants through lower heating costs and increased levels of thermal comfort. When it comes to heating systems, heat pumps are clearly preferred over fossil fuels, such as oil and gas as a heating source. The presence of solar panels on the roof of the apartment building increases tenants' likelihood to choose an apartment, also in combination with the possibility to charge their electric vehicle. Another way to interpret respondents' preferences is to state that tenants are willing to pay a higher

rent for an apartment if these features are available, which in turn opens up the opportunity to overcome the classical tenant-landlord dilemma – in fact, incentives appear to be less split than some of the prior literature may have suggested. For policy makers, the task is to find the right balance between allowing landlords to recover their energy-related investments while still keeping rents affordable for middle-to-low-income households. Especially at the lower end of the income spectrum, there is a trade-off between initial investments and the prospect of longer-term cost savings, which should be taken into account when designing inclusive policies that do not disproportionately affect less affluent tenants.

The results further show an openness to renewable technologies, thus indicating the possibility to proceed with the establishment of solar panels but also EV-charging points in multi-apartment buildings. More than half of respondents expressed an interest in co-investing in solar panels on the roof of the apartment building they are living in, and the experimental treatment showed that enhancing perceived behavioural control tends to strengthen that trend. Shifting attention to the customer segment of tenants will therefore allow to tap into further potential for accelerating the Net Zero transition of the building sector.

5.1. Policy implications

The implications for policy makers are the following. First, it is vital to grasp the power of an until now overlooked customer segment. Tenants make up two thirds of the Swiss population and their part on reaching the Net Zero targets in 2050 must not be overlooked. Policy makers, building planners and real estate agencies need to reflect on their leverage to provide adequate buildings that are fit for a future that needs to withstand the consequences of climate change.

We show that, all else being equal, tenants prefer good insulation, renewable heating, and solar PV. As of now, tenants often lack the information to influence the supply side in the right direction. Our findings therefore provide support for the idea of moving from voluntary¹⁹ to mandatory energy efficiency labels for buildings, that could help to overcome information asymmetries in the rental housing market. Transparent information about the energy-related features of rental buildings would allow tenants to make better choices – for the environment, but also for their purse. The effect of labelling could be further

¹⁹ As of now, a scheme that is similar to the EU's energy efficiency in buildings label, is voluntary in most of Switzerland's 26 cantons (www.geak.ch).

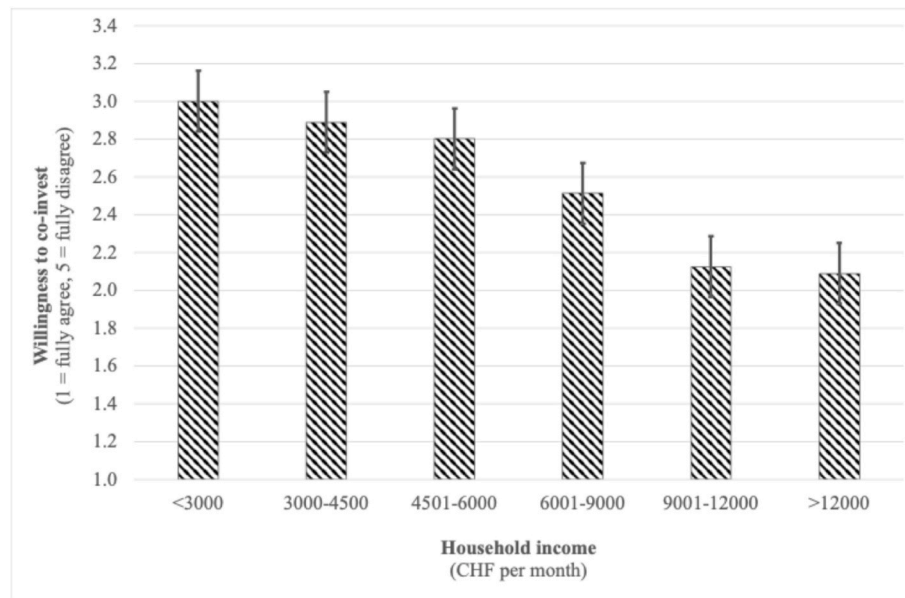


Fig. 7. Willingness to co-invest in solar panels by income groups (N = 1005).

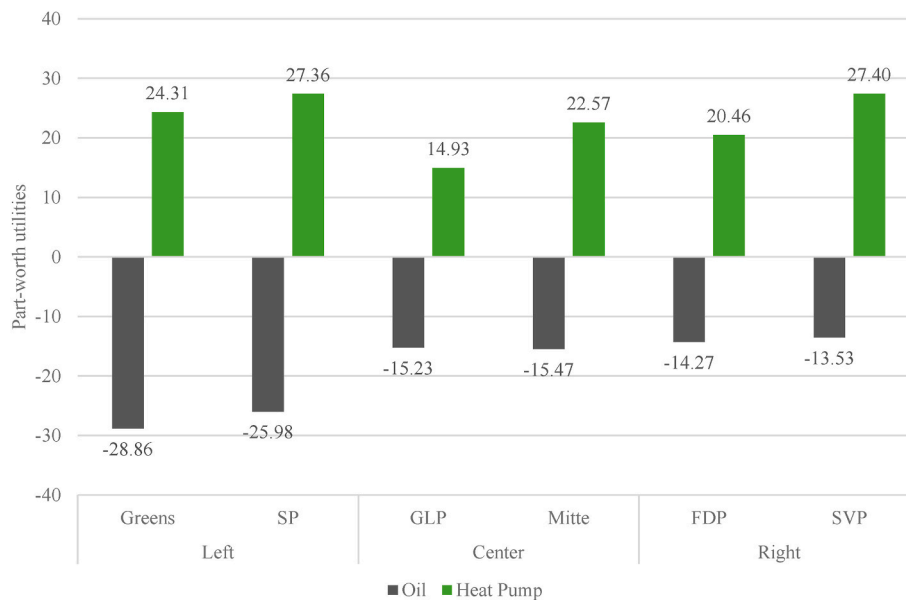


Fig. 8. Political orientation and preference for heating systems (N = 720).

enhanced if combined with dedicated targets for building renovation rates and/or financial supported schemes for clean energy investment.

Our results further show that the population prefers renewable heating in their buildings over fossil fuels. In Switzerland, several cantons are thinking about banning oil and gas heating but are concerned about the potential rejection of such policy proposals at the ballot. Policy makers can find some comfort in our data – *ceteris paribus*, tenants will prefer an apartment with renewable heating over one that still relies on fossil fuels. That said, perceived implications on rental prices could moderate this preference, and this is a factor that opponents of such regulation tend to emphasise in political campaigns.

Tenants show a high willingness to co-invest in solar panels on their roof-tops, making them a new and not-to-be-overlooked customer group. Giving them access to solar investments via monetary incentives can make the energy transition more inclusive, not only between tenants and owners, but also across income levels.

For policymakers seeking to promote the switch to electric mobility

in the rental housing market, our findings suggest that more work needs to be done to explain tenants the advantages of having these technologies integrated in their buildings. Offering incentives to combine EV chargers with rooftop solar installations might be a promising route and might also create benefits for grid integration of both technologies in the long run. However, it is important to note that installing EV charging facilities to rental housing is only one piece in the puzzle of decarbonizing transport. Especially for low- and medium-income households, the availability of affordable EV models will also be important, and the role of public transport should not be underestimated.

5.2. Limitations and further research

Our results are based on a large-scale survey involving a carefully crafted empirical design and data analysis. As any other piece of scholarly work, it is subject to limitations that can serve as starting points for further research.

The first point refers to the geographical focus of our study. Switzerland has a high share of tenants, making it a suitable context for studying their preferences for clean energy features of buildings, but it is also characterized by a high average income. While cost of living is also higher than elsewhere, further research could compare and contrast our findings with tenants' preferences in lower-income countries. Furthermore, the Swiss rental housing market is characterised by high levels of stability, with tenants staying an average of 8.5 years in their apartment²⁰ and a minimum notice period of at least three months. Further research could explore whether the preference for co-investing in clean energy features is equally pronounced in countries with higher turnover in the rental housing market. A cross-country analysis may also reveal differences in technology-specific preferences. For example, Swiss tenants in our sample had a clear preference for heat pumps relative to heating systems running on fossil fuels. This may to some extent reflect the longstanding track record of the Swiss heat pump industry, as well as a high awareness about climate change resulting from repeated popular votes on the issue in Switzerland's direct democracy. Replicating our study in countries with lower climate awareness or less familiarity with heat pumps could lead to different results. An interesting case in point could be a comparison with Germany, which has experienced a controversial media debate around heat pumps in the summer of 2023 in the context of a new heating law, and where consequently consumer confidence in the technology took a hit.²¹

Another limitation refers to our methodological choices. We conducted a cross-sectional analysis of stated preferences, which is an efficient way of collecting information about a large sample of the population. Future research could follow changes over time by adopting a longitudinal design, which would allow to capture some of the dynamics of social acceptance of renewable energy adoption (Ellis et al., 2023). It would also be interesting, although methodologically demanding, to combine stated and revealed preferences, for example targeting tenants who have already adopted one of the clean energy technologies we investigated and assess their propensity to engage in further adoption (Loder, 2024). This might be particularly insightful at the intersection between solar energy and electric mobility, two technologies that could either both create challenges for grid integration or complement each other.

A third point refers to our finding regarding tenants' preferences for

insulation. In describing the levels of this attribute, we have emphasized the comfort implications of poor insulation. Apart from improving thermal comfort, better insulation also lowers energy bills. Further research could test whether emphasizing the financial benefits of well-insulated apartments would result in an even stronger preference for good insulation.

Finally, while prior research has focused more on landlord's preferences and we believe our complementary focus on tenants has provided important new insights, it would be particularly interesting to bring both perspectives together. This could be done by either doing matched samples of landlords and their tenants in future quantitative surveys, or by extending the methodological focus to a more qualitative research design, for example by doing focus groups where tenants and landlords – and possibly further stakeholders – jointly discuss questions of accelerating the energy transition in the rental housing market.

CRedit authorship contribution statement

Katharina Reidl: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rolf Wüstenhagen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

The authors would like to thank Hans Auer and the team at the Chair for Management of Renewable Energies for helpful feedback on an earlier draft of this manuscript and Dean Tindall and Diogo Alves at Sawtooth Software Inc. for methodological advice. All remaining errors are our own.

Appendix A. Sample characteristics

Table A1 Sample characteristics

Switzerland					
Variable	Category	Overall Population	Sample (N = 1005)	German (N = 696)	French (N = 309)
Gender ^a	Male	49.6%	49.9% (501)	50%	49.5%
	Female	50.4%	50.0% (502)	49.7%	50.5%
	Diverse	N/A	0.2% (2)	0.3%	0%
Age ^b	18–29	16.5%	21.4%	25.3%	12.6%
	30–44	26.2%	32.1%	35.2%	25.2%
	45–59	26.1%	29.6%	26.4%	36.6%
	60+	31.2%	16.9%	13.1%	25.6%
Language Region ^c	German	61.8%	69.3%	–	–
	French	22.8%	30.7%	–	–

^a <https://www.bfs.admin.ch/bfs/en/home/statistics/population/effectif-change/sex.html>.

^b <https://www.bfs.admin.ch/bfs/en/home/statistics/population/effectif-change/age.html>.

^c <https://www.bfs.admin.ch/bfs/en/home/statistics/population/languages-religions/languages.html>.

²⁰ https://realestate.nzz.ch/de/newsletter/news_november24_fokusbeitrag_wohnungsmarkt.

²¹ <https://www.cleanenergywire.org/news/germanys-transition-clean-heating-risk-heat-pump-sales-collapse-industry-warns>.

Appendix B Translation of treatments

Treatment 1

Please read this text carefully. It is very important for answering the following questions.

Did you already know ... ?

The supply of Switzerland with domestic, renewable energies enjoys great support among the population. A majority of voters in your canton of residence have also spoken out in favour of it. In the referendum on June 9, 2024, the Federal Act on a Secure Electricity Supply with Renewable Energies was approved by 72.17% in the canton of Zurich.

Treatment 2

Please read this text carefully. It is very important for answering the following questions.

Did you already know ... ?

Tenants can also get involved when it comes to using renewable energy. Using the example of this multi-apartment building in eastern Switzerland, we will show you how it works.

Solar power from your own roof.

The solar installation on the roof of this apartment block generates 83,300 kWh of electricity per year. This corresponds to the average electricity consumption of around 18 households. The tenants can consume the electricity produced on the roof directly on site. In return, they receive a credit note on their electricity bill. When the system is not producing electricity (e.g. in the evening), tenants will continue to receive electricity from the local power station. The solar systems comply with the cantonal recommendations from the 'Solar systems - from good to best' guide.

Source: energieagentur-sg.ch.

Appendix C

Table C-1: Willingness to co-invest in solar PV across experimental groups (N = 1005)

	Control (N=333)		Social Norms (N=336)		Perceived Behavioral Control (N=336)	
1 Fully agree	66	19.8%	63	18.8%	81	24.1%
2 Rather agree	115	34.5%	125	37.2%	110	32.7%
3 Neutral	66	19.8%	70	20.8%	69	20.5%
4 Rather disagree	37	11.1%	39	11.6%	46	13.7%
5 Fully disagree	49	14.7%	39	11.6%	30	8.9%
Mean	2.664		2.601		2.506	
Std. Err.	0.072		0.068		0.068	

Table C-2: Willingness to co-invest in solar PV by income groups (N = 1005)

	Income						
	<3000 CHF	3000-4500 CHF	4501-6000 CHF	6001-9000 CHF	9001-12000 CHF	>12000 CHF	prefer not to say
1 Fully agree	14 12.7%	22 14.4%	21 13.4%	40 18.2%	62 31.0%	43 42.6%	8 12.5%
2 Rather agree	33 30.0%	52 34.0%	54 34.4%	88 40.0%	82 41.0%	30 29.7%	11 17.2%
3 Neutral	23 20.9%	28 18.3%	36 22.9%	49 22.3%	34 17.0%	13 12.9%	22 34.4%
4 Rather disagree	19 17.3%	23 15.0%	27 17.2%	25 11.4%	13 6.5%	6 5.9%	9 14.1%
5 Fully disagree	21 19.1%	28 18.3%	19 12.1%	18 8.2%	9 4.5%	9 8.9%	14 21.9%
Subtotal	110 100.0%	153 100.0%	157 100.0%	220 100.0%	200 100.0%	101 100.0%	64 100.0%
Mean	3.00	2.89	2.80	2.51	2.13	2.09	3.16
Std. Err.	0.127	0.108	0.098	0.078	0.075	0.126	0.162

Data availability

Data will be made available on request.

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