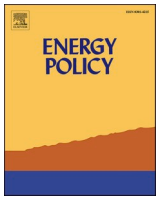
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Preferences of homeowners for heat-pump leasing: Evidence from a choice experiment in France, Germany, and Switzerland

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ABSTRACT

While heat pumps are a promising solution for decarbonizing residential buildings, financial barriers often hinder their diffusion. Asset leasing – whereby service providers lease equipment and provide services in exchange for monthly payments – could help overcome some of the barriers to adoption. This study investigates homeowners' preferences for heat-pump leasing, examines their inclination to lease or purchase, and quantifies their willingness to pay for different services. Empirical insights are drawn from a discrete choice experiment conducted with 915 single-family house owners who undertook 9150 hypothetical leasing decisions in France, Germany, and Switzerland. Survey results show an interest in flexible, all-inclusive leasing offerings, especially in markets where heat pumps are at an early stage of diffusion. However, preferences for asset leasing differ between countries. German house owners are the most open to leasing and would on average be willing to pay up to three times more than their French counterparts to shield themselves against technical risk. Given the role asset leasing could play in decarbonizing residential heat and enhancing energy security, policy makers may wish to adapt policy incentives to account for these service-based offerings.

1. Introduction

Heat contributes to over 40% of global energy-related carbon dioxide emissions, and 46% of heat consumption occurs in buildings where supply relies heavily on fossil fuels (IEA, 2021a). Achieving the goal of net-zero emissions by 2050[1] requires considerable investment in low-carbon heating equipment for buildings. Heat pumps – devices that transfer thermal energy between spaces using electricity[2] – are a promising solution thanks to their low environmental impact, high energy-efficiency, and flexibility (Brockway and Delforge, 2018; Giambastiani et al., 2014; Howden-Chapman et al., 2009). To reach net zero, heat pumps would need to supply 20% of the global heat demand in buildings by 2030. This represents a sharp increase from the 7% observed today (IEA, 2021b). Beyond decarbonization, heat pumps have also recently garnered particular interest in Europe as a means of reducing dependence on oil and gas imports from Russia (European Commission, 2022; IEA, 2022). However, although the number of such installations has increased in the European Union (IEA, 2021c), only 6% of European residential buildings are heated using heat pumps (EHPA, 2021a).

Heat-pump adoption by homeowners is faced with several challenges – see Gaur et al. (2021). In particular, financial factors such as high investment costs are among the most important barriers (Pezzutto and Grilli, 2017). Access to sufficient capital at low cost is key for determining the economic viability of heat pumps. While extended mortgages may represent attractive financing solutions, many homeowners have limited borrowing capacity (Kelly et al., 2016). Given the important role heat pumps could play in the energy transition, several scholars have called for policy support or innovative financing solutions to increase their market uptake (Hlavinka et al., 2016; Karytsas, 2018; Raghavan et al., 2017).

Asset leasing – whereby a service provider leases an appliance (e.g., heat pump) and provides services to an end-user in exchange for monthly payments – has recently emerged as a solution to help

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[1] Several countries have pledged to achieve the net-zero emissions objective of balancing greenhouse gas emission production and removal from the atmosphere by mid-century in an effort to limit the rise in global temperature to well below 2 °C compared to pre-industrial levels, and preferably to a maximum 1.5 °C increase (UN, 2020).

[2] For example, devices that convert heat sources such as air, water, or ground to heat that can be used for space heating/cooling and hot water supply. Heat pumps powered by renewable electricity produce low-carbon heat. See EHPA (2023a) for details about the types of heat pumps and their functions.

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overcome the high acquisition costs of heat pumps (see Subsection 2.2). However, little is known about the preferences of homeowners for such offerings. Within this context, this study explores the suitability of asset leasing as a novel, service-based model to facilitate heat-pump adoption.

We do so by presenting insights derived from a discrete choice experiment (DCE) conducted with 915 single-family house owners who made a total of 9150 hypothetical heat-pump leasing decisions in France, Germany, and Switzerland. The objective was to clarify their preferences for leasing offerings, examine their inclination to lease or purchase, and quantify their willingness to pay (WTP) for different services. We also shed light on the drivers and barriers associated with household heat-pump adoption and leasing. We were particularly interested in these three countries because they exhibit interesting contrasts in terms of their level of reliance on oil and gas for residential heating, degree of heat-pump diffusion, and annual heat-pump unit sales. German homeowners are highly reliant on fossil-fuel-fired boilers compared to their French and Swiss counterparts. While Switzerland has the highest degree of heat-pump diffusion among the three countries, France and Germany recently emerged as the first and third leading European markets for heat pump sales (see Subsection 4.1.1 for details). Hence, our country selection enables us to compare and discuss implications of heating service provision across different market contexts.

To our knowledge, this study is the first to provide fined-grained empirical insight into house owners' preferences for different heat-pump leasing offerings in multiple countries. Specifically, our findings show that asset leasing could contribute to decarbonizing residential heat, especially in markets where heat pumps are at an early stage of diffusion (e.g., Germany). This is so, most prominently, due to the model's suitability in overcoming high acquisition costs and the simplification of maintenance and repair activities. Our results further reveal that offering flexible contracts (e.g., lease-to-own) is desirable as the length of leasing agreements is perceived as a major drawback. Since uncertainty about operational performance is of concern for German house owners, service providers could also consider offering a performance guarantee in addition to leasing services. Our findings contribute to the emerging academic research that investigates service-based business models for low-carbon heating. They are relevant for service providers as they shed light on best practices for the design of leasing offerings. Our insights could also serve as a basis for informing policy makers about policies that can enable the large-scale diffusion of heat pumps.

The remainder of this study is organized as follows: Section 2 reviews factors shaping heat-pump adoption decisions and introduces the concept of 'service-based business models'. Section 3 describes the methodological approach and choice experiment design. Section 4 presents and discusses results. Section 5 summarizes the main findings, discusses implications for industry actors and policy makers, and suggests avenues for future research.

2. Background

First, we review factors shaping households' decision-making for energy technology adoption, with a focus on heat pumps. Second, we introduce service-based business models to conceptually ground our empirical findings.

2.1. Drivers and barriers shaping household energy technology adoption

Substantial research has been devoted to examining the factors shaping households' decision-making for energy technologies, with studies diverging in terms of technological focus, geographical scope, and behavioural aspects (Karytsas, 2018; Kikuchi et al., 2009; Leurent et al., 2018; Mahapatra and Gustavsson, 2008). Factors can be categorised as individual and contextual – i.e., "household-internal" and "household-external," respectively.

Individual factors acting as barriers to energy technology adoption may include low-income levels (Stewart, 2022), low credit worthiness (Wolske, 2020), high levels of risk perception or risk aversion (Tanveer et al., 2021), and low levels of knowledge and familiarity with technologies (Irfan et al., 2021; Weber et al., 2009). Regarding heat-pump adoption, socio-demographic factors like levels of education appear to play an ambivalent role in shaping decisions. While some scholars show that highly educated individuals prefer technologies such as wood pellets (Ruokamo, 2016; Sopha et al., 2010), others argue that a high level of education has a positive effect on heat-pump adoption (Karytsas and Theodoropoulou, 2014). Environmental awareness (Bach et al., 2020; Decker et al., 2009; Kennedy and Basu, 2013), energy security concerns (Balcombe et al., 2014; Michelsen and Madlener, 2013), and age (Michelsen and Madlener, 2012; Willis et al., 2011) also influence heat-pump adoption decisions.

Contextual factors shaping energy technology adoption decisions include the cost structure of technologies (Friedman et al., 2016), level of market maturity (Reeves et al., 2017), access to –and cost of– capital (Jones and Leibowicz, 2021), and the availability of –and eligibility for– policy instruments like rebates (Reeves and Rai, 2018), feed-in tariffs (Strupeit and Palm, 2016), or low-interest loans (Shen et al., 2022). Social relations and peer effects[3] have also been identified as prominent factors driving household decisions (Graziano and Gillingham, 2015; Palm, 2016; Rai et al., 2016), including heat-pump adoption (Michelsen and Madlener, 2013; Sopha et al., 2010).

Importantly, the 'cost' factor has been consistently identified as a major barrier for household heat-pump adoption (Peñaloza et al., 2022; Singh et al., 2010). Despite their lower operational costs and electricity savings potential,[4] heat pumps represent a considerable expenditure for households across numerous jurisdictions. Acquisition and installation costs vary in function of several factors, including the type of technology (i.e., air-, water-, ground-sourced heat pump), its functionalities (e.g., space heating and cooling, hot water provision) and its size. For example, the acquisition and installation costs of an average air-to-water heat pump[5] that offers space heating and cooling services as well as hot water provision for a single-family house can reach the order of up to CHF 38,500 in Switzerland (Helion, 2023; Kazakov, 2023), € 18,750 in Germany (Kloth, 2023), or € 19,000 in France (Effy, 2023). Across the EU, the average upfront costs for heat-pump acquisition are two to four times higher than that of gas boilers (EHPA, 2023b). Hence, higher income households are more inclined to (and capable of) adopting a heat pump than lower income groups despite the salience of other socio-behavioural factors (Lillemo et al., 2013). Karytsas and Theodoropoulou (2014) emphasize the need to inform consumers about the recovery of heat-pump investments to offset their perceptions of the technology's elevated acquisition costs, long payback times, and lack of proper business models.

[3] Refers to individuals within a geographically delimited area nudging one another to adopt an energy technological innovation by exchanging information and user experiences (Palm, 2016; Rai et al., 2016).

[4] Some studies have emphasized the technical viability of 'smart' heat pumps through in-built flexible load management programmes, as a suitable means for lowering operational costs and reduce household energy consumption (Cooper et al., 2014; Globisch et al., 2020; Yilmaz et al., 2021, 2022).

[5] Air-to-water heat pumps can be used for space heating and cooling as well as for hot water supply. In winter, heat is extracted from the outside air and transferred to a refrigerant, which cycles through a heat exchanger and heats water. This water can in turn be used for hydronic heating, hot water supply, or as a heat source for ducted systems. In summer, heat is extracted from the indoor air to provide a cooling effect (Trethewey, 2023). Air-to-water heat pumps are highly efficient and produce low-carbon heat when powered by renewable electricity, offering this way a climate-friendly alternative to fossil-fuelled heating systems (e.g., gas or oil boilers).

2.2. The 'cost' factor: building a case for service-based business models

Service-based business models are emerging as a solution to help overcome the barriers faced by homeowners when assessing heating system alternatives. The notion of 'service-based' can be understood as an umbrella term comprising various business models whereby financial, technical, performance, behavioural, and energy-price risks are borne (in-full or in-part) by service providers instead of consumers (Delta-EE, 2019).[6] Value offerings can bundle various activities like advising, installing, and financing infrastructure, or managing assets through maintenance and repair activities (Helms, 2016). Revenue streams emerge from margins made on system installation, financing, and subscription-based contracts (IRENA, 2020). Within this broad category, third-party ownership (TPO) models such as asset leasing stand as a particularly well-suited solution to lower the acquisition cost barrier described above (Coughlin and Cory, 2009; Overholm, 2015). Under asset leasing, a service provider leases an appliance like a heat pump to an end-user and provides various services (e.g., installation, financing, repair/maintenance) for a monthly payment specified at a predetermined rate (Sovacool et al., 2021). By doing so, the model removes upfront investment requirements and reduces risk and complexity for end-users, facilitating the deployment of climate solutions across new market segments (Drury et al., 2012; Hobbs et al., 2013).

Notwithstanding the model's widespread use to accelerate the diffusion of clean energy technologies like solar photovoltaics (PV)[7] (Munsell, 2014), only a few European companies offer heat-pump leasing despite an apparent interest from households for such option (Tix, 2022).[8] This is paired with scarce empirical evidence on household preferences for service-based business models such as those captured via TPO value offerings (Britton et al., 2021; Brown et al., 2022; Davidson et al., 2015; Sovacool and Martiskainen, 2020). For instance, Sovacool et al. (2021) examine households' attitudes towards heat decarbonization in five European countries. The authors show that 18.9% of survey respondents would likely consider heat-pump leasing as a means to obtain heating services. However, they do not provide insights into how household preferences vary across different leasing offerings or countries. Similarly, Schleich et al. (2021) show that nearly a third of houseowner-occupiers in the United Kingdom would prefer to rent a heating system over owning it. They also show that homeowners prefer offerings that provide greater potential for energy savings and longer warranties. Correspondingly, there is a need to obtain a better understanding of how and to what extent different heat-pump leasing offerings influence the willingness of homeowners to pay for heating services across different countries, and to clarify their interest for such mode of adoption.

3. Methodology

We investigate the preferences of single-family house owners (hereafter 'house owners') for heat-pump leasing offerings and examine their inclination towards leasing or purchasing using a discrete choice experiment (DCE). This approach builds on discrete choice and random utility theory (Manski, 1977; McFadden, 1974). It posits that products or services can be deconstructed into bundles of attributes, and that each attribute is associated with a specific level of utility. The total utility of a service equates to the sum of its parts' utilities, known as part-worth utilities. Individual stated preferences for service features are elicited by requiring participants to systematically choose a service offering from a set of hypothetical concepts that vary randomly according to different attributes. Participants are assumed to choose the services that would be likely to provide them with the highest utility. Part-worth utilities are estimated using choice modelling methods (Rao, 2014).

Choice experiments have been widely used by scholars to examine the preferences of households for clean energy products (Achtnicht and Madlener, 2014; Hille et al., 2018; Petrovich et al., 2019; Sagebiel et al., 2014), including heating appliances (Achtnicht, 2011; Meles et al., 2022; Rouvinen and Matero, 2013; Scarpa and Willis, 2010; Schleich et al., 2020). This strategy has the advantage of using a realistic setting for decision-making (Hill, 2017). Applying a stated-preference method is especially pertinent in this context given the scarcity of historical data on house owners' decisions related to heat-pump leasing offerings (Louviere et al., 2000).

Next, we first describe the survey structure and provide a thorough account of the experiment design. We then present an overview of the data analysis methods employed in this study. Finally, we describe the data collection process and sample.

3.1. Survey development

The online survey was programmed and fielded using Sawtooth Software's module SSI Web.[9] First, we asked house owners questions about their heating practices and preferences. This included questions about the types of heating systems installed in their house, the duration their main heating system had been in operation, their average annual heating costs, heating replacement plans, and the type of system they would be most likely to install if they were planning to replace their main heating system. Second, we asked DCE questions to elicit their stated preferences for heat-pump leasing offerings (see Subsection 3.2 for details). Third, we surveyed house owners about the factors driving and hindering their preference for heat-pump installation and leasing. Fourth, we concluded the survey by gathering socioeconomic data (see Table A1 and A2 in appendix). The survey also included a quality control to ensure that the observations of inattentive respondents were excluded.[10]

To facilitate comprehension and enhance completion rates, the survey was offered in French to respondents living in France or in the French-speaking part of Switzerland, and in German to respondents living in Germany or in the German-speaking part of Switzerland. The French and German questionnaires used euros (€) as currency, whereas the Swiss questionnaires used Swiss francs (CHF). The monetary values used in the choice experiment were also adapted to reflect country-specific market realities (see Subsection 3.2 for details). Hence, four versions of the questionnaire were developed. The questionnaires and DCE designs were pre-tested with 12 experts and house owners to verify their adequacy and intelligibility. Adjustments were made accordingly prior to the fieldwork.

3.2. Experimental design

The DCE comprised two sections: an introductory part followed by ten randomized choice tasks. First, we asked respondents to imagine that they were planning to replace their heating system the following year and were considering installing an air-to-water heat pump. We also

[6] Financial risk relates to potential payment default by the end-user; technical risk pertains to equipment deficiencies or maintenance and repair activities; performance risk can be associated with appliances' efficiency and house-specific characteristics; behavioural risk emerges from end-users' heating habits (e.g., volume and timing of heat demand); energy price risk is linked to variability in wholesale electricity prices (Delta-EE, 2019).

[7] Most notably in the United States of America (EPA, 2022).

[8] For example, Thermondo and LG Electronics jointly offer heat-pump leasing solutions to homeowners in Germany (Enkhardt, 2022; Tix, 2022). Further, OK offers heat-pump leasing options in Denmark (OK, 2023).

[9] A web-based software tool specialising in conjoint analysis for market research applications. For details see: https://sawtoothsoftware.com.

[10] The quality-control measure consisted of an attention check and was designed following Petrovich et al. (2021).

asked them to assume that the heat pump could be installed in their house. We explained that the device would use electricity to take thermal energy from the outside air to heat water and indoor spaces, and that it had an expected service life of 15 years. Further, we told respondents that they had the option to lease the heat pump by making fixed monthly payments for the duration of the leasing contract – namely, 15 years. We informed them that at the end of the lease agreement they would become the owner of the heat pump. Additionally, we pointed out that if they moved before the contract ended, they could transfer the lease to the new house owner or terminate it by paying the balance of what was owed on the heat pump and installation costs. We also specified that the contract did not include the cost of the electricity needed to operate the heat pump. At the end of this introductory part, we informed respondents that their leasing options varied according to the attributes presented in Table 1. These factors were chosen as they represent important considerations in heating system procurement decisions.

The attribute *monthly lease payment* referred to what respondents needed to pay to lease the heat pump and benefit from certain services. We specified three levels – namely, 130 €, 155 €, and 180 € in the French and German surveys, and 195 CHF, 230 CHF, and 265 CHF in the Swiss survey. Monthly payments were calculated by drawing on prior studies and researching market-specific prices for air-to-water heat pumps as well as installation, maintenance, and repair activities. We also discussed this design with industry actors and experts to test their accuracy, along with the overall DCE design. Defining such levels enabled us to estimate house owners' WTP for different heat-pump leasing features as specified by the other attributes.

The attribute *type of leasing contract* described the elements included in the lease agreement and comprised three levels. The basic package included the heat pump and installation costs. The maintenance package comprised the costs included in the basic package as well as yearly maintenance fees. The all-inclusive package included the heat pump, its installation, maintenance, and all potential repair or replacement costs. This design enabled us to compute WTP estimates for maintenance and repair services.

Finally, the attribute *service provider* specified the type of actor providing the services. This included a heat pump manufacturer, local energy utility, and heating specialist. Research has shown that several actors can provide heating services, and that specific actors may be preferred in certain countries (Schleich et al., 2021). These levels allow us to examine if and to what extent French, German, and Swiss house owners differentiate between different service providers.

In the second section of the DCE we presented ten consecutive two-stage choice tasks to respondents: 1) preferred leasing model, and 2) preference between leasing and purchasing. First, we displayed three heat-pump leasing concepts simultaneously in each choice task and invited respondents to select their preferred offering (see Fig. 1). To mitigate the hypothetical bias, we instructed respondents to make their choices as if these were real-life decisions and to consider how this would affect their budget (Hensher, 2010). The heat-pump leasing concepts varied randomly without any prohibition according to the attributes and levels described in Table 1. Respondents could revisit these definitions at any time during the choice tasks by scrolling their pointer over the attribute and levels of each leasing concept to avoid confusion or misinterpretation. We used a symmetrical DCE design to avert the number-of-levels effect, whereby attributes with more levels are awarded higher importance scores than other attributes (Wittink et al., 1992).

Once respondents had selected their preferred leasing option, we asked them in a second stage to imagine that they now also had the option to purchase the heat pump for a specific price, paid upfront. We explained that the purchasing price included the installation costs and a two-year warranty, but no maintenance.[11] We then instructed respondents to indicate if they would prefer to lease the heat pump as they had indicated in the first part of the choice task, or would rather purchase it.

This multi-stage design enabled us to first focus on the trade-offs that house owners make when choosing heat-pump leasing offerings by testing several concepts simultaneously. It also provided us with additional information regarding adoption intentions (Orme, 2016). To ensure the adequacy of our choice experiment, we generated an efficient DCE design using Sawtooth Software.[12] Further, we included three manipulation checks at the end of the choice experiment to control if respondents had understood the choice situation correctly.[13] The DCE design was also validated using inputs from practitioners.

Table 1
Attributes and attribute levels manipulated in the choice experiment.

Attributes	Description	Attribute levels
Monthly lease payment	Monthly payments house owners pay to lease the heat pump and benefit from services (in CHF or €).	- 195 CHF or 130 € - 230 CHF or 155 € - 265 CHF or 180 €
Type of leasing contract	Equipment and services included in the lease agreement.	- Basic package: Heat pump and installation costs included - Maintenance package: Heat pump, installation, and yearly maintenance costs included - All-inclusive package: Heat pump, installation, yearly maintenance, repair, and replacement part costs included
Service provider	Type of actor providing the services.	- Heat pump manufacturer - Local energy utility - Heating specialist

3.3. Model specification and willingness-to-pay estimates

We estimated part-worth utilities associated with different features of heat-pump leasing offerings by specifying Hierarchical Bayes (HB) models using the Sawtooth Software. HB models are widely used to investigate consumer behaviour as their hierarchical structure enables information to be extracted from two levels (Allenby et al., 2005). At the lower level, the probability of each individual respondent to choose specific heat-pump leasing offerings is specified by a multinomial logit model. At the higher level, individual choices are described by a multivariate normal distribution expressed by a mean vector and variance-covariance matrix. The latter model describes the

[11] The purchasing prices shown to respondents were the same as the price assumptions used to derive the lease payment per month levels.

[12] Following Petrovich et al. (2021), we generated an efficient DCE design with Sawtooth Software. Specifically, we used the *Test Design* function to estimate the precision of parameter estimates given a certain experimental design. To do so, the software generates dummy answers and performs a logit run to estimate their main effects. Standard errors are reported to give an indication of the precision of each parameter estimate. For this study, multiple designs were tested, with different number of attribute levels, sample size, etc. The final DCE design was optimal as it resulted in lower, uniform standard error estimates within each attribute, of which values were in line with suggested guidelines (Sawtooth Software, 2022). The frequency report also suggested that all levels within attributes were shown an equal number of times. Our DCE design therefore meets the requirements for 'efficiency' set out in the software's guidelines. See Sawtooth Software (2022) for details.

[13] We designed the manipulation checks based on Schleich et al. (2021). The latter consisted of three items regarding which respondents were asked to indicate if a statement was "true," "false," or they did not know ("I don't know"). Statements were adapted to the context of this study and formulated as follows: 1) "after 15 years of leasing, the heat pump will belong to you," 2) "if you move before the end of the 15-year leasing contract, the new houseowner will be forced to take over the leasing contract," and 3) "if you lease the heat pump, you will have to pay monthly payments."

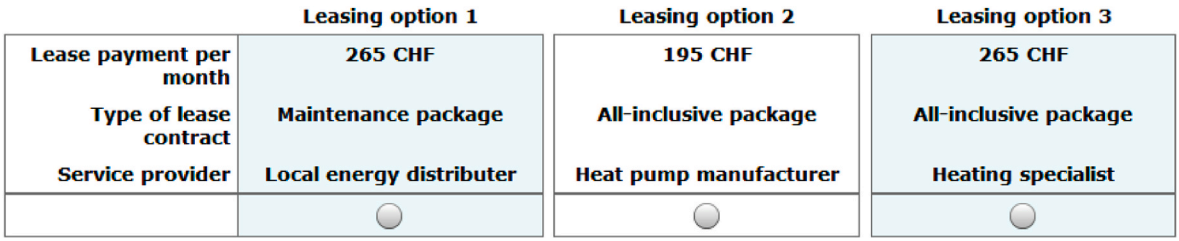


Fig. 1. Example of heat-pump leasing concepts displayed to house owners.

heterogeneity of preferences across the sample (Orme and Howell, 2009). This modelling approach enabled us to address any lack of information at the individual level by collecting information across respondents.

In line with prior research, we used the root likelihood (RLH) parameter as a measure of the 'goodness-of-fit' between part-worth utility estimates and the choices made by respondents (Côté et al., 2022; Salm et al., 2016). RLH represents the geometric mean of all estimated probabilities. It is computed by taking the *n*th root of the likelihood that respondents would make the decision that they actually made in each task, with *n* corresponding to the total number of choices they made in all tasks (Orme, 2016). High RLH values indicate a good fit between the data and model, with RLH = 1 being the highest possible value. In our DCE, respondents were presented with three heat-pump leasing concepts to choose from. The predictability of their decisions based on chance is thus 1/3 = 0.33. Since the average RLH values computed for the three models are more than twice that of the level of chance ($RLH_{France} = 0.678$; $RLH_{Germany} = 0.672$; $RLH_{Switzerland} = 0.685$), we can assume a good fit between the data sets and models (Hille et al., 2018).

Finally, we calculated implicit willingness-to-pay values using part-worth utility estimates following Salm and Wüstenhagen (2018). WTP estimates correspond to the upper limit of the amount house owners would be willing to pay for a heat-pump leasing offering that has a preferred feature compared to an offering with the least preferred feature. In this way, any upgrade relative to the least preferred option can be ascribed a monetary value.

3.4. Data collection and sample

The survey was fielded between February and March 2022 by a market research institute using respondent panels representative of the French, German, and Swiss general populations. Single-family house owners were specifically targeted as they are generally more likely to make decisions about heating system replacement than tenants or flat owners (Davis, 2023; Krishnamurthy and Kriström, 2015). This may be so particularly in the case of heat pumps, as installation activities can require considerable retrofitting work and hence the approval of a higher number of parties (Fedrizzi, 2023). While our national subsamples represent fractions of the wider populations, they still offer valuable insights with respect to household preferences over different heat-pump offerings. For indication, Table 2 showcases the shares of people living in households owning their home and population living in a house for each of our sampled countries.

Single-family house owners were recruited using a precise screening rule and by stratifying survey invitations to match the distributions of national populations. The selection question was: "Do you own a single-family house?" Only respondents who answered 'yes' to this question were provided access to the survey. The quota questions were designed according to five variables – namely, age, sex, level of education, income, and region (see Table A1 in appendix for details). Only respondents who fulfilled our selection criteria were considered. We first conducted a soft launch with 29 Swiss house owners to further test the questionnaire and analyse initial responses. Since our preliminary observations were satisfactory, we proceeded with the final implementation of the Swiss survey. Data collection in France and Germany followed the same sequential approach. Respondents took on average 17 min to complete the questionnaire and received tokens exchangeable for goods or services as compensation for their participation.

A total of 1582 single-family house owners who fulfilled our selection criteria accessed the survey (see Table 3). Responses from house owners who failed the quality control (149) or who provided incomplete responses (456) were excluded. Additionally, observations from 'speeders' who completed the survey in less than half of the median response time achieved by their national subgroup (62) were also removed from the sample. The final sample includes insights from 915 single-family house owners who conducted an aggregated 9150 hypothetical heat-pump leasing decisions. Respondents in national subsamples mostly follow the same distribution as the general populations in terms of sex and region (see Table A1 in appendix). However, their household monthly income is higher, and they are older, on average. These trends are in line with what has been observed in several countries: homeowners tend to represent the wealthiest fraction of the population and are generally older (Andrews and Sánchez, 2011).[14] Expectedly, respondents in the French subsample have a higher level of education than the general population. However, the distribution in the German and Swiss subsamples largely followed that of the respective national populations.[15]

Table 2
Shares of homeowners and of people living in a house for all sampled countries in 2021. Source: Eurostat (2023).

Country	Share of homeowners	Share of people living in a house
France	64.7%	65.6%
Germany	49.1%	40.9%
Switzerland	42.2%	34%

4. Results and discussion

First, we present descriptive results about respondents' heating practices and intentions. We then shed light on the perceived drivers and barriers associated with heat-pump installation and leasing. This enables us to gain a better understanding of house owners' decision-making considerations. Second, we describe the results of the first part of the DCE by showing part-worth utility estimates and discussing preferences for heat-pump leasing offerings. Third, we present the results of the second part of the DCE and explore differences in preferences between leasing and purchasing. Fourth, we delineate importance score estimates

[14] Andrews and Sánchez (2011) show that the probability of homeownership in selected OECD counties tends to rise with age and real household disposable income (although peaking near retirement age). They also show that households with higher levels of education are more likely to own property.

[15] The compositions of our national subsamples varied. The cross-country comparison results presented in Section 4 are not designed to specify causal relationships. Rather, they provide rich descriptive insights into different market realities and allow us to define important implications for service providers and policy makers.

Table 3
Survey response funnels (number of respondents and response rates).

	French subsample		German subsample		Swiss subsample		Final sample	
	No. resp.	Resp. Rate	No. resp.	Resp. Rate	No. resp.	Resp. Rate	No. resp.	Resp. Rate
Survey accessed	581		472		529		1582	
Incomplete responses	171	29.4%	99	21.0%	186	35.2%	456	28.8%
Failed attention check	86	14.8%	41	8.7%	22	4.2%	149	9.4%
Survey completed	324	55.8%	332	70.3%	321	60.7%	977	61.8%
Speeders (<1/2 median)	20	3.4%	24	5.1%	18	3.4%	62	3.9%
Final sample	304	52.3%	308	65.3%	303	57.3%	915	57.8%

and examine the relative weight of attributes in leasing decisions. Finally, building on the part-worth utilities, we compute WTP estimates for national subgroups. This allows us to clarify how and to what extent different heat-pump leasing offerings influence house owners' willingness to pay.

4.1. Descriptive results

4.1.1. Heating practices and intentions

A considerable share of respondents rely on fossil fuels for heating. Nearly 39.1% of French, 80.8% of German, and 52.1% of Swiss respondents used natural gas or oil to heat their single-family houses (see Fig. 2). These values are in line with the shares of national residential building stocks that rely on these fuels for heating.[16] In contrast, fewer respondents claimed to use a heat pump (18.8% of French, 8.8% of German, and 33.7% of Swiss house owners, respectively), although the technology appears to be most widely used by Swiss respondents. This could be explained by their greater affluence (see Table A1 in appendix) and the relatively low carbon-intensity of the electricity mix in Switzerland compared to Germany. However, these values are relatively higher than the level of heat pump deployment observed in national residential building stocks.[17] Differences between the degree of diffusion in single-family houses and multi-family buildings may partly explain this deviation (Cauret, 2021). Hence, our results underscore the dependence of these countries on fossil fuels for residential heating, particularly in Germany, and reflect different stages of heat pump market diffusion.

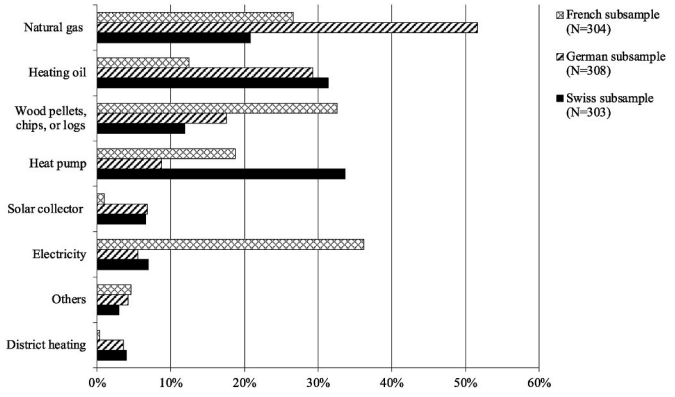


Fig. 2. Share of respondents per type of energy source(s) used for heating (multiple answers possible).

[16] The share of residential buildings that rely on gas or oil as a primary energy source for heating is 52.3% in France (2020), 75.7% in Germany (2018), and 60.1% in Switzerland (2017) (BFS, 2018; Destatis, 2021; SDES, 2021).

[17] Nearly 1.9% of German residential buildings are heated using ground or other ambient heat (2018), whereas 9.7% (2020) and 17.9% (2017) of French and Swiss buildings use heat pumps, respectively (BFS, 2018; Destatis, 2021; SDES, 2021).

Most house owners have the intention to adopt a low-carbon heating system. Indeed, considerable shares of respondents stated that they would most probably install a heat pump if they were planning to replace the main heating system in their house, suggesting a high demand for the technology – 40.8% of French, 30.5% of German, and 58.4% of Swiss respondents, respectively (see Fig. 3). Altogether, 25.8% of these respondents (N = 395) foresaw doing so within the next five years. This apparent interest in heat-pump adoption reflects recent market developments whereby France and Germany have emerged as the first and third leading European markets for heat-pump-unit sales, respectively (EHPA, 2021b). These developments can be explained by the general ubiquity of electrical heating in France, and the absolute size of the heat pump market in Germany (Lowes et al., 2022). Further, our results show that the share of French house owners who use electric heaters could plummet – a fall that could be partly driven by high operational costs (MTE, 2021). House owners may thus be keen to substitute electric heaters for more efficient electric heat pumps, although a trend toward the adoption of solar collectors may also be observed.

Further, 12.5% of French, 28.2% of German, and 8.9% of Swiss respondents would probably choose to install a natural-gas-fired or oil-fired boiler if they replaced their current heating system (see Fig. 3). Given that most respondents do not plan to replace their main heating system in the near future and that domestic boilers can have a lifespan of well over 20 years (see Table A2 in appendix), a considerable share of households could still be using fossil fuels for heating in 2050. To avoid this scenario and ensure the attainment of the net-zero goal, the International Energy Agency urged countries to implement bans on new fossil-fuel-fired boiler sales from 2025, except for hydrogen-ready boilers (IEA, 2021d). Similarly, several scholars have stressed the necessity of a prompt phase-out of fossil-fuel heating and called for more stringent policies in these jurisdictions (Frank and Quitzow, 2022; Lowes et al., 2022; Nägeli et al., 2020). Both carrot and stick policies such as financial incentives, regulations, and even prohibitions have been shown to play an important role in accelerating the decarbonization of heat (Chaudry et al., 2015; Kerr and Winskel, 2021). However,

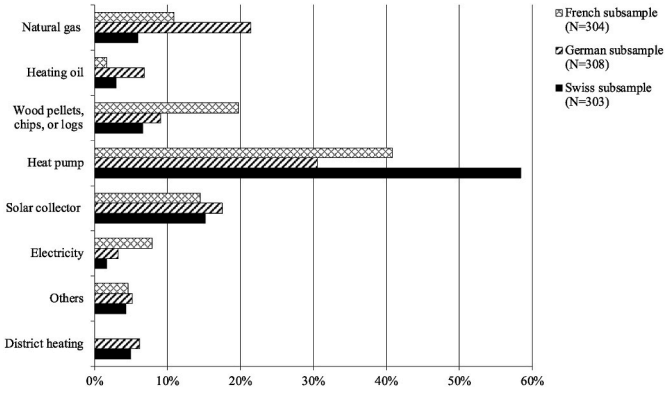


Fig. 3. Share of respondents per type of energy source they would most probably choose if they were planning to replace the main heating system in their house (one answer possible).

despite the introduction of financial incentives and the tightening of regulations for buildings in the respective countries, none have banned the sale or installation of fossil-fuel heating from 2025.[18]

4.1.2. Heat-pump adoption and leasing: drivers and barriers

Environmental protection and energy security are key drivers of heat-pump adoption amongst our respondents (see Table 4). These findings support studies which show that heating decisions are driven by aspirations to deal with external threats like environmental degradation or dependence on fossil fuels (Achtnicht, 2011; Michelsen and Madlener, 2012, 2016). Hedging against energy price volatility was further identified as one of the three most salient drivers shaping adoption decisions of German and Swiss respondents. As for French house owners, benefiting from financial incentives such as subsidies and tax deductions emerged as a key consideration. Perhaps this can be explained by the recent increases in the price of natural gas in Europe, on which German homeowners are strongly reliant (Bloomberg, 2022). It may also be attributed to the introduction of attractive incentives to promote low-carbon heating in France – see Bercy Infos (2022) and Kerr and Winskel (2021). Policy makers could leverage this prolonged price hike to accelerate heat-pump uptake (Globisch et al., 2020; Yilmaz et al., 2021, 2022). Importantly however, this should be spearheaded by the continued use of ambitious policy support to lower the technology's high acquisition costs.[19] Various studies have shown that incentives play a key role in investment decisions (Mahapatra and Gustavsson, 2008), and that beyond cost reductions, homeowners value obtaining subsidies as such (Schleich et al., 2022). Since most of the policy focus has so far been on facilitating equipment purchase (Tognetti, 2020), repurposing financial incentives towards service-based offerings could help expedite heat-pump uptake (Schleich et al., 2021).

Financial and technical factors are the most important barriers to heat-pump diffusion. A considerable share of respondents view the high purchase price as well as operation and maintenance concerns as being the most important barriers to heat-pump adoption. While a lack of available funds is also highlighted as an impediment by French and Swiss respondents, uncertainty regarding its performance is a major hindrance for German respondents. These results corroborate the findings of scholars who claim that financial factors, especially acquisition costs, are the most important barriers to adoption (see Subsection 2.1). They also suggest a lack of confidence in the technology, particularly in Germany where the degree of heat-pump diffusion is considerably less. This provides further evidence on the salient role familiarity plays in the decisions of homeowners (Irfan et al., 2021; Weber et al., 2009), who tend to prefer the technologies already in use in their home (Lang et al., 2021).

Heat-pump leasing could contribute to mitigating risks for end-users. Most respondents foresee the main benefit of such offerings as being the elimination of upfront investment requirements and the simplicity of all-inclusive packages covering installation, maintenance, and repair services. However, the length of leasing agreements generally appears to constitute an important drawback, pointing to the desirability of offering flexible leasing contracts. For example, this could be achieved by including an option for house owners to purchase the heat pump at any point in time, similarly to a lease-to-own model (Klein et al., 2021). Further, other service-based offerings such as 'efficient asset leasing' – whereby in addition to asset leasing a service provider would include a

Table 4
Drivers of and barriers to heat-pump adoption and leasing.

Variable name	Description	% in French subsample (N = 304)	% in German subsample (N = 308)	% in Swiss subsample (N = 303)
Drivers of adoption	*Three most important factors in favour of heat-pump installation (three answers required).*			
Reducing impact on the environment		**59.2%**	**56.2%**	**75.2%**
Access to subventions and/or tax benefits		**50.0%**	22.1%	24.1%
Decreased dependence on foreign energy sources		**44.1%**	**60.7%**	**49.8%**
Hedging against potential energy price increases		37.8%	**48.4%**	**37.3%**
Relatively low operating costs		34.2%	40.3%	35.0%
Increased home value		30.9%	22.7%	24.8%
Staying at the frontier of technological innovation		24.3%	34.7%	26.1%
Positive experience of heat pump owners in surrounding		18.1%	12.0%	24.4%
Others		1.3%	2.9%	3.3%
Barriers to adoption	*Three most important factors hindering heat-pump installation (three answers required).*			
Relatively high purchase price		**86.5%**	**76.0%**	**75.6%**
Lack of funds to pay the purchase price		**49.7%**	46.1%	**50.8%**
Operation and maintenance concerns		**41.1%**	**46.8%**	**42.9%**
Uncertain performance		40.5%	**51.9%**	38.3%
High complexity of projects		33.9%	27.9%	30.7%
Lack of subvention or tax benefits		26.3%	30.5%	34.3%
Negative experience of heat pump owners in surrounding		14.8%	12.0%	9.9%
Decreased home value		4.3%	3.2%	2.3%
Others		3.0%	5.5%	15.2%
Drivers of leasing	*Two most important factors in favour of heat-pump leasing (two answers required).*			
No upfront investment required (purchase price)		**79.3%**	**74.0%**	**85.1%**
Simplicity of all-inclusive packages		**60.9%**	**70.1%**	**58.4%**
Possibility to transfer the leasing contracts to new homeowners		25.7%	13.0%	21.1%
Attractive financing rates		23.7%	30.5%	17.8%
Unavailability of other financing solutions		9.5%	10.4%	13.9%
Others		1.0%	1.9%	3.6%
Barriers to leasing	*Three most important factors hindering heat-pump leasing (two answers required).*			
The length of the lease agreement		**59.2%**	**51.6%**	**55.8%**
Additional costs		**56.6%**	42.9%	**47.9%**
Potential challenges with transferring the lease to new owners		29.3%	28.2%	32.3%
Third-party ownership		27.3%	**43.5%**	43.6%
The complexity of the lease agreement		26.3%	31.8%	16.8%
Others		1.3%	1.9%	3.6%

[18] In France, a carbon-efficiency threshold was introduced in 2022 to limit emissions from new single-family houses (MTE, 2021). Heating equipment that relies exclusively on fossil fuels is de facto excluded. This limit may be reduced by 2030 (ECOS, 2021). Oil-fired boiler and coal furnace installation has been prohibited since 2022 (Direction de l'information légale et administrative, 2022). In Germany, the installation of mono-fuelled oil or coal systems will be prohibited in all buildings from 2026 (Braungardt et al., 2021; Bundesregierung, 2020). The same restrictions will apply to new fossil-fuel-fired boilers (BMI, 2021). An obligation to use renewable energies will also be imposed (Braungardt et al., 2021). In Switzerland, there is currently no nationwide ban on oil or gas-fired heating systems, but combustion boiler emissions are restricted (Bundesrat, 2021). A tightening of energy standard regulations for buildings can nonetheless be observed in several cantons, including restrictions or even bans on certain types of installation (Direction de l'énergie, 2021; SWI, 2021). For example, Basel-City, Geneva, Glarus, and Zurich adopted legislations that ban fossil-fuel heating, although deadlines and specific conditions vary.

[19] Please see Table A3 in the appendix for an overview of existing policy measures to support heat-pump adoption across our sampled countries.

performance guarantee in the service offering to mitigate performance-related risks for end-users (Sovacool et al., 2021) – could contribute to overcoming some of the barriers to heat-pump diffusion. This may be particularly relevant in Germany, where uncertainty about performance appears to be of concern.

4.2. Preferences for heat-pump leasing

Preferences for heat-pump leasing offerings are investigated by specifying three country-specific HB models using 9150 hypothetical leasing decisions made by 915 house owners (see Table 5). Part-worth utility estimates indicate the relative preferences house owners associate with specific features and were zero-centred to enable within-attribute comparisons. Unsurprisingly, results show that respondents prefer offerings with lower *monthly lease payments*, as the lowest level of this attribute is associated with the highest level of utility across the three national subsamples. However, Swiss respondents appear to be less reluctant than their French and German counterparts to lease a heat pump for higher monthly payments as the spread between their part-worth utilities is significantly smaller ($p < 0.01$ – see Table A4 in appendix). Since heat-pump-acquisition costs in Switzerland are relatively higher than in the other countries (see Subsection 2.1), higher monthly payments might still stand as an attractive alternative for Swiss respondents.

Regarding the *type of lease contract* attribute, house owners prefer all-inclusive packages in which the cost of the heat pump, its installation, yearly maintenance, and potential repairs and part replacements are all included. This may be explained by the fact that such packages could contribute to addressing operation- and maintenance-related concerns, which are viewed as some of the most important barriers to heat-pump installation (see Subsection 4.1.2). These results suggest that house owners perceive the risk of technological failure to be high. This appears to be especially true of German and Swiss respondents as the spread between their part-worth utilities is significantly higher than for French respondents ($p < 0.01$ and $p < 0.05$, respectively – see Table A4 in appendix).

As for the *service provider* attribute, preferences seem to diverge between countries. While French and German respondents tend to favour obtaining the services from a heating specialist, Swiss respondents appear to favour a local energy utility. However, Swiss respondents do not seem to differentiate much between providers, as the spread between their part-worth utilities is small. Further, the relatively large standard deviations associated with this attribute indicate a high level of heterogeneity among preferences. These findings differ from those of earlier research which showed that British homeowners would be more inclined to rent a heating system from an equipment manufacturer, followed closely by an energy utility (Schleich et al., 2021). Diversifying the types of service providers may thus be an additional way to meet the preferences of a wider range of end-users.

To investigate the robustness of our DCE results, we conducted a series of additional analyses. First, we specified country-specific HB models using only the responses of house owners who had correctly passed the three manipulation checks (see Footnote 13) by following the model-specification approach described in Subsection 3.3. We then carried out Mann-Whitney *U* tests to examine if the mean part-worth utility estimates of attribute levels varied significantly between the full models and curtailed ones (see Table A5 in appendix). Since the results of the curtailed subsamples are largely similar to the ones found for the full national subsamples, we can assume that our DCE results are not affected by the inclusion of those who provided inexact answers to the manipulation checks. This holds true for all models except for the case of Switzerland, where respondents in the curtailed subsample appear to have a slight preference for services obtained from a heat pump manufacturer. This can be explained by the fact that Swiss respondents do not differentiate much between service providers and that their preferences are rather heterogeneous.

Second, we specified additional HB models, this time retaining only responses from house owners who stated that they planned to replace their main heating system with a heat pump. Mann-Whitney *U* test results confirm that the preferences of these respondents mainly match the ones for the full subsamples, except for the case of the service provider (see Table A5 in appendix). French and Swiss respondents who planned to install a heat pump appear to be slightly more inclined to procure the services of a manufacturer. This underlines the relevance of diversifying service providers to meet the preferences of different end-users.

4.3. Preferences related to leasing and purchasing

The results of the second part of the DCE suggest a certain interest in heat-pump leasing, although to a different extent across countries. French respondents planning to replace their heating system with a heat pump favour leasing rather than purchasing in 49.6% of cases (N = 1240).[20] In contrast, Swiss respondents appear to be less inclined to lease heat pumps as they chose to do so in only 33.3% of cases (N = 1770). This may be explained by their greater average affluence (see Table A1 in appendix). Interestingly, German respondents seem to be the most open to asset leasing, as they chose to lease the heat pump in 63.6% of cases (N = 940). Concerns about maintenance and operational performance (see Subsection 4.1.2) and the low degree of heat-pump diffusion in Germany could explain this result. Scholars have shown that end-users who worry about technical factors are more inclined to lease equipment (Rai et al., 2016). Further, as highlighted in Subsection 2.1, peer effect (or lack thereof) is determinant for households' clean energy adoption decisions, as this may reduce (increase) intrinsic uncertainty. Our results also show that the strength of preferences for either leasing or purchasing is high (see Fig. A1 in appendix). Overall, these insights underscore the relevance of asset leasing, especially for markets where heat pumps are at an early stage of diffusion and technological risk is perceived to be high.

4.4. Average importance of attributes in leasing decisions

Average importance scores were computed using the Sawtooth Software to estimate the relative weight each attribute has in heat-pump leasing decisions. Results show that the *monthly lease payment* attribute has an important weight in decisions, especially for French and German respondents – 43.9% and 40.9%, respectively (see Table 6). These insights corroborate the findings of previous studies showing that cost is the most important factor in homeowners' decisions about heating systems (see Subsection 2.1). The *type of lease contract* also plays an important role, particularly for German and Swiss respondents who award relatively more importance to this factor (40.1% and 38.0%, respectively) than French respondents (34.4%). In contrast, the type of *service provider* seems to be assigned considerably less weight in leasing decisions, especially for French and German respondents (21.8% and 18.9%, respectively) as opposed to Swiss ones (24.8%). Mann Whitney *U* test results confirm these significant distinctions.

4.5. Willingness to pay for heat pump services

We calculated implicit WTP values to estimate the amount house owners would be willing to pay for leasing offerings that include a preferred feature instead of the least preferred one. Fig. 4 shows aggregated WTP estimates. WTP values of zero indicate the least preferred feature of an attribute, as specified in Subsection 4.2.

French respondents would be willing to pay up to 30.66 € per month to move from a basic package that comprises a heat pump and its

[20] In this case, "N" does not refer to the number of respondents, but rather to the number of choice tasks – i.e., the number of times respondents had to choose between leasing or purchasing a heat pump.

Table 5
Zero-centred utility, lower and upper 95% confidence interval, and standard deviation (SD) estimates.

Number of respondents (N = 915)		HB model French house owners (N = 304)			HB model German house owners (N = 308)			HB model Swiss house owners (N = 303)		
Attribute	Attribute levels	Zero-centred utility	Lower & upper 95% confidence interval	SD	Zero-centred utility	Lower & upper 95% confidence interval	SD	Zero-centred utility	Lower & upper 95% confidence interval	SD
Monthly lease payment	130 € (or 195 CHF)	51.74	[46.75; 56.73]	44.39	51.46	[46.75; 56.17]	42.13	44.21	[38.97; 49.45]	46.52
	155 € (or 230 CHF)	10.13	[7.68; 12.58]	21.82	5.38	[3.29; 7.47]	18.72	1.77	[–0.17; 3.70]	17.16
	180 € (or 265 CHF)	−61.87	[–66.68; −57.06]	42.79	−56.84	[–61.43; −52.26]	41.06	−45.98	[–50.78; −41.18]	42.62
Type of lease contract	Basic package	−53.61	[–57.73; −49.49]	36.63	−50.63	[–54.76; −46.49]	37.00	−47.98	[–52.14; −43.81]	37.01
	Maintenance package	16.06	[13.48; 18.64]	22.98	−8.24	[–10.36; −6.11]	19.03	−4.40	[–7.04; −1.76]	23.45
	All-inclusive package	37.55	[34.32; 40.78]	28.74	58.86	[54.53; 63.20]	38.83	52.38	[48.04; 56.71]	38.49
Service provider	Heat pump manufacturer	3.19	[–0.35; 6.73]	31.47	−8.43	[–11.33; −5.53]	25.98	−0.65	[–4.81; 3.51]	36.93
	Local energy utility	−11.80	[–15.95; −7.65]	36.91	1.55	[–2.04; 5.13]	32.12	1.90	[–2.89; 6.70]	42.63
	Heating specialist	8.61	[4.71; 12.51]	34.71	6.88	[3.42; 10.35]	31.01	−1.25	[–5.47; 2.96]	37.44
None		158.79	[112.84; 204.74]	408.76	10.46	[–24.16; 45.07]	309.94	255.12	[212.95; 297.29]	374.51

Table 6
Average importance scores (AIS), standard deviations (SD), and Mann Whitney *U* test (2-tailed) results, by attribute.

	French house owners (N = 304) (1)		German house owners (N = 308) (2)		Swiss house owners (N = 303) (3)		*P*-value[a] for difference test between (1) and (2)		*P*-value[a] for difference test between (1) and (3)		*P*-value[a] for difference test between (2) and (3)	
Attribute	AIS (%)	SD (%)	AIS (%)	SD (%)	AIS (%)	SD (%)						
Monthly lease payment	43.88	20.0	40.93	20.4	37.19	20.4	0.078	*	0.000	***	0.020	**
Type of lease contract	34.37	17.0	40.14	19.6	38.01	18.1	0.001	***	0.013	**	0.272	
Service provider	21.75	16.7	18.93	14.2	24.80	17.5	0.108		0.017	**	0.000	***

[a] *** Significance level of 1% ($p < 0.01$), ** Significance level of 5% ($p < 0.05$), * Significance level of 10% ($p < 0.1$).

installation to one that also includes yearly maintenance, whereas Swiss respondents would pay up to 33.82 CHF monthly. In contrast, German respondents would only pay up to 19.57 € per month. Despite operation and maintenance being an important concern for German house owners (see Table 4), these respondents seem to view the risk of encountering complications during such activities to be relatively low compared to French respondents. As for all-inclusive packages, preferences are similar across countries. While French respondents would be willing to pay up to 40.12 € per month for an all-inclusive package that in addition to basic features would include yearly maintenance and potential repair activities, German respondents would be willing to pay up to 50.55 € monthly. Interestingly, the difference between the WTP of German respondents for an all-inclusive package and maintenance package (30.98 €) is considerably higher than that of French respondents (9.46 €). These findings suggest that German respondents may be willing to pay more than three times as much as their French counterparts for subscription-based repair services, or to shield themselves against the risk of a technical failure. Similarly, Swiss respondents would also pay considerably more for an all-inclusive package than for a maintenance package (up to 44.07 CHF per month). Overall, these findings stress the relevance of providing heat pump services, especially in Germany where the degree of diffusion is low and interest in leasing high (see Subsection 4.3).

Regarding the *service provider*, WTP estimates suggest that both French and German respondents would be willing to pay a small premium to obtain the services of a heating specialist instead of the ones of a local energy utility or heat pump manufacturer, respectively. However, other results are inconclusive.

5. Conclusions and policy implications

This study has investigated the preferences of single-family house owners for heat-pump leasing, examined their inclination to lease or purchase such a system, and quantified their willingness to pay for different heating services. It also clarified the drivers and barriers of heat-pump adoption and leasing. Based on 9150 experimental leasing decisions made by 915 house owners in France, Germany, and Switzerland, we provide novel empirical insights about preferences related to heat-pump adoption across different countries. In doing so, we draw conclusions for the design of heating service offerings and related policy measures that could help overcome the barriers to low-carbon heating technology diffusion.

Our results indicate that heat-pump adoption is primarily driven by the ambition to curb environmental impacts and reduce dependence on foreign energy sources. A desire to hedge against energy price increases was also identified as a notable driver for German and Swiss respondents, who tend to be more reliant on fossil fuels for heating. At the same time, French respondents perceive policy incentives as an important driver of heat-pump uptake in France, which has emerged as the leading European market in terms of unit sales. However, financial considerations, notably high acquisition costs, remain prominent barriers to adoption across all three countries. This is coupled with technical and operational concerns, which appear to challenge heat-pump uptake, especially in Germany where the technology is at an early stage of diffusion.

Heat-pump leasing could contribute to addressing some of these barriers by removing the need for initial investment and simplifying maintenance and repair activities. Monthly lease payments and the type of lease contract emerged as the most important considerations in

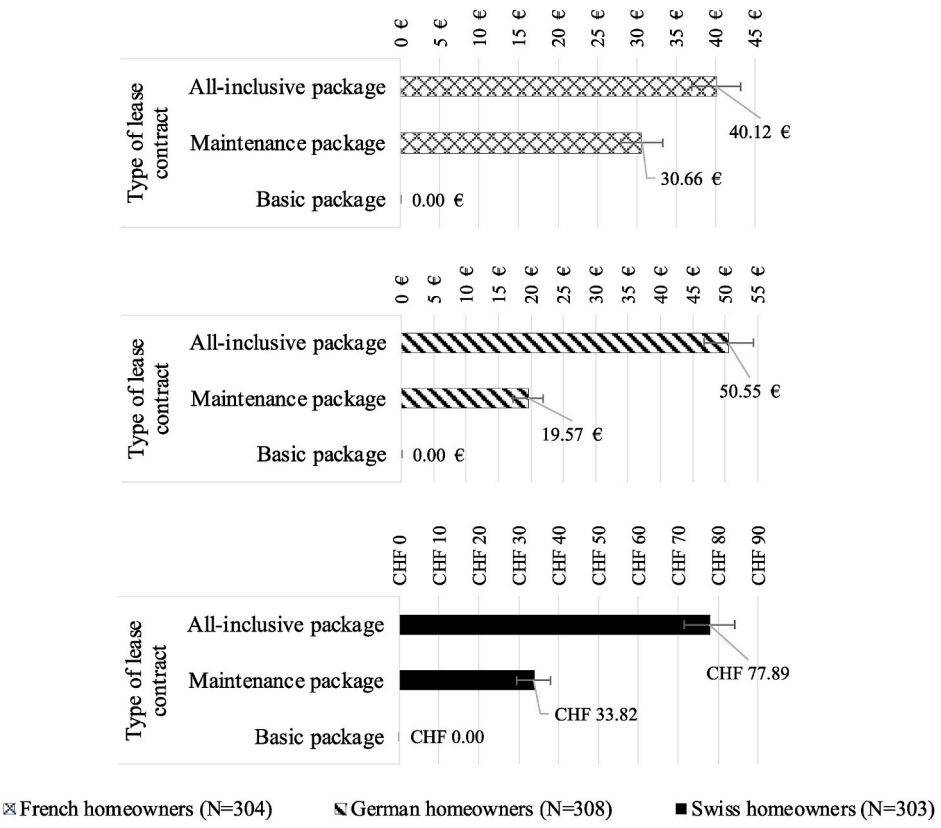


Fig. 4. Monthly willingness to pay of house owners for heat-pump leasing services.

leasing decisions. House owners prefer leasing offerings with lower monthly payments in which the heat pump, its installation, yearly maintenance, and all potential repair activities are included. Their average willingness to pay for an all-inclusive package relative to a basic package that would only include the heat pump and installation is similar across countries. However, German house owners would on average pay up to three times as much as their French counterparts for an all-inclusive package than for a maintenance package in which only the heat pump, installation, and yearly maintenance are included (up to 30.98 € and 9.46 € per month, respectively). Swiss respondents would also be willing to pay considerably more for subscription-based repair services (up to 44.07 CHF per month).

However, Swiss house owners who plan to install a heat pump are those least likely to lease, as they chose to do so in only 33.3% of cases (N = 1770). This may be explained by their greater affluence and the relatively high degree of heat-pump diffusion in the country. In contrast, German respondents favoured leasing in 63.6% of cases (N = 940), and French respondents in 49.6% of cases (N = 1240). Interestingly, German house owners appear to be those most likely to leasing a heat pump. These insights highlight the relevance of asset leasing, especially in markets where heat pumps are at an early stage of diffusion like in Germany. However, our results also show that the length of leasing agreements is perceived as a major drawback, underlining the relevance of offering flexible contracts.

Despite a general trend towards low-carbon heating adoption, our results also indicate that a considerable share of house owners would likely choose to replace their main heating systems with natural-gas-fired or heating-oil boilers if they were allowed to do so. This is especially so in the case of Germany, where fossil fuels contribute to heating the great majority of respondents' single-family houses. Although, this preference for fossil-fuel heating may have changed since the beginning of the Russo-Ukrainian war in Europe.

Building on these insights, we specify four implications for service providers and policy makers. First, heating specialists, local energy utilities, and heat pump manufacturers could consider providing – alone or in collaboration – lease offerings in which the heat pump, installation, yearly maintenance, and potential repairs and part replacement costs are all included. Since uncertainty about operational performance appears to be an important barrier to heat-pump adoption for German house owners, service providers could also consider offering a performance guarantee in addition to heat-pump leasing services (i.e., efficient asset leasing). For example, the cost of the electricity used to operate the heat pump could be, fully or partly, also included in the service offering.[21] This type of service-based business model may be particularly relevant for markets at an early stage of diffusion. Second, since the length of leasing agreements appears to be a drawback, service providers could put forward the option for house owners to terminate leasing contracts at any time by paying the remainder of what is owed for the heat pump and installation (lease-to-own). Third, policy makers who wish to promote the adoption of heat pumps could consider providing support tailored to different modes of adoption, including asset leasing. For example, this could be achieved by reforming income tax regimes so that monthly lease payments can – at least partly – be deducted for tax purposes, as suggested by Schleich et al. (2021). Fourth, since a considerable share of respondents plan to install natural-gas-fired or heating-oil-fired boilers in their houses beyond 2025, policy makers may wish to consider strengthening country-wide energy efficiency or carbon emission regulations to ensure the timely phaseout of fossil-fuel heating. This could help set countries on the path of meeting their climate goals whilst reducing their dependence on fossil fuel imports.

[21] This way, customers would not have to bear the additional charges if the heat pump does not perform as expected. The electricity cost would be factored in the monthly payments, as specified in the 'efficient asset leasing' service offering. Similarly, Danish service provider Best Green reimburses customers for the power use by their heat pumps (Delta-EE, 2019).

The limitations of this study indicate avenues for future research. First, we applied a stated-preference method to investigate the preferences of house owners for heat-pump leasing offerings. This strategy is pertinent, given the novelty of these services and the scarcity of the historical data required to implement revealed-preference methods. However, not all respondents will transpose their intentions into actual leasing decisions. As service-based offerings expand into markets, scholars could further examine preferences for heat-pump leasing using revealed-preference methods. Second, this study focused on owners of single-family houses, as heat-pump diffusion tends to be greater for this market segment than for others, e.g., multi-family buildings (Cauret, 2021). However, this segment represents only a fraction of homeowners, let alone of the national population (see Subsection 3.4). Future research could also explore the role of service-based business models in decarbonizing other types of buildings (e.g., multi-family residential, business, or industrial buildings). Third, while this study focused on asset leasing, scholars could also explore preferences for other types of service-based offerings such as 'Heat-as-a-Service' – i.e., a business model whereby financial, technical, performance, behavioural, and energy price risks are all borne by service providers (Delta-EE, 2019). Fourth, as we propose tailoring policy measures to account for service-based offerings, scholars could elaborate on what types of policy incentives are preferred by end-users and industry actors (e.g., direct subsidies or rebates, fiscal incentives, or a combination of measures). Fifth, the results of this study are drawn from datasets from three specific countries. Further research could also look at how preferences for asset leasing differ in other markets. Finally, it is important to note that the data used in this study was collected mostly prior to the start of the latest Russian invasion of Ukraine, and that household heat-pump adoption intentions may since have changed. Further research could focus on elucidating the influence of the current energy crisis on households' preferences for heating services, including heat-pump leasing.

Disclaimer

The results and conclusions in this publication reflect only the authors' views. The European Commission, the Swiss Federal Office of Energy (SFOE), and Romande Energie SA are not responsible for any use that may be made of the information it contains.

CRediT authorship contribution statement

Elizabeth Côté: Conceptualization, Methodology, Software, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Cristian Pons-Seres de Brauwer:** Writing – review & editing.

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.

Data availability

The authors do not have permission to share data.

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Appendix

Table A.1
Socioeconomic and demographic descriptive statistics.[a, b]

Variable name	Description	% in French subsample (N = 304)	% in French population	Description	% in German subsample (N = 308)	% in German population	Description	% in Swiss subsample (N = 303)	% in Swiss population
Region[c]	Ile de France	12.5%	18.9%	South	29.9%	29.2%	German-speaking	74.6%	62.6%
	Northwest	24.3%	20.0%	North	19.2%	16.2%	French-speaking	25.4%	22.9%
	Northeast	20.1%	22.0%	West	33.1%	35.2%	Italian-speaking		8.2%
	Southwest	25.3%	18.4%	East	17.9%	19.4%	Romansh-speaking		0.5%
	Southeast	17.8%	20.7%						
Sex	Male	49.0%	47.6%	Male	47.4%	48.9%	Male	57.1%	49.2%
	Female	51.0%	52.4%	Female	52.6%	51.1%	Female	42.9%	50.8%
Household income[d]	*Monthly net income*			*Monthly net income*			*Monthly gross income*		
	Up to 1499 €	9.2%	22.2%	Up to 1499 €	9.1%	23.1%	Up to 6000 CHF	14.2%	30.0%
	1500–2499 €	38.2%	48.7%	1500–3499 €	49.0%	48.2%	6001–9000 CHF	22.1%	25.0%
	≥2500 €	52.6%	29.2%	≥3500 €	41.9%	28.1%	9001–12,000 CHF	26.4%	19.0%
							>12,000 CHF	37.3%	27.0%
Age	18–29 years	5.9%	25.0%	18–29 years	7.8%	16.0%	18–29 years	4.3%	17.4%
	30–44 years	24.7%	15.7%	30–44 years	18.5%	30.2%	30–44 years	20.5%	26.0%

(*continued on next page*)

Table A.1 (*continued*)

Variable name	Description	% in French subsample (N = 304)	% in French population	Description	% in German subsample (N = 308)	% in German population	Description	% in Swiss subsample (N = 303)	% in Swiss population
	45–59 years	26.6%	33.0%	45–59 years	29.9%	19.2%	45–59 years	38.3%	26.8%
	≥60 years	42.8%	26.3%	≥60 years	43.8%	34.7%	≥60 years	37.0%	29.8%
Level of education[e]	Low/middle	52.3%	68.3%	Low/middle	63.6%	66.4%	Low/middle	65.0%	62.0%
	High	47.7%	32.4%	High	36.4%	33.6%	High	35.0%	38.0%
Level of wealth[f]	*Ability to invest 30,000 € without a loan from a bank, an acquaintance or a relative.*			*Ability to invest 30,000 € without a loan from a bank, an acquaintance or a relative.*			*Ability to invest 50,000 CHF without a loan from a bank, an acquaintance or a relative.*		
	Yes	25.0%	n.a.	Yes	40.3%	n.a.	Yes	71.3%	n.a.
	No	70.4%	n.a.	No	50.0%	n.a.	No	25.7%	n.a.
	Rather not say	4.6%	n.a.	Rather not say	9.7%	n.a.	Rather not say	3.0%	n.a.

[a] Aggregated percentages could differ from 100% due to potential rounding errors.

[b] National population statistics are drawn from the French National Institute of Statistics and Economic Studies (*Institut national de la statistique et des études économiques, Insee*), French National Institute of Demographic Studies (*Institut national d'études démographiques, Ined*), German Federal Statistical Office (*Statistisches Bundesamt, Destatis*), Swiss Federal Statistical Office (*Office fédéral de la statistique, OFS*), Statista and Eurozensus.

[c] *Regions*: French Northwest (incl. Brittany, Centre-Val de Loire, Normandy, and Pays de la Loire), Northeast (Bourgogne-Franche-Comté, Grand Est, Hauts-de France), Southwest (New Aquitaine, Occitania), and Southeast (Auvergne-Rhône-Alpes, Corse, Provence-Alpes-Côte d'Azur); German South (incl. Bavaria and Baden Württemberg), North (Hamburg, Bremen, Schleswig-Holstein, Lower Saxony), West (Saarland, Hesse, North Rhine-Westphalia, Rhineland-Palatinate), and East (Berlin, Brandenburg, Thuringia, Saxony, Saxony-Anhalt, Mecklenburg-Western Pomerania); Swiss German-speaking (incl. All economic zones contained in the Alps and Pre-Alps, West Midland, and East Midland regions as defined by the WEMF/REMP) and French-speaking (incl. All economic zones contained in the Swiss Romandie region).

[d] *Household income*: monthly net income values were used in the French and German survey, whereas monthly gross income was used in the Swiss survey to reflect country-specific practices.

[e] *Levels of education*: French low and middle education levels (incl. Respondents with no diploma or certificate of education, *Brevet des collèges*, CAP, BEP, Bac, *brevet professionnel*) and French high education level (Bac + 2 or higher diploma); German low and middle education level (incl. Respondents with no diploma, secondary (elementary) school-leaving certificate, and *Realschule* or equivalent qualification), German high education level (advanced technical college qualification or general university qualification); Swiss low and middle education levels (incl. Respondents with no school-leaving qualification, compulsory school, household apprenticeship, commercial school, apprenticeship, diploma school, technical college, traffic school, vocational apprenticeship, full-time vocational school) and Swiss high education level (Matura, vocational baccalaureate, teacher training college, university, ETH, FH, PH, and higher vocational training).

[f] f Level of wealth: the ability to invest 30,000 € (or 50,000 CHF) without a loan from a bank, an acquaintance or a relative.

Table A.2
Descriptive statistics.

Variable name	Description	% in French subsample (N = 304)	% in German subsample (N = 308)	% in Swiss subsample (N = 303)
Construction period	*Period of construction of the single-family house.*			
	Before 1946	21.4%	20.5%	17.5%
	1946–1980	28.3%	37.7%	24.1%
	1981–2000	27.0%	25.6%	32.0%
	2001–2020	21.7%	15.6%	25.1%
	After 2020	1.6%	0.6%	1.3%
Living space	*Living space of the single-family house.*			
	Up to 119 square meters	59.9%	21.8%	9.9%
	120–159 square meters	30.9%	45.8%	52.1%
	160 square meters or more	9.2%	32.5%	38.0%
Operating duration	*Operating duration of the main heating system.*			
	Up to 5 years	24.0%	23.7%	17.8%
	6–15 years	35.2%	29.5%	35.6%
	16–25 years	20.7%	23.7%	27.7%
	More than 25 years	17.4%	21.1%	17.2%
	I don't know	2.6%	1.9%	1.7%
Retrofit plans	*Planning to replace the main heating system within the next 5 years.*			
	Yes	25.0%	25.3%	23.1%
	No	62.2%	65.3%	70.3%
	I don't know	12.8%	9.4%	6.6%
House acquisition	*Since when the single-family house has been owned by respondent.*			
	Before 1980	3.6%	8.8%	4.6%
	1980–1989	12.5%	14.3%	11.9%
	1990–1999	12.5%	17.2%	22.4%
	2000–2009	23.0%	22.4%	30.0%
	After 2010	44.7%	32.8%	30.4%
	Don't know	3.6%	4.5%	0.7%
Residency status	*Residing primarily in the single-family house (primary residence).*			
	Yes	96.4%	96.1%	93.7%
	No	3.6%	3.9%	6.3%

(*continued on next page*)

Table A.2 (*continued*)

Variable name	Description	% in French subsample (N = 304)	% in German subsample (N = 308)	% in Swiss subsample (N = 303)
Residential buildings owned	*Total number of residential buildings owned.*			
	1–2	96.4%	95.8%	90.8%
	3–5	3.3%	4.2%	7.6%
	More than 5	0.3%	0.0%	1.7%
Heating Cost	*Estimated average annual heating-related costs (€/CHF).*	1336 € (N = 247)	1859 € (N = 247)	2104 CHF (N = 214)

Table A.3
Overview of direct policy support targeting residential heat-pump adoption for the selection of sampled countries included in the analysis. Source: Own elaboration based on European Heat Pump Association – EHPA (2023c), German Heat Pump Association – BWP (2023), French Public Service for Housing Renovation – ANAH (2023), French Ministry for the Energy Transition – MTE (2023), myclimate (2023), and Francs Energie (2023).

Country	Policy support instrument	Building type eligibility	Amount (€/CHF)	Duration
France	• Investment subsidies to lower acquisition costs • VAT tax reduction • Both support measures are mutually inclusive	• Only applicable for renovation of existing buildings. New buildings not eligible	• Up to €1200 for sanitary hot water heat pumps (SHW) • Up to €9000 for air-to-water (ATW) and hybrid heat pumps (HHP) • Up to €15,000 for ground source heat pumps (GSHP) • All investment subsidies depend on family income • 5.5% VAT tax reduction (only for hydraulic heat pumps)	2020–2024
Germany	• Investment subsidies covering a share of acquisition costs	• Only applicable for renovation of existing buildings. New buildings not eligible	• Up to €15,000 or 25% of total acquisition costs for air-to-air (ATA) and ATW heat pumps • Up to €18,000 or 25% of total acquisition costs for GSHP. Additional bonus of 5% of total acquisition costs for GSHP • Up to 10% of total acquisition costs for replacement of a fossil fuel boiler	2023–2030
Switzerland	• Investment subsidies at the cantonal level	• Eligibility covers renovation of existing and new buildings (differences across cantons)	• Up to CHF 5000 for ATA heat pumps. Only applies to renovation of existing buildings and not across all cantons • Up to CHF 13,000 for ATW heat pumps – depending on power capacity. Only applies to new buildings and not across all cantons • Up to CHF 42,400 for GSHP with a thermal capacity of 500 kW-thermal. Only applies to new buildings and not across all cantons	Not specified

Table A.4
Robustness checks – Mean utility estimates by attribute level, expressed as difference to the baseline level for all homeowners within national subsamples.

		HB models			*P*-value for Mann Whitney *U* test (2-tailed)[a]		
		French HB model (1)	**German HB model (2)**	**Swiss HB model (3)**	Difference test between **(1) and (2)**	Difference test between **(1) and (3)**	Difference test between **(2) and (3)**
Subsample size (N)		304	308	303			
Number choice sets		3040	3080	3030			
Attribute	**Attribute level**						
Monthly lease payment	130 € (or 195 CHF) *(Baseline)*	0	0	0			
	155 € (or 230 CHF)	−41.61	−46.08	−42.45	0.509	0.911	0.441
	180 € (or 265 CHF)	−113.61	−108.30	−90.19	0.312	0.000 ***	0.008 ***
Type of lease contract	Basic package *(Baseline)*	0	0	0			
	Maintenance package	69.67	42.39	43.58	0.000 ***	0.000 ***	0.827
	All–inclusive package	91.15	109.49	100.35	0.001 ***	0.036 **	0.181
Service provider	Heat pump manufacturer *(Baseline)*	0	0	0			
	Local utility	−14.99	9.98	2.56	0.000 ***	0.001 ***	0.081 *
	Heating specialist	5.42	15.31	−0.60	0.004 **	0.128	0.000 ***

[a] *** Significance level of 1% ($p < 0.01$), ** Significance level of 5% ($p < 0.05$), * Significance level of 10% ($p < 0.1$).

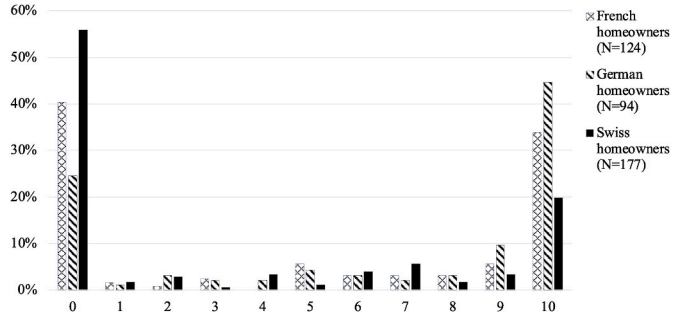


Fig. A.1. Share of homeowners who planned to replace their heating system with a heat pump by the number of times they chose to lease the heat pump instead of purchasing it in all DCE choice tasks.

Table A.5
Robustness checks – Mean utility estimates by attribute level, expressed as difference to the baseline level for homeowners who passed all manipulation checks and who planned to install a heat pump.

	HB models			*P*-value[a]			
	All country-specific homeowners (1)	Passed all manipulation checks (2)	Planned to install heat pump (3)	Difference test between (1) and (2)		Difference test between (1) and (3)	
France							
Model size (N)	304	82	124				
Share of subsample	100.0%	27.0%	40.8%				
Attribute level							
130 € (195 CHF) *(Baseline)*	0	0	0				
155 € (230 CHF)	−41.61	−36	−38	0.444		0.362	
180 € (265 CHF)	−113.61	−110.55	−104.68	0.700		0.198	
Basic package *(Baseline)*	0	0	0				
Maintenance package	69.67	69.11	77.8	0.765		0.174	
All–inclusive package	91.15	97.15	99.48	0.451		0.134	
Manufacturer *(Baseline)*	0	0	0				
Local utility	−14.99	−14.94	−35.48	0.680		0.001	***
Heating specialist	5.42	10.93	−5.60	0.768		0.180	
Germany							
Model size (N)	308	102	94				
Share of subsample	100.0%	33.1%	30.5%				
Attribute level							
130 € (195 CHF) *(Baseline)*	0	0	0				
155 € (230 CHF)	−46.08	−52.17	−46.66	0.309		0.748	
180 € (265 CHF)	−108.30	−122.68	−109.65	0.099	*	0.835	
Basic package *(Baseline)*	0	0	0				
Maintenance package	42.39	38.93	45.12	0.465		0.969	
All–inclusive package	109.49	103.65	104.61	0.395		0.749	
Manufacturer *(Baseline)*	0	0	0				
Local utility	9.98	8.96	7.95	0.762		0.606	
Heating specialist	15.31	15.58	13.04	0.654		0.667	
Switzerland							
Model size (N)	303	105	177				
Share of subsample	100.0%	34.7%	58.4%				
Attribute level							
130 € (195 CHF) *(Baseline)*	0	0	0				
155 € (230 CHF)	−42.45	−46.43	−44.82	0.447		0.855	
180 € (265 CHF)	−90.19	−95.08	−100.41	0.732		0.234	
Basic package *(Baseline)*	0	0	0				
Maintenance package	43.58	56.3	44.93	0.030	**	0.677	
All–inclusive package	100.35	107.47	97.14	0.220		0.628	
Manufacturer *(Baseline)*	0	0	0				
Local utility	2.56	−15.75	−10.68	0.030	**	0.036	**
Heating specialist	−0.60	−6.15	−10.49	0.781		0.053	*

[a] *** Mann Whitney *U* test (2-tailed): significance level of 1% ($p < 0.01$), ** Significance level of 5% ($p < 0.05$), * Significance level of 10% ($p < 0.1$).

Table A.6
Monthly willingness to pay of house owners for heat-pump leasing services (WTP), lower and upper 95% confidence intervals (CI), and standard deviation estimates.

		HB model French sample (N = 304)			HB model German sample (N = 308)			HB model Swiss sample (N = 303)		
Attribute	Attribute levels	Monthly WTP (€)	Lower & upper 95% CI	Standard deviation	Monthly WTP (€)	Lower & upper 95% CI	Standard deviation	Monthly WTP (CHF)	Lower & upper 95% CI	Standard deviation
Type of lease contract	Basic package *(baseline)*	0.00	0.00	0.00	0.00	0.00	0.00	0.00		0.00
	Maintenance package	30.66	[27.99; 33.33]	23.76	19.57	[17.29; 21.85]	20.41	33.82	[29.58; 38.07]	37.69
	All-inclusive package	40.12	[37.06; 43.17]	27.16	50.55	[46.76; 54.33]	33.90	77.89	[71.62; 84.16]	55.72

References

Achtnicht, M., 2011. Do environmental benefits matter? Evidence from a choice experiment among house owners in Germany. Ecol. Econ. 70, 2191–2200. https://doi.org/10.1016/j.ecolecon.2011.06.026.

Achtnicht, M., Madlener, R., 2014. Factors influencing German house owners' preferences on energy retrofits. Energy Pol. 68, 254–263. https://doi.org/10.1016/j.enpol.2014.01.006.

Allenby, G.M., Rossi, P.E., McCulloch, R.E., 2005. Hierarchical Bayes Models: A Practitioners Guide. SSRN Electron. J. https://doi.org/10.2139/ssrn.655541.

ANAH, 2023. MaPrimeRénov [WWW Document] MaPrimeRénov'. https://www.maprimerenov.gouv.fr/prweb/PRAuth/app/AIDES_/BPNVwCpLW8TKW49zoQZpAw*/!STANDARD.

Andrews, D., Sánchez, A.C., 2011. The evolution of homeownership rates in selected OECD countries: demographic and public policy influences. OECD J. Econ. Stud. 2011/1, 39. https://doi.org/10.1787/eco_studies-2011-5kg0vswqpmg2.

Bach, L., Hopkins, D., Stephenson, J., 2020. Solar electricity cultures: household adoption dynamics and energy policy in Switzerland. Energy Res. Social Sci. 63, 101395 https://doi.org/10.1016/j.erss.2019.101395.

Balcombe, P., Rigby, D., Azapagic, A., 2014. Investigating the importance of motivations and barriers related to microgeneration uptake in the UK. Appl. Energy 130, 403–418. https://doi.org/10.1016/j.apenergy.2014.05.047.

BFS, 2018. Energy field: heating system and energy sources [WWW Document] Swiss Fed. Stat. Off. https://www.bfs.admin.ch/bfs/en/home/statistics/construction-housing/buildings/energy-field.html accessed 3.13.22.

Bloomberg, 2022. Europe gas surges to record after supply risks drive wild swings [WWW Document] Bloomberg. https://www.bloomberg.com/news/articles/2022-03-07/european-gas-soars-to-new-record-as-u-s-mulls-russia-energy-ban accessed 4.25.22.

BMI, 2021. The new buildings energy act [WWW Document] Ger. Fed. Minist. Inter. Community Bundesminist. Inn. Für Heim. https://www.bmi.bund.de/EN/topics/building-housing/building/energy-efficient-construction-renovation/buildings-energy-act/buildings-energy-act-node.html accessed 4.25.22.

Braungardt, S., Keimeyer, F., Bürger, V., Tezak, B., Klinski, S., 2021. Phase-out regulations for fossil fuel boilers at EU and national level [WWW Document] Öko-Inst. EV. https://www.oeko.de/fileadmin/oekodoc/Phase-out_fossil_heating.pdf accessed 4.25.22.

Britton, J., Minas, A.M., Marques, A.C., Pourmirza, Z., 2021. Exploring the potential of *heat as a service* in decarbonization: evidence needs and research gaps. Energy Sources B Energy Econ. Plann. 16, 999–1015. https://doi.org/10.1080/15567249.2021.1873460.

Brockway, A.M., Delforge, P., 2018. Emissions reduction potential from electric heat pumps in California homes. Electr. J. 31, 44–53. https://doi.org/10.1016/j.tej.2018.10.012.

Brown, D., Hall, S., Martiskainen, M., Davis, M.E., 2022. Conceptualising domestic energy service business models: a typology and policy recommendations. Energy Pol. 161, 112704 https://doi.org/10.1016/j.enpol.2021.112704.

Bundesrat, 2021. Ordonnance sur la protection de l'air (OPair) [WWW Document] Swiss Fed. Counc. https://fedlex.data.admin.ch/filestore/fedlex.data.admin.ch/eli/cc/1986/208_208_208/20200401/fr/pdf-a/fedlex-data-admin-ch-eli-cc-1986-208_208_208-20200401-fr-pdf-a.pdf accessed 4.25.22.

Bundesregierung, 2020. Building and housing [WWW Document] Ger. Fed. Gov. https://www.bundesregierung.de/breg-en/issues/climate-action/building-and-housing-1795860 accessed 4.25.22.

BWP, 2023. Wärmepumpe [WWW Document] Bundesverb. Wärmepumpe BWP. https://www.waermepumpe.de/waermepumpe/foerderung/ accessed 7.20.23.

Cauret, O., 2021. Heat pumps in multi-family buildings, drivers and barriers [WWW Document] Heat Pump. Technol. Mag. https://heatpumpingtechnologies.org/magazine-1-2021/heat-pumps-in-multi-family-buildings-drivers-and-barriers/ accessed 4.25.22.

Chaudry, M., Abeysekera, M., Hosseini, S.H.R., Jenkins, N., Wu, J., 2015. Uncertainties in decarbonising heat in the UK. Energy Pol. 87, 623–640. https://doi.org/10.1016/j.enpol.2015.07.019.

Cooper, S.J.G., Hammond, G.P., McManus, M.C., Rogers, J.G., 2014. Impact on energy requirements and emissions of heat pumps and micro-cogenerators participating in demand side management. Appl. Therm. Eng. 71, 872–881. https://doi.org/10.1016/j.applthermaleng.2013.12.070.

Côté, E., Đukan, M., Pons-Seres de Brauwer, C., Wüstenhagen, R., 2022. The price of actor diversity: measuring project developers' willingness to accept risks in renewable energy auctions. Energy Pol. 163, 112835 https://doi.org/10.1016/j.enpol.2022.112835.

Coughlin, J., Cory, K., 2009. Solar photovoltaic financing: residential sector deployment (No. NREL/TP-6A2-44853, 950132). https://doi.org/10.2172/950132.

Davidson, C., Steinberg, D., Margolis, R., 2015. Exploring the market for third-party-owned residential photovoltaic systems: insights from lease and power-purchase agreement contract structures and costs in California. Environ. Res. Lett. 10, 024006 https://doi.org/10.1088/1748-9326/10/2/024006.

Davis, L., 2023. The economic determinants of heat pump adoption. SSRN Electron. J. https://doi.org/10.2139/ssrn.4475942.

Direction de l'énergie, 2021. Cinq fiches d'information sur les changements appliqués à Mon foyer ou ma nouvelle maison [WWW Document] État Vaud. https://www.vd.ch/fileadmin/user_upload/themes/environnement/energie/fichiers_pdf/LVLEne_fiches_information.pdf accessed 4.25.22.

Decker, T., Zapilko, M., Menrad, K., Decker, T., Zapilko, M., Menrad, K., 2009. Purchase behaviour related to heating systems in Germany with special consideration of consumers' ecological attitudes. https://doi.org/10.22004/AG.ECON.91300.

Delta, E.E., 2019. Defining heat as a service [WWW Document] DELTA Energy Environ. https://www.delta-ee.com/delta-ee-blog/defining-heat-as-a-service.html accessed 3.13.22.

Destatis, 2021. Housing: dwellings, by type of heating and energy [WWW Document] Stat. Bundesamt Destatis. https://www.destatis.de/EN/Themes/Society-Environment/Housing/Tables/occupied-dwelling-units-residential-buildings-energy.html accessed 3.13.22.

Direction de l'information légale et administrative, 2022. La fin des nouvelles chaudières au fioul ou au charbon à partir du 1er juillet 2022 [WWW Document] Serv. Public - Répub. Fr. https://www.service-public.fr/particuliers/actualites/A15413 accessed 4.25.22.

Drury, E., Miller, M., Macal, C.M., Graziano, D.J., Heimiller, D., Ozik, J., Perry IV, T.D., 2012. The transformation of southern California's residential photovoltaics market through third-party ownership. Energy Pol. 42, 681–690. https://doi.org/10.1016/j.enpol.2011.12.047.

ECOS, 2021. Member States' ambition to phase out fossil-fuel heating – an analysis [WWW Document] Cool. Cool Planet. URL. https://www.coolproducts.eu/wp-content/uploads/2021/07/ECOS-Coolproducts-Background-Briefing-MS-ambition-to-phase-out-fossil-fuel-heating.pdf. accessed 4.25.22.

Effy, 2023. Combien coûte une PAC air-eau [WWW Document] Quelle Énerg. https://www.quelleenergie.fr/economies-energie/pompe-chaleur-air-eau/prix-economies accessed 7.20.23.

EHPA, 2021a. Market Report 2021 [WWW Document] Eur. Heat Pump Assoc. https://www.ehpa.org/market-data/market-report-2021/ accessed 3.8.22.

EHPA, 2021b. Market Data [WWW Document] Eur. Heat Pump Assoc. https://www.ehpa.org/market-data/ accessed 4.25.22.

EHPA, 2023a. About heat pumps [WWW Document] Eur. Heat Pump Assoc. https://www.ehpa.org/about-heat-pumps/ accessed 7.20.23.

EHPA, 2023b. Frequently asked questions [WWW Document] Eur. Heat Pump Assoc. https://www.ehpa.org/frequently-asked-questions/ accessed 7.20.23.

EHPA, 2023c. Heat pumps: the heart of our energy future [WWW Document] Eur. Heat Pump Assoc. https://www.ehpa.org accessed 7.20.23.

Enkhardt, S., 2022. German heating solutions provider offers heat pump leasing [WWW Document] Pv Mag. https://www.pv-magazine.com/2022/06/08/german-heating-solutions-provider-offers-heat-pump-leasing/ accessed 7.20.23.

EPA, 2022. Green power markets: financing [WWW Document] US Environ. Prot. Agency. https://www.epa.gov/green-power-markets/financing#one. accessed 4.25.22.

European Commission, 2022. REPowerEU: joint European action for more affordable, secure and sustainable energy [WWW Document] Eur. Comm. https://ec.europa.eu/commission/presscorner/detail/en/ip_22_1511 accessed 3.13.22.

Eurostat, 2023. House or flat – owning or renting [WWW Document] Eurostat. https://ec.europa.eu/eurostat/cache/digpub/housing/bloc-1a.html?lang=en accessed 7.20.23.
Fedrizzi, R., 2023. Overview Article - Integrating Heat Pumps in Existing Residential Buildings [WWW Document] Eur. Comm. - Build Up. https://build-up.ec.europa.eu/en/resources-and-tools/articles/overview-article-integrating-heat-pumps-existing-residential-buildings.
Francs Energie, 2023. Francs energie [WWW Document] Francs Energ. https://www.francsenergie.ch/fr.
Frank, L., Quitzow, R., 2022. Germany's new building energy act is a missed opportunity [WWW Document] Inst. Adv. Sustain. Stud. IASS. https://www.iass-potsdam.de/en/blog/2020/07/germanys-new-building-energy-act-missed-opportunity accessed 4.25.22.
Friedman, B., Margolis, R., Seel, J., 2016. Comparing photovoltaic (PV) costs and deployment drivers in the Japanese and U.S. Residential and commercial markets. No. NREL/TP–6A20-60360, 1248076). https://doi.org/10.2172/1248076.
Gaur, A.S., Fitiwi, D.Z., Curtis, J., 2021. Heat pumps and our low-carbon future: a comprehensive review. Energy Res. Social Sci. 71, 101764 https://doi.org/10.1016/j.erss.2020.101764.
Giambastiani, B.M.S., Tinti, F., Mendrinos, D., Mastrocicco, M., 2014. Energy performance strategies for the large scale introduction of geothermal energy in residential and industrial buildings: the GEO.POWER project. Energy Pol. 65, 315–322. https://doi.org/10.1016/j.enpol.2013.10.008.
Globisch, J., Kühnbach, M., Dütschke, E., Bekk, A., 2020. The stranger in the German energy system? How energy system requirements misalign with household preferences for flexible heat pumps. Energy Res. Social Sci. 67, 101604 https://doi.org/10.1016/j.erss.2020.101604.
Graziano, M., Gillingham, K., 2015. Spatial patterns of solar photovoltaic system adoption: the influence of neighbors and the built environment. J. Econ. Geogr. 15, 815–839. https://doi.org/10.1093/jeg/lbu036.
Helion, 2023. Kosten für Wärmepumpen in der Schweiz [WWW Document] Helion. https://www.helion.ch/de/warmepumpe/kosten/. accessed 7.20.23.
Helms, T., 2016. Asset transformation and the challenges to servitize a utility business model. Energy Pol. 91, 98–112. https://doi.org/10.1016/j.enpol.2015.12.046.
Hensher, D.A., 2010. Hypothetical bias, choice experiments and willingness to pay. Transp. Res. Part B Methodol. 44, 735–752. https://doi.org/10.1016/j.trb.2009.12.012.
Hill, A.R., 2017. The CBC System for Choice-Based Conjoint Analysis, vol. 28.
Hille, S.L., Curtius, H.C., Wüstenhagen, R., 2018. Red is the new blue – the role of color, building integration and country-of-origin in homeowners' preferences for residential photovoltaics. Energy Build. 162, 21–31. https://doi.org/10.1016/j.enbuild.2017.11.070.
Hlavinka, A.N., Mjelde, J.W., Dharmasena, S., Holland, C., 2016. Forecasting the adoption of residential ductless heat pumps. Energy Econ. 54, 60–67. https://doi.org/10.1016/j.eneco.2015.11.020.
Hobbs, A., Benami, E., Varadarajan, U., Pierpont, B., 2013. Improving solar policy: lessons from the solar leasing boom in California [WWW Document] Clim. Policy Initiat. https://www.climatepolicyinitiative.org/wp-content/uploads/2013/07/Improving-Solar-Policy-Lessons-from-the-solar-leasing-boom-in-California.pdf accessed 7.20.23.
Howden-Chapman, P., Viggers, H., Chapman, R., O'Dea, D., Free, S., O'Sullivan, K., 2009. Warm homes: drivers of the demand for heating in the residential sector in New Zealand. Energy Pol. 37, 3387–3399. https://doi.org/10.1016/j.enpol.2008.12.023.
IEA, 2021a. Renewables 2021 [WWW Document] Int. Energy Agency. https://iea.blob.core.windows.net/assets/5ae32253-7409-4f9a-a91d-1493ffb9777a/Renewables2021-Analysisandforecastto2026.pdf accessed 3.8.21.
IEA, 2021b. Heating [WWW Document] Int. Energy Agency. https://www.iea.org/reports/heating.
IEA, 2021c. Heat pumps [WWW Document] Int. Energy Agency. https://www.iea.org/reports/heat-pumps accessed 3.8.22.
IEA, 2021d. Net Zero by 2050: a roadmap for the global energy sector [WWW Document] Int. Energy Agency. https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf accessed 4.25.22.
IEA, 2022. How Europe can cut natural gas imports from Russia significantly within a year [WWW Document] Int. Energy Agency. https://www.iea.org/news/how-europe-can-cut-natural-gas-imports-from-russia-significantly-within-a-year accessed 3.8.22.
Infos Bercy, 2022. Rénovation énergétique : les aides auxquelles vous pouvez prétendre [WWW Document] Minist. LÉconomie Financ. Relance. https://www.economie.gouv.fr/particuliers/aides-renovation-energetique accessed 4.25.22.
IRENA, 2020. Energy as a service: innovation landscape brief [WWW Document] Int. Renew. Energy Agency. https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2020/Jul/IRENA_Energy-as-a-Service_2020.pdf accessed 3.13.22.
Irfan, M., Elavarasan, R.M., Hao, Y., Feng, M., Sailan, D., 2021. An assessment of consumers' willingness to utilize solar energy in China: end-users' perspective. J. Clean. Prod. 292, 126008 https://doi.org/10.1016/j.jclepro.2021.126008.
Jones, E.C., Leibowicz, B.D., 2021. Co-optimization and community: maximizing the benefits of distributed electricity and water technologies. Sustain. Cities Soc. 64, 102515 https://doi.org/10.1016/j.scs.2020.102515.
Karytsas, S., 2018. An empirical analysis on awareness and intention adoption of residential ground source heat pump systems in Greece. Energy Pol. 123, 167–179. https://doi.org/10.1016/j.enpol.2018.08.001.
Karytsas, S., Theodoropoulou, H., 2014. Public awareness and willingness to adopt ground source heat pumps for domestic heating and cooling. Renew. Sustain. Energy Rev. 34, 49–57. https://doi.org/10.1016/j.rser.2014.02.008.
Kazakov, J., 2023. Installation price of 1 heat pump in Switzerland [WWW Document] Seize. https://seize-sa.ch/en/the-price-of-a-heat-pump/ accessed 7.20.23.
Kelly, J.A., Fu, M., Clinch, J.P., 2016. Residential home heating: the potential for air source heat pump technologies as an alternative to solid and liquid fuels. Energy Pol. 98, 431–442. https://doi.org/10.1016/j.enpol.2016.09.016.
Kennedy, M., Basu, B., 2013. A study on the implementation of renewable heating technologies in the domestic sector in Ireland with implications on consumers' decision-making. J. Clean. Prod. 44, 133–142. https://doi.org/10.1016/j.jclepro.2013.01.018.
Kerr, N., Winskel, M., 2021. A review of heat decarbonisation policies in Europe. https://doi.org/10.7488/ERA/794.
Kikuchi, E., Bristow, D., Kennedy, C.A., 2009. Evaluation of region-specific residential energy systems for GHG reductions: case studies in Canadian cities. Energy Pol. 37, 1257–1266. https://doi.org/10.1016/j.enpol.2008.11.004.
Klein, S.J.W., Hargreaves, A., Coffey, S., 2021. A financial benefit-cost analysis of different community solar approaches in the Northeastern US. Sol. Energy 213, 225–245. https://doi.org/10.1016/j.solener.2020.11.031.
Kloth, P., 2023. Die Wärmepumpe - alle Kosten im Vergleich [WWW Document] Energieheld. https://www.energieheld.de/heizung/waermepumpe/kosten accessed 7.20.23.
Krishnamurthy, C.K.B., Kriström, B., 2015. How large is the owner-renter divide in energy efficient technology? Evidence from an OECD cross-section. Energy J. 36 https://doi.org/10.5547/01956574.36.4.ckri.
Lang, G., Farsi, M., Lanz, B., Weber, S., 2021. Energy efficiency and heating technology investments: manipulating financial information in a discrete choice experiment. Resour. Energy Econ. 64, 101231 https://doi.org/10.1016/j.reseneeco.2021.101231.
Leurent, M., Da Costa, P., Jasserand, F., Rämä, M., Persson, U., 2018. Cost and climate savings through nuclear district heating in a French urban area. Energy Pol. 115, 616–630. https://doi.org/10.1016/j.enpol.2018.01.043.
Lillemo, S.C., Alfnes, F., Halvorsen, B., Wik, M., 2013. Households' heating investments: the effect of motives and attitudes on choice of equipment. Biomass Bioenergy 57, 4–12. https://doi.org/10.1016/j.biombioe.2013.01.027.
Louviere, J.J., Hensher, D.A., Swait, J.D., Adamowicz, W., 2000. Stated Choice Methods: Analysis and Applications, first ed. Cambridge University Press. https://doi.org/10.1017/CBO9780511753831.
Lowes, R., Rosenow, J., Scott, D., Sunderland, L., Thomas, S., Graf, A., Baton, M., Pantano, S., Graham, P., 2022. The perfect fit: shaping the Fit for 55 package to drive a climate-compatible heat pump market [WWW Document]. https://www.raponline.org/wp-content/uploads/2022/03/RAP-heat-pump-report-FINAL_2022_03.pdf. accessed 4.27.22.
Mahapatra, K., Gustavsson, L., 2008. An adopter-centric approach to analyze the diffusion patterns of innovative residential heating systems in Sweden. Energy Pol. 36, 577–590. https://doi.org/10.1016/j.enpol.2007.10.006.
Manski, C.F., 1977. The structure of random utility models. Theor. Decis. 8, 229–254. https://doi.org/10.1007/BF00133443.
McFadden, D., 1974. Conditional logit analysis of qualitative choice behavior. In: Zarembka, P. (Ed.), Frontiers in Econometrics, Economic Theory and Mathematical Economics. Academic Press, New York.
Meles, T.H., Ryan, L., Mukherjee, S.C., 2022. Heterogeneity in preferences for renewable home heating systems among Irish households. Appl. Energy 307, 118219. https://doi.org/10.1016/j.apenergy.2021.118219.
Michelsen, C.C., Madlener, R., 2012. Homeowners' preferences for adopting innovative residential heating systems: a discrete choice analysis for Germany. Energy Econ. 34, 1271–1283. https://doi.org/10.1016/j.eneco.2012.06.009.
Michelsen, C.C., Madlener, R., 2013. Motivational factors influencing the homeowners' decisions between residential heating systems: an empirical analysis for Germany. Energy Pol. 57, 221–233. https://doi.org/10.1016/j.enpol.2013.01.045.
Michelsen, C.C., Madlener, R., 2016. Switching from fossil fuel to renewables in residential heating systems: an empirical study of homeowners' decisions in Germany. Energy Pol. 89, 95–105. https://doi.org/10.1016/j.enpol.2015.11.018.
MTE, 2021. RE 2020 réglementation environnementale: Éco-construire pour le confort de tous [WWW Document]. https://www.ecologie.gouv.fr/sites/default/files/2021.02.18_DP_RE2020_EcoConstruire_0.pdf. accessed 4.25.22.
MTE, 2023. Coup de pouce "Chauffage" [WWW Document]. https://www.ecologie.gouv.fr/coup-pouce-chauffage.
Munsell, M., 2014. Market Share for Leasing Residential Solar to Peak in 2014 [WWW Document] Greentech Media. https://www.greentechmedia.com/articles/read/market-share-for-leasing-residential-solar-to-peak-in-2014 accessed 7.20.23.
myclimate, 2023. Future-proof warmth from nature: support programme for heat pumps in Switzerland [WWW Document] myclimate. https://www.myclimate.org/information/carbon-offset-projects/detail-carbon-offset-projects/switzerland-energy-efficiency-7816/.
Nägeli, C., Jakob, M., Catenazzi, G., Ostermeyer, Y., 2020. Policies to decarbonize the Swiss residential building stock: an agent-based building stock modeling assessment. Energy Pol. 146, 111814 https://doi.org/10.1016/j.enpol.2020.111814.
OK, 2023. Leasing af varmepumpe [WWW Document] OK. https://www.ok.dk/privat/produkter/varmepumper/leasing accessed 7.20.23.
Orme, B., 2016. CBC/HB: Software for Hierarchical Bayes Estimation for CBC Data 113.
Orme, B., Howell, J., 2009. Application of covariates within Sawtooth software's CBC/HB program: theory and practical example. Sawtooth Softw 21.
Overholm, H., 2015. Spreading the rooftop revolution: what policies enable solar-as-a-service? Energy Pol. 84, 69–79. https://doi.org/10.1016/j.enpol.2015.04.021.

Palm, A., 2016. Local factors driving the diffusion of solar photovoltaics in Sweden: a case study of five municipalities in an early market. Energy Res. Social Sci. 14, 1–12. https://doi.org/10.1016/j.erss.2015.12.027.
Peñaloza, D., Mata, É., Fransson, N., Fridén, H., Samperio, Á., Quijano, A., Cuneo, A., 2022. Social and market acceptance of photovoltaic panels and heat pumps in Europe: a literature review and survey. Renew. Sustain. Energy Rev. 155, 111867 https://doi.org/10.1016/j.rser.2021.111867.
Petrovich, B., Hille, S.L., Wüstenhagen, R., 2019. Beauty and the budget: a segmentation of residential solar adopters. Ecol. Econ. 164, 106353 https://doi.org/10.1016/j.ecolecon.2019.106353.
Petrovich, B., Carattini, S., Wüstenhagen, R., 2021. The price of risk in residential solar investments. Ecol. Econ. 180, 106856 https://doi.org/10.1016/j.ecolecon.2020.106856.
Pezzutto, S., Grilli, G., 2017. European heat pump market analysis: assessment of barriers and drivers. Int. J. Contemp. ENERGY 62–70. https://doi.org/10.14621/ce.20170207.
Raghavan, S.V., Wei, M., Kammen, D.M., 2017. Scenarios to decarbonize residential water heating in California. Energy Pol. 109, 441–451. https://doi.org/10.1016/j.enpol.2017.07.002.
Rai, V., Reeves, D.C., Margolis, R., 2016. Overcoming barriers and uncertainties in the adoption of residential solar PV. Renew. Energy 89, 498–505. https://doi.org/10.1016/j.renene.2015.11.080.
Rao, V.R., 2014. Applied Conjoint Analysis. Springer Berlin Heidelberg, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-87753-0.
Reeves, D.C., Rai, V., 2018. Strike while the rebate is hot: savvy consumers and strategic technology adoption timing. Energy Pol. 121, 325–335. https://doi.org/10.1016/j.enpol.2018.06.045.
Reeves, D.C., Rai, V., Margolis, R., 2017. Evolution of consumer information preferences with market maturity in solar PV adoption. Environ. Res. Lett. 12, 074011 https://doi.org/10.1088/1748-9326/aa6da6.
Rouvinen, S., Matero, J., 2013. Stated preferences of Finnish private homeowners for residential heating systems: a discrete choice experiment. Biomass Bioenergy 57, 22–32. https://doi.org/10.1016/j.biombioe.2012.10.010.
Ruokamo, E., 2016. Household preferences of hybrid home heating systems – a choice experiment application. Energy Pol. 95, 224–237. https://doi.org/10.1016/j.enpol.2016.04.017.
Sagebiel, J., Müller, J.R., Rommel, J., 2014. Are consumers willing to pay more for electricity from cooperatives? Results from an online Choice Experiment in Germany. Energy Res. Social Sci. 2, 90–101. https://doi.org/10.1016/j.erss.2014.04.003.
Salm, S., Wüstenhagen, R., 2018. Dream team or strange bedfellows? Complementarities and differences between incumbent energy companies and institutional investors in Swiss hydropower. Energy Pol. 121, 476–487. https://doi.org/10.1016/j.enpol.2018.04.046.
Salm, S., Hille, S.L., Wüstenhagen, R., 2016. What are retail investors' risk-return preferences towards renewable energy projects? A choice experiment in Germany. Energy Pol. 97, 310–320. https://doi.org/10.1016/j.enpol.2016.07.042.
Sawtooth Software, 2022. Testing the CBC design [WWW Document] Sawtooth Softw. https://sawtoothsoftware.com/help/lighthouse-studio/manual/cbc-test-design.html accessed 5.25.22.
Scarpa, R., Willis, K., 2010. Willingness-to-pay for renewable energy: primary and discretionary choice of British households' for micro-generation technologies. Energy Econ. 32, 129–136. https://doi.org/10.1016/j.eneco.2009.06.004.
Schleich, J., Faure, C., Guetlein, M.-C., Tu, G., 2020. Household preferences for new heating systems: insights from a multi-country discrete choice experiment. Fraunhofer-Inst. Für Syst. Innov. ISI Karlsr. Working Paper Sustainability and Innovation 27.
Schleich, J., Tu, G., Faure, C., Guetlein, M.-C., 2021. Would you prefer to rent rather than own your new heating system? Insights from a discrete choice experiment among owner-occupiers in the UK. Energy Pol. 158, 112523 https://doi.org/10.1016/j.enpol.2021.112523.
Schleich, J., Guetlein, M.-C., Tu, G., Faure, C., 2022. Household preferences for private versus public subsidies for new heating systems: insights from a multi-country discrete choice experiment. Appl. Econ. 1–18. https://doi.org/10.1080/00036846.2022.2030043.
SDES, 2021. Consommation d'énergie par usage du résidentiel [WWW Document] Serv. Données Études Stat. SDES Ministère Transit. Écologique. https://www.statistiques.developpement-durable.gouv.fr/consommation-denergie-par-usage-du-residentiel accessed 3.13.22.
Shen, X., Qiu, Y.L., Liu, P., Patwardhan, A., 2022. The effect of rebate and loan incentives on residential heat pump adoption: evidence from North Carolina. Environ. Resour. Econ. 82, 741–789. https://doi.org/10.1007/s10640-022-00691-0.
Singh, H., Muetze, A., Eames, P.C., 2010. Factors influencing the uptake of heat pump technology by the UK domestic sector. Renew. Energy 35, 873–878. https://doi.org/10.1016/j.renene.2009.10.001.
Sopha, B.M., Klöckner, C.A., Skjevrak, G., Hertwich, E.G., 2010. Norwegian households' perception of wood pellet stove compared to air-to-air heat pump and electric heating. Energy Pol. 38, 3744–3754. https://doi.org/10.1016/j.enpol.2010.02.052.
Sovacool, B.K., Martiskainen, M., 2020. Hot transformations: governing rapid and deep household heating transitions in China, Denmark, Finland and the United Kingdom. Energy Pol. 139, 111330 https://doi.org/10.1016/j.enpol.2020.111330.
Sovacool, B.K., Demski, C., Noel, L., 2021. Beyond climate, culture and comfort in European preferences for low-carbon heat. Global Environ. Change 66, 102200. https://doi.org/10.1016/j.gloenvcha.2020.102200.
Stewart, F., 2022. Friends with benefits: how income and peer diffusion combine to create an inequality "trap" in the uptake of low-carbon technologies. Energy Pol. 163, 112832 https://doi.org/10.1016/j.enpol.2022.112832.
Strupeit, L., Palm, A., 2016. Overcoming barriers to renewable energy diffusion: business models for customer-sited solar photovoltaics in Japan, Germany and the United States. J. Clean. Prod. 123, 124–136. https://doi.org/10.1016/j.jclepro.2015.06.120.
SWI, 2021. Zurich voters approve ban on oil and gas heaters [WWW Document] Swissinfo.ch. https://www.swissinfo.ch/eng/zurich-voters-approve-ban-on-oil-and-gas-heaters/47140666 accessed 4.25.22.
Tanveer, A., Zeng, S., Irfan, M., Peng, R., 2021. Do perceived risk, perception of self-efficacy, and openness to technology matter for solar PV adoption? An application of the extended theory of planned behavior. Energies 14, 5008. https://doi.org/10.3390/en14165008.
Tix, M., 2022. Thermondo sees high demand for rental heat pumps [WWW Document] Energate Gmbh. https://www.greentechmedia.com/articles/read/market-share-for-leasing-residential-solar-to-peak-in-2014 accessed 7.20.23.
Tognetti, F., 2020. ANALYSIS OF EXISTING INCENTIVES IN EUROPE FOR HEATING POWERED BY FOSSIL FUELS AND RENEWABLE SOURCES. European Environmental Bureau.
Trethewey, R., 2023. Future House | Understanding Heat Pumps [WWW Document] This Old House. https://www.thisoldhouse.com/heating-cooling/22866833/understanding-heat-pumps accessed 7.20.23.
UN, 2020. The race to zero emissions, and why the world depends on it [WWW Document] U. N. News. https://news.un.org/en/story/2020/12/1078612 accessed 1.16.21.
Weber, S., Baranzini, A., Fragniere, E., 2009. Consumers' choices among alternative electricity programmes in Geneva – an empirical analysis. Int. J. Global Energy Issues 31, 295. https://doi.org/10.1504/IJGEI.2009.027643.
Willis, K., Scarpa, R., Gilroy, R., Hamza, N., 2011. Renewable energy adoption in an ageing population: heterogeneity in preferences for micro-generation technology adoption. Energy Pol. 39, 6021–6029. https://doi.org/10.1016/j.enpol.2011.06.066.
Wittink, D., Huber, J., Zandan, P., Johnson, R., 1992. The Number of Levels Effect in Conjoint: where does it come from and can it be eliminated? [WWW Document] Sawtooth Softw. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.375.9312&rep=rep1&type=pdf accessed 5.25.22.
Wolske, K.S., 2020. More alike than different: profiles of high-income and low-income rooftop solar adopters in the United States. Energy Res. Social Sci. 63, 101399 https://doi.org/10.1016/j.erss.2019.101399.
Yilmaz, S., Cuony, P., Chanez, C., 2021. Prioritize your heat pump or electric vehicle? Analysing design preferences for Direct Load Control programmes in Swiss households. Energy Res. Social Sci. 82, 102319 https://doi.org/10.1016/j.erss.2021.102319.
Yilmaz, S., Chanez, C., Cuony, P., Patel, M.K., 2022. Analysing utility-based direct load control programmes for heat pumps and electric vehicles considering customer segmentation. Energy Pol. 164, 112900 https://doi.org/10.1016/j.enpol.2022.112900.