Navigating Change: The Impact of Experiences and Preferences on the Heating Sector Transition

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***Abstract*—Transformation pathways for residential heating indicate that electrification, particularly through high shares of heat pumps (HP), is the most cost-effective route to climate neutrality. While the use of HP for space and water heating is growing, it remains limited. To accelerate their adoption, it is crucial to identify barriers that households face. This study examines both economic and non-economic factors influencing household perceptions and evaluations of HP, as well as their adoption likelihood. An online survey of around 8,800 participants across eleven EU countries revealed that attitudes towards HP, peer experiences, and current heating system evaluations are key adoption drivers, while cost concerns are less significant. However, the actual decision to adopt HP is more influenced by technical and financial constraints. The findings emphasize the complex interplay of individual values and experiences in promoting sustainable heating solutions, financial issues and the need for positive outreach and supportive policies.**

***Index Terms*—heat pumps, household survey, regression**

I. Introduction and Background

Scenarios on transformation pathways in residential heating display electrification as the most cost-efficient development towards decarbonization. Heating based on large shares of heat pumps (HP) has lower system costs than pathways with large shares of hydrogen or synthetic fuels [1]. The contribution of HP to space and water heating is increasing, but still small [2]. To boost HP deployment, and hence, the transition in the heating sector, identifying barriers towards adoption of HP among households is of utmost importance. In this paper, we focus on understanding the main factors of economic and non-economic nature that affect the households' perception and evaluation of HP and how this is linked to actual adoption of HP.

In literature, we find various studies on barriers and challenges associated with the perception and use of HP. [3] found that for households already using HP, key elements contributing to user satisfaction include indoor climate, comfort, the quality of the heating technology, and the service provided by suppliers. [4] identified additional drivers, such as governmental guidance and financial support, which address economic and value-related aspects.

In line, several studies [5–7] primarily consider economic aspects, such as electricity and gas prices and investment costs, as key drivers. Additionally, socio-economic and demographic factors, along with building characteristics and technology, significantly impact decision-making according to several studies [7–10]

In contrast, [11] stressed the significance of social acceptance for adopting technologies like HP and identified habits and independence from fossil fuels as critical for transitioning to renewable energy. Similarly, [12] found that societal practices and resistance to change can hinder investments in renewable technologies. They also asserted that decision-making extends beyond economic and environmental interests, logic, and rationality. In the electricity sector, trust in the stakeholders, attitudes, perceived usefulness and ease of use are also discussed as influencing factors on acceptance (e.g. by [13]) and adoption (e.g. by [14]).

Based on this literature, this study postulates that in the residential sector, **ratings and evaluations** of HP are primarily influenced by non-financial aspects, such as experiences, trust in policy makers strategies and pathways regarding the energy transition, attitudes and personal interests or values, while the decisions **to adopt** HP is influenced by technical and financial restrictions, as well as self-centered factors such as costs and prices that reflect financial concerns and usefulness of an option, along with efforts and comfort, which stands for the ease of adoption. To test these hypotheses, we conduct econometric analyses using the ratings and perceptions of European households collected in an online survey.

The remainder of the paper is structured as follows: Section II describes the survey data and methodology. The results of the survey are presented in section III. We discuss the results in section IV and conclude in section V.

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II. DATA AND METHODS

Our research methodology involves an online survey of households across eleven EU countries, conducted in the framework of the EU project "Perception - Overview of Heating and Cooling: Perceptions, Markets and Regulatory Frameworks for Decarbonization" (see Appendix 1). The survey included 8,756 participants. Participation was possible from June to August 2022. To receive representative samples, the following quotas per country were applied: education, household size, share of tenants and owners, share of HP and share of district heating (cf. approach in [15]). To ensure high data quality, we implemented control items and excluded respondents from the analyses with low data quality. An overview of the sample is shown in Table I.

TABLE I. OVERVIEW OF SAMPLE

Category	Value
number of respondents	8756
number of HP user	593
number of district heating-user	2235
number of natural gas user	2786
Share female	53%
Average age	48.5
Share tertiary education	58%
Share of owning house	45,5%
Share of renting (house or apartment	28,8%

The survey encompassed questions regarding socio-economic and demographic factors as well as evaluations of heating options, attitudes, interests and trusts in actors and institutions [16]. In addition, we asked for the importance of costs, comfort, efforts, price risks, reliability of new heating system as outlined in [16]. We employed composite variables for the evaluation of HP, and individual value orientations. The composite variables are described in [15]. To test our hypothesis, we employed descriptive statistics and econometric analysis.

We utilize three endogenous variables in our study: (i) the intended adoption of HP, which indicates the likelihood of respondents to install and use HP when selecting a new heating option on a 5 point Likert scale; (ii) the rating of HP, which reflects an individual's positive or negative assessment of HP as a heating solution based on a personal and unrevealed scale and reference technology on a 5 point Likert scale; and (iii) a composite variable termed "evaluation of HP," which assesses HP in relation to other renewable energy sources or fossil-fuel-based heating options (metric), as detailed in [15] and Appendix 6. A low value of the three endogenous variables reveals a low rating, evaluation or likeliness of adoption. As explaining variables, we include demographic factors such as age, home ownership, education level, location and country (see Appendix 2). Furthermore, we incorporate inquiries regarding individual environmental awareness, interest in technology, trust in policymakers, current heating conditions, satisfaction with existing heating systems, peer experiences with HP, the relevance of technical or financial constraints and preferences, importance of community versus self-centered aspects, and value orientations (low values indicate a high altruistic orientation) as outlined in reference [15]. Finally, we include the perceived ease of adoption, reliability of the heating option and secure supply with low price risks (see Appendix 3, 4 and 5). Overall, our approach is a modified version of the adoption model of [14].

We employ an ordered logit model to assess the variation in the likelihood of adoption and the rating of HP (both based on rankings), while an ordinary least squares (OLS) regression is applied for the evaluation of HP as it is a metric variable (see [15] and Appendix 6). The selected models build upon the influencing factors examined in research [11–13]. The complete specification of the ordered logit model is presented in Equation (1) and of the OLS in Equation (2).

$$\text{logit}\left(\frac{P(Y \le j)}{1 - P(Y \le j)}\right) = \alpha_j - \beta_k\,(\text{demographic features}_i + \text{values}_i + \text{attitudes}_i + \text{satisfaction}_i + \text{familiarity}_i + trust_i + \text{peers}_i + \text{country}_i + \text{perceived items}_i) \quad (1)$$

$$Y = \alpha_0 + \beta_k\,(\text{demographic features}_i + \text{values}_i + \text{attitudes}_i + \text{satisfaction}_i + \text{familiarity}_i + \text{trust}_i + \text{peers}_i + \text{country}_i\,) + \varepsilon \quad (2)$$

with
Y = endogenous variables: rating, adoption, evaluation
α_0 and α_j = intercepts (thresholds for category)
β_k = vector of coefficients for independent variables
values = orientation, importance, relevance
attitudes = environment, climate, technology
perceived = ease of use, costs, risks, reliability
k = index of independent variables
i = index of observations
j = index of categories
ε = error term

The analysis is performed using the statistical software STATA, employing the ologit and regress commands for the econometric evaluation. The model accounts for multicollinearity and heteroscedasticity to ensure robustness in the results. For each dependent variable, we initially include values, attitudes, and all demographic characteristics in the first iteration of the analysis. However, we reduce the number of demographic variables when they are found to be non-significant.

III. RESULTS

A. Descriptive results

We outlined specific criteria for determining whether to change a heating system. These criteria included that the new heating system should closely resemble the old one in terms of system type and energy carrier, require minimal effort for implementation, maintain high levels of comfort regarding space heating and service, incur lower costs, and ensure a secure supply of heat at stable prices. Respondents were asked to indicate their level of agreement or disagreement with these criteria. The results, presented in Figure 1, illustrate the frequency of responses for each category as a share, ranging

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from "completely unimportant" to "very important" concerning any changes to a heating system.

While the majority of respondents (78%) view the absence of additional effort in adopting a new heating system as very important or important, about 89% of the respondents regard it as very important or important to avoid high costs during installation. However, nearly 91% of respondents identified reliable heating with minimal price risks as the most important concern (Figure 1), reflecting a strong aversion to risks associated with heating issues. With some distance to the other characteristics, 78% of respondents rated sustainability in heating supply options as important or very important.

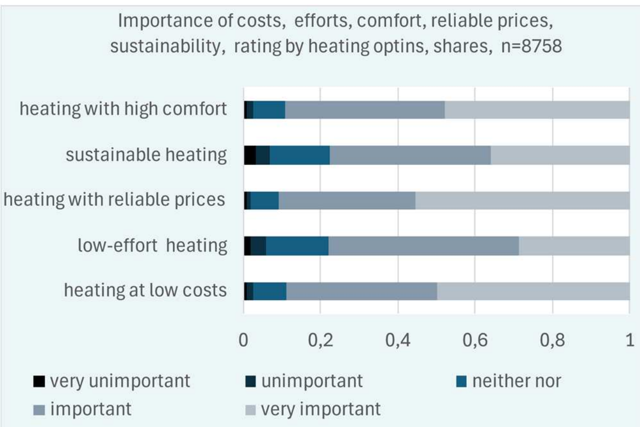

Figure 1: Importance of selected characteristics of heating options: low costs, high comfort, low effort, reliable price, high sustainability when adopting a new heating option?

Regarding the likelihood of adopting HP as a heating option in case their current heating option breaks down, approximately 38% of respondents consider it likely or very likely, while around 55% rate HP as a good or very good heating option. About 9% of all respondents express both a very high likelihood of adoption and a very positive evaluation of the HP option, while 17% indicate a high likelihood and a positive evaluation.

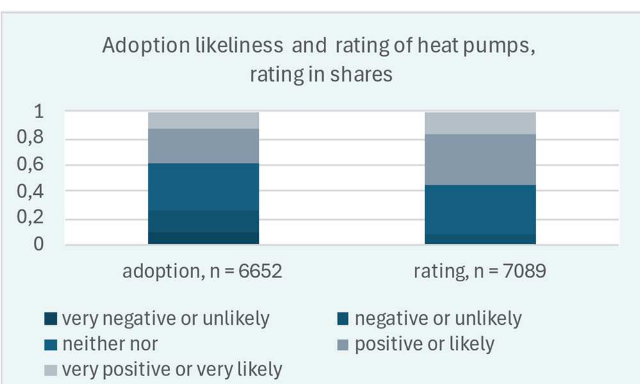

Figure 2: Likely adoption of heat pump if you have to decide for a new heating system? And how do you rate heat pumps?

Overall, half of the respondents display the same level of agreement regarding likely adoption and rating, while 40% report a lower likelihood of adoption compared to their ratings. We identified costs, efforts, comfort, and prices as potential factors explaining the decline from rating to adoption likelihood. The results of a chi-squared test show significant differences between respondents with a gap and those without: Individuals with consistent levels (no gap) assign less importance to low costs, efforts, comfort, and reliable prices than those with a gap ($p < .000$).

Finally, the evaluation of heating options indicates a positive assessment of HP and solar thermal, as shown in Figure 3, with a few outliers.

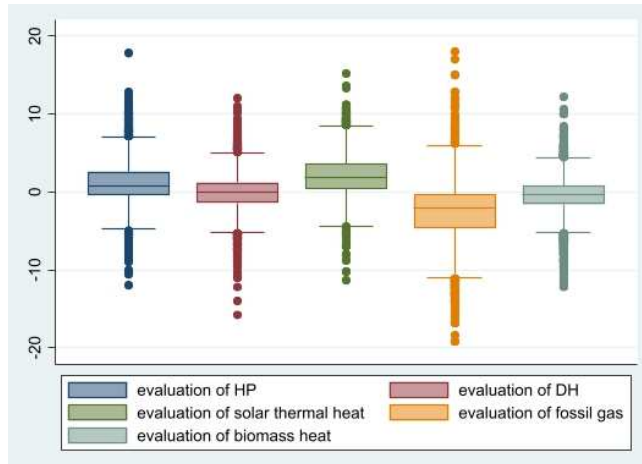

Figure 3: Evaluation of heat pumps in comparison to other heating options: frequency distribution of aggregated deviation from means of perceived costs, climate friendliness, price risks, dependency, reliability and efforts of adoption

In summary, our findings indicate a significant emphasis on a secure supply at low price risks followed by a high importance of low costs when considering the installation of new heating options, along with low efforts related to adoption and user comfort, irrespective of the heating system. These results align with previous research, such as that of [17], which emphasizes the primacy of financial risks and costs, closely followed by security and comfort-related issues. To address these aspects in our economic analysis of factors linked to HP evaluation and adoption, we incorporate specifically perceived costs, price risks, ease of use and reliability of heat supply of HP into our econometric analysis (cf. Tabel II in section B).

B. Econometric results

The econometric analysis was performed for each of the three dependent variables, incorporating personal values and attitudes, individual perceptions regarding HP, and demographic variables (cf. methodology in section II). Most of the variables are ordinal, while some are nominal. Specifically, we utilized dummy variables for country, home ownership, relevance, and importance, with Denmark, ownership of a house, all options being relevant, and the importance of transparency serving as baseline categories, respectively.

The results of the econometric analysis are depicted in Table II. In this table we present only the significant variables, while we have included in the econometric models all variables as outlined in the methodology section. Since we assume a connection between evaluation (or rating) and adoption likelihood, we test the correlation between the endogenous variable adoption and the rating of the HP, which indicates a correlation of 0.6 ($p < 0.000$).

Our findings reveal the following (cf. Table II):

1. A positive evaluation of HP (OLS, metric) is primarily linked to high environmental awareness, age, and familiarity with HP. Conversely, individuals who prioritize technical and financial concerns tend to rate HP less favorably, which has the largest impact after accounting for country effects. However, the significance level is low for environmental awareness and restrictions. Country-specific factors, encompassing e.g. regulations, historical HP usage, policies, wealth levels, and climate issues, account for negative evaluations of HP in Italy and Lithuania. Notably, the econometric model explains only about 15% of the variance.

2. For the rating of HP (ologit, ordinal), a significant coefficient for value tendency indicates that more altruistically oriented individuals tend to rate HP more positively. This altruistic attitude is underpinned by the positive and significant value of concerns regarding climate change. Beyond country effects, which are negative in France, Lithuania, the Netherlands, Poland, and Slovakia, trust in institutions and the distinction between renting and owning an apartment emerge as significant positive influences on HP perception. Additionally, technological interest act as driver, while perceived ease of use with respect to HP shows only weak significance, and financial aspects are completely insignificant. Regarding education, persons with an academic education tend to rate HP less favorable than those with training or high school diploma, but significance level is low.

3. In assessing the likelihood of adopting HP, we find a strong significance associated with both trust in institutions and peer experiences. Environmental awareness, along with a heightened interest in technological issues, positively influences the likelihood of HP adoption. Similarly, ownership or renting of an apartment is positively related to the adoption likelihood of HP. While an altruistic value orientation is a positive factor, its impact is smaller compared to that of trust. Additionally, satisfaction with current heating options tends to hinder the potential adoption of HP. Notably, increased familiarity with and knowledge about HP does not significantly influence adoption, nor do individual preferences, compared to collective considerations. Furthermore, academic education appears to reduce the likelihood of HP adoption. Finally, Lithuania exhibits a significantly negative coefficient, indicating a low likelihood of adopting HP. In contrast to our descriptive findings regarding changes in heating systems, factors such as ease of adoption, risks, and price considerations do not significantly affect the likelihood of adoption.

IV. Discussion

The findings reveal that the primary drivers of HP ratings and adoption include respondents' trust in institutions, particularly policymakers at local, national, and European levels, as well as in heating system experts. Additionally, interest in and openness to innovative technologies emerge as a factor that may positively influence HP ratings, although their impact is less significant than that of trust.

Interestingly, respondents with higher educational backgrounds tend to exhibit less favorable assessments of HP, despite their ability to access and comprehend information about the technology's benefits. This may suggest that higher education results in a more skeptical attitude toward HP. Furthermore, individuals with lower education levels may be less inclined to scrutinize HP technology, resulting in reduced skepticism toward this technology.

Moreover, value orientation (significant, lower value reveals an altruistic orientation) plays a vital role in fostering positive ratings and potential HP adoption. This altruistic orientation is further evidenced by the significance of high environmental awareness and concerns about climate change for positive rating or high adoption likelihood of HP. The pronounced influence of peer experiences on adoption, in contrast to the insignificance of this variable in the rating model, highlights the critical role peers may play in influencing final decisions regarding HP adoption.

Unexpectedly, factors such as specific HP-related costs, risks, and security concerns are not perceived as significant barriers or drivers for HP, contradicting previous findings that emphasize the importance of financial considerations for investments in renewable heating technologies [7,17]. However, ease of use is linked to HP ratings, albeit to a lesser extent, but still underscoring the importance of non-monetary aspects in the evaluation and adoption of technologies. This is consistent with other research [13,17].

The country effects are substantial and predominantly highly significant, suggesting the presence of dominant factors at the national level that are not accounted for by the included variables. Examples of such factors include political strategies and targets related to the transition of the heating sector, the prevalence of existing heating solutions like direct electric heating in France and Italy, the absence of support policies for HP, historical experiences – both positive and negative – with HP, and a high level of satisfaction with current non-HP heating options. Denmark serves as the reference country, characterized by a relatively high share of HP and favorable HP ratings. Conversely, Lithuania exhibits negative values in evaluation, rating, and adoption of HP, which may be attributed to a combination of various factors. Speculating these factors could be a low confidence in the need for an energy transition, lack of awareness of the environmental benefits of climate protection or cultural negative attitudes towards new technologies. Identifying the factors underlying the country variables is particularly important as they can provide insights into the specific contextual elements that influence perceptions and adoption of HP across different countries, thereby informing targeted strategies to enhance HP deployment and address country-specific barriers.

TABLE II. ECONOMETRIC RESULTS

	evaluation of HP (OLS)	*rating of HP (ologit)*	*adoption likelihood (ologit)*
value orientation	0.067	-0.214**	-0.313***
relevance of restrictions	-0.504*	0.212	-0.000
relevance of preferences	0.017	0.160	-0.223
no relevance of restrictions or preferences	-0.281	-0.800	-0.607
importance of constraints & needs	0.027	-0.254	-0.095
importance of peers & community	-0.154	-0.006	0.456
importance of economy & environment	0.154	-0.321	-0.373
climate change concern	0.173	0.163**	-0.081
environmental awareness	0.323*	0.139	**0.303****
interest in technology	0.168	0.399***	**0.179***
trust in institutions	-0.240	0.868***	**1.026*****
satisfaction with current heating system	-0.081	0.049	**-0.128***
peers' experience	-0.406	0.188	**0.873*****
familiarity with HP	0.309***	0.118	-0.066
France	0.025	-1.064***	-0.111
Italy	-1.397**	-0.547	-0.107
Lithuania	-1.340**	-1.032***	**-0.907****
Netherlands	-0.274	-1.470***	-0.523
Poland	0.472	-0.820**	-0.044
Slovakia	0.339	-0.725*	-0.203
age	0.030***	0.007	
high school	0.072	-0.399	-0.004
training on the job	0.069	-0.271	**-0.597***
academic education	0.232	-0.582*	**-0.540***
own apartment	0.374	0.368	**-0.556***
rented house	-0.329	0.717**	**0.413***
rented apartment	0.352	0.329	0.356
ease of adoption HP		0.125*	
Intercept 1 | 2	-2.450*	1.403	1.558*
Intercept 2 | 3		3.526***	2.987***
Intercept 3 | 4		5.768***	4.458***
Intercept 4 | 5		8.128***	6.417***
Observations	632	688	688
p-value for model test	0	0	0
R squared / pseudo-R2	0.147	0.123	0.136
F-test/ chi2	3.457	223.6	292

***** p<0.01, ** p<0.05, * p<0.1. Note: Due to space limitations, we display the significant coefficients, while the models included all variables outlined in the methodology section. Value orientation: small values indicate an altruistic orientation, high values self-centered interests; Endogenous and independent variables: high values signal high agreement or positive assessment.*

Regarding evaluation, we find no significant differences between our OLS and ordered logit assessments, although some distinctions do emerge. For instance, the OLS results indicate a more favorable evaluation of HP with increasing age. In addition, familiarity with HP is reported as a significant variable in the OLS model, but it does not hold the same significance in the ordered logit model. Overall, the analysis with the composite variable "evaluation" does not provide many additional insights into the factors that influence the perception of HP. Therefore, evaluating HP using reference technologies and objectivized rating scales yields results similar to those obtained from a general rating that lacks a specific reference technology and objective scales.

Regarding the links between rating and adoption, we observe that higher ratings of HP correlate positively with the likelihood of adoption. This relationship suggests that favorable perceptions of HP, may play a crucial role in motivating households to adopt this technology. Additionally, the significance of non-monetary aspects, such as ease of use and openness to innovation, further reinforces the connection between positive ratings and actual adoption behavior. On the other hand, although there is a high correlation between rating and adoption likelihood, the country effects differ, with the exception of Lithuania. This suggests that specific national-level factors negatively affecting the rating of HP do not translate to the adoption of HP.

Overall, further research is necessary to gain a deeper understanding of the links between rating and adoption, as well as the direct and indirect effects of non-monetary aspects on the likelihood of adopting HP. Implementing structured or nested models could represent a valuable next step in elucidating the driving factors behind decisions to utilize HP. Finally, understanding the links between perception and adoption is essential for developing effective strategies and policies to promote HP deployment among households.

V. CONCLUSION

Scenarios outlining transformation pathways in residential heating indicate that electrification, particularly through HP, represents the most cost-effective strategy for decarbonization (see section 1). To enhance HP deployment, it is crucial to identify barriers to HP adoption among households. Therefore, in this paper, we focus on understanding the main factors of economic and non-economic nature that affect the households' perception and evaluation of HP and how this is linked to actual adoption of HP.

The paper concludes that decisions in the residential sector are complex, influenced by multiple factors affecting the adoption of sustainable heating solutions. In particular, trust, individual values and attitudes, as well as non-economic aspects, national transitions, and policy strategies are key drivers, although it is challenging to ascertain their actual impact. This research highlights the diverse motivations and barriers in the transition toward sustainable heating with HP emphasizes the significance of trust. It calls for credible and reliable policies, strategies, and transition pathways, as well as the importance of disseminating positive experiences with HP alongside supportive policies to enhance market uptake.

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Appendix

Appendix 1: Online-Survey in the Member States of the EU with respect to HP

Lithuania
Poland
Denmark
The Netherlands
Slovakia
Italy
Germany
Czech Republic
Spain

Appendix 2: Overview of variables

Variable	**Name**	**values or code**
HP rating	*How do you rate HP? -> HP_rating*	1 very negative - 5 very positive (5 points Likert scale)
	How acceptabel do you consider the use of HP? -> HP_acceptance	1 fully inacceptable - 5 fully acceptable (5 points Likert scale)
DH rating	*How do you rate DH ? -> DH_rating*	1 very negative - 5 very positive (5 points Likert scale)
	How acceptable do you consider the use of DH? DH_acceptance	1 fully inacceptable - 5 fully acceptable (5 points Likert scale)
environmental awareness: mean of these categories (highly significant correlation between 0.7 and 0.8)	*To what extent do you agree or disagree with the following statements?*	1 fully disagree - 5 fully agree (5 points Likert scale)
	• *Acting environmentally-friendly is an important part of who I am*	
	• *I am the type of person who acts environmentally-friendly*	
	• *I see myself as an environmentally-friendly person*	
technology interest: mean of these categories (highly significant correlation between 0.6 and 0.7)	*To what extent do you agree or disagree with the following statements?*	1 not interested at all - 5 very much interested (5 points Likert scale)
	• *I am very interested in the latest technology developments*	
	• *It does not take me long to learn to like new technology developments*	
	• *I am always keen to use the latest technological device*	
climate concerns	*In my view, climate change is .... -> climate change*	1 no problem - 5 huge problem (5 points Likert scale)
trust: mean across all 7 categories **trust in national policy**: mean of category 2 and 3	*How much do you trust the following actors in your country to make good decisions regarding district heating?* *1. energy supplier,* *2. local authorities,* *3. national authorities,* *4. European Commission,* *5. landlord,* *6. industry,* *7. neighbour*	1 not at all - 5 completely (5 points Likert scale)
value mix: mean of self-centered aspects ./. mean of altruistic aspects	*no efforts (self-centered)*	1 fully unimportant - 5 fully important (5 points Likert scale)
	new and accepted technology (meso level: peers)	
	low cost (self-centered)	
	high autonomy (self-centered)	

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Variable	Name	values or code
	no changes (self-centered)	
	high comfort (self-centered)	
	reliable heat (self-centered)	
	clean heat (altruistic)	
	economy (altruistic)	
relevance of restrictions (see Appendix 4)	*1. group: restriction & costs;* *2. group: comfort & for others;* *3. both groups;* 4. *none of the groups*	selection of one option
importance (see Appendix 3)	*1. constraints & needs (self-centered)* *2. peers & community (meso-level peers)* *3. economy & environment (altruistic)* 4. *transparency & fairness (self-centered)*	1: least important 5: most important
evaluation of heating options (see Appendix 5)	*low cost (fossil, biomass, solar thermal, DH, HP)*	1 fully agree - 5 fully disagree (5 points Likert scale)
	climate friendly (fossil, biomass, solar thermal, DH, HP)	
	low price risks (fossil, biomass, solar thermal, DH, HP)	
	reliability of technology (fossil, biomass, solar thermal, DH, HP)	
	high dependency (fossil, biomass, solar thermal, DH, HP)	
	high transactions (fossil, biomass, solar thermal, DH, HP)	
socio-demographic	*sex*	categorical: 1-4
	age	numeric: 17-67
	education	1 primary, 2 high school, 3 training, 4 academic
	country	11 CZ, 12 DK, 14 FR, 15 DE, 19 IT, 21 LT, 24 NL, 25 PL, 28 SK, 30 ES, 31 SE
	location	< 2000, 2000-19999, 20000-199999, 200000-1 mio, >1 mio
	ownership	own house, own apartment, rented house, rented apartment

Appendix 3: Importance of self-centered (hedonic or egoistic) versus altruistic aspects

Which of these aspects do you consider as the most important and the least important when choosing a new heating system? Please select the least and the most important aspect.

Most or least important:	nature of aspects	caring for
My specific needs comprising comfort, heating needs, the technical features of my housing, expenditures for heating, heating technology, autonomy in heating	egoistic, hedonic	oneself
The heating systems most often used in my community or neighborhood or promoted by the local municipality	hedonic	oneself
Impacts that my purchase decision has on economic growth, employment, national income distribution, global environment and climate change	altruistic	others
That there are mechanisms in place that ensure fair pricing of my heat, e.g. price controls, obligation to publish prices or costs	hedonic	oneself

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Appendix 4: Relevance of constraints and preferences

Please select one (or both or none) of the two groups that include in your view the most decisive topics when choosing a new heating system:

Relevance of constraints and preferences	**factor level**	**relevance of ...**	**caring for ...**
Group 1:			**constraints - caring for oneself**
Low total expenditures of the heating system (incl. funding opportunities)	micro	preference (egoistic)	
Availability of money to pay for the heating system		constraint	
Appropriate technical features of the building or grid connection required for the new heating system			
Qualified and reliable information or recommendation about the heating technology e.g. from experts (professionals)			
Group 2:			**preferences - caring for oneself and others**
High heating comfort that the system provides	micro	preference (hedonic)	
High degree of autonomy I get with this heating technology			
Low effort and work needed to install the new heating system			
Low emissions of air pollutants, particles and CO_2	macro	preference (altruistic)	

Appendix 5: Influencing factors and values when choosing a new heating system (values)

Which factors are very important, less important or unimportant for you when choosing a new heating system? (Selection 1-5; not important at all - very important):

Ratings of ...	**impact or factor level**	**nature of aspects ...**	**caring for ...**
Low investment expenditures and low operating expenditures	micro	egoistic (financial)	**oneself**
Secure supply of heat and certain energy prices for many years	micro	hedonic partly egoistic (financial)	
High autonomy and independency of supplier, e.g. from fuel supplier or service supplier	micro	hedonic partly egoistic (partly financial)	
Efforts needed to adopt the new system should be low (e.g. no additional constructions or extensive paperwork)	micro	hedonic partly egoistic (non-financial)	
No or minor changes e.g. in the heating technology, energy supplier, system control	micro	hedonic	
High comfort of the heating system (i.e. pleasant space heat and hot water, and convenient handling, low maintenance)	micro		
Novelty of the heating technology and acceptance by friends	meso		

Appendix 6: Calculation of the dependent variable evaluation as outlined in [15]

$$e_h = \sum_{c=1}^{6} (e_{ch} - m_c) \tag{3}$$

with
h = type of heating option (fossil gas, solar thermal, DH, HP, biomass)
c = characteristics, c = 1,… ,6 (low costs, reliable supply, low transaction efforts, climate friendly, independent, low price risk)
e_h = indicated evaluation of h by respondent
e_c = individual evaluation of heating technologies' characteristics by respondent
m_c = mean of e_c by respondent across heating technologies

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