CONSUMER CHOICE FOR HEATING SYSTEM TECHNOLOGIES: DO LOW CARBON TECHNOLOGIES WIN?

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Overview

Decarbonisation of heating is one of the priorities of UK government's commitment towards achieving net zero emissions by 2050. Residential energy consumption for space and water heating in the UK accounts for ~63% of the economy's energy use for space and water heating. About %88 of energy used by residential sector for space and water heating is from gas, oil and solid fuels which should be replaced with low-emission alternatives as part of the decarbonisation agenda. Gas central heating account for ~78% of total residential heating systems. To reduce carbon emissions from heating, government's goal is to install 600,000 heat pumps annually by 2028 and provides grants to encourage shifting towards heat pumps for existing homes. In addition, heat networks play a key role in achieving net zero in the UK, but they are monopolies with no possibility to switch supplier for households.

The endeavours to decarbonize residential heating requires a synergistic approach, integrating supportive policies, evolving consumer preferences, and technological advancements. A heating system includes several features, including capital, installation and operating costs, energy efficiency, and supplier switching flexibility, among the others. The choice of a heating system depends on the attributes that homeowners prioritise when selecting a heating system for their homes. Therefore, it is crucial to investigate household preferences and willingness to pay (WTP) for heating system features (Scarpa & Willis, 2010).

In this work, we employ a discrete choice experiment to investigate households' preferences and WTP for a set of heating system attributes for three different heating systems in Surrey County Council, UK. Our findings provide us the chance to examine how people feel about heat pumps and heat networks, which are seen as more cutting-edge, technologically based renewable technologies, vs traditional gas central heating.

Methods

In this study we have considered three alternative heating systems: gas boiler, heat pump and heat network. After making multiple changes in accordance with experts' opinions and web resources, we ultimately settled on seven attributes of heating systems, and each attribute has varying levels. Our main interest is to understand how CO2 emissions, grant availability, energy efficiency, and provider switching options for heating systems affect consumer preferences. In addition to above attributes, we also consider three financial attributes i.e. instalment costs, fixed costs and operational costs which are essential for households when choosing a heating system.

We designed the choice experiment and collected the data in SurveyEngine online platform. The respondents are homeowners of Surrey County Council in the UK. The questionnaire has two parts: the first part includes some socio-demographic, building characteristics and heating related questions. The second part is the choice experiment, here the respondents are faced with three unlabeled heating system alternatives with seven attributes and their levels. The respondent is asked to choose one alternative each time they face a choice task. The number of such choice tasks for each respondent is eight. An illustrative example of a choice task is given in Table 1. After pilot data, to identify the most efficient variety of choice sets while still allowing us to estimate the primary effects, we employed a D-efficiency design. Overall, 79 final responses were collected from Surrey representative participants in Summer 2022 through the online questionnaire (we faced budget constraints for data collection). The sample is representative in terms of gender, age and district in Surrey. Since eight choice tasks were presented to each respondent we have total of 632 observations for estimation.

We apply the Mixed Logit Model (MXL) which is a flexible specification and can approximate any random utility model (McFadden & Train, 2000). For the mixed logit model, the utility of individual i choosing alternative j $(j = 1,,,J)$ in the choice task t $(t = 1,,,T)$ is as follow:

$$U_{ijt} = A'_{ijt}\beta_i + W'_{ijt}\delta + Z'_i\gamma_j + \varepsilon_{ijt},$$

where β_i are random coefficients that vary among individual decision-makers in the population, whereas A'_{ijt} is a vector of alternative-specific variables. δ are fixed coefficients on W'_{ijt}, another vector of alternative-specific variables. γ_j are fixed coefficients on Z'_i, a vector of case-specific variables. The idiosyncratic error ε_{ijt} is assumed to be independently and identically distributed (IID) and of the extreme value one (EV1) type (D. McFadden, 1974). In this specification, each homeowner's utility function has some random taste parameters β_i that follow an underlying probability distribution $f(\beta_i|\theta)$. The parameters of this indirect utility function can be estimated by the maximum simulated likelihood. These estimated coefficients cannot be directly interpreted as their contribution to utility (Bergmann et al., 2006).

Therefore, after estimating the coefficients using econometric methods, we calculate the willingness to pay for each heating system attribute. In simple linear models, the WTPs are calculated as follow:

$$WTP = -\frac{\beta_{attribute}}{\beta_{price}}$$

Where β_{price} and $\beta_{attribute}$ are the estimated coefficients of price (here investment cost) and each attribute respectively.

Table 1: An illustrative example of a choice task

Attributes	Option 1	Option 2	Option 3
Investment costs, including installation (£)	10000	20000	0
Annual fixed costs (e.g., standing charge, connection fee) (£)	650	100	165
Annual variable fuel costs (£)	1000	400	700
Annual CO_2 emissions	Medium	High	Very high
Grant option available (share of a grant from investment costs)	30%	0	50%
Energy efficiency	Medium	Very high	High
Energy supplier switching option	No	Yes	No
Which option would you choose?	□	□	□

Results

Our preliminary results show that capital investment costs, energy efficiency, and energy supplier switching options significantly affect the likelihood of households' choices for heating system. Households are willing to pay ~£4000 for higher energy efficiency of the heating system and having the option to switch the energy supplier. However, fixed costs, running costs, grants, and CO_2 emissions generally have statistically insignificant effect on the likelihood of households' choice of heating systems. Moreover, socio-demographic variables are almost non-influential in selecting a home heating system.

Conclusion

By using a discrete choice experiment with homeowners in the Surrey County, we offer new evidence of consumers' attitudes toward conventional as well as low-carbon residential heating systems. Based on our experiment among the three heating system alternatives, heat pumps are the most popular and heat networks are the least popular choice for households. Furthermore, homeowners prioritise energy efficiency and provider switching over grants or CO_2 emission levels of a heating system. We suggest stepping up the process of information sharing so that more people are aware of environmental issues and the process of financial help that the government is providing through decarbonisation programmes to promote the uptake of cleaner technologies.

References

Bergmann, A., Hanley, N., & Wright, R. (2006). Valuing the attributes of renewable energy investments. Energy Policy, 34(9), 1004–1014.

McFadden, D [D.]. (1974). Conditional logit analysis of qualitative choice behavior.: In Frontiers in Econometrics (P. Zarembka, Ed.). Academic Press.

McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. Journal of Applied Econometrics, 15(5), 447–470.

Scarpa, R., & Willis, K. (2010). Willingness-to-pay for renewable energy: Primary and discretionary choice of British households for micro-generation technologies. Energy Economics, 32(1), 129–136.