WHAT DRIVES HOMEOWNERS TO CLIMB UP THE ENERGY LADDER? LESSONS FROM THE REPLACEMENT OF RESIDENTIAL HEATING SYSTEMS IN GERMANY

Carl Christian Michelsen* and Reinhard Madlener
*Institute for Future Energy Consumer Needs and Behavior (FCN), School of Business and Economics / E.ON Energy Research Center, RWTH Aachen University, Mathieustr. 10, 52074 Aachen, Germany
CMichelsen@eonerc.rwth-aachen.de

(1) Overview

In the coming decades, Germany will have to face the challenge of ambitious climate protection goals including an 80% to 95% reduction of greenhouse gases (mostly energy related CO_2 emissions) until the year 2050 compared to 1990 levels. In order to achieve this long-term goal, the German government announced the *Energiewende*, i.e. to move towards a more sustainable energy system. This involves climbing up the so-called "energy ladder", i.e. the transformation from a fossil fuels-based to an almost renewables-based energy system (see Van der Kroon et al., 2013, for an overview of the energy ladder model), and a significant improvement of the energy end-use efficiency in all sectors of the economy.

In particular, the generation of heat for residential purposes, processes and hot water generation had a share of about 58% of the final energy demand and represented about 40% of the energy-related CO_2 emissions in Germany in 2008 (DLR et al., 2012). Around 50% of the final energy demand for heat was consumed for space heating, whereof about two thirds were used in residential buildings. Fossil fuels, such as oil and natural gas, cover about 72% of the final energy demand in the heat sector. This shows the high importance of the residential heat sector for realizing the climate protection targets. Therefore, in 2010, the German government announced to reduce the primary energy requirements of the residential buildings stock by at least 80% until 2050. Renewable energy sources are supposed to cover the remaining energy requirements. Consequently, besides reducing the energy requirements of residential buildings by improvements of the building shell or the first-time installation of innovative residential heating systems (RHS) in newly built homes, the replacement of obsolete, inefficient and fossil fuel-based RHS by more efficient appliances based on renewable energy sources in existing homes plays a crucial role in the transition towards a more sustainable energy system. For the coming decades, this requires that most owners of existing homes have to "to climb up the energy ladder" by replacing their old fossil fuels-fired and CO_2 intensive RHS by a less CO_2 intensive and (partly) renewables-based RHS. Therefore, a better understanding of what drives homeowners to make no (stick with the same fossil fuel), a small (e.g. switch from an oil-fired to a gas-fired RHS or from a gas-fired RHS to a heat pump) or a large step (e.g. switch from an oil-fired RHS to a wood pellet-fired RHS) on the energy ladder is of high relevance.

Against this background, our research investigates the determinants of the RHS replacement behavior (in terms of the size of the steps taken) of owners of existing 1-2 family homes in Germany by accounting for socio-economic and home characteristics, the geographical location and preferences (motivational factors). While empirical economic research on *energy appliance and fuel choice* is relatively extensive and covers different sectors such as transport (e.g. He et al., 2012), energy utilities (e.g. Tauchmann, 2006) or households (e.g. Liao and Chang, 2002; Mansur et al., 2008; Michelsen and Madlener, 2012; Michelsen and Madlener, 2013), research on *energy appliance and fuel switching behavior* focuses to a large extent on stoves and fuels for cooking in developing countries by applying the energy ladder model (see Van der Kroon et al., 2013, for a meta-analysis). For explaining switching behavior, most of the studies use as explanatory variables socio-economic characteristics (in particular income), attributes of the home and the location or energy prices, while the role of motivational aspects, preferences or energy-related knowledge is less analyzed. Thus, our research contributes to the literature on households' energy appliance and fuel switching behavior in the context of an industrialized country.

(2) Methods

A questionnaire survey (N=1599) conducted in 2010 among owners of existing homes in Germany who have recently replaced their old oil- or gas-fired RHS by a new gas- or oil-fired condensing boiler, heat pump or wood pellet-fired boiler provides the empirical foundation (see Michelsen and Madlener, 2012, for details of the survey). In order to explore the RHS replacement behavior, we apply logistic regression techniques (ordered logit, multinomial logit) on the survey data. In our logistic regression models, there are four categories of variables including (i) socio-economic characteristics (e.g. homeowners' income, age, gender, education), (ii) attributes of the home (e.g. vintage class, size, type, energy standard), (iii) locational variables (e.g. rural area, South or East Germany) and, (iv) motivational aspects (e.g. costs, capital grant, attitude, external threats, comfort issues, influence of peers or RHS-related knowledge). Moreover, we analyze the determinants of the decision to generate a certain share of heat by means of solar thermal collectors. This includes solar thermal support for (i) hot water generation only, or for (ii) both hot water generation and heating support.

(3) Results

The preliminary results of our analysis show that socio-economic characteristics of the homeowner, attributes of the home and locational variables are relatively less important determinants for switching to a renewables-based RHS. For the variable age of the homeowner, we find that younger homeowners are more likely to climb up the energy ladder. Moreover, a location in South Germany also increases the probability for switching to a renewables-based RHS.

Furthermore, we find preferences and RHS-related knowledge to be significant drivers for climbing up the energy ladder. We show a positive effect for concerns related to the security of energy supply and environmental issues, the relevance of the capital grant or the influence of peers (e.g. family, friends, and neighbors). On the other hand, a higher preference for comfort, and that the new system is compatible with existing habits and routines, makes a homeowner more likely to stick with a fossil fuels-based RHS. Finally, we find a positive influence of RHS-related knowledge, i.e. more informed homeowners have a higher probability of switching to a renewables-based RHS.

(4) Conclusions

Our research shows the drivers behind the homeowners' decisions to climb up the energy ladder. While socio-demographic characteristics, attributes of the home and locational variables are found to be relatively less important, RHS-related knowledge and preferences regarding RHS-specific attributes are significant for switching from old fossil fuels-fired to renewables-based RHS. In particular, RHS-related knowledge seems to be an important driver for climbing up the energy ladder. This implies that policy makers should support the homeowners' decisions by providing information (e.g. information campaigns targeting renewables based RHS or energy consulting). Moreover, our findings have implications for understanding the likely future transition dynamics of the energy system in the residential heat sector, the design of policy measures targeting RHS, and marketing strategies of RHS manufacturers.

References

DLR, Fraunhofer IWES, IfnE (2012), Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global, Study commissioned by Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit, Online available at: http://www.erneuerbare-energien.de/fileadmin/ee-import/files/pdfs/allgemein/application/pdf/leitstudie2011_bf.pdf [accessed January 30, 2013]

He, L., Chen, W., Conzelmann, G. (2012), Impact of vehicle usage on consumer choice of hybrid electric vehicles, *Transportation Research Part D*, 17(3), 208-214.

Liao, H.-C., Chang, T.-F. (2002), Space-heating and water-heating energy demands of the aged in the US, *Energy Economics*, 24 (3), 267-284.

Mansur, K., Mendelsohn, R. and Morrison, W. (2008), Climate change adaptation: a study of fuel choice and consumption in the US energy sector, *Journal of Environmental Economics and Management*, 55 (2), 175-193.

Michelsen, C.C., Madlener, R. (2012), Homeowners' Preferences for Adopting Innovative Residential Heating Systems: A Discrete Choice Analysis for Germany, *Energy Economics*, 34(5), 1274-1283.

Michelsen, C. C., Madlener, R. (2013), Motivational Factors Influencing the Homeowners' Decisions Between Residential Heating Systems: An Empirical Analysis for Germany, *Energy Policy* (in press, available online 26 February 2013).

Tauchmann, H. (2006), Firing the furnace? An econometric analysis of utilities' fuel choice, *Energy Policy*, 34(18), 3898–3909.

Van der Kroon, B., Brouwer, R., Van Beukering, P.J.H., (2013), The energy ladder: Theoretical myth or empirical truth? Results from a meta-analysis, *Renewable and Sustainable Energy Reviews*, 20, 504-513.