Energy Policy 102 (2017) 288–306

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

The trigger matters: The decision-making process for heating systems in the residential building sector

Maria Hecher[a,*], Stefanie Hatzl[a], Christof Knoeri[b], Alfred Posch[a]

[a] Institute of Systems Sciences, Innovation and Sustainability Research, University of Graz, Austria
[b] Group for Sustainability and Technology, ETH Zurich, Switzerland

ARTICLE INFO

Keywords:
Adoption decision
Trigger type
Private homeowner
Residential building
Fossil heating system
Alternative heating system

ABSTRACT

As heat demand of buildings accounts for a significant amount of final energy use and related carbon emissions, it's important to gain insights into the homeowners' decision-making processes and to identify factors determining the choice of heating systems. In this study, data was collected in an online survey carried out in 2015, from private homeowners of existing and newly built single and double-family houses in Austria who had invested in a new heating system within the last ten years (N=484). In contrast to previous studies, this study specifically investigates the triggers behind homeowner decisions to invest in a new heating system (e.g. problem, opportunity, or new building situation). Results of binary logistic regression analysis show that subsidies for heating system tabinvestments and infrastructural adjustments reveal to be most effective for homeowners in problem situations to foster alternative heating systems. For homeowners in opportunity situations (e.g. building refurbishment), in addition operational convenience appears to be important. For new buildings, the main barriers for alternative heating system adoption were found in the positive perception of fuel supply security and feasibility of fossil systems. Thus, the use of trigger-specific policy measures is proposed to foster alternative heating systems in the residential building sector.

1. Introduction

Building energy demand, three quarters of which is used for thermal purposes (GEA, 2012), accounts for 34% of global final energy demand. The long lifetimes of buildings and building technologies imply that immediate action needs to be taken in order to reduce energy demand and to avoid lock-in into inefficient building technologies. According to the Global Energy Assessment Report, energy demand for heating and cooling could be reduced by about 46% by 2050 compared to the 2005 levels by applying today's best practice technologies while still more than doubling the usable floor area. In particular, end-use technologies such as heating systems hold a large potential for efficiency improvements but more so for climate mitigation (Grubler et al., 2012; Wilson et al., 2012). In the European Union, the heating sector has thus been targeted by the European Directive for Renewable Energy Directive, (2009/28/EC) and the related National Renewable Energy Actions Plan of each member state (NREAP, 2010).

In Austria, almost a quarter of the final energy demand is from the residential building sector, of which more than two thirds are used for space heating (Statistics Austria, 2016, 2015). In 2014, the Austrian energy demand for space heating accounted for 165 PJ. While 48% of the residential heat supply is still based on fossil fuels (i.e. oil, gas, electricity, and coal), 37% of the heat demand is met by biomass, heat pumps and solar-thermal systems, and 15% through district heating systems (Statistics Austria, 2016). Compared to other European countries, Austria has a relatively high penetration of such renewables (Biermayr et al., 2016; Kranzl et al., 2013). Still, one issue regarding the replacement of heating systems is the homeowners' preference for the incumbent, and thus more familiar, type of heating system. This is especially true for those systems based on oil and gas (Kranzl et al., 2013).

Recently, a growing interest of the social dimension of energy transition and the role of users emerged, putting human needs, values, preferences and behaviour at the center of system change (Rotmann, 2016; Brauch, 2013). Within this context, also research on energy prosumers emerged where consumers begin to be more proactive in areas traditionally thought of as production, while Ellsworth-Krebs and Reid (2016) suggest to broaden this concept from electricity (i.e. photovoltaic panels) to heat prosumption (e.g. wood-based stoves). To design interventions aimed at promoting behavioural change, it is

Abbreviations: P, Problem; O, Opportunity; NB, New building

* Corresponding author.
E-mail address: maria.hecher@uni-graz.at (M. Hecher).

http://dx.doi.org/10.1016/j.enpol.2016.12.004
Received 21 August 2016; Received in revised form 30 November 2016; Accepted 1 December 2016
Available online 22 December 2016

thus key to gain a better understanding of the homeowner decision-making process regarding heating system replacements and new installations, and of those factors which foster or hinder the adoption of alternative heating systems (e.g. Braun, 2010; Lillemo et al., 2013; Mahapatra and Gustavsson, 2010; Michelsen and Madlener, 2013; Sopha et al., 2010).

In recent years, an increasing number of studies have investigated factors which influence heating system adoption decisions. According to Karytsas and Theodoropoulous (2014), these studies can be classified in terms of (i) data used; (ii) variables examined; and (iii) theoretical concepts on which authors base their research. Regarding the data basis, most studies use survey data based on hypothetical questions (e.g. asking about potential future behaviour), whereas a smaller number of studies use data based on stated preferences in past decisions. In the case of the latter, two approaches are used to examine adoption decisions. One approach is to use regression analysis employing contextual variables such as socio-demographic variables (e.g. income, educational level, household size, number of children, gender, age), spatial variables (e.g. urban versus rural area, and climate), residential variables (e.g. building type, building size, construction period, ownership), and heating system characteristics (e.g. investment costs, operating cost, and physical work). The other approach additionally considers personal variables such as the influence of consumers' attitudes, intentions, norms, and preferences for a specific type of heating technology (for a detailed list of studies, please see Balcombe et al., 2013; Karytsas and Theodoropoulou, 2014; Michelsen and Madlener, 2013). Studies using the latter approach are usually based on either theories of innovation and technology diffusion (e.g. Diffusion of innovation model; Rogers, 2003) or theories of consumer behaviour (e.g. Theory of planned behaviour; Ajzen, 1991).

However, despite the number of previous studies on the subject, three outstanding issues remain. First, theories of innovation and technology diffusion need to be grounded in and combined with theories of human behaviour (Feola and Binder, 2010). To date, only relatively little research has managed to combine innovation and technology diffusion theories with behavioural models and to consider the impact of 'personal-sphere' elements (Michelsen and Madlener, 2013). Second, research on technology adoption has to consider the selection of heating systems as a process rather than as a fixed choice at a certain point (Rogers, 2003). Most studies investigate the factors determining adoption decisions, but do not analyse the underlying decision processes (Friege and Chappin, 2014). Although a lot of work is based on Rogers' perceived characteristics of innovations as one stage in the innovation decision process (e.g. Bjørnstad, 2012; García-Maroto et al., 2015; Mahapatra and Gustavsson, 2008; Maya Sopha et al., 2011; Nyrud et al., 2008; Sopha and Klöckner, 2011), research on the earlier triggers behind homeowner decisions to invest in a new heating system, is still lacking. Finally, most studies use survey data based on hypothetical questions rather than ex-post data on real experiences. To the present authors' knowledge, no study based on the latter approach currently exists with respect to Austria.

To summarise, our study on heating system decisions contributes to research in a threefold manner: (i) by combining innovation diffusion theory and behavioural models in order to conceptualize the homeowner adoption decision; (ii) by considering the decision-making process of homeowners with respect to the triggers behind the adoption of a new heating system; and (iii) by analysing data on real adoption decisions of private homeowners in Austria. The main objective of this study is to show how the triggers underlying installation of a new heating system affect the factors determining the adoption of alternative (i.e. biomass boilers and heat pumps) and fossil heating systems (i.e. oil and gas boilers).

The paper is structured as follows. In Section 2, we describe the theoretical background of this study and present the conceptual framework we apply to empirically investigate homeowner heating system adoption decisions. In Section 3, we present the methodological procedure of the survey and the empirical data analysis. In Section 4, we illustrate the results of our empirical study, elaborate on the implications, and derive possible policy measures which may be used to foster alternative heating systems in the residential building sector. In Section 5, we summarise the key results and policy implications.

2. Conceptual model for homeowners' decision-making processes for heating systems

To operationalize the homeowner decision-making process with respect to central heating systems, we adapted a conceptual model which is based on three theoretical approaches: (i) the model of strategic decision processes established by Mintzberg et al. (1976); (ii) the five stages model in the innovation-decision process by Rogers (2003); and (iii) the integrated theoretical framework with respect to the homeowners' decision for residential heating systems by Michelsen and Madlener (2010). The first two approaches provided a complementary basis and facilitated consideration of adoption decisions as a process, the third approach is a conceptual framework which aids the integration of innovation diffusion theory and behavioural models and

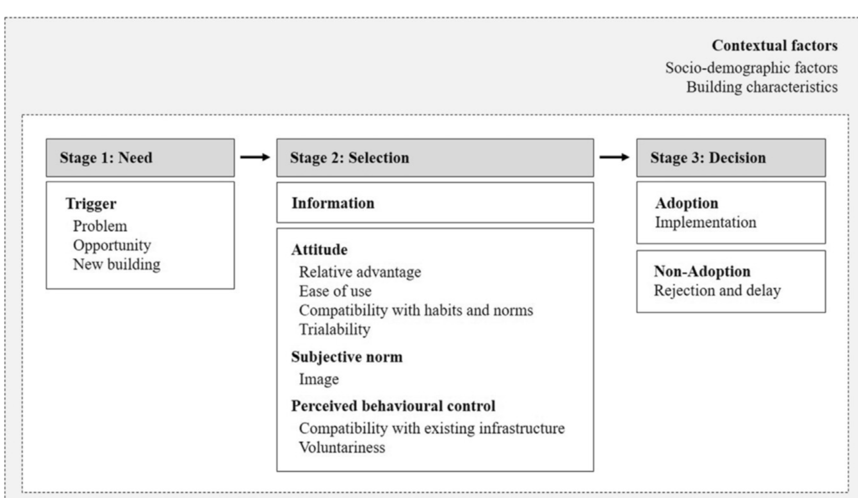

Fig. 1. Conceptual framework of homeowners' decision-making process for central heating systems (based on Michelsen and Madlener (2010), Rogers (2003), and Mintzberg et al. (1976)).