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Research article

Acceptance of energy efficient homes in large Japanese cities: Understanding the inner process of home choice and residence satisfaction

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ABSTRACT

In Japan's Long-term Energy Supply and Demand Outlook, promotion of energy-efficient homes (EEHs) is essential. For most people, however, energy efficiency is not a primary motivating factor when selecting a home. People cannot be satisfied with their own homes just as the home is energy efficient. For EEH promotion policies, it is important to identify factors that affect people's choice of homes and factors that affect their satisfaction with living in their homes. In addition to searching for such factors, constructing a model that explains the process through which people choose homes and are satisfied with living in their homes contributes to the implementation of EEH promotion policies.

In this study, we conducted a web questionnaire survey to investigate which factors affect people's choice of EEHs and which factors affect their satisfaction with their residences. Based on observed facts and with reference to a behavioral model in the social psychological field, we constructed a theoretical model that explains the process through which people choose homes and are satisfied with their residences. As a result, in order to promote EEHs, first it is necessary to make people choose EEHs by appealing to their health consciousness and community considerations. Second, it is necessary to have people realize the satisfaction of living in EEHs by following up on how to use EEHs' technology and by raising awareness of the environment. Based on the observed facts, revealing people's decision-making and physiological process in choosing a home and their satisfaction with their residence is useful for planning EEH promotion policies.

1. Introduction

In Japan's Long-term Energy Supply and Demand Outlook (Ministry of Economy, Trade and Industry (METI, 2015), the government plans to realize 13% energy conservation for Business as Usual (BAU) in 2030 with advanced energy saving measures. Of the total planned energy savings, 23% is planned to be attributed to energy saving in the household sector. Japan's Strategic Energy Plan (METI, 2016) aims to promote energy-saving renovations to existing houses as well as the construction of new houses with high insulation efficiency and advanced energy saving systems and devices. The Council for Science, Technology, and Innovation has proposed the construction of "smart societies" in which various smart technologies, including housing-related technologies, are integrated. A smart society aims to disseminate energy-efficient homes (EEHs) that combine convenience and the comfort of residents with energy efficiency.

Despite this goal of promoting EEHs, people's choice of homes is affected not only by energy performance oriented factors but also by

humanistic and social factors (Zhao et al., 2015). For EEH promotion policies, it is important to identify factors that affect people's choice of homes and factors that affect their satisfaction with living in their homes. In addition to searching for such factors, constructing a model that explains these decision-making and physiological processes when they choose EEHs and are satisfied with living in their homes contributes to the implementation of EEH promotion policies. It is important to understand that an EEH is a home that is simultaneously satisfying residents' need for comfort, convenience, and energy efficiency (in other words, a home aimed at being part of achieving a smart society).

In this research, we conducted a web-based survey and, using a multivariate probit model, analyzed factors that affect people's choice of EEHs and their satisfaction with living in these homes. Our analysis not only identified the factors that affect people's choice of home and their satisfaction, but also measured the magnitude of the impact these factors have on the choice of home and their satisfaction. Based on the analytical results, we constructed a theoretical model to explain

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people's decision-making and physiological processes from the choice of EEHs to their satisfaction with their residences. In previous studies, many social psychologists have investigated factors affecting pro-environmental behavior and energy-saving behavior, and have modeled people's psychological processes leading to such behavior (Bamberg and Möser, 2007). These models have provided important suggestions for the construction of our theory to clarify people's decision-making and physiological processes.

2. Literature review

2.1. People's acceptance of energy efficient homes

With the growing concern about EEHs in recent years, more and more researchers have become interested in people's perceptions and attitudes towards such homes. Several researchers have studied factors influencing households' energy consumption behavior or purchasing behavior of heating appliances. Mills and Schleich (2012) are investigating demographic factors that affect household energy use behavior using large scale survey data of 5000 households in 11 European countries. Sardianou and Genoudi (2013) determined the factors that significantly affected people's willingness to adopt renewable energies based on binary probit models. Research on the factors that influence the choice of residential heating systems in Germany pointed out that environmental concerns and technical understanding are more important factors than economic incentives (Decker and Menrad, 2015; Michelsen and Madlener, 2016). Ruokamo (2016) studied what kind of home heating system would be acceptable to people using a choice experiment. Although these studies contribute to identifying factors that affect people's preferences, they do not mention the decision-making or physiological processes leading to such behavior. In the most recent research, these considerations came into focus, and those studies refer to behavioral models in the field of social psychology. For example, social psychological models have been applied to the choice of Austrian home heating systems in Hecher et al. (2017), to the transition process to EEHs in Schaffner et al. (2017) and in Liu et al. (2018), and to the introduction process of smart meters in Chen et al. (2017). In addition to extracting factors that affect people's acceptability of energy-efficient equipment, by structuring those factors according to some behavioral models, it becomes easier to derive implications for energy policy.

2.2. Factors affecting people's home selection

Factors affecting people's choice of EEH and their satisfaction with their residences are not limited to energy-saving measures in their homes. These factors include not only energy-related advantages but also co-benefits such as improved comfort at home (Jakob (2006), Banfi et al. (2008)). Balta-Ozkan et al. (2013) surveyed previous articles and categorized EEH co-benefits into several types. Communication and health services were found to be the most frequent co-services associated with EEHs. In Japan, Sato (2013) noted that in the future smart products and services must be developed in accordance with users' targeted needs, e.g., health, education, child and elderly care, and other

community-related services. In this context, in addition to individuals' environmental consciousness, we focus on individuals' community and health consciousness as factors that affect their choice of EEH and their satisfaction with their residences.

Many previous articles have noted the difficulty of prodding people to continue their energy-saving behavior (Kato (2012), Yagita et al. (2014), Mizuho Information and Research Institute (2015), Nakano and Washizu (2016)). In other words, even when people choose EEHs with advanced energy-saving technologies, they do not always continue to use them. Farsi (2010) and Nakano and Washizu (2016) noted that residents' familiarity with advanced systems and devices leads to their actively using them and to their sense of satisfaction with living in EEHs. Therefore, we focus on individuals' interests and familiarity with advanced technologies as the factors that affect the choice of EEHs and satisfaction with their residences.

2.3. Social psychological models

In this sub-section, we will briefly mention representative social psychological models to explain people's decision-making and physiological processes leading to pro-environmental behavior including energy saving.

According to Bamberg and Möser (2007), pro-environmental behavior is a mixture of self-interest and pro-social motives. Researchers who view environmental behavior as pro-socially motivated use the norm-activation model (NAM, Schwartz (1977)), whereas researchers who view self-interest as the most important motive rely on the theory of planned behavior (TPB, Ajzen (1991)). Whether environmental problems are perceived as social problems or as self-interest problems likely depend on the environmental problem being researched. Environmental actions such as the protection of national parks and the conservation of ecosystems may belong to the former type of research, whereas environmental actions such as purchasing energy conservation equipment and recycling activities may belong to the latter type of research.

The NAM considers that a norm is a direct determinant of pro-environmental behavior, and is activated by people's sense of responsibility. The NAM was further extended by Stern et al. (1999) to create the value-belief-norm (VBN) theory. The VBN theory introduced a new ecological paradigm, based on various values related to nature and ecology, as a factor activating the sense of responsibility in the NAM (see Fig. 1). In these models, a chain of factors leading to pro-environmental behavior is described on a straight line.

This research examines people's acceptance of EEHs. Thus, it may be appropriate to select a TPB-type model focused on self-interest. Many previous studies have applied the theory of planned behavior (TPB) (Ajzen (1991)) to explain environmentally conscious behavior such as saving energy and recycling.

According to TPB, people first have the intention to perform a given behavior and then they put that behavior into action. The motivational factors that affect intention are attitude toward the behavior (the individual's evaluation of the behavior), subjective norms (positive evaluation of the behavior from others), and perceived behavioral control (an individual's access to the behavior) (Fig. 2). TPB was originally

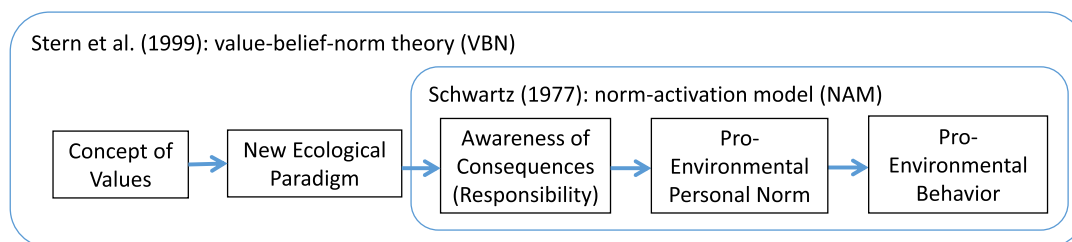


Fig. 1. Norm-activation model (NAM) and value-belief-norm (VBN) theory.

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