



Intervention strategy to stimulate energy-saving behavior of local residents

Q. Han^{a,*}, I. Nieuwenhijzen^a, B. de Vries^b, E. Blokhuis^a, W. Schaefer^a

^a Construction Management and Urban Development, Department of Built Environment, Eindhoven University of Technology, PO Box 513, 5600 MB Eindhoven, The Netherlands

^b Design Systems, Department of Built Environment, Eindhoven University of Technology, PO Box 513, 5600 MB Eindhoven, The Netherlands

H I G H L I G H T S

- ▶ A latent class model to identify segments with preferred energy-saving interventions.
- ▶ An integrated energy-saving behavior model of casual relations.
- ▶ A tree structure overview of potential interventions

A R T I C L E I N F O

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This study investigates intervention strategy in stimulating energy-saving behavior to achieve energy neutral urban development. A tree structure overview of potential interventions classified into three categories is revealed. An integrated behaviour model is developed reflecting the relations between behaviour and influence factors. A latent class model is used to identify segments of local residents who differ regarding their preferences for interventions. Data are collected from a sample of residents in the Eindhoven region of the Netherlands in 2010. The results indicate that social-demographic characteristics, knowledge, motivation and context factors play important roles in energy-saving behaviour. Specifically, four segments of residents in the study area were identified that clearly differed in their preferences of interventions: cost driven residents, conscious residents, ease driven residents and environment minded residents. These findings emphasize that the intervention strategy should be focused on specific target groups to have the right mixture of interventions to achieve effective results on stimulating them to save energy.

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1. Introduction

Sustainable urban development has developed in the past a few decades in the Netherlands to a mature subject of policy, research and innovation with various titles, such as low carbon city, energy neutral city, etc. The strategy of the local government to realize the energy-neutral target is based on the Trias Energetica: reduce energy demand, use renewable energy resources and use fossil fuels efficiently. The first step in this approach is to reduce energy demand because energy-saving is one of the cheapest ways to reduce CO₂ emission (IEA, 2008). More than 25% of residential energy use could be reduced using readily available technologies (Gardner and Stern, 2008). Despite all efforts currently being undertaken, the energy-saving rate of residents is still very low (Laitner et al., 2009). Therefore, it is important to investigate how residents can be encouraged to save energy.

There are two different types of energy-saving behaviors: investment behavior and curtailment behavior. Investment behavior is about spending money on the improvement of energy efficiency, and consequently saving energy. Curtailment behavior is about reducing energy usage by behavioral changes, such as shortening shower duration, lowering room thermostat settings. Contextual factors, knowledge, motivations, abilities and socio-demographic variables may influence such energy-saving behavior (Lutzeniser, 1993). There are certain interventions that local government can apply to promote energy-saving behavior, such as providing information, demonstration, offering free products, commitment with goal setting, giving feedback, rewards, financial support and legislation.

There are a few researches about behavior models with causal relations between influence factors and behavior. Olander and Thøgersen's (1995) developed Motivation-Opportunities-Abilities model (MOA-model) with the focus on behavior in general. Value-Belief-Norm model developed by Stern (2000) addressed the environmental behavior in particular. However, an integrated behavior model with the focus on interventions and energy-saving behavior of residents is still missing.

* Corresponding author. Tel.: +31 40 2475403; fax: +31 40 2478488.
E-mail address: q.han@tue.nl (Q. Han).

There are also researches that investigate household preferences for energy-saving measures using conjoint analysis (Poortinga, 2003), the relative impacts of two social change paradigms on residential behavioral energy-savings using regression model (Tiedemann, 2009), and behavior patterns and household profiles related to energy spent on heating using factor analysis (Guerra Santin, 2011). However, as we believe that people are different, interventions aimed at residential energy-saving may have different influences for different people (Guns, 2007). The intervention strategy that recognizes and accommodates the ways in which people differ will be more effective. In this paper, we propose a latent class model to tackle this problem.

This paper is structured as follows: in Section 2 energy use behavior and its influence factors are discussed; Section 3 describes interventions; in Section 4 theoretical model of latent class are proposed; Section 5 provides information of data collection; in Section 6 all the analysis results are reported; and its implications for policy making are discussed in Section 7; finally some conclusions are drawn in Section 8. The main objectives of this study were to: (1) provide a overview of potential interventions, (2) attempt to present an integrated energy-saving behavior model of casual relations, (3) apply a new approach to identify segments with preferred energy-saving interventions. The results of this paper can provide decision support for local government in their policy making to effectively stimulate residents to save energy.

2. Energy use behavior

Households in the Netherlands use energy directly in forms of natural gas and electricity and indirectly through the energy that is used to develop the products and foods that households consume (Vringer and Blok, 1995). The amounts of electricity consumed and natural gas used per household are comparable to a total energy of about 73.4 GJ/yr on average. The amount of electricity and natural gas use per household slightly changed over the past 10 years. In comparison to former years more electricity and less gas is used per household (CBS, 2011).

Arkel et al. (1999) distinguished energy use into two categories, namely dwelling related energy use and user behavior related (or appliances related) energy use. The dwelling related energy use consists of space heating (which is influenced by insulation and ventilation) and electricity consumption for mechanical ventilation is present. The user behavior related energy use consists of using all kinds of appliances related to shower, cleaning, cooling and preparation of food and audio-, video- and telecommunication, etc. Lighting is conditioned by the design of the house together with the lifestyle of the residents. Therefore, it is part of both dwelling related energy use and user behavior related energy use. In this research, energy demand is assumed to depend on both the behavior of the residents and the characteristics of the dwelling. Consequently, energy-saving are related to both the curtailment and investment behavior of the residents.

Since the energy use for heating covers more than 50% of the total energy uses of a household (Itard et al. 2009), technical characteristics of dwellings – energy label – are important factors when determining energy demand and consequent energy-saving potentials. Dwelling technical characteristics such as constructional measures, insulation measures and method of heating and lighting are important factors. Ownership of the housing, duration of the residence may influence the maintenance of the dwelling and indirectly impact the energy efficiency.

Recent studies have shown that residents' behavior has a significant impact on the energy demand of households (Guerra

Santin et al., 2009). Such behavior has a strong association with the characteristics of the user (Guerra Santin and Itard, 2010a). The study conducted by Leidelmeijer and Cozijnsen (2010) shows that age is an important factor in energy use. The age of residents influences thermostat settings, frequency and length of shower, and the number of used appliances (Groot et al., 2008). Moreover, the age of residents may imply the strength of the habitual behavior, since the behavior is likely to be repeated when outcomes are satisfactory, and such habitual behaviors are commonly observable in elderly people (Ariely, 2009).

The household-size and composition, which represents the total number of people living in the same dwelling, determines the frequency of activities over the week, such as washing, dishwashing, tumble drying and refrigeration (Groot et al., 2008), therefore directly related to the total energy demand (Abrahamse and Steg, 2009). Furthermore, other socio-demographic factors, such as income, education level, and work status, may serve as barriers or opportunities for energy usage and saving.

There are two types of energy-saving behaviors: investment behavior and curtailment behavior. Investment behavior is about investment in the measures to increase the quality of dwellings in terms of energy efficiency (e.g., change the old single glass window to the double HR glass), or the purchase of energy-efficient appliances to reduce energy usage (e.g., LED light). Behaviorally efficiency improvements usually involve one-time purchase decisions: there is a financial expense and the potential of future monetary savings; it is energy smart technology choice without loss of the amenities. Curtailment behavior is about the decrease in the usage of existing equipments or appliances by behavioral changes, such as shortening shower duration, lowering thermostat setting, etc. Behaviorally these responses usually must be repeated or continual to achieve maximum energy-savings: they rarely cost money, but they do ask change in habit and lifestyle adjustment; it is energy smart lifestyle choice with the possibility of loss of amenities. However, with the energy-saving behavior there is also a risk for rebound behavior (Berkhout et al., 2000).

Contextual factors, knowledge, motivations, abilities and socio-demographic variables are the important factors that could influence residents' energy usage and saving (Steg, 2008). Because investment and curtailment behavior involve different sorts of behavior, they may be influenced by different factors (Lutzenliser, 1993) and consequently promoted by different interventions. For example, investment measures are more available to higher income residents and to homeowners, whereas curtailment measures may be the only option for renters and for those who cannot afford new equipment.

There are multiple studies about behavior models in general with causal relations between influence factors and behavior. The MOA-model is often used and it visualizes the theory of reasoned action (Olander and Thøgersen, 1995). According to this model, behavior is caused by three main influence factors (motivation, ability and opportunity). Motivation includes beliefs, attitudes, intention and social norms. Habits and knowledge are part of the ability factor. The behavior model addressing the energy aware behavior and the energy use (Van de Maele-Vaernewijck et al., 1980) concentrates on demographic factors and housing characteristics as influence factors. Certain aspects of this model overlap with the value-belief-norm (VBN) theory model (Stern, 2000). The VBN theory is a causal chain leading to different types of environmental behavior. The model consists the variables such as: personal values (altruistic, egoistic and traditional), belief, and personal norms for pro-environmental action. Considering our specific topic about interventions and energy-saving behavior, an integrated energy-saving behavior model is required.

Although people often seem to be aware of the environmental and energy problems, they often do not act in line with their

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