



Determinant factors of residential consumption and perception of energy conservation: Time-series analysis by large-scale questionnaire in Suita, Japan



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HIGHLIGHTS

- Questionnaire was conducted to households in two years for time-series analysis.
- We analyzed residential energy consumption and perception of savings in households.
- Determinant factors for consumption and perception of savings were identified.
- Households being wasteful of energy are also found willing to cut consumption.
- Policy intervention could affect consumption pattern and perception of savings.

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ABSTRACT

In this study, we examined determinant factors associated with the residential consumption and perception of savings of electricity and city gas; this was based on data collected from a large-scale questionnaire sent to households in Suita, Osaka Prefecture, Japan, in two different years: 2009 and 2013. We applied an ordered logit model to determine the overall trend of the determinant factors, and then we performed a more detailed analysis in order to understand the reasons why the determinant factors changed between the two periods. Results from the ordered logit model reveal that electricity and gas consumption was primarily determined by such factors as household income, number of family members, the number of home appliances, and the perceptions of energy savings; there was not much difference between the two years, although in 2013, household income did not affect the perception of energy savings. Detailed analysis demonstrated that households with high energy consumption and those with moderate consumption are becoming polarized and that there was a growing gap between consumption behavior and the perception of conservation. The implications derived from the analyses provide an essential insight into the design of a municipal policy to induce lifestyle changes for an energy-saving society.

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1. Introduction

Change in lifestyle is a key component to saving energy and becoming a low-carbon society. As of 2011, households accounted for about 14.2% of the total energy consumption in Japan; this has more than doubled since the 1970s (Ministry of Economy, Trade and Industry, 2013), while the energy consumed by the industrial sector has almost stabilized due to their conservation efforts. This

shows why, in Japan, it is essential to pursue energy conservation at the household level, and we note that the household level is recognized as one of the indispensable targets of energy policy in other countries, as well (Saidur et al., 2007; Wang et al., 2011).

Such changes in lifestyle can be enhanced by effective policies, and citizens' attitudes have traditionally been important factors when determining energy policy (Viklund, 2004). A thorough understanding of behavioral patterns and perceptions about energy consumption and conservation is the basis for effective policy formations and ultimate changes in lifestyle. Past studies have considered which factors are essential for affecting the public's

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energy efficiency and attitudes towards energy conservation (Atari et al., 2010; Barr et al., 2005; Becker et al., 1981; Gatersleben et al., 2002; Gromet et al., 2013; Martinsson et al., 2011; Mizobuchi and Takeuchi, 2013; Moll et al., 2005; Ouyang and Hokao, 2009; Sweeney et al., 2013; Wang et al., 2011). For example, Wang et al. (2011) explored factors related to electricity saving behavior, such as economic benefits, policy and social norms and past experiences, by conducting questionnaire survey in China. Mizobuchi and Takeuchi (2013) examined the influences of financial factors, such as income and rewards, and non-financial factors, such as social norms, on electricity saving behavior by looking into random sample of Japanese households. Other studies have explored policy measures that can induce changes in behavior, such as by changing pricing and providing information (Albadi and El-Saadany, 2008; Herter, 2007; Ueno et al., 2006; Vine et al., 2013). However, there have been few large-scale surveys of municipal households, aimed at systematically discovering attitudes and perceptions of energy conservation. Furthermore, no studies have comprehensively performed time-series analyses of changes in energy consumption and perceptions of conservation in Japan, although it has been claimed that the Great East Japan Earthquake that occurred in 2011 could have influenced behavior, motivation, and perception of energy consumption and conservation (Kosugi, 2014). We hypothesized that these factors would have been influenced by that earthquake. Following the Great East Japan Earthquake in 2011, due to the stoppage of nuclear power plants, there have been shortages of electricity in Japan. This has led to required electricity conservation, with a specific target of 10% in the summer of 2012, within the Kansai Electric Power Company's service area, in which the city of Suita, the case study area of this study, is located. This could have affected energy consumption and perceptions of conservation. While some studies have attempted to delve into the possible impacts of the intervention after the earthquake (Kosugi 2014; Nishio and Ofuji, 2014), to the best of our knowledge, no studies have performed substantiated analyses of any changes in the determinant factors.

In this study, we examine the determinant factors associated with the residential consumption and perception of conservation of electricity and city gas (hereinafter gas); this was based on data collected from a large-scale questionnaire distributed to households in Suita, Osaka Prefecture, Japan, in two different years: 2009 and 2013. We consider the consumption of electricity and gas to be an indicator for energy consumption at household level, and we investigate the factors and attributes of the individual households that could potentially determine consumption and perception of savings or willingness to conserve. We then compare the results of the 2009 and 2013 surveys and explore possible changes in the determinant factors affecting consumption pattern or perception of savings over the two-year period. We also address the policy implications of these results. The information and implications derived from this study provide an essential insight into the design of a municipal policy that can induce lifestyle changes that result in an energy-saving society, and can be the basis for detailed analyses in the future as to how the people's energy consumption and perception of savings could have been affected after the policy intervention of the government of Japan following the earthquake.

2. Methods

2.1. A large-scale questionnaire in Suita

Suita, the location of our study, is the commuter town located in the northern part of Osaka Prefecture. Its population is around 0.36 million, its area is 36 km², and there were about 0.16 million

households in 2013. Its population has been slightly increasing just recently while many municipalities in Japan see a declining population. It is therefore an urgent task for the city to formulate policies to pursue energy conservation in households particularly in the context of combating climate change (City of Suita, 2014).

In close collaboration with the City of Suita, we used the register of residents and randomly chose households in all parts of the city for participation in the survey: 10,000 households in 2009 and 4000 in 2013. The numbers of households selected were different due to the budget in each fiscal year, but we ensured that conditions were the same so that the results could be compared. The questionnaire was conducted between October and November in 2009 and between February and March in 2013. Note that the questionnaire contained the same questions in both years 2009 and 2013, with the exception that in 2013, a few items were added to assess the possible impact of the policies imposed following the Great East Japan Earthquake in 2011 on the behavior and perceptions regarding energy consumption and conservation.

In both years, the questionnaires were mailed to the selected households. The response rates were 44.5% (4448) in 2009 and 31.1% (1245) in 2013. These rates were sufficiently high that we considered the results sufficient for analysis.

2.2. Items in the questionnaire

The questionnaire was designed to elicit comprehensive responses about behavior and perceptions regarding energy consumption and conservation, awareness about new energy sources, including renewable energy, and how these items related to the various attributes of each household. Table 1 lists the main items that are contained in the questionnaire. The main items were questions about the attributes of the chosen households (Q1–Q4), the consumption behavior and perceptions about energy and resources (Q5 and Q6), the use of energy related to transportation (Q7 and Q8), practices and awareness related to energy conservation (Q9 and Q10), and consciousness of new energy sources and energy-saving equipment (Q11–Q15).

Questions Q1–Q4 asked about the attributes of the households, including the location of the residence, the type of residence, the composition of the family, and the household income. Questions Q5 and Q6 asked about the types of energy and resources used, including electricity, gas, kerosene, water, and solid waste. Although the primary target of this survey was energy, we also collected data on water consumption and solid waste discharge for comparison in future study.

As discussed above, the questions were the same in 2009 and 2013, with the exception for the addition of questions related to impacts due to policy changes following the Great East Japan Earthquake that occurred in 2011; these additional questions were added to Q9 as sub-items. For example, one of these asks each household about energy-saving measures and practices that were adopted following the 2011 earthquake.

The questions were multiple choice in order, as exemplified in Q4 of Table 1, which asks the annual household income (i.e., 1: less than two million yen, 2: between two million yen and five million yen, 3: between five million yen and 10 million yen and 4: more than 10 million yen).

Although the data derived from the questionnaire can be used for various types of analyses, in this study, we focus on clarifying the determinant factors for energy consumption and perceptions about energy conservation; we do this by analyzing their relationships with the attributes of each household and delving into any possible changes in such factors between the values in 2009 and those in 2013. The data most valuable for this were those obtained from Q1 to Q6. Table 2 illustrates the details of Q6, which asks about the current consumption practices and perceptions

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