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Paper or screen? Examining the effectiveness of messaging delivery means in promoting household energy conservation in China

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ABSTRACT

With the advent of the Paris Climate Agreement and China ratifying it recently, there is a need to adopt a diversified approach to address climate change; this is especially the case of promoting residential energy conservation. This study is one of the first household energy intervention studies that focuses on the comparison of two message delivering means, paper-based versus instant messaging tool, as a platform for sharing energy-saving tips and engaging households to save energy in China. Conducted in several communities in Hangzhou, Zhejiang Province of China, the effectiveness of using a widely used application known as WeChat in promoting household energy conservation is compared with that of using stickers. It was found that WeChat is the most effective in reducing monthly consumption, but the effects are short-lived. Comparatively, using stickers as a mean of engaging households produces more sustained results in terms of energy savings. This study also provides evidence to correlate the changes in energy consumption behavior with personal perception of one's responsibility and quality of life. That is, certain behavior can be triggered if residents are willing to impose energy ration in their households or are given more opportunities in the form of local programs that enable them to have more practices in energy conservation.

1. Introduction

China is presently regarded as a country with “transition economy”, whereby this transition brings a huge change to people in terms of their shared values, consumer behavior, standards of living and other socio-demographic indicators. China's electricity consumption has been increasing across various sectors over the years. Electricity consumption in the residential sector has known to be the highest consumption in overall, as compared to Service & Commercial, Agriculture & Forestry sector (TEC, 2014). The National Bureau of Statistics of China (NBSC) found a drastic increase of consumption over 10 years, with annual rise of 10.78% in average (NBSC, 2017). The World Energy Issues Monitor 2016 also showed noted that the average electricity consumption of electrified household and electricity consumption for electrical appliances and lighting rise by 1% over the last 10 years, leading to a drastic increase of 3.5% of carbon dioxide (CO₂) emissions in households between 1990–2014 (WEC, 2016). This highlights the significance of utilization of electrical appliances to household energy consumption.

Given the rising electricity consumption trend in China, studies on the effectiveness of energy conservation efforts are of critical

importance. While there are various legislations and incentive schemes to control and encourage energy efficiency and conservation in different sectors, the effectiveness of the measures or actions has not successfully brought about considerable impact to household energy conservation. The electricity consumption across all sectors, in particular, the residential sector, is also largely dependent on the residents themselves, which depends on whether they are educated or motivated to make a difference to the energy conservation.

Existing studies have seldom quantified and compared the effectiveness of information conveying on the change of occupancy behavior and resultant energy consumption. Due to occupant behaviors are influenced by a wide range of factors such as personality and residential surrounding environment (Gatersleben et al., 2002), the measurement of energy behavior is challenging. Existing methods of studying occupant behavior have mainly relied on the statistical analysis on large-scale electricity data, laboratory experiment (Pichert and Katsikopoulos, 2008; Chen et al., 2017) or simulations. The true causal effect between intervention means and occupant behavior has not been fully examined. Previous studies provided little evidence to explain why different effects present when occupants are intervened by a uniform

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strategy (Shen and Cui, 2015; Shen et al., 2015). That is, intervention conveying means are also highly depended on different occupancy attributes, such as their personality, life style, willingness, and motivations (Milfont and Sibley, 2012). Hence this study would seek to explore the following question: what is the effectiveness of different means of information conveying, and to what extent, a particular conveying means is more effective than others, in changing occupant energy behavior and resultant energy consumption when considering the heterogeneity of occupants' lifestyle, behavioral and psychological factors.

The present study was thus conducted to find out how effective of different types of household energy intervention methods in encouraging Chinese households to save electricity consumption. Specifically, the key research objectives are: 1) to evaluate and compare the effectiveness of various antecedent intervention methods (that is, stickers and WeChat), with respect to household self-reported energy consumption behavior and amount of electricity used; and 2) to find the relationship between various human behavioral and psychological factors, energy consumption behavior and electricity consumption. To fulfill the objectives, two sets of intervention strategies, namely paper-based messages and electronic-based instant message, were designed to disseminate energy use tips to residences in a few communities in the city of Hangzhou, China. Meanwhile, residents' demographics, quality of life (QoL) standard, and other psychological factors have also been recorded and evaluated using a questionnaire and tested for its effectiveness to change occupant energy behavior. The results of the study show promising effect of employing online platform (e.g. WeChat) to engage households energy conservative behavior over large areas, such as mega cities, with consideration of different types and preferences of electricity users. Meanwhile, the results also demonstrate the practical implication of optimizing energy savings by customizing tailored energy information and delivery to individuals based on the demographics of user groups, their life style, and purpose of the intervention.

2. Literature review

2.1. Intervention methods, contents and conveying means

Intervention strategies in the domain of energy conservation can be categorized into two groups, respectively informational strategies (e.g. information, feedback, education) and structural strategies (e.g. services, price policies). Structural strategies mainly focused on changing contextual factors, such as providing incentives or disincentives, however, its effect of changing residents' pro-environmental behaviours is limited due to "crowding out" the intrinsic motivation of saving energy (Frederiks et al., 2015). Regarding the information-based strategies, the provision of energy-saving tips is one of the powerful and commonly used strategies and can be used together with other types of intervention strategies, such as energy audits (Corradi et al., 2013). The effectiveness of engaging energy-use feedback intervention for the change of residents' behaviours has been tested in a multitude of field experiment studies (Nilsson et al., 2014; Schultz et al., 2015; Lynham et al., 2016). Scholars argues that energy-saving tips have better effects than other traditional programmes, such as education and media campaigns, which only deliver pro-environmental information to the public without consequential triggering of durable behaviour change due to the gap of attitude-to-action (Asensio and Delmas, 2015a,b). Information intervention methods can be further divided into two types: antecedent and consequence. Antecedent intervention is developed before the act of using energy to encourage energy-saving behavior through knowledge-strengthening information. Consequence intervention occurs after the act of energy consumption (for example, providing feedback based on the outcome of consumption). Intervention to conserve household energy works well when there is a combination of tailored information, goal setting, and feedback. The scope of this research is focused on antecedent intervention (tailored information) on direct energy.

The effectiveness of providing feedback to intervene residents' behaviors is various and depended on various factors such as customized information and frequency of delivery. The individual intervention, in which the information of a resident's energy consumption in the current period compared to the amount in the previous period, can generate significant energy reductions about 5–12% (Dietz et al., 2009; Jain et al., 2012). Studies also found that residents who received comparative feedback of their energy use in relation to peers' consumption tend to show more energy-saving manners than those who received only individual feedback (Shen et al., 2016), because the comparative feedback generate motivational effect that encourages participants to save more energy. Similarly, Delmas and Lessem tested the efficacy of detailed private and public information on electricity conservation in an unique field experiment context in university residence halls (Delmas and Lessem, 2014). Private information that contains energy usage information was delivered through an online dashboard coupled with weekly emails, while public information was presented in the form of posters that publicly rated rooms as above or below averages energy users additionally. They concluded their study that while private information alone was ineffective, a combination of public and private information motivated a 20% reduction in electricity consumption. The competition orientation created by such an intervention strategy can lead to continuous savings even after the intervention (Siero et al., 1996; Abrahamse et al., 2007). For residents living in a well-connected social network so they can effectively communicate among their peers, the intervention-induced energy savings are suggested to be higher (Nilsson et al., 2015).

Another often-raised debate with the feedback intervention is to determine the impact of delivering method of the feedback in reducing energy consumption. A Sweden study that included more than 2000 households evaluated the effects of the different ways of presenting feedback used for different intervention groups (Vassileva et al., 2012). Emails become popular in many behavior intervention studies (Asensio and Delmas, 2015a,b; Carrico and Riemer, 2011; Gulbinas and Taylor, 2014; Jain et al., 2013). Jain et al. employed weekly eco-feedback emails in their experiments to examine the impact that information representation has on energy consumption behavior by comparing the effectiveness of direct energy feedback versus feedback represented as environmental externality (Jain et al., 2013). They revealed that information representation has a statistically significant impact on the energy consumption behavior of uses. However, the experiment that provides paper-based manual feedback on energy conservation suggested no significant effect on reducing energy use (Katzev et al., 1980), and this result aligns with other studies (Kua and Wong, 2012). Websites or in-home display that have used by relatively high-income families can provide easy and instant access to energy information that reflects residents' energy behavior (Vassileva et al., 2013). Web-based feedback resulted in being the most effective compare to direct display and paper-based and achieved approximately 15% electricity savings (Vassileva et al., 2012). A recent research stated that counselling is more powerful in residents' energy conservation (He and Kua, 2013).

Given uncertain impact by various delivery methods, it is essential to compare and to choose optimal delivery methods as part of the energy intervention for achieving maximum conservation. In the non-residential building context, Gulbinas and Taylor developed an eco-feedback system in a novel 9-week system study and demonstrated that the organizational network dynamics can significantly affect energy conservation among commercial building occupants (Gulbinas and Taylor, 2014). Weekly emails and stickers were used to remind employers to increase the engagement of the energy management systems. Carrico and Riemer also selected to use monthly group-level feedback emails and peer education to test different energy conservation motivations in the workplace, in addition to the usage of a series of four postcards in the early information campaign (Carrico and Riemer, 2011). The results showed that feedback and peer education resulted in a 7% and 4% energy reduction, respectively (Carrico and Riemer,

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