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Lessons for integrated household energy conservation policy from Singapore's southwest Eco-living Program

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HIGHLIGHTS

- Energy intervention was implemented on 151 households.
- Outreach methods included stickers, leaflets and counseling.
- Self-reported behavioral and actual reductions were recorded.
- Actual reduction was correlated to large housing apartments not in control group.
- Intervention program found to be cost effective and promote stakeholder engagement.

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ABSTRACT

This study describes a district-level energy intervention and conservation program designed and implemented with the help of community stakeholders, which include students and staff of an educational institution, the National University of Singapore, a local non-governmental environmental group in Singapore and the district government. The program – known formally as the Eco-living Program – was funded by the district government and implemented in the Hong Kah North Residential Council in the south western part of Singapore. The research objectives are three-fold: (1) compare the effectiveness of different intervention methods, based on self-reported behavior scores and actual electricity reduction; (2) investigate how behavior and electricity consumption are influenced by values, situational and psychological factors; (3) assess the effectiveness of different methods of intervention and provide recommendations for improvement. It was found that a combined use of leaflets and stickers resulted in highest (that is, 15.8%) reduction in average consumption. Ease of practicing the recommended energy conservation actions is a strong motivators to change energy consumption behavior. This program exemplifies the important role that community-initiated bottom-up programs can play in promoting sustainable consumption with the financial support from the local (district) government.

1. Introduction

1.1. The importance of studying household energy consumption and conservation

In the wake of climate change and escalating energy prices, studies on the effectiveness of energy conservation efforts have become even more important than ever. Households are an important target group because they are responsible for approximately 15% to 20% of total energy demands in OECD countries (OECD, 2001; Steg, 2008). Singapore is an island state with a land area of approximately 712.4 km^2. The total population in Singapore as of 2010 was about five million, making Singapore one of the most densely populated countries in the world. Without significant indigenous energy resources, Singapore is dependent on fossil fuel imports to meet its energy requirements. About 80% of Singapore's electricity is generated using natural gas. In 2009, Singapore imported 146.1 Mtoe of energy products. The main imports were petroleum products and crude oil, and natural gas liquids, which constituted 61.8% and 33.2% of total energy imports, respectively (Energy Market Authority , 2011). Given that Singapore imports most of its energy resources, household conservation has always been given high priorities in the national environmental agenda. Energy consumption of buildings (industrial, commercial as well as residential) took up about 17% of Singapore's total electricity production (Chua and Chou, 2010; Hwang and Tan, 2010). Households

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account for close to 10% of the electricity consumed (Ministry of Trade and Industry, 2007) and 6.9% of the total gas consumption (Energy Market Authority, 2011). In a typical household, refrigeration and air-conditioning account for a large proportion (about 60%) of electricity consumption.

Several noteworthy programs have been implemented around the world (for example, programs by Defra (2008) and the Mindspace (Dolan et al. (2010)) to examine the use of behavioral theories and strategies to promote pro-environmental behavior. In spite of these studies, as observed by Altan (2010), there is still a general lack of rigorous methodologies for successful user intervention, especially those based on knowledge in how different compounding social or behavioral factors influence energy consumption.

To fill this gap in knowledge, a feasibility study for Eco-living Program (Kua and Wong, 2012) was done in 2008 to identify the key factors influencing decision-making behind pro-environmental actions. Building on that study, this present study examines the actual Eco-living Program, which was implemented over a larger area within the southwest district of Singapore. It delineates the key lessons gleaned from six months of study and data collection and presents a set of lessons that can be applied generally to any similar program around the world. As suggested by Kua and Wong (2012), community programs such as the Eco-living Program have an advantage over nationwide top-down policies because most are flexible, can be implemented easily and potentially more cost effective (because mostly are supported by volunteer efforts within the associated communities).

The following section reviews the different aspects of a successful intervention programs to promote energy consumption. Section 3 describes the detailed research methodology adopted for this study, whereas Section 4 analyses the key results. Section 5 concludes.

2. Role of tailored information and feedback in energy intervention programs

"Residential energy" can be broadly defined into direct and indirect consumptions. Energy consumed in the house, either in the form of electricity, natural gas, or petroleum is defined as "direct consumption"; energy embodied in goods and services which are purchased by households is called "indirect consumption". Most interventions are targeted at direct consumption, whereas indirect consumption is seldom discussed. Studies that discussed indirect consumption found no significant difference in indirect energy consumption in subjects that were subjected to energy conservation treatments (Benders et al., 2006; Abrahamse et al., 2007). This study focuses on examining direct consumptions of households.

Abrahamse et al. (2005) divided intervention techniques into antecedent and consequence interventions. Antecedent interventions are methods that influence one or more determinants prior to the performance of pro-environmental actions. An example is providing households with information on energy conservation that may result in energy reductions. Conversely, consequence interventions are implemented after the occurrence of a pro-environmental behavior, by means of providing a consequence that is contingent on the outcome of the behavior. For example, giving households feedback on their energy reductions may encourage them to further reduce energy consumption due to their heightened level of self-efficacy. These concepts are detailed in the next two sections.

2.1. Antecedent intervention

According to a study by the Oak Ridge National Laboratory, the use of personalized information is an important characteristic of effective educational programs on conservation (Sorensen, 1985). Similarly, Coltrane et al. (1986) independently proposed that successful marketing in energy conservation must contain important elements, including having vivid and personalized information (using individually tailored recommendations), and personal appeal (by using face-to-face interactions). More recent studies, for example those by Abrahamse et al. (2005), Benders et al. (2006), EPRI (2009), Schultz et al. (2007), and Carrico and Riemer (2011), found that antecedent actions – providing home energy audits and offering tailored energy advice – had positive effects on household energy use reduction.

Leaflets and stickers are widely used as outreach instruments in intervention programs. McDougal et al. (1981) found evidence that incorporating leaflets with utility bills can help reduce residents' energy consumption. However, Geller (1981) found that information alone will not result in substantial change in behavior; leaflets must be complemented with other forms of outreach. This conclusion was supported by Scott (1997) and Schipper and Hawk (1991). Similarly, studies on the use of stickers under various circumstances to promote pro-environmental behavior had shown that they are most effective when applied with other outreach instruments (for example, Wijarso, 1983; Crossley, 1983; Hirst and Goeltz, 1982; Brechling and Smith, 1994).

2.2. Consequence intervention

Provisions of feedback are an important element of consequence interventions. Feedback through face-to-face means, leaflets or website forms a majority of existing studies. For example, Bittle et al. (1979) conducted a study in which a group of users received daily feedback whereas the control group did not receive any. Results showed that the first group saved more energy—an average of 4% of their consumption (compared to the baseline). Hayes and Cone (1981) examined the effect of monthly feedback on electricity use, and found that households that received feedback reduced electricity use by 4.7% on average, while the control households actually increased electricity use by 2.3%. Similar conclusions were arrived at by Van Houwelingen and Van Raaij (1989), who conducted similar experiments on household gas consumption. Darby (2006) reviewed past interventions and found that immediate direct feedback was extremely valuable. More recently, studies conducted by EPRI (2009), Petersen et al. (2007) and Riemer and Bickman (2010) had all shown that feedback is effective in reducing energy consumption by 5–15%.

A detailed review on feedback was done by Fischer (2008). Twenty-two intervention programs were covered and the success or flaws were analyzed. It was found that many of interventions in the past did not have sufficient numbers of participators to reach a statistically valid conclusion. The most important conclusion was that the most successful feedback is that which is given frequently and over a long time, provides an appliance-specific breakdown, is presented in a clear and appealing way, and uses computerized and interactive tools.

In comparison, assessments on the relative effectiveness of using leaflets, stickers and face-to-face interaction in providing tailored information in a single study are not as common (the feasibility study for Eco-living Program (Kua and Wong, 2012) was one of the most recent in this respect). This present study further contributes to the existing literature on examining the relative effectiveness of these different modes of providing tailored information.

2.3. Assessment of outcome

Self-reported actions do not necessarily lead to actual energy reduction (for example, Olsen and Cluett (1979), Warriner et al. (1984) and Staats et al. (1996)). Hence, a well-designed study