Integrated Energy Conservation Policies from the Ground Up: Lessons from the Eco-living Program of Singapore's South West District

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Abstract

This study documents 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. The Program was 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 interventions based on self-reported behavior scores as well as actual electricity reduction; 2) investigate how behavior and electricity consumption are influenced by values, situational and psychological factors; 3) examine the methods of intervention used according to residents' feedback and make recommendations for improvement. The key lesson is that providing information about energy conservation in the right form is useful in interventions. For the residents in our study, straightforward and easily implemented measures, emphasis on the amount of money they can save with energy conservation and evoking environmental concern in them are pivotal to effective intervention. Most importantly, this Program exemplifies the important role that community, bottom-up initiatives can play in promoting sustainable consumption with the resource support of the government. It provides a model that other districts, or even countries, can adopt in engaging different stakeholders in promoting energy conservation at the community level.

1 The Need to Study 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. The total energy consumption of a geographical territory can be divided into three categories –industrial, commercial and residential consumptions. Given that Singapore imports most of its energy resources, household conservation has always been given high priorities in the national environmental agenda. Ironically, systematic studies of household energy consumption behavior have been lacking and this study aims to contribute to this cause, while contributing to the worldwide knowledge database on how household energy usage behavior can be modified. This study aims to address these questions through an intervention program that was implemented in a local community situated in the south western part of Singapore.

2 Literature Review

2.1 Energy Consumption in Singapore

In our efforts to change energy consumption behavior to reduce our reliance on fossil fuels, 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). Energy consumption of buildings (industrial, commercial as well as residential) took up about 17% of Singapore's total electricity production (Chua and Chou, 2010). Households account for close to 10% of the electricity consumed (Ministry of Trade and Industry, 2007). In a typical household, refrigeration and air-conditioning account for a large proportion (about 60%) of electricity consumption.

Table 1. Singapore's energy consumption by sectors in 2005

Percentage (%)	Power generation	Industry	Transport	Buildings	Households	Others [a]
Fuel consumption	51 [b]	32	16	<1	<1	-
Electricity consumption		22	2	16	9	2
End-Use consumption		~54	~18	~17	~10	~2

a. Includes consumption for utilities, communication, construction, agriculture, etc.
b. Electricity consumption is the part of power generation under the category of fuel consumption

2.2 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. Even for those with discussion on indirect consumption, no significant difference of indirect energy reductions emerged (Benders, 2006; Abrahamse et al., 2007). This study focuses on examining direct consumptions of respondents.

To reduce residential direct energy consumption, besides sustainable building design and technology innovations leading to improved energy efficiency, intervention programs aimed at modifying behavior are essential. Two types of strategies are identified to promote residential energy conservation. Psychological strategies are aimed at changing people's knowledge, perceptions, motivation, cognitions and norms related to energy use and conservation. An example is the provision of information. Structural strategies are aimed at changing the context in which decisions are made so as to make energy conservation more attractive. Examples are new or better products and services, changes in infrastructure, pricing policies and legal measures (Steg, 2008).

In their review of the different intervention studies aimed at household energy conservation, 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-saving that may result in energy reductions. On the other hand, consequence interventions are actions taken 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 due to their heightened level of self-efficacy.

In fact, studies on effective antecedent interventions, in the form of tailored information, dated back to the early 1980s. According to a study by the Oak Ridge National Laboratory, an important characteristic of effective educational programs on conservation is the use of personalized information (Sorenson, 1985). Similarly, Coltrane et al. (1986) independently proposed that successful marketing in energy conservation must contain important ingredients, include having vivid and personalized information (using individually tailored recommendations), and personal appeal (by using face-to-face interactions). More recent

studies, notably those by Abrahamse et al. (2005); Benders et al. (2006), EPRI (2009), Schultz et al. (2007), and Carrico and Riemer (2011), found that antecedent interventions in the form of home energy audits using tailored energy advice had positive effects on household energy use reduction.

Pamphlets and stickers are widely used as outreach instruments in intervention programs. McDougal et al. (1981) found evidence that incorporating pamphlets with utility bills can help reduce residents' energy consumption. However, Geller (1981) found that information alone will not result in substantial change in behavior; pamphlets must be complemented with other forms of outreach. This need for a "multi-pronged approach" was also 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). In particular, in Crossley's (1983) study, the conservation commitment of respondents who were given stickers as reminders on energy conservation tips was one of the highest.

An important element of consequence interventions is the provisions of feedback, which can be sub-divided into continuous feedback, daily feedback and weekly/monthly feedback. Feedback through face-to-face means, pamphlets 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). As part of a counselling session, 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%. Van Houwelingen and Van Raaij (1989) conducted similar experiments on household gas consumption, and found that household receiving continuous feedback recorded more reductions in use than the group receiving monthly feedback. 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%. However, studies using comparative feedback – in which households were verbally compared with their neighbors – did not find it to be more effective than individual feedback (Midden et al., 1983; Brandon and Lewis, 1999). A likely reason given by these authors is that many subjects felt that their electrical and gas consumptions were unique and hence they perceived comparisons of their consumptions with those of others' with whom they were compared to

be irrelevant; in other words, comparisons with others' consumption had no effect on their consumption levels.

With regards to providing feedback using electronic equipment, McClelland and Cook (1980) gave households continuous feedback over a period of 11 months through an electronic monitor display to show the costs of electricity used by them. They found that these households used an average of 12% less electricity than a control group. More recent studies by Mountain (2006), Anderson and White (2009a, 2009b), OFGEM (2009), Darby (2001, 2006) and Hargreaves et al. (2010) had all shown that making energy consumptions visible has the potential of effecting reductions of between 5% and 15%.

In comparison, assessments on the relative effectiveness of using pamphlets, stickers and face-to-face interaction (also used as a mode for providing feedback on energy consumption) in providing tailored information in a single study are not as common. Furthermore, there is a lack of intervention studies in the existing literature on Asian householders. It is in these respects that this work contributes to the literature. However, the study on using electronic means of providing feedback was not included into the scope of this work.

2.3 Outcome assessment

Studies had found that self-reported actions do not necessarily lead to actual energy reduction (after all, self-reported behavior may be influenced by social desirability, among other factors). For example, Olsen and Cluett (1979) found no correlation between reported household conservation actions and the amount of actual energy saved by them. These were later supported by studies by Warriner et al. (1984) and Staats et al. (1996). Hence, a well-designed study must take these two outcomes – self-reported actions and actual changes in energy consumptions – into account.

In the literature, behavioral outcome is usually measured by means of comparing responses to surveys on a set of conservation actions (for example, Staats et al. (1996)). There is a need to ensure that the contexts within which the actions are taken, or not taken, are noted because this can help explain any difference between actions and actual changes in energy consumption. Measuring of actual consumptions can take the forms of referring to utility bills or directly reading off meters. In Singapore, three types of meters are used for recording water, gas and electricity consumptions respectively. They are physically checked by inspectors from the utility companies on a regular basis and so the utility bills accurately reflect the values actually measured by these meters. In this study, both reported actions and actual consumptions were measured and compared.

2.4 Consumer behavior aspect of energy conservation

Energy use is not only driven by the embodiment of knowledge and concerns for the environment. Various social and environmental psychological studies related to household energy use had been embarked; this line of inquiry is theory driven and aims to identify underlying determinants of energy use, including attitudes (for example, Becker et al., 1981) and socio-demographics. In other studies, both the effectiveness of an intervention and changes in underlying determinants of energy use are monitored simultaneously (for example, Staats et al. (1996)). Later studies looked into different social factors that play a role in deciding consumption, such as comfort, effort, and status (Stern, 2000) play a role in deciding behavioral changes. McKenzie-Mohr (2000) further highlighted the need to understand these factors as barriers and opportunities for effecting longer lasting behavioral changes. Gardner and Stern (2002) categorized energy conservation behavioral into efficiency and curtailment behavior. The former is a one-shot behavior and may entail the purchase of energy-saving equipment, whereas the latter is a repetitive effort to reduce energy use. In our study, we assessed the curtailment behavior of respondents. In this sub-section, we reviewed three streams of research that were applied in our research methodology. They are: value-related, psychological and situational factors.

2.4.1 Values influencing behavior

Values are typically conceptualized as important life goals or standards that serve as guiding principles in life (Rokreach, 1973) and thus can provide a basis for the formation of attitudes and determine behavioral choices. Stern et al. (1995) proposed a hierarchical model in relating values to behavior; this model comprises values (which are antecedents to worldviews), beliefs, attitudes, and behavior. Values are situation-transcending beliefs about what is important in life, whereas worldviews are general beliefs related to a specific domain of life, such as environmental concern. In this model, it is proposed that values and worldviews act as filters for new information received, after which congruent attitudes and beliefs emerge. These attitudes and beliefs then determine environmental behavior.

In studying how values determine behavior, several notable models were introduced; an example is the New Environmental Paradigm (NEP) (Dunlap et al., 2000), which measures views on the human-environment relationship and general environmental concern. Kollmuss and Agyeman (2002) highlighted a need for more exact measurements on the quality of life (QOL) that consumers embrace and assess QOL indicators with other factors in designing intervention programs. Poortinga et al. (2004) defined twenty-two QOL indicators that take

into consideration a variety of values, including environmental values and self enhancement values; the authors concluded that those who embraced environmental quality values were more likely to undertake environmental action. Conversely, self-enhancement values were negatively related to environmental concern. However, self-enhancement can be tapped on as a potential solution to environmental problems; for example, economic self-interest to save money can encourage pro-environmental action (which was in line with findings by DeYoung (2000)). However, Tucker and Speirs (2003) argued that even if people value environmental quality more than economic considerations, that environmental values must be highly salient to the individual before they increase the motivation to behave. In fact, stronger correlations are usually found between behaviors and the constraints and barriers to accomplishing those behaviors. These are also known as "inconvenience" factors, which are important reasons not to practice environmental action, such as the efforts and the time required.

Due to its comprehensiveness, Poortinga et al.'s model on QOL was chosen and applied to our study to characterize a respondent's value. Questions related to these factors are incorporated into questionnaire 2 (annex 2).

2.4.2 Psychological factors

These factors reflect the specific perceptions that people hold towards particular behaviors, and consist of a diverse variables (Gilg and Barr, 2005). The key variables, studied by various scholars, are summarized as follow:

a) Social influence and self-presentation: the role of friends, relatives and other influential individuals play a part in formulating and encouraging environmental behaviors (Barr, 2007). This is because behavior is likely to be modified when people are aware of a given social norm, and are more willing to accept this norm when others around them are practicing the social norm as well.
b) Intrinsic motivation and personal satisfaction: De Young (2000) argued that participating in environmental action can allow one to gain a sense of satisfaction and an inner sense of well-being, alongside a belief that society is benefiting from one's behavior. This "feel good" outcome was the intrinsic motivation driving one to have environmental behavior.
c) Personalization of environmental issues: if a person internalizes environmental concerns and perceives environmental problems as tangible threats to the well-being and health of himself, his family and friends, he is more likely to practice environmental measures (Baldassare and Katz, 1992).

d) Outcome beliefs: environmental problems are often perceived as major global problems, and some people feel that individual actions have little or no impact in reducing the effects of environmental problems. However, if this perception can be changed, and people realize and believe in their tangible impact on the environment through environmental behavior, they are more willing to act (Hopper and Nielson, 1991).

e) Self-efficacy: this refers to the extent to which people believe they are able to carry out the behavior and undertake action. Gilg and Barr (2005) and Ajzen (1991) termed this as perceived behavioral control, which is defined as how easy or difficult performance of the behavior is likely to be. If a person has a strong belief that he can carry out environmental action, he is more likely to undertake it.

f) Trust and responsibility: as discussed earlier, the extent to which people trust environmental information provided to them is crucial in eliciting positive behavioral responses, in particular those provided by the government, non-governmental organizations and commercial organizations. The higher the level of trust, the higher will be the likelihood of environmental behavior.

In this paper, all these six factors were measured in an effort to relate respondents' psychological traits with both their reported behavior changes and actual changes in consumptions. Questions related to these factors are incorporated into questionnaire 3 (annex 3).

2.4.3 Situational factors

These define a given personal situation and consider the different contexts in which a person resides and makes decision (Barr, 2007). The key situational factors that were discussed in the literature can be categorized as below:

a) Socio-demographics: variables such as age group, household type, size and composition, education level, income level all play a part in influencing environmental behavior. For example, households with children and youth may have more needs that determine energy use to a large extent, such as teenage use of lengthy showers.

b) Environmental and behavioral knowledge: environmental knowledge is defined as being a representation of general knowledge about the state of the environment and an awareness of environmental problems such as climate change. Behavioral knowledge is termed as concrete knowledge, which is knowledge needed for action, such as

knowing how to save water in the kitchen (Schahn and Holzer, 1990). It is a significant prerequisite for environmental behavior, and thus determines high or low levels of environmental action. Environmental knowledge is important as it can influence psychological factors like personalization of environmental issues. Theoretically, it is only when people are highly aware of environmental issues that they are more likely to feel that these problems are a tangible threat to personal well-being.

c) Service availability: access to services catered for environmental action influences environmental action. This is likely to have certain positive normative and behavioral effects as people perceive access to service as convenient and time-saving, which increases their level of self-efficacy (Barr, 2007).

d) Policy knowledge and intervention: government policies can influence environmental behavior indirectly and directly. Four areas of policies that influence environmental behavior indirectly are: demographics, socio-cultural developments, economics and physical/spatial developments. An example of a policy with potential direct influences on environmental behavior is high electricity tariff.

In this paper, all these four factors were measured in order to understand how respondents' situational traits can be related to both their reported behavior changes and actual changes in consumptions. Questions related to these factors are also incorporated into questionnaire 3 (annex 3).

3. Research Methodology

The objectives of this study are three-fold: 1) compare the effectiveness of different intervention methods, based on self-reported behavior scores as well as actual reductions in electricity consumptions; 2) investigate how behavior and electricity consumption are influenced by values, situational and psychological factors; 3) critique the intervention methods used according to residents' feedback, and make recommendations for improvement. Three types of intervention instruments – leaflets, stickers and face-to-face interactions (or, counselling sessions) – are used to provide tailored information and feedback to promote household energy conservation within an Asian context. Outcome measurements were done by self-reported behavioral changes and changes in actual energy use. Any correlations of these outcomes to behavioral determinants – values, psychological and situational factors – were examined. The approach taken is new in the sense that it correlates the effectiveness of the intervention instruments to, among other factors, the twenty-two QOL factors within an Asian context.

The target area of the study is a public housing estate known as Hong Kah North. Since over 80% of Singapore residents live in public housing, focusing on public housing is meaningful and representative. The local district governing units – the Southwest Community Development Council of Singapore (SWCDC) and Hong Kah North Residential Council – provide the endorsement and financial support for this intervention program, which is officially named the "Eco-living program". The National Environment Agency (NEA) provides the leaflets and stickers. An educational institution – the Institute for Technical Education (ITE) College West – registered its students as volunteers to assist in conducting the experiments. ECO Singapore, a local non-government organization with the aim of promoting eco-friendly events in Singapore, partners with the National University of Singapore (NUS) to provide the necessary training and monitoring of the student volunteers.

In this study, the basic sample is a household, which entails all the residents living in the same apartment. The program started in October 2010 and ended in July 2011. From October through November 2010, visits were conducted to encourage the residents to participate in the program; electricity consumption data (herein referred to as the baseline consumption data) was collected and energy consumption behavior was survey (with parts A and B of questionnaire 1, shown in annex 1). From December to January, households were visited again and their energy consumption data and behavior were surveyed. The intervention officially began in February 2011 and continued through July 2011.

The households under study were divided into 3 groups: leaflet group, counselled group and control. The treatments of these three groups were as follow:

- Leaflet group (also known as group 1)
    - February 2011: households energy consumption behaviour was surveyed (using only part B of questionnaire 1) and actual energy consumption data was collected. Leaflets and stickers were also distributed.
    - March through July 2011: energy-related behavior was surveyed and analysed (using only part B of questionnaire 1).
- Counselled group (group 2)
    - February through July 2011: households energy consumption behaviour was surveyed (using only part B of questionnaire 1) and actual energy consumption data was collected. Counselling was provided monthly to encourage residents to implement more energy-saving measures.

- Control (group 3)
    - February through July 2011: households energy consumption behaviour was surveyed (using only part B of questionnaire 1) and actual energy consumption data was collected.

In July 2011, for all the three groups, other than surveying the energy consumption behaviour and collecting actual consumption data, questionnaires 2 and 3 were answered by the households.

The leaflets distributed to the leaflet group are designed by the NEA for the "Energy Efficient Singapore – Fight Climate Change" Program. Reminder stickers were also distributed to this group, and they include exactly the same information as the leaflets.

As shown in questionnaire 1 (annex 1), energy-related behavior is classified according to types of home appliances, such as air-conditioner, refrigerator, water heater, light, home electronics, and clothes dryer. Under each category, there are several questions on different energy-related behavior. Explanations on the reasons and benefits of recommended energy-saving behavior are given by the volunteer only to the counselled group. Specifically, if volunteers noted that a "never" or "rarely" response is given to a particular question, they will ask the residents for explanations for their decisions and offer advices for the residents to implement these neglected actions in the following month. In other words, tailored information is provided to the residents in the counselled group.

Questionnaire 2 aims to uncover any correlation between respondents' value (QOL factors) and their energy consumption behaviour. The questions in questionnaire 3are mainly in two categories: first, questions on whether the program has worked as designed; and second, questions to find out what people regard as important reasons for adopting the energy reduction measures. These reasons include reduction money, environmental concern, convenience of information, encouragement, trust in information source, satisfaction from energy reduction behavior and easiness of behavior. These questions aim to correlate residents' energy consumption behavior to different psychological and situational factors, as described in the sub-sections 2.4.2 and 2.4.3.

Besides via questionnaires, actual data on electricity consumptions was collected from the monthly utility bills of the households and actual meter readings.

The Statistical Package for Social Sciences (SPSS) and Microsoft Excel 2011 was used for data analyses. Since the 5-point Likert scale was used in all the questionnaires, non-parametric methods were used to analyse the data. These methods included the Wilcoxon sign-ranked Test and Mann-Whitney U Test. Furthermore, to identify any grouping of the factors (independent variables), factor analysis was used. Finally, ordinary least square

regression was employed to illustrate any linear correlation between any reductions in electricity consumption and the different factors (value, situational and psychological factors).

4. Results and Analyses

151 households participated in the entire experiment. Their profile is shown in tables 1 and 2.

Table 1. Sample sizes of the different treatment and control groups

Group	Number of households
Leaflet Group (Group 1)	61
Counselled Group (Group 2)	41
Control Group (Group 3)	49
Total	151

Table 2. Ethnic distributions of all treatment and control groups

Ethnic group	**Percentage of the samples (%)**	**Percentage of Singapore residents in the whole Singapore (%)**
Chinese	59.8	74.1
Malay	16.2	13.4
Indian	19.7	9.2
Other	4.3	3.3

As mentioned earlier, all the households involved in the study live in public housing. To be as representative as we can, all the categories of local public housing are included. The distributions are shown in table 3.

Table 3. Distributions of different housing types in all treatment and control groups.

Housing type	**Percentage (%)**
2-room flat (2RF)	2.2
3RF	28.5
4RF	59.1
5RF	0.7
Executive apartment	1.5
Executive maisonette	8.0

Number of people living in the households is another important factor in determining the eventual electricity consumption of the households concerned. The distributions of the number of people in each household are shown in table 4. Age is not a differentiating factor – a baby and an aged person are treated equally when assessing the consumption per capita.

Table 4. Distributions of number of people in each household

Number of people	Percentage (%)
2	8.3
3	19.4
4	31.3
5	21.5
6	13.9
7	4.9
8	0.7

The income and household educational level are also important factors considered. The distributions are shown in tables 5 and 6 respectively.

4.1 Electricity Consumption and Gini Coefficient

Using Kruskal-Wallis test, it was found that there is no significant difference amongst the three treatment and control groups in terms of their baseline consumption (October and November data). The average electricity consumption per household is around 12.8kWh per day and average electricity consumption per capita is about 3.1kWh per day. Using these data, the cumulative share of electricity consumption is plotted against the cumulative share of residents from low to high electricity consumption; the Gini coefficient for electricity – a measure of how uniformly distributed electricity consumption among the 151 households are – is calculated and found to be 0.253. This means that electricity consumption is relatively equitable. The results for these two months are shown in table 7.

Table 5. Distributions of income levels in all treatment and control groups.

Income (S$)	Percentage (%)
0-1999	26.9
2000-3999	30.8
4000-5999	21.2
6000-7999	11.5
8000-9999	3.8
10000-11999	1.9
12000 and over	3.8

Table 6. Educational levels of all treatment and control groups.

Education level	Head of the household (%)	Highest in the family (%)	Person most oftenly at home (%)
Pre-school Education	0	0	2.9
Primary school	12.3	4.7	20.2
Secondary school	37.7	17.0	32.7
Junior college	2.8	5.7	1.9
Institute of technical education	2.8	6.6	3.8
Polytechnics	8.5	18.9	9.6
Undergraduate	24.5	28.3	22.1
Postgraduate	11.3	18.9	6.7

4.2 Self-reported behavior scores

The self-reported behavior scores in the first (October 2011) and last (July 2011) rounds of the experiments were used. Behaviour scores are defined as the raw numerical scores that the residents gave on the 5-point Likert scale in response to questions in questionnaire 1. Wilcoxon signed rank test was employed to assess whether there is any statistically significant difference in the scores before and after treatment; this is also a measurement of the effectiveness of the each of the two treatment methods.

Table 7. Baseline average electricity consumptions of different treatment and control groups in October and November 2010.

Unit: kWh per day

Group	Mean	Standard deviation	Per capita mean	Per capita standard deviation
Leaflet group	12.08	6.08	3.01	1.18
Counselled group	12.10	6.64	2.93	1.12
Control Group	14.38	8.01	3.34	2.24
Total	12.81	6.89	3.09	1.56

As shown in table 8, out of all 21 recommended energy-saving behavior (refer to questionnaire 1, in annex 1), Group 1 has 11 positive changes (indicated by an increase in the behavior scores between the results in October and July 2011). However, statistical analyses

showed that only 2 out of the 11 positive changes are significant. The results for the other groups are also shown in table 8.

Table 8. Self-reported behavior scores for all treatment and control groups.

Group	**Number of positive changes in…**		**Statistically significant positive changes**	
	All 21 behavior traits	Behavior traits number 1,3,16,17	All 21 behavior traits	Behavior traits number 1,3,16,17
Leaflet	11	2	2	0
Counselled	14	3	4	0
Control	9	2	1	0

Behavior numbered as 1, 3, 16 and 17 were highlighted because these were specially highlighted in the leaflets and stickers designed by the NEA, and distributed to the households in the leaflet group. These traits are:

- Use electric fans rather than air-conditioners.
- Set the thermostat of air conditioners to 25^{o}C or above.
- Turn off home appliances instead of leaving on standby.
- Switch top boxes and internet modem units off when not in use.

Table 8 shows that none of these 4 highlighted traits recorded any statistically significant positive change. In other words, the messages in the leaflets (check contents, if possible) and stickers are found to be ineffective in this study.

The key results for the three groups are summarized below:

- *Leaflet group*: significant positive changes were observed in terms of ensuring that
    - Refrigerators are placed away from a heat source (for example, direct sunlight, cookers and oven).
    - Refrigerators are not too crowded.
- *Counselled group*: significant positive changes were observed in terms of
    - Raising the temperature settings for air conditioners while using fans at the same time to provide comfortable conditions,
    - Ensuring that refrigerators are placed away from a heat source (for example, direct sunlight, cookers and oven).
    - Ensuring that refrigerators are not too crowded.
    - Performing regular checks on air conditioners and cleaning air filters frequently.

- *Control:* significant positive change is found for
    - Ensuring that refrigerators are placed away from a heat source (for example, direct sunlight, cookers and oven).

4.3 Actual reductions in electricity consumptions

Table 9 shows the changes in electricity consumptions in all the time periods of study. Paired sample t-test was used for analysis.

Table 9. Changes in actual electricity consumption in all the treatment and control groups.

Unit: kWh per person per day.

Pairs of time period compared		**1 & 2**	**2 & 3**	**3 & 4**	**4 & 5**	**1 & 5**
Leaflet	Mean	1.38	0.50	-1.96	1.77	2.21
	Significance (2-tailed)	0	0.015	0.005	0.025	0
Counselled	Mean	1.17	0.29	-1.37	0.48	0.84
	Significance (2-tailed)	0.001	0.263	0	0.197	0.034
Control	Mean	2.05	-0.19	-1.45	1.08	1.79
	Significance (2-tailed)	0.009	0.663	0.003	0.035	0.027

Positive values indicate reductions of electricity, while negative values indicate increase in consumption. Period 1 represents October and November, 2010. Period 2 represents December and January, 2011. Period 3 represents February and March, 2011. Period 5 represents April and May, 2011. Period 5 represents June and July, 2011.

In the first paired comparison between period 1 (October and November, which serves as a baseline consumption) and oeriod 2 (December and January), a significant electricity consumption reduction is shown in each group. The reason may be the existence of Hawthorne effect, which means subjects in experiments improve their behavior simply because they know that they are being observed. However, what is more important is whether there are any subsequent reductions in electricity consumptions after the introduction of the intervention methods.

In the second paired comparison, it is observed that only the leaflet group recorded statistically significant reduction. The following paired comparison – between period 3 and 4 – shows a significant increase of electricity consumption in all three groups. The main reason is the temperature increase during this period; since air conditioning accounts for the majority

of household electricity consumption, it is expected that an increase in temperature results in increase in electricity consumption.

Comparing the electricity consumption of the last round and the round before the program started, it is found that all three groups show a significant reduction of electricity consumption. On average, the leaflet group achieved a 15.8% reduction, the counselled group reduced 7.1% and the control group reduced 2.7%.What is counter-intuitive is that even the control group experienced a significant reduction. This may be because in the interactions with the households, volunteers may inevitably have to share with the households their knowledge on energy reduction measures, especially when the households asked them questions related to these measures.

4.4 Factor Analyses of the QOL Variables

Cronbach's alpha, a measure of internal consistency, is calculated for the set of 21 reported behavior scores as well as the set of 22 QOL variables. It was found that the Cronbach's alpha coefficients for both are greater than 0.7, which signified high internal consistency of both. The data was further checked and found to pass the Kaiser-Meyer-Olkin test of sampling adequacy and the Bartlett's test of sphericity.

Then the 22 QOL variables were analysed using factor analysis (with respect to self-reported behaviour and baseline consumptions) and after varimax rotation was conducted, a six-factor solution was obtained. In summary, the six-factor solution accounts for an acceptable 68.5% of the original variance in the data. These factors are described as follow:

- Factor 1 contains 6 variables, which can be related to "environmental externality".
- Factor 2 contains 3 variables, which can be related to respondents' "openness to change" – meaning people with high scores in this value are open to changes and value beauty and excitement.
- Factor 3 contains items related to family, work, health and religion. This can be related to "traditional family value".
- Factor 4 is related to "environment and freedom".
- Factor 5 covers money, comfort, leisure time and social justice, hence representing "enjoyment"; and,
- Factor 6 contains only one variable – "education".

Next, the average self-reported behavior score and baseline electricity consumption before the experiment were regressed to the six values (QOL) factors and the situational and psychological variables.

4.5 Regression analysis of self-reported behavior scores and baseline consumptions with respect to situational, psychological and values (QOL) factors

Annex 4 shows the results of our correlation of the self-reported scores and baseline consumptions with the different factors considered in this study. In summary, about 14.3% of the original variance of self-reported behavior scores can be explained by the model. Among the values (QOL) factors, the strongest predictor is the "traditional family value" factor, followed by the "openness to change" factor. Ethnics also play an important role in self-reported behavior scores. Malay families have bigger correlation with self-reported improvements in behavior scores.

Number of people in the household, housing type, and air-conditioner possession have significant positive correlation with actual electricity consumption; none of the values (QOL) variables have a significant correlation with actual electricity consumption. The households in larger apartments with more people and using air-conditioners are consuming more electricity. The variance explained in this regression model is 17.7%.

The finding that values (QOL) do not influence actual baseline consumptions is similar to previous findings by scholars (for example, Gatersleben, Steg and Vlek (2002) and Poortinga, Steg and Vlek, (2004)).

4.6 Regression analysis of reductions in consumption with respect to situational, psychological and values (QOL) factors

Percentage of consumption reduction between the baseline consumption and the data taken from July 2011 was regressed on demographics, values (QOL), self-reported behavior score, and groupings (that is, whether the residents belong to any of the two treatment groups or the control). Dummy variables are used to describe groupings – that is, the variable "leaflet" is given the value of "1" if the household is from the leaflet group, and "0" if otherwise. The results are shown in annex 5.

Housing type has a positive correlation and the dummy variable for the control group has a negative correlation with percentage of consumption reduction. This implies that households who live in larger units but are not in the control group are more likely to save more energy. The fact that households not in the control group tend to save more implies that the intervention methods have been successful.

4.7 Feedback on the program

The residents' subjective feedback on the program was given via questionnaire 3 (annex 3). The results are summarized in figure 1, in which the numbers in parentheses are the average of the responses based on the 5-point Likert scale.

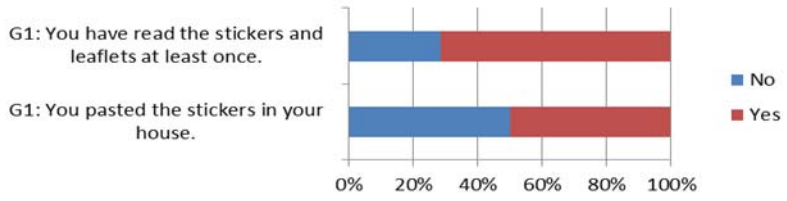
In summary, in the leaflet group, 71.4% of the respondents claimed that they have read the leaflets at least once. Only about 50% of the households said they pasted the stickers in their apartments. Over 60% of the counselled group agreed that they had spread the information from the discussions with the volunteers to other family members, and only less than 10% of them disagreed or strongly disagreed that they have done so. Based on comparison of the two questions, it was found that residents in the counselled group are more willing to share the energy reduction information to other family members, although passing on the materials seems relatively easier.

The reasons why the residents adopt energy reduction measurements are also enquired. The reasons, in decreasing order of importance, is: ease of measures, prospect of saving money, environmental concern, trust in information source, convenience of information, satisfaction from energy reduction behavior, and encouragement by the volunteers.

5. Lessons for Integrated Policymaking for Household Energy Conservation

The five main results from the Eco-living Program can be summarized as follow:

- Households in the counselled group recorded the most improvements in self-reported energy consumption behavior; however, this does not translate into actual reduction in consumptions, because households in the leaflet group recorded the highest average reduction in consumption (15.8%). A possible reason for this difference could be that the duration and frequency of the actions taken do not produce sufficient impact in reducing overall energy consumptions.



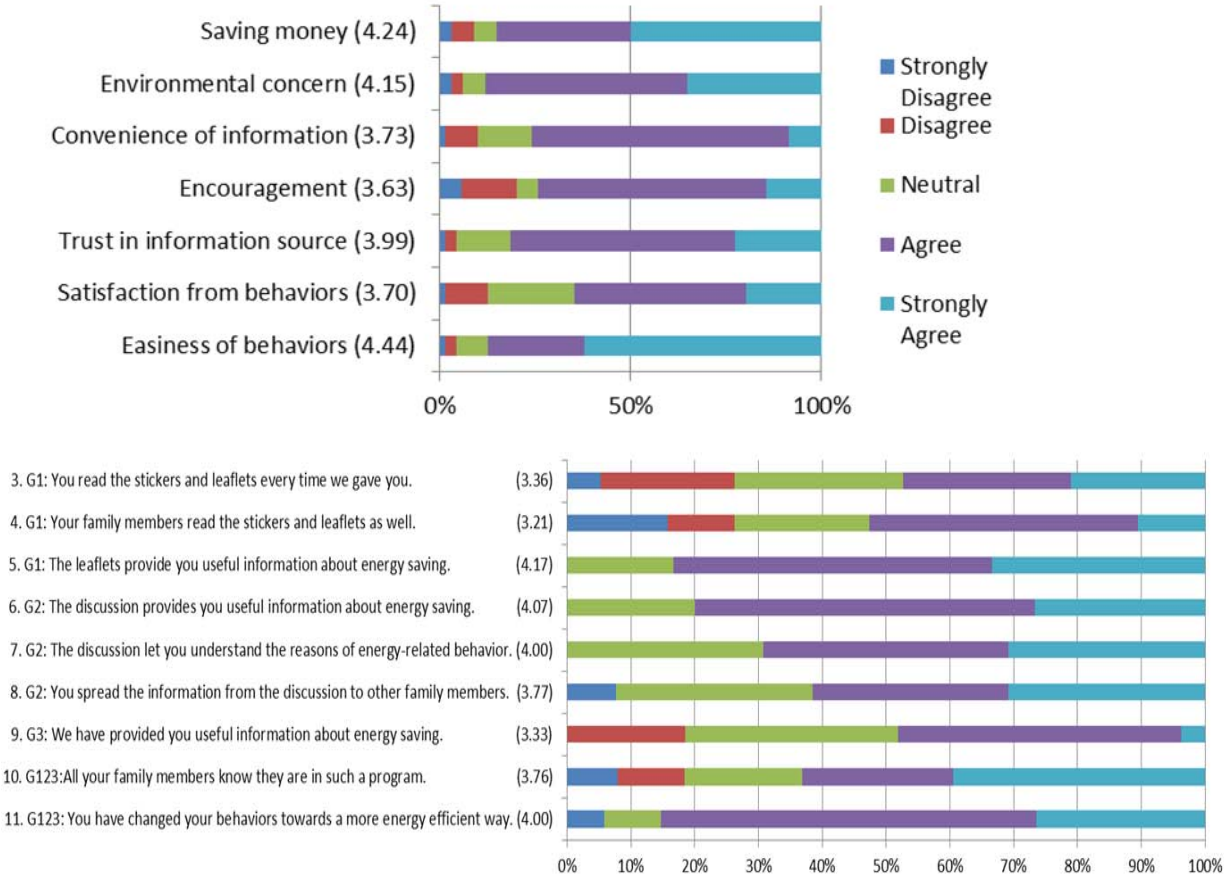


Figure 1. Responses to feedback. "G1" refers to the leaflet group; "G2" refers to the counselled group and "G1" is the control group.

- Self-reported results show that the information given in the leaflets and stickers on four specific energy-saving measures are not effective in changing behavior. However, since leaflets and stickers were found to be the most effective in reducing general consumption, there is reason to believe that the information given in the leaflet may have prompted households to adopt other measures that are mentioned in the questionnaires but not explicitly highlighted in the leaflets and stickers. In other words, these leaflets and stickers may have served the purpose of reminding households to conserve energy in general.
- Number of people in the household, housing type, and air-conditioner possession have significant positive correlation with actual electricity consumption; none of the values (QOL) variables have a significant correlation with actual electricity consumption.

- The three most important reasons given for adoption of energy-saving measures are the ease of implementing the measures, the prospect of reduction electricity bills, and concern for the environment.
- Only housing type of the households is a predictor of the actual reductions in consumptions. Households from bigger apartments tend to record higher level of reductions. An explanation is that these households have higher utility bills and so they view energy conservation as an effective mean to save money.

How can these results help us in planning for future integrated energy intervention program?

Firstly, a distinguishing element of the Eco-living Program is the engagement of the ITE College West and the non-governmental environmental group in the execution of the project. This is an element that contributes toward the integrated nature of this program. In order for this element to be effective in supporting a country's energy conservation policies, the volunteers and social workers must be trained adequately so that they can effectively communicate the essential information to the households. Such information must enable them to explain the energy-saving measures to the household clearly and accurately, so that the latter feel that these measures are easy to adopt. Furthermore, volunteers should also be equipped with the knowledge to explain energy reductions in terms of potential cost reductions for households and presenting information to them to evoke a sense of concern for the environment. Doing so will require the SWCDC to collaborate well with the local universities. A possible idea to consider for future programs is to engage university students to train the volunteers, as well as engage interested university students to become volunteers.

Secondly, energy reduction actions should be further simplified as much as possible. Furthermore, during the counselling sessions, volunteers may demonstrate some of these actions to ensure that households correctly understand the execution of these actions. For example, instead of saying "Do not leave the fridge door open for too long", a more concrete action such as "should not leave the refrigerator door open for more than 10 seconds or counts" can be prescribed. This will require the questionnaires to be improved.

Thirdly, the content of the leaflets and stickers should be improved. A possible way of improvement is to have the volunteers or their coaches from the university design the contents of the leaflets and stickers, so that they are congruent with the key messages that the volunteers aim to bring across to the households.

Finally, in relationship to the previous point, volunteers may try supplementing their verbal messages with short clips that can be shown to the households via multi-media electronic gadgets such as portable computers.

The “Eco-living” program has the potential to be an exemplar of bottom-up approach to promote energy conservation in households. If designed and executed correctly, such a program can become an important component of any country’s holistic policy approach toward energy conservation. An attractive aspect of this program is its integrated nature, which involves student volunteerism and establishing a multi-agency collaborative platform that engages different governmental and non-governmental stakeholders.

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ANNEX 1: QUESTIONNAIRE 1

Part A. Basic information

House Type(delete accordingly): 1 room flat / 2 room flat / 3 room flat / 4 room flat / 5 room flat / Executive Apartment / Executive Maisonette

Floor area: _____m^2

1. **Ages** and **genders** of all family members: _____

   E.g. if there are 3 people in a house of age and gender as follow: 33 year-old, male; 33 year-old, female; and 5 year-old, male. Fill in as "**33(M), 33(F), 5(M)**".

2. Monthly income of the whole family: _____ (Make a choice.)

   A. 0-1999
   B. 2000-3999
   C. 4000-5999
   D. 6000-7999
   E. 8000-9999
   F. 10000-11999
   G. 12000-13999
   H. 14000-15999
   I. 16000-17999
   J. above 18000

Notes: If the resident is reluctant to tell about it, let him know that we are only asking for a range and we will keep the information confidential. The information is for research only.

3. Education level of the householder:

   A. Pre-School Education B. Primary School C. Secondary School
   D. Junior CollegeE. Polytechnics F. Institute of Technical Education
   G. Bachelor H. Postgraduate

4. Education level of the person who is at home most often: ____ (Make a choice from below.)

   A. Pre-School Education B. Primary School C. Secondary School
   D. Junior CollegeE. Polytechnics F. Institute of Technical Education
   G. Bachelor H. Postgraduate

5. Highest education level in the family: ____ (Make a choice from below.)

A. Pre-School Education B. Primary School C. Secondary School
D. Junior College E. Polytechnics F. Institute of Technical Education
G. Bachelor H. Postgraduate

6. Ethnics:

A. Chinese B. Malay C. Indian D. Others:

Part B.

Behavior	**1 Never**	**2 Rarely**	**3 Sometimes**	**4 Usually**	**5 Always**
Air-Conditioner					
a. Possession: Yes/No. If yes, number?:					
1. Use fans rather than air-conditioners.					
2. When using air-cons, use fans and raise the temperature at the same time to save energy.					
3. Set the thermostat above 25^{o}C.					
4. Use automatic time switch when possible.					
5. Regularly check the air-cons and clean air filter timely.	Never	even less	once/4 years	once/3 years	>once/ 2 years
6. Keep windows and doors closed when the air-con is on.					
Refrigerator					
b. Possession: Yes/No Number:					
7. Refrigerator placed away from a heat source. (e.g. direct sunlight, cookers, oven)	Very close, several heat sources	/	Close but with insulation	/	Away
8. Allow some space all around the fridge.	No	/	Small space	/	Enough space
9. A not too crowded refrigerator.	No space	/	Little space	/	Enough space
10. Cool down hot food before storing in fridge.					
11. Cover liquids stored in the refrigerator.					
Water Heater					

c. Possession: Yes/No					
12. Heat enough water without too much unused. (For an instantaneous one, switch it on before shower and turn off after use. For a storage type, switch it on about 20 minutes before shower, and turn it off after use.)					
Lighting					
13. Make full use of daylight during the daytime.					
14. Turn lights off when nobody is in.					
15. Use task lighting for activities requiring small amount of focus light. (e.g. reading lamps).					
Home Electronics					
16. Turn off home appliances instead of leaving on standby.					
17. Switch top boxes, modems off when not in use. (e.g. overnight)					
18. Allow computer to be on hibernation mode after 10- 15 min. Switch off the computer completely when not in use for more than 30 minutes.					
19. Unplug chargers after use.					
Electric Air-Pot					
d. Possession: Yes/No					
20. Turn it on only necessary. Turn it off if not in use overnight.					
Clothes Dryer					
e. Possession: Yes/No					
21. Dry laundry under natural sunlight whenever possible.					

ANNEX 2: QUESTIONNAIRE 2

Rate the importance of the following aspects to your family:

1 =Unimportant, 2 =Slightly important, 3 =Important, 4 =Very important, 5 =Critical

	Description	1	2	3	4	5
1	Being able to enjoy the beauty of nature and culture.	Unimportant	Slightly important	Important	Very important	Critical
2	Having challenges and experiencing pleasant and exciting things.	Unimportant	Slightly important	Important	Very important	Critical
3	Having a varied life, experiencing many things as possible.	Unimportant	Slightly important	Important	Very important	Critical
4	Having a comfortable and easy daily life.	Unimportant	Slightly important	Important	Very important	Critical
5	Having the chance to get a good education and to gain general knowledge.	Unimportant	Slightly important	Important	Very important	Critical
6	Having access to clean air, water and soil. Having and maintaining a good environmental quality.	Unimportant	Slightly important	Important	Very important	Critical
7	Freedom and control over the course of one's life, to be able to decide for yourself, what you do, when and how.	Unimportant	Slightly important	Important	Very important	Critical
8	Being in good health, access to adequate health care.	Unimportant	Slightly important	Important	Very important	Critical
9	Having sufficient self-respect and being able to develop one's own identity.	Unimportant	Slightly important	Important	Very important	Critical
10	Having enough time after work and household work and being able to spend this time satisfactorily.	Unimportant	Slightly important	Important	Very important	Critical
11	Having nice possessions in and around the house.	Unimportant	Slightly important	Important	Very important	Critical
12	Having enough money to buy and to do the thing necessary and pleasing.	Unimportant	Slightly important	Important	Very important	Critical
13	To enjoy natural landscapes, parks and forests. Assurance of the continued existence of plants and animals and maintaining biodiversity.	Unimportant	Slightly important	Important	Very important	Critical
14	Having an intimate relation, a stable family life and good family relationships.	Unimportant	Slightly important	Important	Very important	Critical

15	Having opportunities to be yourself, do your own things, a place of your own.	Unimportant	Slightly important	Important	Very important	Critical
16	Being safe at home and in the streets. Being able to avoid accidents and being protected against criminality.	Unimportant	Slightly important	Important	Very important	Critical
17	Feeling attended to and cared for by others.	Unimportant	Slightly important	Important	Very important	Critical
18	Having equal chances and rights as others, being treated righteously.。	Unimportant	Slightly important	Important	Very important	Critical
19	Having good relationships with friends, colleagues, neighbors.	Unimportant	Slightly important	Important	Very important	Critical
20	Being able to live a life with an emphasis on spirituality and/or with your own religious persuasion.	Unimportant	Slightly important	Important	Very important	Critical
21	Being appreciated and respected by others.	Unimportant	Slightly important	Important	Very important	Critical
22	Having or being able to find a job and being able to fulfill it as pleasantly as possible.	Unimportant	Slightly important	Important	Very important	Critical

ANNEX 3: QUESTIONNAIRE 3

This section is only for the study of usefulness of the program.
For each household, please only ask the questions designed for the particular group.

G123: Group 1, 2 and 3; G1: Group 1; G2: Group 2; G3: Group 3.

Do you agree or disagree with the following opinions?
1: Strongly disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly agree

1. G123: All your family members know they are in such a program.	1	2	3	4	5
2. G1: You have read the leaflets and stickers at least once.	Yes / No				
3. G1: You pasted the stickers in your house.	Yes / No				
4. G1: You read the leaflets and stickers every time we gave you.	1	2	3	4	5
5. G1: Your family members read the leaflets and stickers as well.	1	2	3	4	5
6. G1: The leaflets provide you useful information about energy reduction.	1	2	3	4	5
7. G2: The discussion provides you useful information about energy reduction.	1	2	3	4	5
8. G3: We have provided you useful information about energy reduction.	1	2	3	4	5
9. G2: The discussion let you understand the reasons of energy-related behavior.	1	2	3	4	5
10. G2: You have spread the information from the discussion to other family members.	1	2	3	4	5
11. G123: You have changed your behaviors towards a more energy efficient way.	1	2	3	4	5
12. G123: Why do you practice the recommended measures? To save money.	1	2	3	4	5
13. G123: Why do you practice the recommended measures? I am concerned about the environmental problem.	1	2	3	4	5
14. G123: The information of how to save energy is easy to access so the recommended measures are practiced.	1	2	3	4	5
15. G123: Encouragement makes the recommended measures performed.	1	2	3	4	5
16. G123: Because the energy reduction information is from trusted persons or organizations, the recommended measures are performed.	1	2	3	4	5
17. G123: Why do you practice the recommended measures? A sense of satisfaction is obtained after doing so.	1	2	3	4	5
18. G123: If the measures are easy to perform, they are more likely to perform; if they are difficult, they are unlikely to perform.	1	2	3	4	5
19. G123: Rate the program: 1, lowest; 2, lower than average; 3, average; 4, higher than average; 5, highest.	1	2	3	4	5

ANNEX 4:

CORRELATION OF THE SELF-REPORTED SCORES AND BASELINE CONSUMPTIONS WITH THE DIFFERENT FACTORS CONSIDERED IN THIS STUDY.

	Behavior scores		Actual consumption	
	Standardized coefficients	Significance	Standardized coefficients	Significance
Number of people	.300	.178	0.379	.022*
House type	-.031	.811	0.136	.033*
Income	-.189	.234	0.094	0.602
Education level of the head of household	.069	.759	-0.134	0.735
Education level of the person at home most often	-.061	.736	-0.189	0.561
Highest education level of the household	.164	.420	0.032	0.952
Ethnics: Chinese,1; non-Chinese, 0	-.382	.031*	-0.414	0.24
Ethnics: Malay, 1; non-Malay, 0	-.597	.004*	-0.334	0.249
Ethnics: Indian, 1; non-Indian, 0	Excluded due to too small tolerance		-0.189	0.532
Air-conditioner possession (No: 0; yes: 1)	.234	.097	0.245	.046*
Factor 1: relation to externality	.161	.225	-0.02	0.559
Factor 2: openness to change	.185	.036*	0.082	0.978
Factor 3: traditional family value	.142	.026*	-0.004	0.977
Factor 4: environment and freedom	-.195	.116	-0.004	0.053
Factor 5: enjoyment	-.106	.425	-0.279	0.08
Factor 6: education	.129	.335	0.008	0.957
R square	0.332		0.346	
Adjusted R square	0.143		0.177	

Note: significantly correlated variables are shown with asterisks.

ANNEX 5

	Standardized coefficients	Significance
Number of people	.262	.277
House type	.605	.003*
Income	.035	.872
Education level of the head of household	-.393	.236
Education level of the person who is most oftenly at home	.293	.221
Highest education level of the household	-.083	.819
Ethnics: Chinese,1; non-Chinese, 0	-1.008	.081
Ethnics: Malay, 1; non-Malay, 0	-.737	.121
Ethnics: Indian, 1; non-Indian, 0	-.241	.615
Air-conditioner possession (No: 0; yes: 1)	-.008	.964
Factor 1: relation to externality	-.015	.933
Factor 2: openness to change	.015	.939
Factor 3: traditional family value	.191	.392
Factor 4: environment and freedom	.291	.183
Factor 5: enjoyment	.266	.188
Factor 6: education	.171	.376
Group 1: if yes, 1; else, 0	Excluded due to too small tolerance	
Group 2: if yes, 1; else, 0	-.241	.176
Group 3: if yes, 1; else, 0	-.550	.007*
Energy consumption before intervention	-.058	.770
Behavior score before intervention	-.172	.371
Change of behavior score	-.376	.085

R square=0.683, adjusted R square=0.332

Note: variables that are significantly correlated with energy reductions are shown with asterisks.