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Using Feedback as a Tool for Household Energy Conservation: An Experimental Approach

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EXECUTIVE SUMMARY

In Thailand, the residential sector is a potential source of energy conservation because it accounts for the third-highest share of national electricity consumption. Previous studies have shown that overall electricity consumption can be reduced if behavioral changes take place amongst residential electricity consumers. Therefore, it is necessary to tap into strategies to transform behavior among electricity consumers. A number of measures and policies are designed to change electricity consumption habits and to encourage reductions in electricity consumption, including the adoption of dynamic electricity tariffs, the provision of non-pecuniary incentives, the provision of information, and the use of social norms. As residential electricity consumers tend to suffer from asymmetric information, this research project focuses on the influence of provision of information, particularly feedback on electricity consumption and energy saving tips, in eliciting behavioral changes.

The field experiment approach was used to assess the effectiveness of information provision and feedback on electricity consumption in influencing electricity conservation by households. This approach relies on statistical methods to establish whether households in the treatment groups experience a reduction in their electricity consumption with respect to the control group. Three treatments were considered, namely, (1) self vs. neighbors' electricity consumption comparison (Treatment 1); (2) the provision of general advice on electricity saving (Treatment 2); and (3) advice on electricity saving as well as self vs. neighbors' comparison (Treatment 3). A total of 161 households in the Minburi and Nongjok districts of Bangkok participated in this experiment and were randomly assigned to control and treatment groups.

We find that households that receive both electricity-saving advice and peer-comparison feedback (Treatment 3) make significant reductions in their electricity consumption relative to the control group. Our findings support our hypothesis that the electricity conservation "nudge" of providing feedback to households on their own and peers' home electricity usage works in terms of eliciting behavioral changes and in influencing a reduction in residential electricity consumption. Telling people how their energy consumption compares to that of their neighbors has the statistically significant impact of reducing their consumption by about 6%, and that providing energy-saving "hints" has a positive but more modest positive effect.

1.0 INTRODUCTION

1.1 Electricity Consumption in Thailand

Thailand's rapidly expanding economy over the past few decades has spurred the need for building more power generation capacity to keep pace with higher electricity demand. The electrification rates in Thailand are high, enabling electricity to be delivered to nearly all of its population. Concern for electricity supply security and grid reliability has prompted the Thai government to create policies that promote planned capacity expansion, diversification of fuel sources, and increase in alternative fuel use, demand-side management, and management of electricity import dependence. This research project emphasizes on demand-side management, which supports a reduction in the demand for electricity. Successful demand-side management can help delay or offset the need for future power plants, and it is perceived to be a relatively cost-effective way to reduce greenhouse gases.

Although Thailand adopted a nationwide demand-side management master plan in 1991, and despite the fact that the Electricity Generating Authority of Thailand (EGAT) has implemented a number of demand-side management programs,[1] overall electricity consumption has continued to grow over the past few years. Figure 1 shows that the share of electricity consumption by sector seems to be stable over time with the industrial, residential, and business sectors accounting for the highest, second-highest, and third-highest shares of Thailand's electricity consumption respectively. As of 2013, the residential sector accounts for 23% of national electricity consumption. This indicates that there is potential for electricity saving. Shippee (1980) argued that neglecting the residential electricity consumer is tantamount to ignoring a potentially enormous source of electricity saving. This result was confirmed by Pilati (1976), who found that, from the experience of the United States, overall electricity consumption can be reduced as a result of behavioral changes within the residential sector.

Ross and Williams (1976) found that behavioral changes in households could result in conservation of electricity in the residential sector. Accordingly, this research project emphasizes on the use of information provision in influencing household electricity consumption behavior.

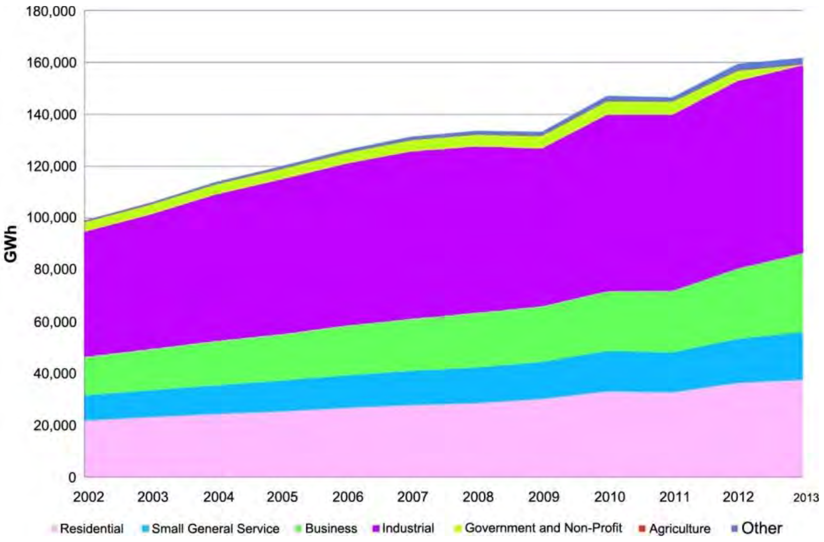

Figure 1. Electricity consumption by sector

Source: EGAT, MEA, PEA

1.2 Use of Feedback Information to Elicit Behavioral Changes

According to Fischer (2008), the invisibility of electricity means that households usually receive little feedback on their electricity consumption. Kempton and Layne (1994) regard electricity consumption to be similar to shopping in a grocery store where no individual item has a price tag. Electricity consumers receive a monthly bill showing the aggregate price for their electricity consumption—they have no idea whether their consumption is relatively high or low or whether it has increased or decreased. Provision of feedback to households on their electricity consumption can help address this asymmetric information.

In this research project, we focused on the impacts of providing electricity-saving advice and feedback on household electricity consumption on household behavioral modifications. We asked which kinds of information or feedback are most successful.

1.3 Research Objectives

The objectives of this research are twofold:

1. To evaluate the impacts of electricity consumption feedback and electricity-saving advice on electricity consumption behavior, and

[1] Some examples of the demand-side management programs implemented by EGAT include a labeling program, lighting program, demand response, strategic load growth, thermal energy storage, and attitude creation program (Chaichinda 2014).

2. To give recommendations to the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), and Thailand's Ministry of Energy regarding strategies that can effectively induce households to reduce their electricity consumption.

1.4 Research Questions

In this research project, the following questions were asked and tested:

1. Does the feedback on electricity consumption successfully motivate households in the treatment groups to reduce their electricity consumption?
2. Which type of feedback leads to the highest reduction in household electricity consumption?
3. What types of behavioral changes are observed among households in the treatment groups?

2.0 LITERATURE REVIEW

2.1 Feedback on Consumption and Behavioral Changes

Different strategies have been used to encourage households to reduce their electricity consumption or change their electricity-consumption habits. Examples of these strategies include changing the electricity rate structure, using non-pecuniary strategies, increasing awareness of social norms, and providing information to electricity consumers (Pollitt and Shaorshadze 2011). Given that this research project focused on evaluating the impact of non-pecuniary strategies and the provision of feedback on electricity consumption, this section is devoted to reviewing previous studies that used field experiments to assess the influence of the provision of tailored feedback information: examples include peer-comparison or norm-based messages and technical electricity-saving advice on household electricity consumption behavior.

A number of studies have assessed the impact of using non-pecuniary strategies and feedback on consumption to influence the behavior of utility customers by conducting randomized field experiments. Ferraro and Price (2011) partnered with a metropolitan water utility to implement a natural field experiment with more than 100,000 households in the United States in order to examine the effect of non-pecuniary strategies or norm-based messages on residential water demand. Their results indicate that social comparison messages have a greater influence on behavior than simple pro-social messages or water saving tips alone. Moreover, they found that social comparison messages are most effective among households identified as the least price sensitive or high-users. However, the effectiveness of such messages wanes over time. In order to sustain residential water conservation, Ferraro and Price (2011) supported using both pecuniary and non-pecuniary strategies. Ayres, Raseman, and Shih (2009) analyzed data from two large-scale random-assignment field experiments conducted by utility companies, and found that electricity and gas consumption can be reduced by providing monthly or quarterly mailed peer feedback reports to electricity and gas customers. They found reductions in energy consumption ranging from 1.2%–2.1%, with the decline in energy consumption sustained (7–12 months).

In the field experiment undertaken by Allcott (2011) in Minnesota, United States, households were randomized into treatment and control groups, and home energy reports were mailed to the households in the treatment group. The home energy report compared a household's energy usage to that of its neighbors, and it also contained energy-conservation advice. Allcott (2011) found that these home energy reports successfully motivated households to reduce their energy consumption; but the impact was not sustained over time. Mack and Hallmann (2004) conducted a small-scale field experiment with 30 households in Germany. Households in the treatment groups were designed to receive weekly written feedback on their electricity consumption and meter readings. Their results show that households in the treatment group experienced a 2%–4% reduction in electricity consumption annually.

Brandon and Lewis (1999) conducted a field experiment comprising of 120 households in Bath, United Kingdom. The households that took part in the experiment had their energy consumption monitored over a nine-month period. Their energy consumption was also compared with that of the previous year. Households in the treatment groups received various forms of feedback. The results show that installing computers helped reduce electricity consumption most markedly.

The experiment conducted by Haakana, Sillanpää, and Talsi (1997) comprised 105 households in Southern Finland. Households in the treatment group received feedback and focused advice on energy consumption over period of 17–21 months. After the treatment period, households in the treatment group experienced a reduction in their energy consumption for space heating of around 3%–9% compared with the same month of the previous year. Their study also discussed the behavioral modifications among the households in the treatment groups. The energy-saving measures embraced by households included turning off lights in empty rooms and reducing the room temperature.

This research project adopted the approach taken by Ferraro and Price (2011) and Ayres, Raseman, and Shih (2009). We used a field experiment to examine the effect of social comparison messages and technical advice on how to save electricity contained in monthly mailed feedback reports on residential electricity consumption. Given that we did not directly partner with the electricity authorities, we were able to conduct a small-scale field experiment along the line of Haakana, Sillanpää, and Talsi (1997) and Brandon and Lewis (1999).

Field experiments are experiments conducted in the everyday or real-life environment of the participants or in a real-life setting rather than in a laboratory. Behavior in a field experiment is more likely to reflect reality because of its natural setting. Although our experiment comprised 161 households at the time of the household survey, we were able to collect detailed socioeconomic information, information on household electricity consumption behavior, and information on household electricity-saving activities from only 138 households.[2] Provided that we had a one-year data on electricity consumption before the treatment period and electricity consumption for the same household during the treatment periods, we used panel data analysis to estimate the treatment effects. In particular, we examined whether households in the treatment groups who had received monthly feedback on their electricity consumption actually experienced a reduction in their electricity consumption compared to households in the control group. We also determined which treatment group had the highest and statistically significant reduction in household electricity consumption. To the best of our knowledge, there exists no previous study that evaluated the impact of feedback on household electricity consumption in Thailand. This research was created to fill this gap and to contribute to the design of an effective demand-side management program to be implemented by EGAT and the Ministry of Energy.

2.2 The Design of Mailed Feedback Packages

Designing the feedback on energy consumption or home energy report in this study was challenging. Many previous studies have found that there is a risk of a “boomerang” problem, which causes the use of norm-based or peer-comparison messages to have no effect on household behavior (Fischer 2008). The boomerang effect tends to occur if individuals who have underestimated the level of an activity are inadvertently inspired to increase that activity (e.g., electricity consumption) after being informed of peer behavior. To address this problem, Cialdini, Kallgren, and Reno (1991) recommended using both injunctive norms (norms that express social values rather than actual behavior) and descriptive norms in order to neutralize the boomerang effect. Schultz et al. (2007) evaluated the effectiveness of using social norm messages alongside energy-saving tips to reduce home energy consumption. They found that combining descriptive and injunctive messages (the emoticons ☺ and ☹) lowered energy consumption and reduced the boomerang effect. The home energy reports in Ayres, Raseman, and Shih (2009) also used a combination of descriptive norms as well as injunctive norms, such as ☺ emoticons, to influence electricity consumption and to counteract the boomerang effect.

The home electricity report in this research project was designed along the same lines as those in Ferraro and Price (2011) and Ayres, Raseman, and Shih (2009). All households in the treatment group received home electricity reports on a monthly basis from November 2013 to August 2014. Our home

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[2] At the time of the household survey that took place at the end of the treatment period, some houses were vacant so the enumerators were unable to collect household-specific data despite repeated visits. These households were, therefore, not included in our econometric analysis.

electricity report contained the following personalized components: (1) current-period neighbor comparison—a bar chart comparing the household's recent electricity use to a group of comparable neighbors with both normative and injunctive messages designed to motivate action, and (2) electricity-saving advice.

3.0 RESEARCH METHODOLOGY

3.1 Analytical Method

The approaches commonly used to evaluate the effectiveness of behavior-based efficiency programs and energy feedback programs are the survey-based approach and the experimental design approach (Mahone and Haley 2011). Under the survey-based approach, the residential energy consumers exposed to the programs are interviewed by the program evaluators using a set of questions about their experience of the programs. This approach is regarded as appropriate for raising an individual's awareness of behavior-based energy efficiency programs, what they have learned from the program, and their perceptions about the programs (Mahone and Haley 2011). However, this approach does not allow researchers to verify whether a participant's behavior has changed as a result of the program. The experimental design approach can address this problem because it relies on statistical methods to establish whether households subjected to program treatments experience a reduction in their energy consumption. Therefore, this research project used the experimental design approach to assess the effectiveness of electricity-feedback programs in influencing reductions in residential electricity consumption.

To establish whether feedback on electricity consumption leads to savings in electricity consumption, two types of comparisons were considered in this research project. First, we compared household electricity consumption in the pretreatment period with consumption during the treatment periods. For this approach to work, it is necessary that baseline electricity consumption be established. Baseline electricity consumption or "historic electricity consumption" is the amount of electricity consumed by households during the periods before treatment. For this research project, we obtained households' 12-month pretreatment electricity consumption from the Minburi branch of MEA. Second, households were randomly assigned into control and treatment groups. We then compared the electricity consumption of households in different treatment groups with that of the control group. One can establish that feedback leads to electricity conservation if the households in the treatment groups save more electricity than the households in the control group. This latter comparison also enabled us to identify the most effective type of electricity consumption feedback that would lead residents to save electricity.

Once we had collected the pretreatment and posttreatment electricity consumption data from MEA and the household-specific data through the household survey, we transformed these data into the panel data set that has both cross-sectional and time-series dimensions since we followed the same households in this research project and monitored their electricity consumption at several subsequent points in time. We then applied the fixed-effects estimation. However, under this fixed-effects model, the time-constant variables (e.g., gender) could not be included. The fixed effect model considered here is

$$y_{it}= \beta_1 \mathrm{Treatment}_{it1}+\beta_2 Treatment_{it2}+\beta_3 Treatment_{it3}+\beta_4 Temperature_{it} +\beta_5 dJanuary_t+\ldots+\beta_{16} dDecember_t+a_i+u_{it} \qquad \text{Equation (1)}$$

where:

T = 1, 2, … , 22,
y_{it} = household electricity consumption in kilowatt hours (kWH),
a_i = fixed effect, and
u_{it} = error term.

In Equation (1), we included three treatment variables to identify whether households were subjected to Treatment 1, 2, or 3. The variable $Temperature_{it}$ was also included as, in the previous studies, there appears to be a link between temperature and electricity consumption.

3.2 Sample Description

The households that participated in the field experiment were recruited from 3,238 mailed invitations sent to 13 housing estates in the Minburi and Nongjok districts, which are residential areas on the eastern side of Bangkok (Figure 2). Minburi and Nongjok districts were selected because these areas are comprised of households with a fair degree of variation in terms of their demographic and socioeconomic characteristics. These districts are located in the suburban areas of Bangkok. Given that house prices in Minburi and Nongjok are lower than in the business or tourist areas of Bangkok, residents in the recently developed housing estates that have sprouted up in these districts tend to have some heterogeneity in their socioeconomic characteristics.

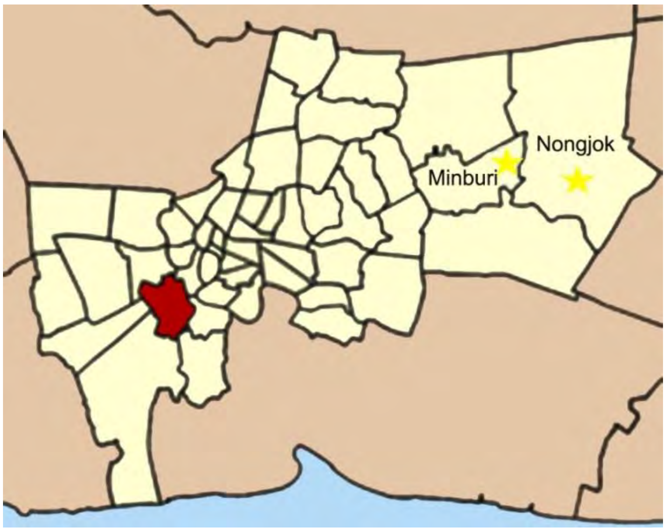

Figure 2. Location of study sites

Out of these mailed invitations, 173 households sent back their consent forms (Appendix 1), which indicated their permission for the research team to access their electricity consumption data from MEA and their agreement to take part in the program. Part of the reason behind the small response rate is that 330 invitations (10.2% of the total number of mailed invitations) were returned as undeliverable by the postal services.

After the preliminary data screening process, only 161 households from 10 housing estates were included in the field experiment. Table 1 gives an overview of the households in each housing estate that were included in the field experiment.

Table 1. Decomposition of households in the field experiment

Housing Estates	Number of Households Included in the Study
Keha Suwindhawong	25
Chatluang	13
Wararom	24
Nonthicha	3
Chanbuasuay	5
Punthiya	10
Panason 2	7
Panason Garden Home 4	14
Nunthawan 5	54
Nunthawan 10	6
Total	**161**

Two main issues concerning our sample need to be highlighted. The first issue is related to the relatively small sample size. This problem emerged because MEA insisted (justifiably so) that only the electricity consumption data of those households that grant the research team permission can be accessed. Specifically, the consent form needed to be signed by the household head and then passed to the head of MEA's Minburi branch. Only 161 households sent us their consent forms in response to our mailed invitations. Note that one reason that could explain this small response rate of 5% is that many of the mailed invitations were returned because there was no individual living at the address registered at the Minburi and Nongjok district offices—this is perhaps because in Bangkok, due to the inconvenience of commuting to work through bad traffic conditions, it is becoming increasingly common for Bangkok residents to own multiple properties. Although the small response rate undermined some of what was intended in the project, there should still be sufficient grounds for drawing useful conclusions about how information on the electricity consumption of others and how electricity-saving advice might influence household electricity consumption behavior and decisions.

Second, the requirement of having a consent form gave rise to the issue of selection bias, i.e., the type of people who agree to take part in the project might be those who are more inclined than others to respond positively to the treatments. Note that a self-selection bias is possible since the people who take the trouble to return the consent form might also be more likely to respond positively to the treatments under this field experiment by reducing their electricity consumption. Self-selection means that it is left to households to select themselves for this field experiment; thus, the researchers are not in control over the selection process. With the possibility of a self-selection bias, the principles of probability sampling are not followed. This could have an impact on the results of the experiment.

As discussed in Bethlehem (2010), having an appropriately designed sampling frame could enable researchers to conduct a survey (or in this context, an experiment) that is based on probability sampling and is not affected by self-selection. Here are some examples of sampling frames of this type: a random sample of households could be selected from the population register of the Minburi Electricity Authority or the Minburi district office; or selected households are recruited for the experiment face-to-face or by telephone.

Nicolini and Dalla Valle (2011) discussed approaches that could correct self-selection bias, namely, the propensity score-matching method, the Heckman two-step procedure, and the Hierarchical Bayesian approach. Propensity score matching attempts to reduce the selection bias that can be found in an estimate of the treatment effect obtained by simply comparing outcomes among households that received the treatment versus those that did not. The Heckman two-step procedure allows us to estimate the values of the variable of interest for not selected households. The idea is based on a model comprising of two equations that are related to each other: the substantial equation and the selection equation. Lastly, the Hierarchical Bayesian approach calculates estimates using information that is supposed to be correlated to the variable of interest.

To mitigate the self-selection bias, we conducted the face-to-face household survey after the treatment period had ended and after the household electricity consumption had been recorded. By doing so, any connection or communication with the households that were subjected to treatments was limited. In this study, provided that no further ways to overcome the possible self-selection problem are being explored, we tentatively suggest that any bias would probably impact on inflating the number of people making changes in their energy consumption rather than on the relative impacts of the different treatments.

However, because the household survey took part only after the treatment period, we did not have access to household socioeconomic characteristics, home characteristics, and electricity consumption behavior at the time we designed the experiment. The unavailability of such information could mean that the treatment and control groups could differ with regard to some pretreatment attributes. In Section 4, we will show that there was no significant variation in the pretreatment attributes of the control and treatment groups.

3.3 Experimental Design

The 161 households that participated in our field experiment were randomly placed into one of four groups: one control group and three treatment groups. The control group did not receive any form of monthly feedback on their electricity consumption. The first treatment group (hereafter, Treatment 1) received self vs. neighbors' electricity consumption comparison or feedback that compared their monthly electricity consumption to an average consumption based on properties of a similar size. The second treatment group (hereafter, Treatment 2) received a leaflet containing general advice on saving electricity. For the third treatment group (hereafter, Treatment 3), households received both general electricity-saving advice and feedback in the form of self vs. neighbors' electricity consumption comparison.[3] For households in Treatments 1–3, feedback or home electricity reports were in the form of printed information and were sent to them by post. Each group contained approximately 40 households, as shown in Table 2. Using Microsoft Excel in the random assignment households into different groups, we found that the distribution of households is fairly balanced.

The design of the feedback on electricity consumption was adopted from the home electricity reports used by Costa and Kahn (2010) and Ayres, Raseman, and Shih (2009) as well as feedback on residential water consumption by Ferraro and Price (2011). All the reports were printed in color on a single A4 sheet of paper and were sent to households in all the treatment groups on the same day each month.

Table 2. Decomposition of households into groups

Housing Estate	Number of Households			
	Control Group	Treatment 1	Treatment 2	Treatment 3
Keha Suwindhawong	7	6	8	4
Chatluang	3	5	2	3
Wararom	7	4	7	6
Nonthicha	0	1	2	0
Chanbuasuay	0	1	3	1
Punthiya	1	3	1	5
Panason 2	3	2	1	1
Panason Garden Home 4	5	3	1	5
Nunthawan 5	14	14	13	13
Nunthawan 10	1	1	2	2
Total	**41**	**40**	**40**	**40**

The details of the three treatment groups/feedback groups are as follows:

1. Treatment 1 received a current-period neighbor comparison (self vs. neighbors' comparison feedback),[4] i.e., a bar chart comparing the household's recent electricity use to a group of comparable neighbors with both descriptive and injunctive messages designed to motivate action (neighbors are defined as nearby homes in the same housing villa as the participant). Figure 3 shows the final form of the feedback report sent to Treatment 1 participants.
2. Treatment 2 received electricity-saving advice: different tips recommended by the electricity authority, the Ministry of Energy, and other organizations on how households can use electrical appliances more efficiently to reduce their electricity consumption. Each month, three selected electricity-saving tips were presented in the information pack. Each tip comprised both a descriptive message and a visual message. Figure 4 shows an example of electricity-saving advice sent to Treatment 2 participants.
3. Treatment 3 received both a current-period neighbor comparison and electricity-saving advice. Figure 5 shows the final feedback report sent to Treatment 3 participants.

The 12-month pretreatment periods started in November 2012 and ended in October 2013. Households in the three treatment groups were subjected to periodic treatments. The 10-month treatment periods took place between November 2013 and August 2014.

[3] See Allcott (2011).
[4] Neighbors' consumption data comprised the average electricity consumption of other households with similar physical characteristics located in the same housing estate.

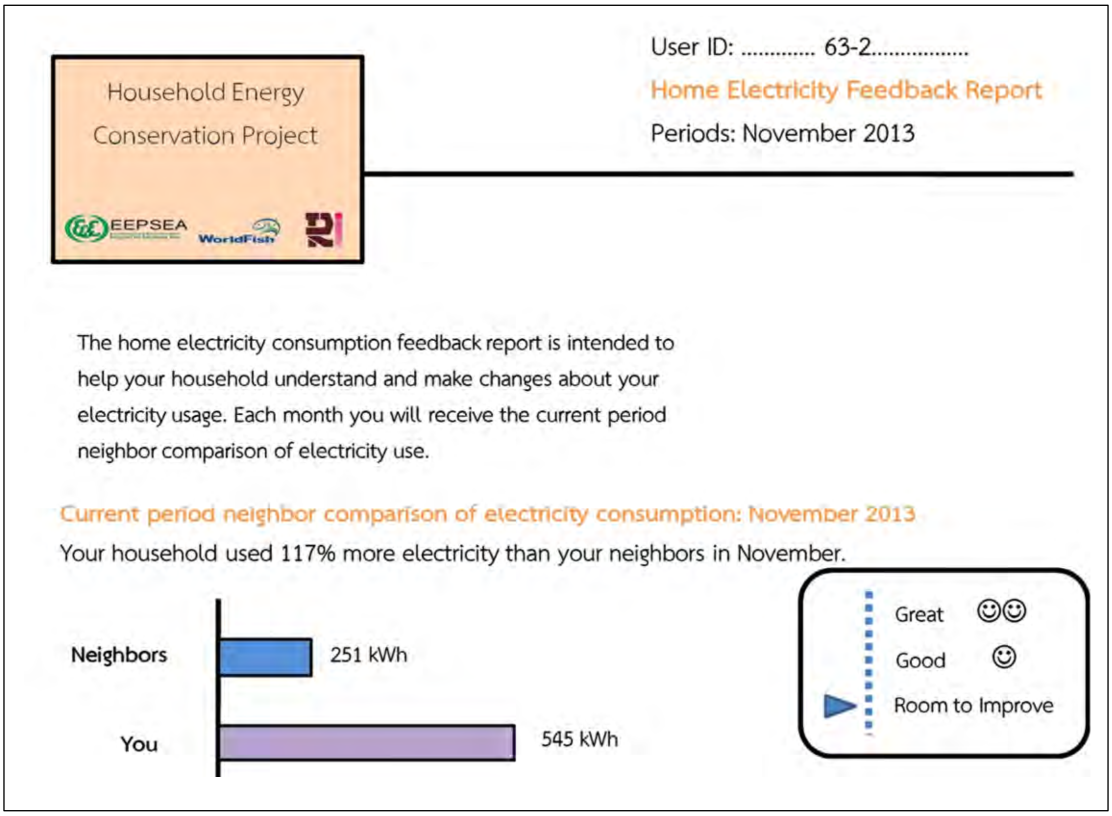

Figure 3. Electricity feedback report sent to Treatment 1 participants

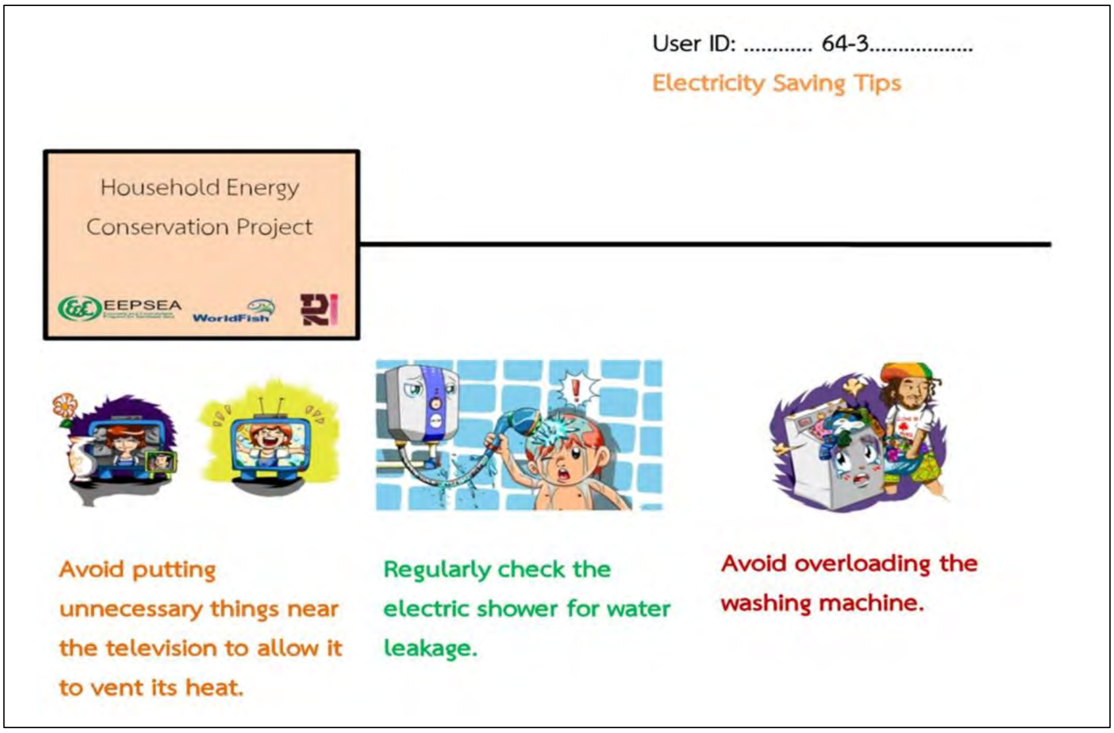

Figure 4. Electricity-saving tips sent to Treatment 2 participants

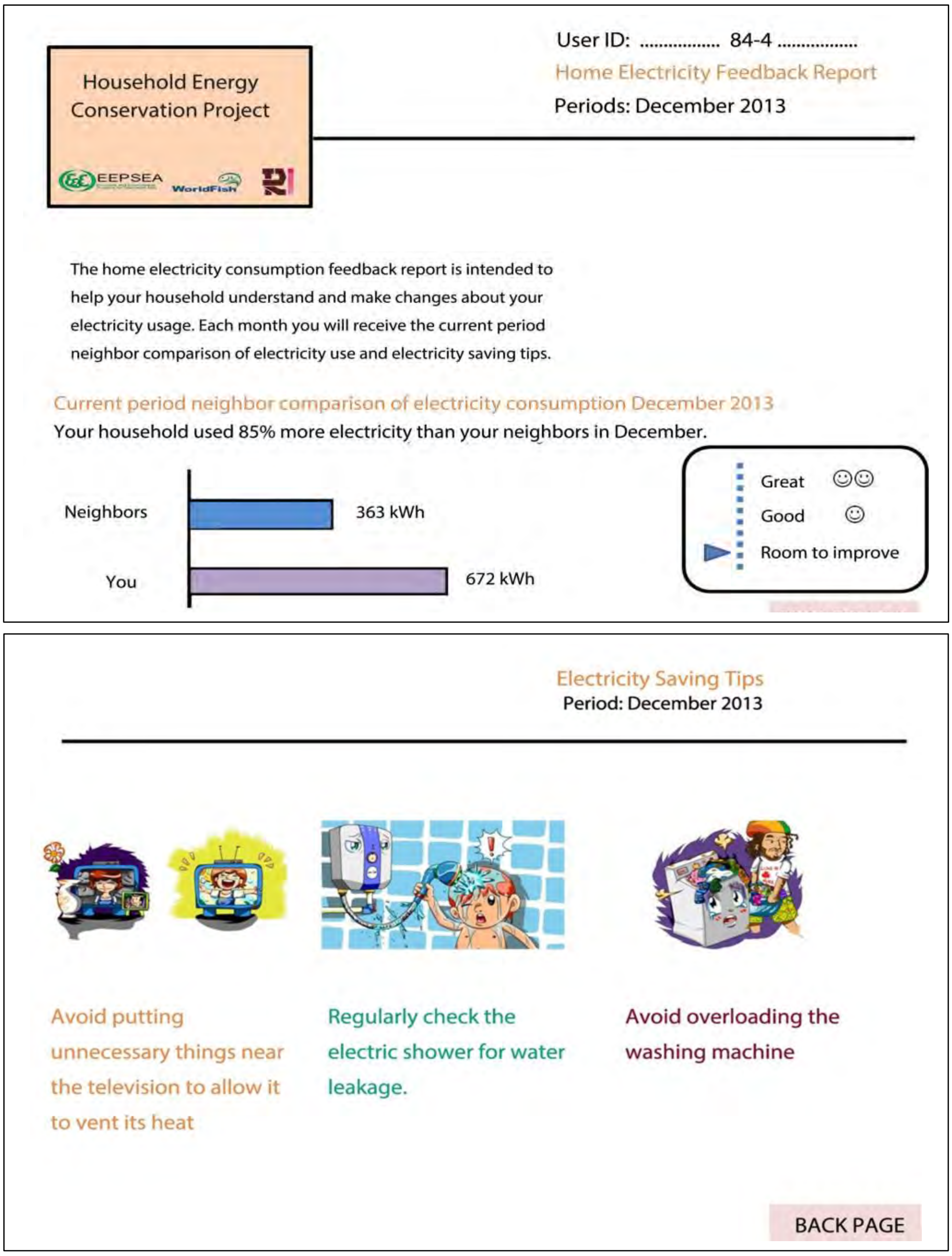

Figure 5. Electricity consumption feedback report sent to Treatment 3 participants

3.4 Household Survey Instrument

Aside from the monthly electricity consumption data provided by MEA's Minburi branch and the temperature data provided by the Department of Drainage and Sewage (Bangkok Metropolitan Administration), other information related to household characteristics and home characteristics were collected in the household survey conducted during the posttreatment period (September 2014). This survey was designed to collect socioeconomic information on the households and information on household electricity consumption behavior. Qualitative information also collected through the survey included, for example, whether households were aware of the monthly feedback they received (Appendix 2). In particular, the questionnaire comprised four parts.

1. **Part 1: Socioeconomic characteristics.** Household size, age profile of each member, gender of each member, level of education, members who stay at home during the daytime, members who stay at home during at night, and household income
2. **Part 2: Home characteristics.** House size, length of residence, number of stories, type of ownership, age of house, and number of bedrooms
3. **Part 3: Electricity consumption behavior.** Are electrical appliances switched off after use? Are appliances unplugged after use? How often are clothes ironed during peak hours? How often is it that only a few clothes are ironed or washed at a time?
4. **Part 4: Electricity conservation activities.** Purchase or replacement of electrical appliances and household electricity conservation activities

The household survey took place in September 2014 after the treatment periods were over. Ten enumerators and three field supervisors were recruited and trained one week before the survey was conducted. These teams of enumerators and supervisors visited 161 houses across 10 housing estates (Table 1). Out of the 161 households that participated in the field experiment, we were able to interview members from only 138 households despite several attempts. The remaining 23 houses were vacant so our enumerators were unable to collect household-specific information. As a result, only 138 households were included in our empirical analysis, which is reported in Section 4.

4.0 RESULTS

4.1 Pretreatment Characteristics of Households

One of the key objectives of this research project is to estimate the treatment effects. We begin by comparing the control and treatment groups of some selected pretreatment characteristics (Table 3). The purpose of doing so is to examine whether the sample is well-balanced between control and treatment groups.

Table 3. Mean comparisons of pretreatment variables

Variable	Treatment 1 (n = 31)	Treatment 2 (n = 36)	Treatment 3 (n = 36)	Control (n = 35)
Average household size (no. of people)	3.3	3.3	3.1	3.2
Average proportion of people aged 60 and above in the household* (percent)	23	14	16	8
Average proportion of people aged 15 and below in the household** (percent)	9	10	14	18
Average proportion of students in the household (percent)	14	19	31	39
Average household income (THB)	61,936	57,196	75,579	71,152
Average proportion of households that own property (percent)	94	94	94	97
Average proportion of household members who stay at home during the day*** (percent)	37	29	37	29
Average length of residence in current home (no. of years)	9.5	8.6	10.6	9.8
Average house size (squared wa)	33.8	32.2	32.6	37.3
Average proportion of household members with at least secondary education**** (percent)	77	81	82	77

Table 3 continued

Variable	Treatment 1 (n = 31)	Treatment 2 (n = 36)	Treatment 3 (n = 36)	Control (n = 35)
Average proportion of household members who are unemployed***** (percent)	3	4	4	4
Average proportion of female members of household****** (percent)	57	50	52	56

Notes: (1) * Average proportion of people aged 60 and above in the household means the ratio of number of household members aged 60 and above to the total number of household members. (2) ** Average proportion of people aged 15 and below in the household means the ratio of number of household members aged 15 and below to the total number of household members. (3) *** Proportion of household members who stay at home during the day means the ratio of the number of household members who are at home during the day to the total number of household members. (4) **** Proportion of household members with at least a secondary education means the ratio of number of household members who received at least a secondary education to the total number of household members. (5) ***** Proportion of household members who are unemployed means the ratio of the number of unemployed members in the household to the total number of household members. (6) ****** Proportion of female members of the household means the ratio of the number of female members to the total number of people in the household.

Table 3 shows that the differences in the "pretreatment variables" are, by and large, judged to be not substantial. However, despite the use of randomization in assigning households into different groups, some of the characteristics appear to be a bit more than this. For instance, the average proportion of household members aged 60 and above ranges from 8%–23%; the average proportion of household members aged 15 and below ranges from 9%– 18%; and the average proportion of students in each household ranges from 14%–39%. The data in Table 3 imply that the households in the treatment group, on average, have more elderly members, fewer young children, and fewer students than the average control group households.

Note that differences in the pretreatment variables are explored to some extent in the fixed-effect model estimates reported and discussed in Section 4.2. Nevertheless, in what follows, we discuss how each household characteristic affects household consumption. To analyze such possible relationships, some simple regression analyses relating pretreatment household consumption to household characteristic could yield some interesting, useful, and easily understood results, indicating which household factors are more important and which are less so. This simple analysis provides not only some interesting findings on its own, but also some information about how the observed differences between the four subsamples can be taken seriously.

The relationship between pretreatment household electricity consumption to characteristics of households is based on the following equation:

$$y_{i,12} = X_i \beta_i + \varepsilon_i \qquad \text{Equation (2)}$$

where:

$y_{i,12}$	=	household *i*'s pretreatment electricity consumption or the level of electricity usage of household *i* in the 12th month or October 2013,
X_i	=	vector of household *i*'s characteristics, and
ε_i	=	residual term.

We then estimate the model as shown in Equation (1). Table 4 shows the household characteristics that affect a household's pretreatment electricity consumption, namely, (1) house size (the physical size of the house, measured in squared wa, or the number of people in the household); (2) whether there are people in the household that stay at home during the day; and (3) whether there are people aged 15 and below in the household.

Table 4. Impacts of household characteristics on pretreatment consumption

Household Characteristic Variables	[1]	[2]
Household size	73.3537*** (14.8797)	
Dummy (whether some members in the household stay at home during the day)	79.1410*** (30.1856)	130.2590*** (38.6551)
Dummy (whether the house is owned by the household)	0.7852 (52.8593)	−10.7158 (46.7181)
Length of residence in current home	3.9063 (4.4709)	2.2910 (4.9951)
House size	2.8313** (1.1227)	3.1962*** (1.2247)
Dummy (whether there are people aged 60 and above in the household)		12.2098 (47.9286)
Dummy (whether there are people aged 15 and below in the household)		68.9946** (37.2236)
Constant	−54.1696 (67.3181)	133.3841 (52.3726)

Notes: (1) *, ** and *** denote statistical significance at 10%, 5%, and 1%, respectively. (2) Robust standard errors are shown in parentheses.

According to Model (1), other things being equal, households with more members consume more electricity. Larger households may need more electricity in order to undertake different activities.[5] In addition, other things being equal, households with some members occupying the house during the day tend to have higher electricity consumption. When some household members are at home during the day, they may require electricity to operate different appliances. Last but not least, households with larger homes may use more electricity to light different rooms and operate electrical appliances. One additional characteristic that affects a household's pretreatment electricity consumption, according to Model (2), is the presence of a person aged 15 and below in the household.

Next, we examine the average electricity consumption of households in the control group and the three treatment groups (Figure 6).

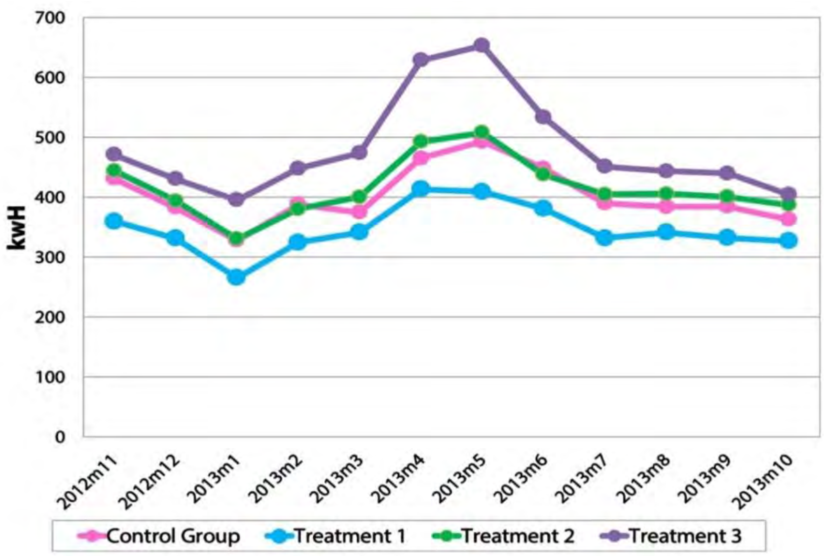

Figure 6. Mean comparisons of pretreatment electricity consumption

[5] This result is similar to the findings of Statistics Canada, which is available at http://www5.statcan.gc.ca/olc-cel/olc.action?objId=11-526-S&objType=2&lang=en&limit=0 (last retrieval date: March 2015).

In Figure 6, although there were some differences in the average pretreatment levels of electricity consumption among the control and the three treatment groups, the mean electricity consumption of the four groups move in the same direction during the pretreatment periods. For instance, the mean electricity consumption of all the groups declined between November 2012 and January 2013 when the weather in Bangkok was relatively cooler; the mean electricity consumption of households in the control and three treatment groups all increased as Thailand's summer approached in March–May 2013, reaching its peak in May (Figure 7).

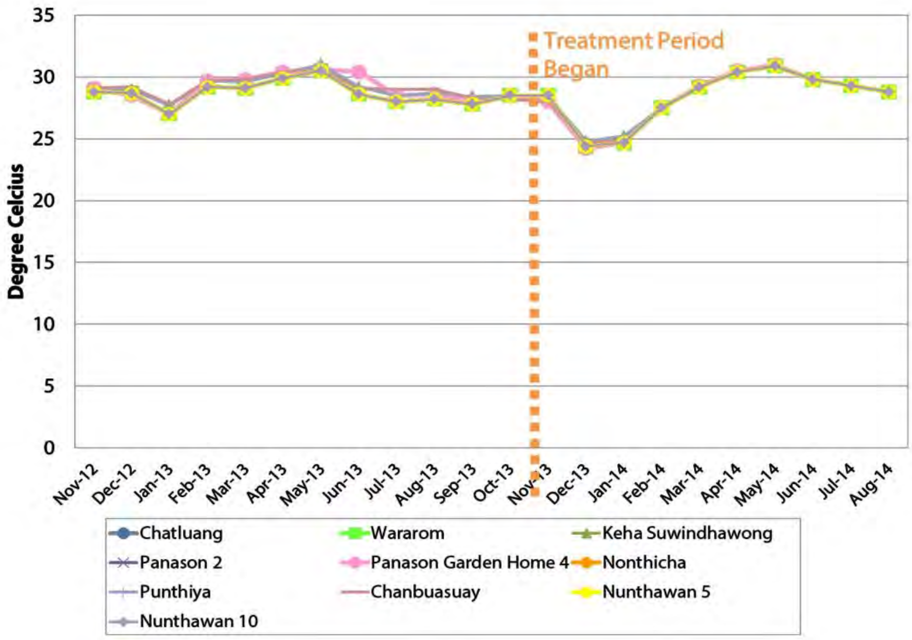

Figure 7. Mean temperature

Source: Department of Drainage and Sewage, Bangkok Metropolitan Administration

As noted earlier, there are differences between the pretreatment electricity consumptions levels of the four randomly assigned treatment subsamples, ranging from 346.48 (Treatment 1) to 480.92 (Treatment 4); these differences are dealt with by using "difference-in-difference" analyses (discussed in Section 4.2), which yield estimates somewhat independent of the differing initial levels of consumption. This is a way to handle the potential problem. Nevertheless, there is a concern that a treatment might show more of an impact on an abnormally high initial consumption level than on a very low one.

4.2 Results of Difference-in-Difference and Fixed Effect Estimations

How can we tell whether the electricity usage feedback or home electricity report influences a reduction in residential electricity consumption? One method is to find the difference-in-difference estimators, $\hat{\delta}_{Treatmenti}$, which can be expressed as

$$\hat{\delta}_{Treatment1} = \left(\bar{y}_{pre,Treatment1} - \bar{y}_{post,Treatment1}\right) - \left(\bar{y}_{pre,Control} - \bar{y}_{post,Control}\right) \qquad \text{Equation (3)}$$

$$\hat{\delta}_{Treatment2} = \left(\bar{y}_{pre,Treatment2} - \bar{y}_{post,Treatment2}\right) - \left(\bar{y}_{pre,Control} - \bar{y}_{post,Control}\right) \qquad \text{Equation (4)}$$

$$\hat{\delta}_{Treatment3} = \left(\bar{y}_{pre,Treatment3} - \bar{y}_{post,Treatment3}\right) - \left(\bar{y}_{pre,Control} - \bar{y}_{post,Control}\right) \qquad \text{Equation (5)}$$

where "pre" and "post" stand for pretreatment period and posttreatment period, respectively and $\bar{y}$ denotes the mean electricity consumption. Table 5 shows the results of the difference-in-difference estimations.

Table 5. Difference-in-difference estimation results

Group	Mean Electricity Consumption during Pretreatment Period [1]	Mean Electricity Consumption during Posttreatment Period [2]	[1] – [2]	Difference-in-Difference (kWh)
Control Group	402.58	400.71	1.87	
Treatment 1	346.48	324.27	22.20	20.34
Treatment 2	415.53	404.10	11.43	9.56
Treatment 3	480.92	451.95	28.97	27.10

According to the last column of Table 5, households in all the treatment groups experienced a reduction in their mean electricity consumption compared with the households in the control group. Treatments 3 and 1 experienced the highest and second-highest reductions in their mean electricity consumption, respectively. Treatments 1, 2, and 3 experienced savings on their electricity consumption of around 20.34 kWh, 9.56 kWh, and 27.10 kWh, respectively. Figure 8 shows the mean electricity consumption of the three treatment groups and the control group both during the pretreatment and posttreatment periods.

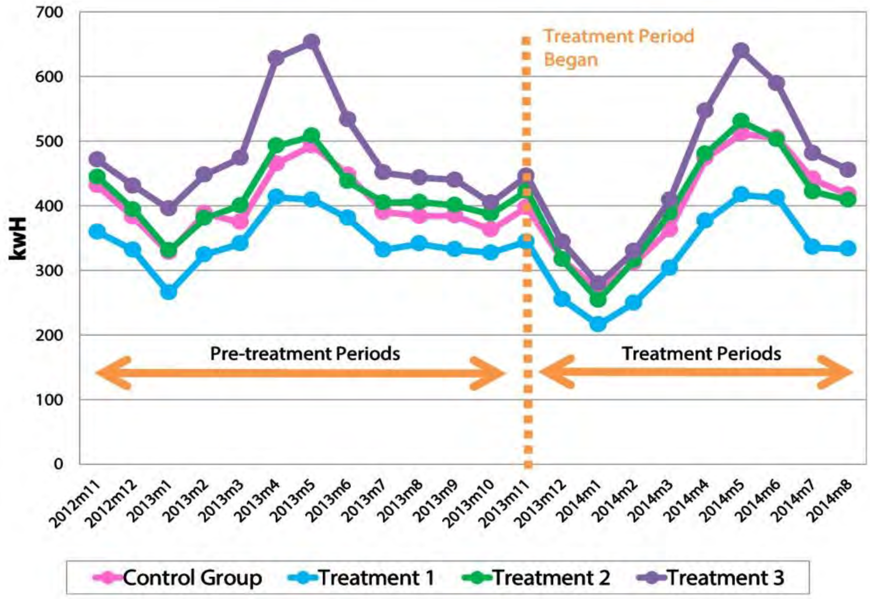

Figure 8. Mean electricity consumption during both pre- and posttreatment periods

Source: Author's own computation using electricity consumption data from MEA

The difference-in-difference estimation results indicate that peer-comparison feedback does have a significant impact on household electricity consumption. Households in Treatments 1 and 3 were motivated to save electricity after being informed that their electricity consumption was higher or lower than their neighbors'. Although providing electricity-saving tips did lead to a decline in residential electricity consumption in Treatment 2 group as compared with the control group, the electricity savings were rather small. This result is consistent with the findings of Ferraro and Price (2011), who found that social comparison messages had a greater influence on household behavior than technical information.

It is important to highlight that, in this case, we did not provide a formal test as to whether the difference-in-difference estimators shown in Table 5 are statistically different from zero; their standard errors were not obtained and reported alongside the estimation results. Next, we proceeded to present the results of the fixed-effect estimations. We organized each household's electricity consumption data over 22 months (between November 2012 and August 2014) on the 138 households together with the data on household socioeconomic characteristics into the panel data set. We then estimated the fixed-effect model as shown in Equation (1). Table 6 reports the fixed-effect estimation results under the two model specifications.

Table 6. Estimation results of the fixed effect model

Variables	Model (1)	Model (2)
Treatment Dummies		
d_Treatment1	−20.6128 (13.8932)	−21.1481 (13.7610)
d_Treatment2	−7.4584 (17.4705)	−7.5574 (17.4691)
d_Treatment3	−25.0497* (12.8066)	−24.8587* (12.6382)
Time Dummies		
2	−42.2555*** (4.8419)	−39.3960*** (4.6960)
3	−96.6350*** (8.6827)	−63.6886** (23.0709)
4	−42.4769*** (11.0042)	−51.3331*** (12.9884)
5	−30.0131** (11.1658)	−37.5528** (12.7755)
6	74.0884*** (14.2786)	52.3411** (19.5629)
7	92.8763*** (15.0335)	60.6007** (25.0264)
8	24.4384** (11.6542)	23.7416** (11.6164)
9	−31.2624** (11.7377)	−17.7307 (13.9160)
10	−34.3827** (12.3493)	−24.2999* (13.4742)
11	−38.5566*** (10.8984)	−20.6157 (15.6437)
12	−58.0856*** (12.1385)	−50.2656*** (13.1233)
13	−11.9164 (14.8788)	−2.4108 (15.9564)
14	−105.7094*** (15.9389)	−21.6543 (55.0835)
15	−160.9817*** (16.3638)	−83.27671 (51.4499)
16	−112.4248*** (16.4279)	−85.8084*** (22.0727)
17	−48.4817** (15.5628)	−54.2396** (16.3943)
18	56.1778** (16.7307)	27.7095 (24.8338)
19	112.5546*** (18.6200)	74.6237** (30.2686)
20	89.1850*** (16.6477)	72.2914*** (19.3866)
21	9.1851 (13.5887)	1.7779 (13.9604)
22	−9.5573 (13.6455)	−7.5127 (13.6886)
Climate Variable		
Temperature		18.9252 (12.0741)
Constant	430.2942 (9.2794)	−116.6871 (349.0179)
Number of Observations **R-squared within**	3,025 0.3986	3,025 0.3995

Notes: (1) *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively. (2) Standard errors were adjusted for 138 clusters in household ID. (3) Robust standard errors are shown in parentheses.

The difference between these two specifications is that the mean temperature variable is included in the second model specification. The estimation results from both model specifications indicate that the mean electricity consumption of households that were subjected to Treatment 3 (i.e., receiving a home electricity report containing both peer-comparison feedback and electricity-saving advice) statistically declined in relation to the control group. The average reduction in electricity consumption of households in Treatment 3 relative to the control group was around 25 kWh. Although an increase in temperature seems to cause electricity consumption to increase, the coefficient of the temperature variable is not statistically significant.

As a robustness check, in what follows, we ran a regression using any pair of control and treatment groups. Table 7 shows that the paired regressions [Models (1), (2) and (3)] give identical results to using the pooled groups [Model (4)].

Table 7. Estimation results: Paired vs. pooled regressions

Variables	Model (1)	Model (2)	Model (3)	Model (4)
Treatment Dummies				
d_Treatment1	−21.0948 (13.9039)			−21.1481 (13.7610)
d_Treatment2		−7.3213 (17.6046)		−7.5574 (17.4691)
d_Treatment3			−24.8587* (12.6687)	−24.8587* (24.8587)
Time Dummies				
Dec–12	−35.2995*** (5.8302)	−50.7921*** (5.8740)	−39.3833*** (7.1508)	−39.3960*** (4.6960)
Jan–13	−60.6349** (28.9805)	−122.0190*** (31.3528)	−42.0656 (25.7676)	−63.6886** (23.0709)
Feb–13	−52.0010*** (12.7920)	−52.8680*** (12.8571)	−47.2149** (21.8869)	−51.3331*** (12.9884)
Mar–13	−49.4674** (14.3900)	−49.7069*** (13.3750)	−38.6531* (21.5606)	−37.5527** (12.7755)
Apr–13	15.7868 (23.5838)	47.3318** (23.2748)	65.7750** (28.2616)	52.3411** (19.5629)
May–13	20.5049 (30.2409)	72.9675** (30.6256)	77.6983** (34.0494)	60.6007** (25.0264)
Jun–13	19.3745 (11.6099)	2.2963 (11.5064)	35.3342* (19.2171)	23.7416** (11.6164)
Jul–13	−17.4033 (15.3162)	−48.0963** (17.7691)	−12.8944 (19.7725)	−17.7307 (13.9160)
Aug–13	−24.0787* (12.4361)	−49.4281** (16.1289)	−24.6856 (19.9114)	−24.2999* (13.4742)
Sep–13	−19.2125 (17.4179)	−54.7754** (21.6255)	−15.2587 (19.5757)	−20.6157 (15.6437)
Oct–13	−44.9554** (15.4139)	−68.1919*** (16.0839)	−58.5608** (19.2044)	−50.2656*** (13.1233)
Nov–13	−6.6645 (16.4111)	−30.0539 (18.2851)	−4.4492 (20.6133)	−2.4108 (15.9564)
Dec–13	−5.1089 (73.8886)	−153.0224* (77.3448)	10.0749 (58.4027)	−21.6543 (55.0835)
Jan–14	−55.8934 (68.2946)	−205.6419** (72.5904)	−57.7878 (54.0464)	−83.2767 (51.4499)
Feb–14	−76.8722** (27.0774)	−133.7159*** (29.8543)	−80.7380** (24.7566)	−85.8084*** (22.0727)
Mar–14	−61.4648*** (16.5116)	−58.4792** (17.9695)	−61.9962** (23.0229)	−54.2396** (16.3943)

Table 7 continued

Variables	Model (1)	Model (2)	Model (3)	Model (4)
Time Dummies				
Apr–14	4.6579 (28.9788)	51.5370* (29.0865)	31.2438 (32.8874)	27.7095 (24.8338)
May–14	32.9038 (37.6028)	99.3581** (37.3411)	84.3578** (38.3592)	74.6237** (30.2686)
Jun–14	51.6039** (22.3998)	74.0010*** (21.0810)	84.4154** (26.8227)	72.2913*** (19.3866)
Jul–14	−3.7805 (15.8812)	0.3044 (14.8364)	10.9210 (18.3896)	1.7779 (13.9604)
Aug–14	−10.3342 (15.2821)	−22.2718 (14.9700)	−1.0663 (17.2344)	−7.5127 (13.6886)
Climate Variable				
Temperature	21.8465 (16.5452)	−7.4421 (16.7813)	26.4197* (13.4563)	18.9252 (12.0741)
Number of Observations	1,423	1,535	1,557	3,025
R-squared within	0.4002	0.413	0.44	0.3995

Notes: (1) *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively. (2) Robust standard errors are shown in parentheses.

According to Table 8, while Treatment 3 (i.e., information on neighbors' consumption plus electricity conservation hints) reductions were the largest (around 25 kWh), relative to its very high pretreatment consumption level (481 kWh), it is proportionally less than Treatment 1 (i.e., only information on neighbors' consumption)—a reduction of 5.17% for the Treatment 3 vs. 6.09% for Treatment 1. However, as shown in Tables 6 and 7, only the electricity reduction under Treatment 3 is statistically significant.

Table 8. Percentage reduction in electricity consumption

Treatment	Pretreatment Consumption (Unit: kWh)	Reduction in Consumption (Unit: kWh)	Percentage Reduction in Electricity Consumption (Unit: Percentage)
Treatment 1	346.48	−21.0948	−6.09%
Treatment 2	415.53	−7.3213	−1.76%
Treatment 3	480.92	−24.8587	−5.17%*

Note: *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively.

Our analysis thus far has focused on the changes in aggregated electricity consumption among households in the treatment groups relative to those in the control group. Although we found evidence of treatment effects in these aggregated data, there is a growing empirical literature suggesting the impermanence of non-pecuniary incentives (Gneezy and List 2006; Ferraro and Price 2011). According to Gneezy and List (2006), the impermanence is consistent with non-pecuniary incentives (i.e., social comparisons and appeals to social norms) having greatest impact during the initial phases of decision making or in the few weeks following the intervention. However, over time, these feelings may dissipate as the household's focus of attention shifts elsewhere. Thus, the decay or waning of treatment effects is plausible.

Our experimental design allowed us to evaluate whether the electricity-conservation strategies considered in our study are subject to the same type of decay noted in other studies. We consider the effectiveness of each treatment during the months after the first mailing of home energy reports.

According to Table 9, Treatment 3 was effective in reducing household electricity consumption from the first month, suggesting that the effects were immediate. Specifically, in households belonging to Treatment 3, electricity usage significantly reduced during the first five months and the last two months (*d_Treatment_November 2013* to *d_Treatment_March 2014*; *d_Treatment_July 2014* and *d_Treatment_August 2014* as shown in Figure 9). Thus, this experiment shows that the effects of the home energy report combined with peer comparison and electricity-saving tips continues to be strong up to 10 months after households begin to receive reports (with exceptions to the sixth, seventh, and eighth months after the dispatch of the first home energy reports). However, we do not know whether these impacts will be permanent because we have not monitored household electricity consumption since the end of the treatment. If the treatment groups are no longer subject to treatment, it is possible that they would behave as they did before being treated.

Table 9. Persistence of treatment effects

Variable	Eq. (1)	Eq. (2)	Eq. (3)
Time Dummies			
Dec–12	–35.4214*** (5.9050)	–50.7508*** (5.8927)	–39.3062*** (7.1825)
Jan–13	–61.9768** (29.5045)	–121.5389*** (31.0872)	–41.3197 (25.3842)
Feb–13	–51.6460*** (12.8553)	–52.9974*** (12.8558)	–47.4142** (21.8999)
Mar–13	–49.1677** (14.4582)	–49.8174*** (13.3246)	–38.8257* (21.5711)
Apr–13	16.6629 (23.8885)	47.0142** (23.1930)	65.2884** (28.0918)
May–13	21.8094 (30.6406)	72.4963** (30.5019)	76.9820** (33.5480)
Jun–13	19.4065 (11.6453)	2.2865 (11.5405)	35.2874* (19.2727)
Jul–13	–17.9616 (15.4516)	–47.9000** (17.7731)	–12.5910 (19.7766)
Aug–13	–24.4943* (12.5407)	–49.2816** (16.1355)	–24.4582 (19.9380)
Sep–13	–19.9422 (17.6903)	–54.5136** (21.5457)	–14.8544 (19.4888)
Oct–13	–45.2628** (15.5276)	–68.0769*** (16.1087)	–58.3861** (19.2261)
Nov–13	–17.5067 (16.5502)	–40.5909** (18.0662)	–2.4758 (19.8523)
Dec–13	–14.7240 (74.439)	–149.6357* (75.7924)	23.1071 (58.1431)
Jan–14	–69.6058 (68.5788)	–194.5478** (69.8119)	–33.8074 (54.0921)
Feb–14	–84.6277** (28.6875)	–132.9686*** (30.0501)	–64.4473** (27.3873)
Mar–14	–69.0741*** (17.8152)	–68.8955*** (18.4317)	–58.7862** (22.2550)
Apr–14	16.0101 (28.6994)	50.0859* (27.6957)	19.3868 (29.5422)
May–14	43.1456 (36.1340)	91.3453** (35.3912)	43.6427 (34.5666)
Jun–14	60.4430** (23.3322)	77.0717*** (22.4182)	67.3769** (26.6486)
Jul–14	7.2780 (17.2931)	9.7828 (17.0928)	17.0916 (22.1977)
Aug–14	–6.5046 (16.4082)	–18.1236 (17.3131)	6.1887 (21.1222)
Climate Variable			
Temperature	21.0818 (16.8582)	–7.1659 (16.6289)	26.8412** (13.1459)

Table 9 continued

Variable	Eq. (1)	Eq. (2)	Eq. (3)
Months after First Treatment			
d_Treatment_November 2013	0.8612 (16.2355)	13.4361 (14.6375)	–28.2250* (15.2916)
d_Treatment_December 2013	–8.0589 (25.0951)	–11.5219 (24.8108)	–46.5780** (22.5566)
d_Treatment_January 2014	1.0798 (27.7895)	–26.6897 (30.8776)	–67.5468** (28.0327)
d_Treatment_February 2014	–7.0738 (23.6496)	–8.0206 (27.4301)	–55.4155** (24.9994)
d_Treatment_March 2014	–4.6347 (16.8608)	12.7669 (20.9335)	–31.2666* (18.3336)
d_Treatment_April 2014	–42.4687* (23.1062)	–5.3099 (24.5211)	–3.3246 (24.0131)
d_Treatment_May 2014	–39.3387 (27.9925)	7.1803 (26.3622)	51.6476 (31.0044)
d_Treatment_June 2014	–38.1810 (25.2297)	–13.7739 (28.4483)	7.1171 (25.8293)
d_Treatment_July 2014	–44.0504** (21.7150)	–26.2414 (25.0664)	–37.0148* (21.2968)
d_Treatment_August 2014	–29.2806 (22.1519)	–15.4607 (23.1570)	–38.6913* (21.2390)
Number of Observations	1,423	1,535	1,557
R-squared within	0.4045	0.4152	0.4486

Note: (1) *, **, and *** denote statistical significance at 10%, 5%, and 1%, respectively. (2) Standard errors were adjusted for clusters in household ID. (3) Robust standard errors are shown in parentheses.

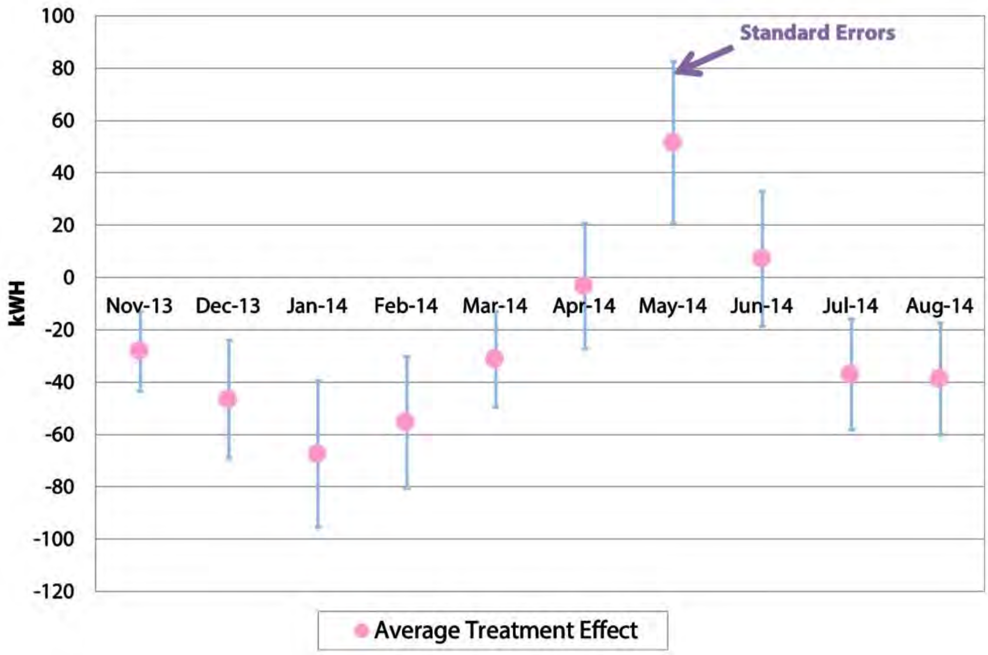

Figure 9. Average changes in electricity consumption for Treatment 3 during the treatment periods

Note: Blue vertical bars denote standard errors.

4.3 Household Electricity Consumption Behavior and Conservation Efforts

The information collected through our household survey enabled us to discuss household behavior and conservation efforts. Table 10 contains some descriptions of household electricity consumption behavior. On the average, all the households that took part in our field experiment did not exhibit electricity-wasting behavior.

Table 10. Household electricity consumption behavior (unit: households)

Indicator	All the Time	Most of the Time	Sometimes	Never	Not Applicable
1. Use washing machine when not fully loaded	12 (9%)	14 (10%)	27 (20%)	72 (52%)	13 (9%)
2. Iron clothes at peak hours	8 (6%)	30 (22%)	44 (32%)	43 (31%)	13 (9%)
3. Leave mobile phone charged overnight	22 (16%)	22 (16%)	38 (28%)	56 (41%)	0 (0%)
4. Leave the light on at night to prevent burglars	39 (28%)	5 (4%)	7 (5%)	87 (63%)	0 (0%)

Source: Household survey conducted by Thailand Development Research Institute.

Concerning household electricity-saving measures, our results show that around 86% of the 138 households that participated in our field experiment regularly monitored their electricity usage via the information printed on their monthly electric bill. Moreover, around 72% of households understood that electricity conservation is important to them. In the interview, we also asked whether, during the treatment periods, households replaced electrical appliances with more energy-efficient models. Table 11 contains a summary of our results. About half of households replaced lightbulbs with energy-saving ones. For other larger appliances, the proportion of households that replaced electrical appliances was quite low.

Table 11. Replacement of electrical appliances with energy-efficient models

Response	A/C	Fridge	Lightbulb	Iron	TV	Washing Machine	Electric Shower
Yes	7%	10%	49%	8%	13%	7%	1%
No	80%	87%	49%	86%	83%	85%	68%
Not applicable	13%	3%	2%	6%	4%	8%	30%

Note: A/C = air conditioner

5.0 CONCLUSIONS AND POLICY RECOMMENDATIONS

Economists and policy makers have begun to explore the effect of non-pecuniary strategies, such as the use of social comparisons, as a means to promote pro-social behaviors such as water or electricity conservation. This research project sought to further our understanding of non-pecuniary strategies or peer-comparison feedback by exploring whether they influence household electricity consumption decisions. We investigated the effectiveness of feedback on electricity consumption in a small-scale natural field experiment carried out in conjunction with the Minburi branch of MEA.

We find that households receiving both electricity-saving advice and peer comparison feedback (Treatment 3) make significant reductions in their electricity consumption. Our findings support our hypothesis that the electricity conservation "nudge" of providing feedback to households on their own and peer home electricity usage works in terms of eliciting behavioral changes and influencing reduction in residential electricity consumption. Treatments 1 and 2, where households received self vs. neighbor comparisons and electricity-saving advice, respectively, did not experience a statistically significant reduction in their electricity consumption compared to the control group. From a policy-making perspective, this calls into question the economic significance of information-only electricity conservation efforts.

Our field experiments suggest that governmental entities should consider incentivizing MEA and PEA to adopt peer-comparison reporting, as we have shown that peer comparison reports can benefit both individual households and the environment. Government officials should also consider investing in scientifically designed studies that could increase knowledge in this area, such as determining the cost effectiveness of sending peer feedback with the regular utility bill. There are endless ways public or private entities might employ such feedback to drive desired behavior.

For future studies, quite a few extensions can be done. With regard to the first extension, further testing for different forms of “hints” used in this study could be conducted. Such future study could follow much the same experimental design as this one, with different treatments containing much more specific electricity-saving tips. For instance, rather than just state “avoid overloading the washing machine,” it might be more effective to let people know how much more electricity is used by an overloaded washing machine compared to a properly loaded one.

A second further study could consider investigating the extent to which any observed impact of behavioral changes triggered by information regarding neighbors’ electricity consumption levels wanes over time. Such a study requires the experiment to be carried out over a longer period. In addition, multiple treatments conveying differing messages about behaviors of neighbors could be included. One possible extension could be to investigate the impact of giving a small “reward” or recognition for “beating” the household electricity consumption of neighbors.

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APPENDICES

Appendix 1. Consent Form

มูลนิธิสถาบันวิจัยเพื่อการพัฒนาประเทศไทย
565 ซอยรามคำแหง 39 (เทพลีลา 1) ถนนรามคำแหง แขวงวังทองหลาง เขตวังทองหลาง กรุงเทพฯ 10310
THAILAND DEVELOPMENT RESEARCH INSTITUTE FOUNDATION
565 Soi Ramkhamhaeng 39 (Thepleela 1) Ramkhamhaeng Road Wangthonglang District Bangkok 10310

Consent Form

The Thailand Development Research Institute (TDRI) is currently undertaking the research project on households' electricity consumption. Under this research project, having access to households' electricity consumption data – both the historical data on households' electricity consumption (November 2012 to October 2013) and the electricity consumption data of households during November 2013 and September 2014) – are necessary.

Responding to the above request, I hereby agree to take part n this research project and willing to grant authorization to the TDRI researchers to access my households' electricity consumption data administered by the Minburi Branch of Metropolitan Electricity Authority (MEA).

……………………………………..

Signature of Homeowner

Name of Homeowner………………………………

House Number………………………………………

Name of Housing Estate……………………………

Appendix 2. Questionnaire Used in Household Survey

Household Electricity Conservation Survey

First name…………………………………….. Family Name………………………………..
House number………………………………...
Housing estate:

◯ Nunthawan 5 ◯ Nunthawan 10 ◯ Keha Suwindhawong
◯ Chatluang ◯ Wararom ◯ Chanbuasuay
◯ Nonthicha ◯ Punthiya ◯ Panason Garden Home 4
◯ Panason 2

Landline tel: .... Mobile number …………………………………...
Date: …………………………………………...

Thailand Development Research Institute (TDRI) is conducting a survey which aims at gathering information about households' electricity consumption behavior and electricity conservation activities. This survey is a part of the project entitled "Household Energy Conservation Project" funded by EEPSEA-WorldFish. The data collected from this survey will help us develop policy recommendations to encourage electricity conservation by households. Your personal data will be treated with strict confidence. Please kindly complete the following survey.

Enumerator……………………………………………
Checked by ………………………………………..

Part 1: Socioeconomic characteristics

1. Total number of family members ……..

Member	Age	Employment Status	Relationship with Household Head	Gender	Education	Personal Income
1.		□ Working □ Private company □ Civil servant □ Public enterprise □ Self-employed □ Freelance □ Unemployed □ Studying □ Maid/domestic assistant	□ Household head □ Husband/wife □ Parent □ Grandparent □ Child/in-law □ Grandchild □ Sibling □ Grandchild □ Relative □ Maid	□ Male □ Female	□ No formal schooling □ Primary school □ Lower secondary □ Upper secondary □ Vocational diploma □ Undergraduate □ Postgraduate	
2.		□ Working □ Private company □ Civil servant □ Public enterprise □ Self-employed □ Freelance □ Unemployed □ Studying □ Maid/domestic assistant	□ Household head □ Husband/wife □ Parent □ Grandparent □ Child/in-law □ Grandchild □ Sibling □ Grandchild □ Relative □ Maid	□ Male □ Female	□ No formal schooling □ Primary school □ Lower secondary □ Upper secondary □ Vocational diploma □ Undergraduate □ Postgraduate	

Appendix 2,' Part 1: Socioeconomic characteristics' continued

Member	Age	Employment Status	Relationship with Household Head	Gender	Education	Personal Income
3.		□ Working □ Private company □ Civil servant □ Public enterprise □ Self-employed □ Freelance □ Unemployed □ Studying □ Maid/domestic assistant	□ Household head □ Husband/wife □ Parent □ Grandparent □ Child/in-law □ Grandchild □ Sibling □ Grandchild □ Relative □ Maid	□ Male □ Female	□ No formal schooling □ Primary school □ Lower secondary □ Upper secondary □ Vocational diploma □ Undergraduate □ Postgraduate	
4.		□ Working □ Private company □ Civil servant □ Public enterprise □ Self-employed □ Freelance □ Unemployed □ Studying □ Maid/domestic assistant	□ Household head □ Husband/wife □ Parent □ Grandparent □ Child/in-law □ Grandchild □ Sibling □ Grandchild □ Relative □ Maid	□ Male □ Female	□ No formal schooling □ Primary school □ Lower secondary □ Upper secondary □ Vocational diploma □ Undergraduate □ Postgraduate	
5.		□ Working □ Private company □ Civil servant □ Public enterprise □ Self-employed □ Freelance □ Unemployed □ Studying □ Maid/domestic assistant	□ Household head □ Husband/wife □ Parent □ Grandparent □ Child/in-law □ Grandchild □ Sibling □ Grandchild □ Relative □ Maid	□ Male □ Female	□ No formal schooling □ Primary school □ Lower secondary □ Upper secondary □ Vocational diploma □ Undergraduate □ Postgraduate	

2. Household's gross monthly income…………………………………..THB

3. Nature of occupancy:

Member	At home during daytime?	At home during the night?
1.	□ Yes □ No	□ Yes □ No
2.	□ Yes □ No	□ Yes □ No
3.	□ Yes □ No	□ Yes □ No
4.	□ Yes □ No	□ Yes □ No
5.	□ Yes □ No	□ Yes □ No

4. Type of home ownership
   ◯ Renting ◯ Ownership

5. Length of occupancy ………………days……………..months ………………..years

Part 2: Home Characteristics

6. Type of house
   ◯ Detached house
   ◯ Semi-detached house
   ◯ Terrace house/townhouse

7. Do you use your house to operate business?
   ◯ No
   ◯ Yes (please specify type of business)
      ◯ Beauty salon
      ◯ Grocery store
      ◯ Automobile repair
      ◯ Pharmacy
      ◯ Other (please specify) …………………………..

8. Number of stories
   ◯ One-story house ◯ Two-story house ◯ Three-story house

9. Number of bedrooms
   ◯ 1 bedroom ◯ 2 bedrooms ◯ 3 bedrooms
   ◯ 4 bedrooms ◯ 5 or more bedrooms

10. House age …………………………..years

11. House size ………........................... squared wa

Part 3: Electricity Consumption Behavior

12. How often do you turn off lights in the toilet after use?
   ◯ Always
   ◯ Most of the time
   ◯ Sometimes
   ◯ Never

13. How often do you switch off the following electrical appliances when not in use?

13.1 TV	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No TV	
13.2 Air conditioner	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No air conditioner	
13.3 Fan	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No fan	
13.4 Water pump	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No water pump	
13.5 Stereo	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No stereo	
13.6 Computer	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No computer	
13.7 Wireless router	◯ Always	◯ Most of the time	◯ Sometimes
	◯ Never	◯ No wireless router	

14. How often do you put on the washing machine when it is not full?
   ◯ Always
   ◯ Most of the time
   ◯ Sometimes
   ◯ Never
   ◯ No washing machine/hand wash
   ◯ Use laundry services

15. How often do you use the washing machine? …………………………..times/week

16. Do you iron few pieces of clothes (five pieces or less) at a time?
    - ◯ Always
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never
    - ◯ No iron
    - ◯ Use laundry services

17. How often do you iron your clothes? ………………………………….....times/week

18. How often do you iron your clothes during peak hours (2–4 pm and 6–8 pm)?
    - ◯ Always
    - ◯ Most of the time (more than three days per week)
    - ◯ Sometimes
    - ◯ Never
    - ◯ No iron
    - ◯ Use laundry services

19. How often do you leave electric kettle on or not unplugged for the whole day?
    - ◯ Every day
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never
    - ◯ No electric kettle

20. How often do you leave rice cooker on for the whole day?
    - ◯ Every day
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never
    - ◯ No rice cooker

21. How often do you leave the cordless phone at the charger station for the whole day?
    - ◯ Every day
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never
    - ◯ No cordless phone

22. How often do you leave the mobile phone charger plugged in overnight?
    - ◯ Every day
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never
    - ◯ No mobile phone

23. How often do you leave the light on at night when not in use to prevent burglars?
    - ◯ Always
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never

24. How often do you leave the light inside your house on when no one is at home to prevent burglars?
    - ◯ Always
    - ◯ Most of the time
    - ◯ Sometimes
    - ◯ Never

Part 4: Electricity Conservation Activities

25. Has the state of the economy and changes in the electricity tariff affected your habits regarding electricity use?
    ◯ Yes ◯ No

26. Do you look at your electricity usage when is printed on your bill each month?
    ◯ Yes ◯ No

27. How important is energy conservation to you?
    Please give score from 1–5, where 5 denotes very important and 1 denotes not important
    ◯ 1 ◯ 2 ◯ 3 ◯ 4 ◯ 5

28. During the last 10 months, has your family replaced the following electrical appliances with energy-efficient ones?

28.1 Air conditioner	◯ Yes	◯ No	◯ No air conditioner
28.2 Refrigerator	◯ Yes	◯ No	◯ No refrigerator
28.3 Lightbulb	◯ Yes	◯ No	◯ No lightbulb
28.4 Iron	◯ Yes	◯ No	◯ No iron
28.5 Television	◯ Yes	◯ No	◯ No television
28.6 Washing machine	◯ Yes	◯ No	◯ No washing machine
28.7 Electric shower	◯ Yes	◯ No	◯ No electric shower

    28.8 Others (please specify)………………………………………………..

29. How often do you clean the air filter in the air conditioner?
    ◯ Every three months
    ◯ Every six months
    ◯ Once a year
    ◯ Once every two years or more than that
    ◯ Never
    ◯ No air conditioner

30. What is your feedback on the monthly home electricity report?
    ◯ Haven't yet received the home electricity report.
    ◯ Received the reports but did not pay attention to them.
    ◯ Read the reports but the information had no impact on electricity consumption.
    ◯ Information contained in the reports did have an impact on households' electricity consumption.

[Thank You]

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