



Development of the “Home Energy Conservation Support Program” and its effects on family behavior



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HIGHLIGHTS

- The Home Energy Conservation Support Program was developed on the Internet.
- Energy reduction rates suggest it has prompted energy-saving behavior of members.
- It enables continuous estimation of energy consumption characteristics by attributes.
- Energy-saving for “lighting and electric appliances” is harder than for “heating”.

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ABSTRACT

The Home Energy Conservation Support Program in this study was developed by authors, available on the internet. This program was designed to promote residential energy conservation by encouraging family communication and rivalry against other families, and to get their energy consumption data sustainably for analysis. This paper describes the results of the program's performance evaluation through its implementation.

The program members can obtain evaluation results about their energy consumption by inputting their monthly energy consumption data and also utilize the information obtained to save energy in the future.

The estimated reduction rates in energy consumption of members suggest that the program has prompted energy-saving behavior among them, and that energy-saving for “lighting and electric appliances” is harder than for “heating”. Additionally, this program demonstrated the possibility of sustained investigation on energy consumption characteristics.

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1. Introduction

In Japan, effective measures for tackling global warming risks and natural resource depletion are required, particularly in the residential sector.

To encourage energy consumption reduction at home, it is important for the family to learn effective ways to save energy in their daily lives. It is considered indispensable to give feedback on energy consumption to the family. For the short-term, energy conservation support is important in promoting family knowledge, action, and continuation of energy-saving behavior by giving them evaluation results about their own energy consumption. For the long-term, it is important to analyze the relationship between family energy consumption and their attributes, as well as to utilize the obtained results for designing energy consumption systems and houses. This study is aimed at developing a mechanism to

provide feedback about residential energy consumption for both short-term and long-term perspectives. The effectiveness of the developed system is verified through its operation, as follows:

- Energy conservation support at home (for the short-term perspective). An incentive is provided for continuous energy conservation at home. For continuing energy conservation behavior, it is important to continuously provide family members with opportunities to conserve energy while enjoying themselves together. Providing feedback, such as data to compare usage with other families, helps to keep them interested in energy conservation.
- Continuous survey and analysis of energy consumption (for the long-term perspective).

Information on energy consumption and home attributes is continuously obtained and analyzed to consider changes in family attributes over time. The results of this analysis can be used as a basis for designing new houses.

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The website [1] was developed in support of residential energy conservation to visualize the information related to family energy consumption. The amount of CO₂ emission caused by consuming energy such as electric power, gas, water, and oil is also shown in graphs. The amount of energy consumption for previous years and their mean values by housing type or by the number of household members are also available in this website. Simply providing the mean of energy consumption, however, cannot lead the users to recognize their relative position in a society. Thus, this website is not considered fully effective to be promoting energy conservation of the users. Internet-based tool with tailored feedback of energy consumption [2] also showed the effects on households energy consumption. But this research took place about only 5 months and they did not mention about the long-term perspective. Additionally, no mechanism has been developed to help families conserve energy while enjoying themselves together in these internet-based tools. Another example of the prevailing tools to encourage energy conservation is “energy consumption monitoring equipment [3,4]”. Although the equipment informs the family of the amount of electric power consumption, it provides no information for comparison with other families.

Many energy-consumption surveys in the residential sector have been executed, and their results have been partly open to the public [5–9]. However, the relationship between energy consumption and family attributes such as family member characteristics and houses has not been investigated. In Ref. [10], electric power and gas consumption data levels were measured in 30-minute intervals by using an energy-consumption information system, and the energy consumption characteristics in the residential sector were then analyzed. The consumption levels, however, were only collected within a limited period, and their relationship to family attributes has not been reported. In Ref. [11], large-scaled questionnaire surveys were conducted and the relationship attributes were studied. The surveys, however, were not conducted continuously, and the changes in energy consumption within samples were not analyzed.

This paper first describes the characteristics of the Home Energy Conservation Support Program (referred to as the “program” hereafter) developed in this study. Then, the estimated results of energy consumption reduction efforts through the program’s implementation are shown, and lastly, the effectiveness of the program is verified.

2. Development of the Home Energy Conservation Support Program

The program has been accessible on the Internet since 2002 [12], and anyone can register as a member of the program for free. The design guidelines and features of the program are listed in Table 1.

For supporting energy conservation at home, it is important that a cycle of guidelines (1) through (4) in Table 1 be continuously repeated. Understanding the results of actions ((3) in Table 1) encourages families to progress to the next step. To make that progress, information such as changes in energy consumption and the rank and distribution of energy consumption by attributes compared to other members are provided to them. The data related to energy consumption are represented in the amount of electric power, gas, oil, water, and in the CO₂ equivalent. The data helps them to understand how the reductions compare to the previous year, seasonal energy consumption changes, and their rank among the members. When parents and children enjoy the program, they are encouraged to continuously utilize it. Therefore, interfaces that interest both parents and children are very important ((iv) in Table 1). This program provides the interface that families can utilize together while enjoying themselves [13].

It is important to accumulate residential energy consumption information in order to continuously improve system and house design. The program enables continuous accumulation of data about the amount of energy consumption among members and the analysis of the relationship between energy consumption and home attributes.

The data flow related to energy consumption in the program is based on the guidelines from Table 1 and is shown in Fig. 1. The amount of electricity, gas, water, oil, and occasionally gasoline that is consumed, as well as the weight of garbage from the house is input on a monthly basis by members. The input data is sent to the arithmetic module of the program, and then the evaluation results are output immediately for planning subsequent member energy conservation actions.

The membership levels and the attributes of members participating in the program are listed in Table 2. Membership has been increasing by about 200 individuals per year. Female members increased slightly from 2004 to 2005. There have been no observable changes among age groups, housing types, or average household sizes.

3. Verification of the effects of support for residential energy conservation

First, the changes in annual energy consumption for the families participating in the program are shown. Then, the effectiveness of the program for “i. energy conservation support at home” is verified based on total energy consumption reduction and energy consumption reduction by usage, that is, “heating”, “cooling”, “hot-water supply”, “lighting and electric appliances”, and “kitchen appliances”. The adopted energy conversion factor in this paper is 3.6 MJ/kW h for electric power, gross heating value for town gas, 110.3 MJ/m³ N for LPG, and 37.3 MJ/liter for oil.

Table 1
Guidelines and features for home energy-conservation support.

Guidelines	Features
(1) Understand the need	Explanation and learning of background and importance
(2) Plan energy-conservation actions	Energy-conservation diagnosis and list of goals of actions
(3) Recognize and understand the results of actions	Input and understanding of energy consumption data Presentation of the results of evaluation of actions Comparison of time-based energy consumption data for oneself (CO ₂ emissions graph and graphs for different energy sources), comparison with the results of other members (ranking and distribution), presentation of environmental impact
(4) Keep interested (provides interface for family members to share)	Comparison with the results of other members (ranking and distribution) Use of characters Statements of commendation or encouragement Mini games

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