Effect of Energy Saving Campaign in Fukushima

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1. Introduction

Expectation of a distributed local energy system is growing to utilize local energy sources and to develop resilient energy supply system after the Great East Japan Disaster of 2011. Especially some municipal governments in Tohoku region promote to develop it not only for development of the resilient energy system but also for the reconstruction from the disaster [1]. The data related to energy demand, such as the amount of demand, price elasticity, and energy saving potential, are useful to design adequate system for the area. These data are also expected to mitigate brown out during the peak demand period.

There are some existing empirical studies focusing on the energy demand side in Japan. Ito et al. (2015) investigated the influence of moral suasion and economic incentives to electricity demand by using household-level consumption data in Keihanna area of Kyoto prefecture [2]. Mukai et al. (2015) estimated the peak and daily demand saving effect by the four interventions; economic incentives, real time feedback, weekly advice report, and peak alert [3]. However, these studies are focused on the urban area. Thus it is necessary to identify the effect of demand side management in the rural area where the development of the distributed local energy system is expected.

In this study, we estimated the effect of energy saving campaign, which encourage reducing electricity demand by visualizing their demand data and providing advice reports, in Shinchi Town in Fukushima prefecture, Japan. In the Great East Japan Disaster of 2011, this town has suffered enormous human and physical loss. In 2012, it was selected as an FutureCity, and are reconstructing with harmonizing regional society, economy, and environment. A distributed local energy system is also planned in this town. Thus, the result of this study can help it as local energy demand data.

2. Methods

Effect of energy saving campaign was estimated by following three steps. First, we recruited the household who adopt the electricity monitoring and distributed the monitoring system. Next, the

energy saving campaign was conducted to the household who confirmed their participation. Finally, effect of energy saving campaign was estimated by statistical analysis using monitoring data.

2.1. Installing the electricity monitoring system

We distributed power monitoring system and tablet computer to about 62 households lived in detached houses in Shinchi Town in Japan from June 2014 to March 2015. Electricity consumption of household total and 6 selected lines were measured by 15 minutes' step. Hourly electricity consumption of individual household is visualized by the dedicated application in the tablet computer. The dedicated application has seven functions; the electricity visualization, the regional information map, the regional bulletin board, health support advice, disaster information, the online questionnaire, and the What's New in the local municipality. The frequency of using each function in the application is also monitored. Note that although the number of participants is relatively small for the statistical analysis, the participants had already reached more than 2% of total households in Shinchi Town. Thus, it is future task to recruit large scale sample not only Shinchi Town but surrounding municipality to increase the possibility of statistical analysis.

2.2. Designing the energy saving campaign

Energy saving campaigns was implemented three times in the fiscal year 2014; September 8th to 21st, November 5th to 18th, and March 8th to 21st. We asked the households about the participation in the energy saving campaign through the tablet for approximately one week before the campaign. 22 and 12 households of 50, and 24 households of 57 were participated to each campaign, respectively.

Households can browse the campaign webpage, shown in the Figure 1, during the campaign periods. The webpage includes four contents; the mean energy saving rate for individual household and all participants, the trend of electricity consumption for individual household, the latest ranking in all participants, and the ranking trend during the campaign for individual household. Non-participated households can only see the mean energy saving rate for all participants and other contents are not available. The energy saving rate are calculated based on the mean daily electricity consumption of each household in one week before the campaign. Note that the above energy saving rate is calculated just for providing the information to the household and not equal to the effect of energy saving campaign estimated by the method explained in section 2.3. The flower circle mark is given to the households whose energy saving rate is positive and whose ranking is higher than the sixth to mitigate the boomerang effect, the phenomenon that the households whose energy consumption is lower than the average get relaxed and increase their energy consumption by learning that their energy consumption is lower than the average in a household energy conservation context. The regional coupons, equivalent to 1,600, 1,200, and 800 yen, respectively, are given to the top three households for the incentive of energy saving. Specific information about the reward is not announced to the participants before the campaign excluding the third campaign.

Before the third campaign, the advice report of electricity use, shown in Figure 2, is provided.

The advice report is customized for each household using the electricity monitoring data collected before the campaign. The advice report includes the following contents; (a) trend of daily electricity consumption per person, (b) the mean hourly electricity consumption per person in winter, (c) the proportion of electricity consumption by intended purpose in autumn and winter, and (d) the suggested electricity saving measures for individual household. The data of all participants and non-all-electric home / all-electric home are also depicted for the contents (a) and (b).

* This mark is equivalent to the “gold star” in Japan

Figure 1 Campaign webpage

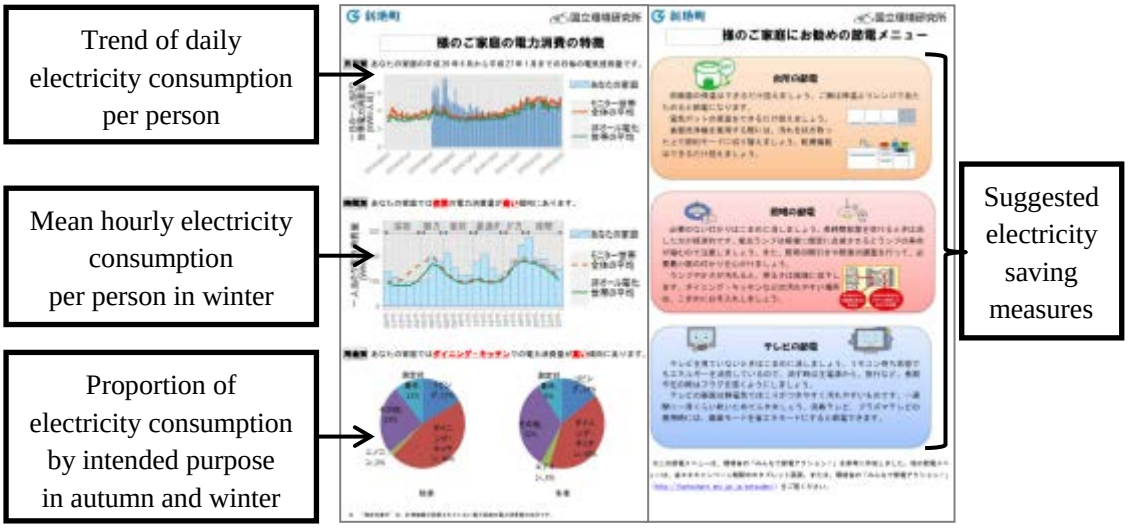

Figure 2 Example of advice report for electricity use

2.3. Estimating the effects of energy saving campaign

Effect of energy saving campaign was estimated by following fixed-effect model following the existing study [2]:

$$\ln y_{it} = \alpha + \beta x_{it} + \gamma W_t + \theta_i + e_{it} \quad (1)$$

where y_{it} is total daily electricity consumption in household i in day t. x_{it} equals 1 if household

i participate the energy saving campaign in day t. W_t is a matrix which related to electricity consumption such as mean temperature in day t, mean temperature in previous three days, mean humidity in the day t, and weekday dummy. θ_i is fixed effect of household i. α is intercept, β and γ are estimated coefficients for each variables, and e_{it} is error term.

Daily electricity consumption data of 48, 45, and 53 households were used in the analysis after the exclusion of the household with missing value although the numbers of participated households were 50 in the 1st and 2nd campaign and 57 in the 3rd campaign. We employed the difference-in difference design and the data from the pre-experiment days and treatment days were included in the fixed-effect model.

3. Results and discussion

Table 1 shows the results of regression analysis. The number in the brackets is the standard error. Because we use the natural log for the explained variable, the values in the table are log points. The effects in the exact percentage term can calculated by $\exp(\beta) - 1$. The variables which related to electricity consumption are statistically significant excluding mean temperature in the previous three days in the second campaign. Row 1 in Table 1 shows the effects of energy saving campaign on daily electricity use. The first energy saving campaign in September has a negative effect to the electricity consumption by 0.01 log points (0.96 percent) with statistically insignificant. The second campaign in November has a positive effect by 0.05 log points (5.09 percent). One of the reason may be due to the wearout effect according to the analysis with the application use data explained in the next paragraph. The third campaign which distributes the advice report of electricity use caused a reduction in daily electricity consumption by 0.029 log points (2.86 percent) with statistically significant (1 percent level).

Table 1 Effects of Energy saving campaign on daily electricity use

	1st campaign	2nd campaign	3rd campaign
Energy saving campaign	-0.010	0.050***	-0.029***
	(0.012)	(0.016)	(0.009)
Mean temp. in the day	0.008***	-0.018***	-0.025***
	(0.002)	(0.002)	(0.001)
Mean temp. in the previous three days	0.020***	-0.001	-0.006***
	(0.003)	(0.002)	(0.002)
Mean humidity in the day	0.001***	0.002***	0.001***
	(0.000)	(0.000)	(0.000)
Weekday dummy	-0.031***	-0.023***	-0.046***
	(0.007)	(0.007)	(0.006)

Intercept	1.844***	2.714***	2.940***
	(0.051)	(0.028)	(0.017)
N (# of household)	48	45	53

Significant code: *** 1%, no symbol >10%. The number in the brackets is the standard error.

Figure 3 shows the median of application use per week by participants and non-participants in each campaign. Basically, the frequencies of application use of participants are higher than that of non-participants in every period. This implies that the participants have higher interests in the application use includes checking their electricity consumption. Comparing to the application use by participants among the campaigns, the frequency of application use in first week in the second campaign was low (0.5 times in a week). This may be caused by the decrease of interest due to repeating the same campaign. The increase of application use in second week in the second campaign may be attributed to the checking their final ranking because most of application use were concentrate near the last campaign day. The use in the first week in the third campaign was high. This may occur due to two reasons; visiting to each household in the week before the campaign and distributing the advice report of electricity use.

The application use in the second campaign period which has positive effect to the electricity consumption was low and that in the third campaign which has negative effect was high. In addition, the application use may be related to the interests in the application and campaign. Thus, the application use may explain the effect of energy saving campaign. It is useful to analyze causal connection with the application use, the energy saving conscious, and the effect of the energy saving to identify the way to promote the energy saving effects.

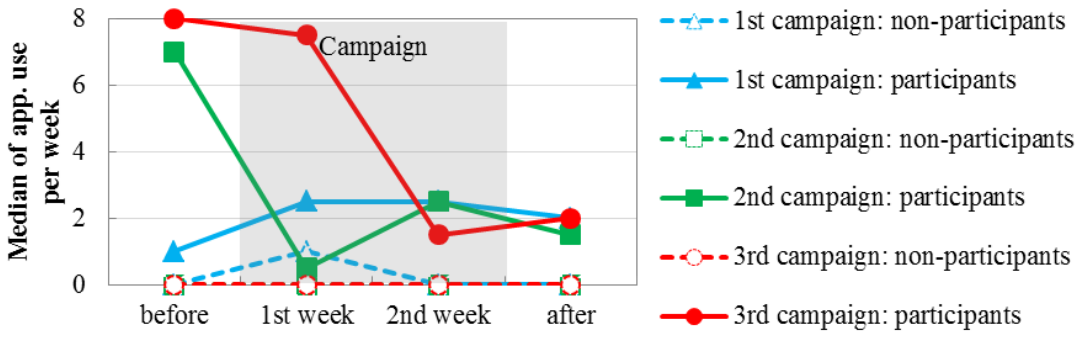

Figure 3 Median of app. use per week by participants and non-participants

This study which focused on detached houses in the rural area shows relatively small effect compare to the existing study which reported 10.1 percent decrease in the multiple dwelling houses in urban area [3]. The reason of the difference may attribute to the household size. The

average household size in this study was 4.3 while that in the existing study was 2.6. Some participants argued that some members in their house were not interested in and uncooperative to the campaign in the hearing survey. The possibility of uncooperative participants would rise by increasing household size. Thus the incentive for the uncooperative participants might be the key to increase the effect of the campaign detached houses in the rural area.

4. Conclusion

In this study, we present the results of monitoring survey to evaluate the effect of energy saving campaign in Shinchi Town in Fukushima prefecture, Japan. The campaigns were implemented three times in the fiscal year 2014 and effect of energy saving campaign was estimated by fixed-effect model. The results showed that the first and third campaigns have 0.96 percent and 2.86 percent of negative effect to the electricity consumption. The advice report of electricity use may enhance the negative effect. The second campaign has 5.09 percent of positive effect to the electricity consumption. This may be due to the “wear-out” effect. The application use in the second campaign period which has positive effect to the electricity consumption was low and that in the third campaign which has negative effect was high. It is necessary to establish the system to continuously promote the energy saving motivation of household.

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