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# A Causal Analysis of the Impact of Understanding Energy Conservation Goal and the Anxiety of a Power Failure on Household Power Savings

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**Abstract**

We design a new model depicting an individual's energy-conserving intention-behavior-effect process in consideration of societal influence and societal impact based on previous studies to clarify the determinants of pro-environmental behavior. The validity of the model is verified by structural equation modeling (SEM), using results from a citizens' survey. By using this model, the difference in the situation according to location (Tokyo, Osaka) and time (summer 2011, winter 2011) clarifies the difference between the influence on individual decision-making and the effect process by multiple group analysis.

The results show that the understanding of energy conservation goal makes for energy-conserving intention, evokes energy-conserving behavior, and contributes to the energy conserving effect. Further, anxiety of a power failure raises energy-conserving intention. Finally, there is no significant difference in path coefficients between the understanding of energy conservation goal and the anxiety of a power failure in Tokyo.

Key words: energy-conserving behavior, electricity, determinants, structural equation modeling

## 1. Background and Purpose

In recent years, the electricity demand in the residential sector has increased more rapidly than in the industrial sector (The Institute of Energy Economics, Japan, 2012). In addition to controlling the electricity demand (kWh) for global warming prevention, control of the maximum power (kW) to the electric power supply uneasiness of these days is also called for.

Research that clarifies the determinants of pro-environmental behavior of the individual, such as energy conservation and waste prevention, is conducted mainly in the field of social psychology based on models, such as the Theory of Planned Behavior (Ajzen, 1991) and Norm Activation Theory. Moreover, many studies have been conducted to improve these models (Hirose, 1995; Perugini and Bagozzi, 2001; Bamberg and Schmidt, 2003; Fujii, 2003; Misaka, 2003; Murakami, 2008; Kurishima et al., 2012; Maeda et al., 2012).

In some studies, typified by the Hirose model (1995) (Fig. 1), emphasis is placed on the mental process leading to an individual's pro-environmental behavior (subjective evaluation of the frequency of the behavior, etc.). Further research is needed on the decision-making process for eliminating gaps in awareness and behavior. Therefore, the impact on society of the effect of individual behavior has not been subject to analysis.

In this study, we evaluate not only a subjective awareness of the need for behavior and actual behavior, but also the objective effect of the behavior through the intention → behavior → effectiveness process. Thereby, this study is focused on the effects of the pro-environmental behavior clarification process concerning environmental impact reduction in order to advance the previous studies on the decision-making process of pro-environmental behavior.

In addition to understanding the subjective energy-conserving motivation and behavior, we conducted a study in accordance with the decision-making process and behavioral effects that target the energy conservation rate in the home using the process of

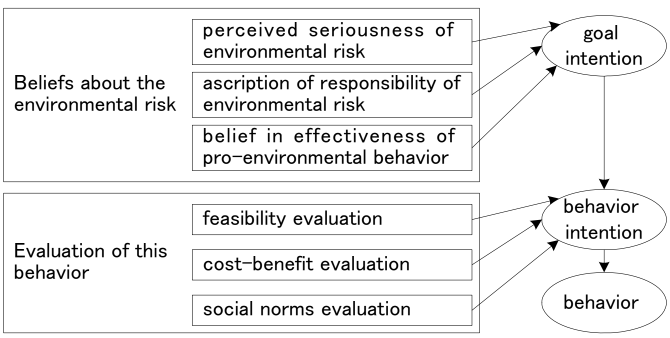


Fig.1 The theoretic model of Hirose (1995)

energy-conserving intention → energy-conserving behavior → energy conservation rate. In addition to the gaps in awareness and behavior shown in previous studies, we examine the gap between behavior and effect. We can consider including the effectiveness of an energy-conserving effect in addition to the feasibility of energy-conserving behavior. For the first time, we can clarify the effects of actual decision-making and behavioral processes leading to energy conservation in the home, and knowledge of the factors that contribute to the expansion of the energy-conserving effect is acquired.

We considered external factors resulting from the Great East Japan Earthquake, which has a psychological influence on the process behavior, intention, and energy-conserving effect. More specifically, the factors were set according to two phenomena. The first is an energy-conserving request as part of an energy conservation goal set by the government, etc. Second, the power failure immediately after the earthquake disaster, and rolling blackouts (32 times total) out of a total of 10 days to 28 days of March 14, 2011 in the Tokyo Electric Power district.

Thereby, we can analyze the social impact of energy conservation, as well as the social events that affect the intention of energy conservation. This model studies the process of decision making and the behavioral effects after taking into consideration an explicit point of contact with society.

In this study, we design a new model concerning the energy-conserving effect process of the individual while considering the influence from society and the impact on society based on previous studies to clarify the determinants of pro-environmental behavior. The validity of the model is verified by structural equation modeling (SEM) using a citizen survey result. In addition, using this model, the differences according to the area (Tokyo, Osaka) and time span (summer of 2011, winter of 2011) are clarified with respect to their influence on an individual's decision-making and effect process.

## 2. Analytical methods

### 2.1 Setting a theoretical model

We assume the theoretical model of the energy-conserving intention-behavior-effect process as shown in Fig. 2. "Target cognition" (knowledge of the contents of an energy conservation goal) and "blackout fears" (anxiety and fear concerning blackouts) are the structures that affect each element of the "energy-conserving intention" → "energy-conserving behavior" → "energy conservation rate" model.

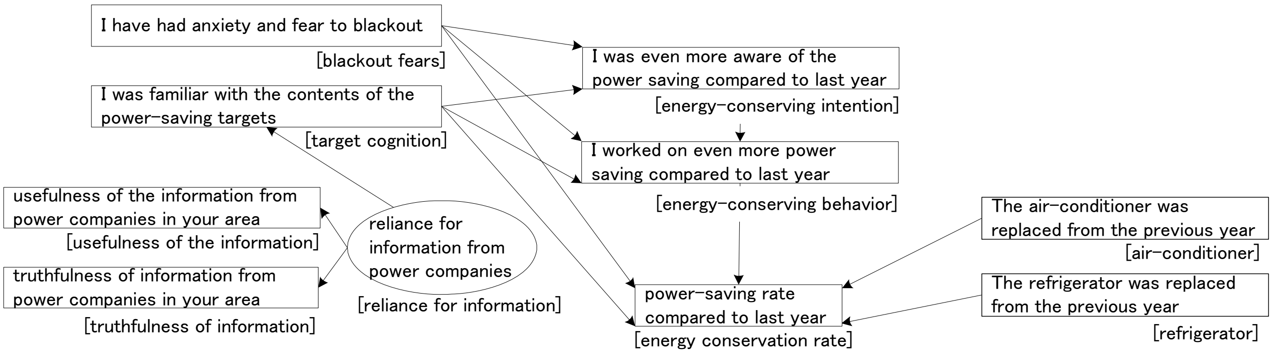


Fig.2 The theoretic model of this study

Table 1 Overview of the energy conservation goal by the Government

| | Summer 2011 | | Winter 2011 | |
|---|---|---|---|---|
| | Tokyo Electric Power Company district | Kansai Electric Power Company district | Tokyo Electric Power Company district | Kansai Electric Power Company district |
| target | ▲15% | More than ▲10% | Power-saving without a numerical target | More than ▲10% |
| period | 7/1-9/22(weekday) 9am-8pm | 7/25-9/22(weekday) 9am-8pm | 12/1-3/30(weekday) 9am-9pm | 12/19-3/23(weekday) 9am-9pm |
| setting time | 5/13 | 7/20 | 11/1 | 11/1 |
| remarks | A large-lot user is asked for ▲15%, based on Article 27 of the Electric Utility Law(willful violation is a penalty). | Union of Kansai Government called for ▲10% (5/26), Kansai Electric Power Company called for ▲15% (6/10) | Government called for reasonable power-saving | Government, Union of Kansai Government, and Kansai Electric Power Company called for more than ▲10% |

Source: Ministry of Economy, Trade and Industry

"Target cognition" and "blackout fears" are the factors that assume the effect of the two phenomena mentioned above. They include energy conservation requests by the government etc., and the implementation of rolling blackouts.

Target cognition is knowledge of the energy conservation goal and time period (Table 1), which are published by the government before the summer (winter) in order to promote a sense of crisis and responsibility. This model considers what kind of influence this has on the energy-conserving intention, behavior, and rate.

For blackout fears, we consider the inconvenience caused by an actual experience, or the preparation for a power outage, etc. and how it plays a role as a psychological factor. It is considered what kind of influence this has on the energy-conserving intention, behavior, and rate.

Moreover, the path of "reliance for information" → "target cognition" was set. Much of the information about energy conservation goals was sent from an electric power company. Thus, "information reliance" is measured by "usefulness of information" (the usefulness of the information from the power company) and "truthfulness of information" (reliability of the information from the power company), and determines the extent of access to the information of the power companies and the sensitivity and attention to the information, etc.

Furthermore, we set paths from “air conditioner” (the air conditioner was replaced after the previous year), and “refrigerator” (the refrigerator was replaced after the previous year) to the “energy conservation rate.” It is expected that any change from older equipment with heavy electricity use such as an air conditioner or a refrigerator will save electricity.

### 2.2 Analytical methods

First, based on the questionnaire data acquired from the citizens as well as consideration of the components of Fig. 2, we verified the validity of the theoretical model by structural equation modeling.

Then, after comparing the level of the components for each area (Tokyo, Osaka) and time (summer of 2011, winter of 2011), the differences in the situation according to the area and time were analyzed by multiple group analysis, with respect to their influence on the energy-conserving intention, behavior, and effect process. Multiple group analysis is the method of verification of the factor structure and the differences in the causal relationship in two or more groups. In this case, while verifying the validity for every group of the model structure to each group classified by area and time, the differences in the path coefficients for each group are verified.

### 2.3 Questionnaire methods

The questionnaire was administered in October 2011 and again in April 2012. The first questionnaire was on the energy-conserving situation in the summer of 2011 and was targeted towards a full-time housewife who was typically at home on weekdays in summer (July–September) 2011 and 2010. Among them mentioned above, we selected the subject without major changes in the external environment (no move, no renovation and extension of residence, no change in the number of people living together, no solar power installation) that affect the demand for electricity in the period. We conducted a survey of 800 people, from ages 20–50, living in Tokyo and Osaka. The age demographics chosen were commensurate with the 2005 census data.

The second questionnaire was on the energy-conserving situation in the winter of 2011 and was administered to candidates meeting the criteria mentioned above, along with to full-time housewives who were typically at home on weekdays of winter (January–March) 2011 and 2010. The number of valid replies was 788 for the first questionnaire, and 794 for the second.

In this study, we surveyed housewives who were generally at home during the day on weekdays. Households that are empty during summer afternoons have a power demand of about 340 W; for households with someone home during summer afternoons, the demand rises to about 1200 W. Therefore, it is assumed that there is a large potential for energy conservation, and that the relationship among the energy-conserving intention → energy-conserving behavior → energy conservation rate is very visible in households that are occupied at that time of the day.

## 2.4 Measurements

### 2.4.1 Energy conservation rate

To calculate the energy conservation rate, we inspected the meter receipts sent to homes from the power company. In addition to the electricity demand (kWh) and the electricity demand days for last month, the meter receipts describe the same information at the same month last year. From these, the energy conservation rate was determined by comparison of the kWh/day during equivalent periods of 2010 and 2011.

Since meter inspection is not necessarily conducted on the same day across homes, we cannot take the electricity demand as one month (e.g. 8/1–8/31) by inspecting a meter receipt. However, the meter inspection day of every month for every local block is the same every year, so that these can be compared, as the kWh in 2010 and 2011 from the meter receipt represent the electricity demand in nearly the same period. Incidentally, since an inspection of a meter day may shift due to the position of Saturdays and Sundays, and the days of an inspection period covered may differ slightly, we compare kWh/day instead of kWh for an entire month.

Fig. 3 shows a histogram of the rate of change of the power demand (kWh/day) by area (Tokyo, Osaka) and time period (summer, winter). A negative value is considered an “energy conservation rate.” The average rate of change is -17.2% in the summer in Tokyo, -13.7% in the summer in Osaka, -0.4% in the winter in Tokyo, and +2.5% in the winter in Osaka.[1)]

### 2.4.2 Other items

“Energy-conserving behavior” was measured on a six point scale of “strongly agree,” “agree,” “somewhat agree,” “somewhat disagree,” “disagree,” and “strongly disagree” in response to the question of “compared to last summer (winter), this summer (winter) I concentrated more on conserving energy.”

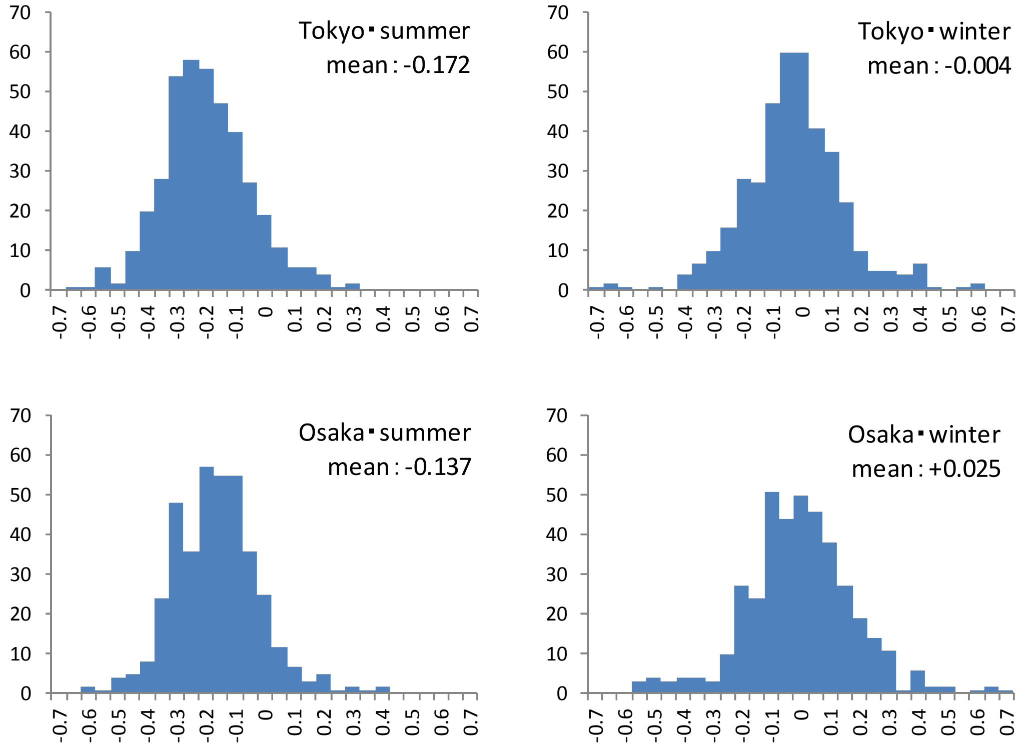


Fig. 3 The histogram of the rate of change of the power electricity demand (kWh/day)

Table 2 Descriptive statistics

| | | Summer 2011 (N=788) | | Winter 2011 (N=794) | |
|---|---|---|---|---|---|
| | | Mean | SD | Mean | SD |
| energy conservation rate | Based on the votes meter reading, power-saving rate of the kWh/day of the same period in summer (winter) 2010 and summer (winter) 2011 | 0.15 | (0.15) | -0.01 | (0.18) |
| energy-conserving behavior | Compared to last summer (winter), this summer (winter), I worked on even more power saving | 4.89 | (1.07) | 3.96 | (1.16) |
| energy-conserving intention | Compared to last summer (winter), this summer (winter), I was even more aware of power saving | 5.03 | (1.01) | 4.11 | (1.16) |
| target cognition | I was familiar with the contents of the power-saving targets by government and power companies | 3.92 | (1.10) | 3.37 | (1.12) |
| blackout fears | I was anxious and scared of a blackout | 3.82 | (1.39) | 3.31 | (1.27) |
| usefulness of the information | Power companies in your area provide useful information for stable power supply and demand | 3.35 | (1.11) | 3.11 | (1.11) |
| truthfulness of information | Power companies in your area tell the truth for a stable power supply and demand | 3.15 | (1.17) | 3.04 | (1.16) |
| air-conditioner | Equipment was replaced after September (March) of last year (1) or the equipment that was available from before August (February) of last year (0) | 0.05 | (0.21) | 0.03 | (0.17) |
| refrigerator | Equipment was replaced after September (March) of last year (1) or the equipment that was available from before August (February) of last year (0) | 0.07 | (0.25) | 0.04 | (0.20) |

Similarly, as shown in Table 2, "energy-conserving intention" was measured on a six point scale in response to the question of "compared with last summer (winter), this summer(winter) I was more aware of conserving energy." 'Target cognition," "blackout fears," "usefulness of information," and 'truthfulness of information" were measured by the responses to the following questions: "I was familiar with the energy conservation goals set by the government and power companies," "I have had anxiety and/or fear of blackouts," "the power companies in your area provide useful information for a stable power supply and demand," and "The power companies in your area tell the truth for the sake of a stable power supply and demand," respectively.

Moreover, “air conditioner” and “refrigerator” were measured according to “the equipment that was available before August (February) of last year” counted as zero points and “equipment that was replaced after September (March) of last year” counted as one point.

## 3. Verification of the theoretical model

The descriptive statistics of the components of the theoretical model are given in Table 2. The values in summer are larger than in winter, and there are significant differences except for “air conditioner” (Table 3). In addition, “target cognition” and “blackout fears” in winter, and “usefulness of information” and “truthfulness of information” in summer and winter are less than midpoint 3.5 away from the midpoint.

With the theoretical model of Fig. 2, the differences in these elements are predicted to lead to a difference in the energy conservation rate in summer and winter. Next, the theoretical model is verified.

Using these data, the theoretical model for Fig. 2 was analyzed by structural equation modeling for both summer and winter. To ensure the identification, restrictions were imposed on the path coefficient from “information reliance” to “usefulness of information,” fixing the path coefficient to one. As a result, calculations using the maximum likelihood method show that in both summer and winter, the paths “blackout fears” → “energy-conserving behavior,” “blackout fears” → “energy conservation rate,” and “target cognition” → “energy conservation rate” were not significant at the 5% level. Therefore, we show the model in Fig. 4 by omitting these paths.

This analysis showed that the fit was acceptable: GFI = 0.986, AGFI = 0.976, CFI = 0.991, and RMSEA = 0.034 in summer; and GFI = 0.966, AGFI = 0.940, CFI = 0.962, and RMSEA = 0.070 in winter. Based on these results, the process by which

Table 3 Test of the difference between the average of summer and winter

| | t value |
|---|---|
| energy conservation rate | 19.57 ** |
| energy-conserving behavior | 16.61 ** |
| energy-conserving intention | 16.84 ** |
| target cognition | 9.96 ** |
| blackout fears | 7.71 ** |
| usefulness of the information | 4.26 ** |
| truthfulness of information | 2.00 * |
| air-conditioner | 1.76 |
| refrigerator | 2.03 * |

Note: ** $p < 0.01$, * $p < 0.05$

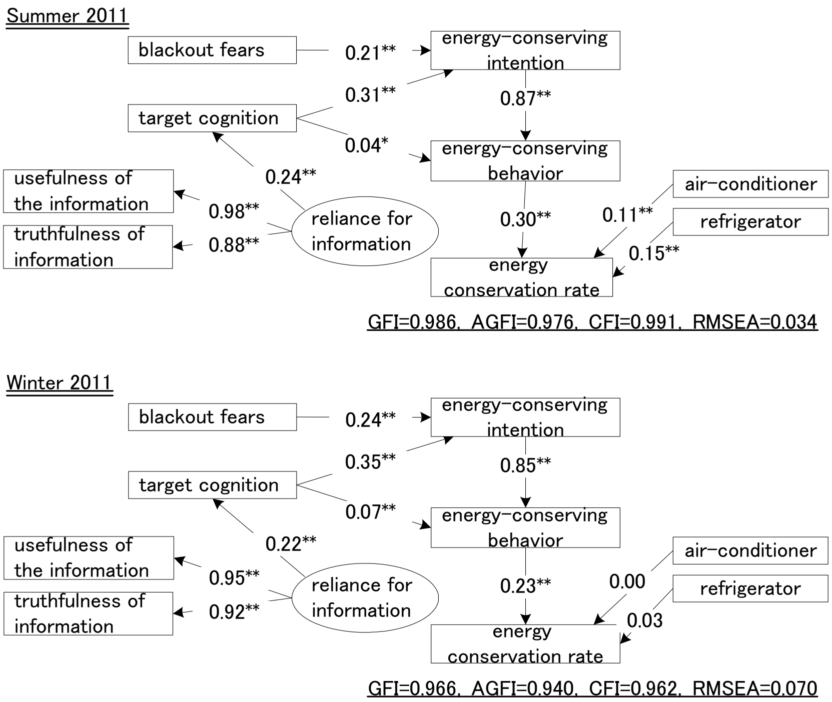


Fig.4 The analysis result of the theoretic model by structural equation modeling

Note: ** p< 0.01, * p< 0.05, All coefficients are based on the standardized solution, Error variable and disturbance variable are omitted.

"target cognition" contributes to "energy conservation rate" by affecting "energy-conserving intention" and "energy-conserving behavior" was proven. Moreover, "blackout fears" contributes to "energy conservation rate" indirectly by affecting "energy-conserving intention." Furthermore, "information reliance" affects "target cognition."

Unlike the assumption by the theoretical model of Fig. 2, "target cognition" and "blackout fears" were not direct determinants of "energy conservation rate." These results show that simply being aware of energy conservation goals and feeling uneasy about power failure do not improve the energy conservation rate automatically. In the process of energy-conserving intention → energy-conserving behavior → energy conservation rate, "target cognition" and "blackout fears" affect "energy-conserving intention" or "energy-conserving behavior," and their contribution to the energy conservation rate was shown indirectly.

Here, when the path coefficients of "target cognition" → "energy-conserving intention" and "blackout fears" → "energy-conserving intention" in summer are compared, "target cognition" → "energy-conserving intention" (0.31) is larger than "blackout fears" → "energy-conserving intention" (0.21) ($z = 3.350$, $p < 0.01$). Even in winter, "target cognition" → "energy-conserving intention" (0.35) is larger than "blackout fears" → "energy-conserving intention" (0.24) ($z = 3.398$, $p < 0.01$). About the contribution to "energy-conserving intention," it was shown that "target cognition" is relatively larger than "blackout fears” in both summer and winter.

Moreover, “air conditioner” → “energy conservation rate” and “refrigerator” → “energy conservation rate” were significant only in the summer. In winter, it is possible that there is use of air-conditioning equipment other than an air-conditioner, and that outside air temperature is low and the power consumption of a refrigerator is relatively small.

## 4. Results by area and time

### 4.1 Difference in the average by area and time

The descriptive statistics by area (Tokyo, Osaka) and time (summer, winter) are given in Table 4. When compared by area, “energy conservation rate” of Tokyo is larger than Osaka, and in Tokyo “energy-conserving behavior,” “energy-conserving intention,” “target cognition,” and “blackout fears” are also larger with significant differences (Table 5).

However, regarding “usefulness of information” and “truthfulness of information,” the value of Osaka is large ($p < 0.01$). From this, the relative unreliability of the information from the Tokyo Electric Power company is indicated.

Table 4 Descriptive statistics by group of area and time

| | summer 2011 | | | | winter 2011 | | | |
|---|---|---|---|---|---|---|---|---|
| | Tokyo (N=399) | | Osaka (N=389) | | Tokyo (N=397) | | Osaka (N=397) | |
| | mean | SD | mean | SD | mean | SD | mean | SD |
| energy conservation rate | 0.17 | (0.15) | 0.14 | (0.15) | 0.00 | (0.18) | −0.03 | (0.19) |
| energy-conserving behavior | 5.07 | (1.06) | 4.72 | (1.06) | 3.98 | (1.18) | 3.93 | (1.14) |
| energy-conserving intention | 5.19 | (0.95) | 4.86 | (1.04) | 4.12 | (1.19) | 4.10 | (1.14) |
| target cognition | 4.05 | (1.08) | 3.79 | (1.12) | 3.32 | (1.12) | 3.41 | (1.13) |
| blackout fears | 4.33 | (1.33) | 3.31 | (1.26) | 3.63 | (1.34) | 2.98 | (1.10) |
| usefulness of the information | 3.16 | (1.16) | 3.55 | (1.01) | 2.93 | (1.15) | 3.30 | (1.04) |
| truthfulness of information | 2.93 | (1.22) | 3.38 | (1.07) | 2.84 | (1.20) | 3.24 | (1.08) |
| air-conditioner | 0.05 | (0.21) | 0.04 | (0.20) | 0.03 | (0.16) | 0.03 | (0.17) |
| refrigerator | 0.07 | (0.26) | 0.06 | (0.24) | 0.05 | (0.21) | 0.04 | (0.20) |

Table 5 Test of the difference in the average among areas (t-value)

| | summer 2011 | winter 2011 |
|---|---|---|
| | Tokyo-Osaka | Tokyo-Osaka |
| energy conservation rate | 3.31 ** | 2.22 * |
| energy-conserving behavior | 4.60 ** | 0.58 |
| energy-conserving intention | 4.66 ** | 0.24 |
| target cognition | 3.24 ** | 1.20 |
| blackout fears | 11.11 ** | 7.49 ** |
| usefulness of the information | 5.06 ** | 4.77 ** |
| truthfulness of information | 5.50 ** | 4.99 ** |
| air-conditioner | 0.26 | 0.21 |
| refrigerator | 0.48 | 0.35 |

Note: ** $p< 0.01$, * $p< 0.05$

Table 6 Test of the difference in the average among time (t-value)

| | Tokyo | Osaka |
|---|---|---|
| | summer-winter | summer-winter |
| energy conservation rate | 14.45 ** | 13.32 ** |
| energy-conserving behavior | 13.59 ** | 9.96 ** |
| energy-conserving intention | 14.09 ** | 9.83 ** |
| target cognition | 9.39 ** | 4.77 ** |
| blackout fears | 7.36 ** | 3.83 ** |
| usefulness of the information | 2.79 ** | 3.43 ** |
| truthfulness of information | 1.12 | 1.87 |
| air-conditioner | 1.48 | 1.00 |
| refrigerator | 1.50 | 1.36 |

Note: ** $p < 0.01$, * $p < 0.05$

In winter, in addition to “usefulness of information” and “truthfulness of information,” the value of Osaka’s “target cognition” is larger than Tokyo’s. As shown in Table 1, in winter, there was an energy conservation goal without a numerical target in Tokyo, while Osaka set up a unified goal. However, these are not significant differences as shown in Table 5. Moreover, the significant difference in “energy-conserving behavior” and “energy-conserving intention” between Tokyo and Osaka in the summer do not exist in the winter. On the other hand, also in winter, the value for “blackout fears” is larger in Tokyo than in Osaka with a significant difference ($p < 0.01$). These results are assumed to be due to the inconvenience of actual experiences of power failure immediately after an earthquake and preparation for rolling blackouts within the Tokyo Electric Power company district in spring 2011.

Next, comparing the time periods, all elements in winter are lower compared with their values in summer. According to Table 6, the elements show a significant difference ($p < 0.01$) excluding “truth of information,” “air conditioner” and “refrigerator.” Moreover, when the difference from the average value is considered, “blackout fears” of Osaka in summer was less than the midpoint 3.5, and “usefulness of information” of Osaka in summer and “blackout fears” of Tokyo in winter exceeded the midpoint 3.5. These results express the regional difference of Tokyo and Osaka, and the time difference of summer and winter.

### 4.2 Multiple group analysis by area and time

First, the four groups, classified by area and time, were analyzed by assuming disposed unchanged (placement of the path matches. the path coefficients may not be equal), in order to verify whether the same factor structure is materialized. By deleting the non-significant paths, we arrived at the structure shown in Fig. 4 and the goodness of fit of the model was acceptable with GFI = 0.961, AGFI = 0.932, CFI = 0.963, RMSEA = 0.0343.[2)]

Table 7 The analysis result according to area and time by multiple group analysis

| | summer 2011 | | winter 2011 | |
|---|---|---|---|---|
| | Tokyo | Osaka | Tokyo | Osaka |
| reliance for information→target recognition | 0.16 ** | 0.39 ** | 0.16 ** | 0.27 ** |
| target cognition→energy-conserving intention | 0.30 ** | 0.32 ** | 0.33 ** | 0.38 ** |
| blackout fears→energy-conserving intention | 0.25 ** | 0.10 * | 0.28 ** | 0.19 ** |
| energy-conserving intention→energy-conserving behavior | 0.88 ** | 0.86 ** | 0.84 ** | 0.86 ** |
| target cognition→energy-conserving behavior | 0.05 * | 0.03 | 0.07 ** | 0.06 ** |
| energy-conserving behavior→energy conservation rate | 0.35 ** | 0.22 ** | 0.30 ** | 0.15 ** |
| air-conditioner→energy conservation rate | 0.07 | 0.16 ** | 0.04 | -0.03 |
| refrigerator→energy conservation rate | 0.14 ** | 0.15 ** | 0.06 | 0.01 |
| Goodness of fit of the model | GFI=0.961, AGFI=0.934, CFI=0.964, RMSEA=0.033 | | | |

Note: ** p< 0.01, * p< 0.05, All coefficients are based on the standardized solution

Based on this result, in order to verify the differences in the path coefficients between groups, equivalence restrictions (let the path coefficients be equivalent) were set for the path coefficients of "usefulness of information" → "reliance for information" and "truthfulness of information" → "reliance for information," and multiple group analysis of the four groups was conducted.

The result is shown in Table 7, and the goodness of fit of the model was GFI = 0.961, AGFI = 0.934, CFI = 0.964, and RMSEA = 0.033. Therefore, based on the results in Table 7, the differences in the path coefficients are dependent on the area and time.

**4.2.1 Results and consideration by area**

In the analysis of the overall data of section 3 for both summer and winter, the path coefficient of "target cognition" → "energy-conserving intention" became large rather than that of "blackout fears" → "energy-conserving intention." However, when verification by area is performed, as shown in Table 8, there is a significant difference only in Osaka ($p < 0.01$). The influence in Tokyo of the consciousness concerning inconvenience due to a power failure and the preparation for a power failure is high, and the difference between "target cognition" and "blackout fears" as promotion factors of "energy-conserving intention" is relatively small compared with Osaka. However, as shown in Table 9, there is no significant difference in the "blackout fears" → "energy-conserving intention" between Tokyo and Osaka.

From the left-hand side of Table 9, "energy-conserving intention" → "energy-conserving behavior" and "information reliance" → "target cognition" of Tokyo and Osaka in summer are significantly different.

Looking at "energy-conserving intention" → "energy-conserving behavior," the value for Tokyo is larger than for Osaka with a significant difference. However, significant differences between Tokyo and Osaka are no longer observed in winter ($z = -0.76$, n.s.). Although the difference between the relationship of "energy-conserving intention" and "energy-conserving behavior" and

Table 8 Test of the difference of the path coefficients (z-value)

| | summer 2011 | | winter 2011 | |
|---|---|---|---|---|
| | Tokyo | Osaka | Tokyo | Osaka |
| "target cognition→energy-conserving intention"-"blackout fears→energy-conserving intention" | 1.63 | 3.63 ** | 1.56 | 2.81 ** |

Note: ** p< 0.01, * p< 0.05, All coefficients are based on the standardized solution

Table 9 Test of the difference of the path coefficients (z-value)

| | comparison by area | | comparison by time | |
|---|---|---|---|---|
| | summer | winter | Tokyo | Osaka |
| | Tokyo-Osaka | Tokyo-Osaka | summer-winter | summer-winter |
| reliance for information→target recognition | -3.92 ** | -1.88 | -0.07 | 1.85 |
| target recognition→energy-conserving intention | -0.52 | -0.52 | -1.18 | -1.20 |
| blackout fears→energy-conserving intention | 1.91 | 0.87 | -1.22 | -1.78 |
| energy-conserving intention→energy-conserving behavior | 2.84 ** | -0.76 | 3.95 ** | 0.32 |
| target recognition→energy-conserving behavior | 0.73 | 0.36 | -0.71 | -1.03 |
| energy-conserving behavior→energy conservation rate | 1.81 | 1.80 | 0.39 | 0.61 |
| air-conditioner→energy conservation rate | -1.43 | 1.02 | 0.04 | 2.27 * |
| refrigerator→energy conservation rate | -0.21 | 0.80 | 0.69 | 1.65 |

Note: ** p< 0.01, * p< 0.05

the influence of the external factors "target cognition" and "blackout fears" that promote these directly or indirectly had arisen between the areas during summer, the difference became small in winter.

About "information reliance" → "target cognition," only the value in summer shows a significant difference between Tokyo and Osaka ($p < 0.01$). Since much of the information concerning energy conservation goals was sent from an electric power company, this path shows the extent of access to the information from the power companies, and the sensitivity and attention to this information. From this result, in Osaka during summer, "information reliance" measured by "usefulness of information" and "truthfulness of information" had a larger influence on "target cognition" than was observed in Tokyo.

Incidentally, from Table 4, the level of "usefulness of information" and "truthfulness of information" of Osaka is higher than Tokyo, and also has a significant difference (Table 5). However, for the level of "target cognition," the value of Tokyo (4.05) is larger than Osaka (3.79) with a significant difference ($p < 0.01$). This suggests that not only the degree of "information reliance" from original sources of information, but also the degree of contact to media such as the newspaper, TV, and internet that process and circulate the information, and the interest level to an electricity supply-and-demand problem, etc. are large influences on "target cognition."

#### 4.2.2 Results and consideration by time

From Table 7, "target cognition" → "energy-conserving behavior" became significant in Osaka in winter, although in summer it was not significant ($p < 0.01$). It is assumed that the unified energy conservation goal was first introduced by the government, Kansai electric power company, and Union of Kansai government in winter, so its role in "target cognition" was to directly promote "energy-conserving behavior."

Here, from the right-hand side of Table 9, "energy-conserving intention" → "energy-conserving behavior" of Tokyo in the summer and winter show a significant difference ($p < 0.01$). Moreover, the "air conditioner" → "energy conservation rate" between the summer and winter of Osaka show a significant difference ($p < 0.05$), and is likely due to the fact that equipment other than an air conditioner is being used in winter and the fact that the contribution of "air conditioner" to the "energy conservation rate" of Osaka in summer was large.

Comparing "energy-conserving intention" → "energy-conserving behavior" of Tokyo in summer and winter, the value in winter became small with significance. Here, from Table 7, the value in the winter of "target cognition" → "energy-conserving behavior" was larger than the value in the summer, while "blackout fears" → "energy-conserving intention" and "target cognition" → "energy-conserving intention" brought the same result. Further, in Osaka, these three paths in winter were larger than in summer, and as mentioned above, "target cognition" → "energy-conserving behavior" became significant.

In addition, the comprehensive effect (sum of direct and indirect effect) that generates "energy-conserving behavior" from "target cognition," "blackout fears," and "energy-conserving intention" is shown in Table 10. A direct effect is indicated by the direct path (standardized coefficients) to the "energy-conserving behavior" from each element. An indirect effect is the sum of the numerical values obtained by multiplying the paths that lead indirectly to "energy-conserving behavior" from each element. When comparing the comprehensive effect by time, both in Tokyo and Osaka, "target cognition" → "energy-conserving behavior" and "blackout fears" → "energy-conserving behavior" both displayed larger values in winter than in summer, while the value of "energy-conserving intention" → "energy-conserving behavior" became smaller in winter than in summer. These results are interpreted to mean that in winter, the relationships of "target cognition" → "energy-conserving behavior" and "blackout

Table 10 The standardized overall effect concerning 'energy-conserving behavior'

| | Tokyo | | Osaka | |
|---|---|---|---|---|
| | summer | winter | sumer | winter |
| target recognition→energy-conserving behavior | 0.318 | 0.348 | 0.305 | 0.385 |
| blackout fears→energy-conserving behavior | 0.223 | 0.235 | 0.088 | 0.161 |
| energy-conserving intention→energy-conserving behavior | 0.878 | 0.836 | 0.856 | 0.855 |

Note: ** p< 0.01, * p< 0.05, All coefficients are based on the standardized solution fears” → “energy conserving behavior” became stronger than in the summer and “energy-conserving intention” → “energy-conserving behavior” became relatively small.

From the comparison of summer and winter path coefficients, and the comparison of the comprehensive effects of the above, it can be said that the influence of “blackout fears” and “target cognition” on “energy-conserving behavior” increased in the winter. In other words, the energy-conserving intention-behavior-effect process controlled by “blackout fears” and “target cognition” has been established and is strengthened by the passage of time.

However, as shown in Tables 4 and 6, comparing summer for both Tokyo and Osaka, not only are “target cognition” and “blackout fears” decreasing in winter, but the same trend is seen in all elements. We interpret this to mean that there was a diminished sense of urgency due to a lack of concrete energy conservation goals and a reduced interest in such goals without legal force, and there was a sense of security that was absent in summer 2011 due to a weakening of uneasiness and fear regarding power failure, etc.

These results suggest that although the energy-conserving intention-behavior-effect process affected by the external factors resulting from the above-mentioned Great East Japan Earthquake are established and strengthened, the energy conservation effect will fall because the level of each element falls in accordance with time. Even if a route of energy-conserving intention-behavior-effect with a small gap between elements is established, an effect will become small if there are fewer things flowing through. Furthermore, the fixing and the stability of the route are also uncertain and continuous verification is required.

## 5. Conclusion

In this study, we designed a new model describing the energy-conserving intention-behavior-effect process of the individual, with consideration of the influence from society and the impact on society. The validity of the model was verified by structural equation modeling (SEM) using a citizen survey result. In addition, using this model, differences in the situation according to the area and time period were clarified by multiple group analysis.

We showed that cognition of an energy conservation goal evokes an energy-conserving intention and behavior, and contributes to the energy conservation effect. Anxiety and fear regarding power failure also inspire an energy-conserving intention. Cognition of the energy conservation goal raises an energy-conserving intention more so than the anxiety over and the fear of a power failure in the energy-conserving intention-behavior- effect process.

In addition, as far as the differences according to the area and time period, it was shown clearly that there is no significant difference in the path coefficient of the cognition of an energy conservation goal that contributes to an energy-conserving intention. In Tokyo, the contribution from uneasiness and fear regarding power failure did not change with respect to time. Comparing the path "energy-conserving intention" → "energy-conserving behavior" in the summer, the value found for Tokyo is larger than Osaka with a significant difference. However, this significant difference disappeared in the winter, and there was a significant difference in the "energy-conserving intention" → "energy-conserving behavior" between summer and winter for Tokyo.

The establishment and strengthening of an energy-conserving intention-behavior-effect process is affected by the external factors resulting from the Great East Japan Earthquake, and we pointed out that the energy-conserving effect decreases due to the level of each element falling in accordance with time.

In order to fix and maintain an energy-conserving intention-behavior-effect process for a medium-to-long period of time, it must depend not only on individual morality and ethics based on the reaction to an external factor, but it must also cope with the social system and structure. A multilayered mechanism design as a society is called for, which promotes personal efforts and leads to routinization, such as compulsion by regulatory measures, consciousness of the environment and energy education, and institutional arrangements incorporating economic incentives.

We applied this study to research the full-time housewife, for whom the energy conservation opportunity in a home is large, and who also influences the electricity demand of a residential sector. This means that when a housewife is compared with an office worker, etc., there is a possibility that the channel of information concerning energy conservation cognition and the valuation criteria for the information from an electric power company may differ. Moreover, in case there are infants, a person requiring care, etc., the degree of anxiety over and fear of a power failure is also assumed to be different for an office worker, etc. compared to the housewife who is at home during the day. Therefore, prudence is necessary when generalizing these research findings.

**Note**

1) It is largely consistent with power demand data (The Federation of Electric Power Companies of Japan).

2) In addition, there was no significant difference in the path coefficients of "reliance for information" → "truthfulness of information" and "reliance for information" → "usefulness of the information" between the four groups.

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