Original article

# Psychological and Demographical Determinants of Adopting Expensive Energy-efficient Facilities in Households

Susumu OHNUMA*, Risa KUWAYAMA* and Tsubasa KOBAYASHI**

**Abstract :** This study explores the psychological determinants of the adoption of expensive energy-efficient facilities in households. Demographic factors, such as household yearly income and type of dwelling, have been considered the primary factors that account for the variance in adoption. However, this study demonstrates that psychological variables are more relevant than demographics to the adoption of expensive energy-saving facilities by employing a self-regulated stage model of behavioral change (SSBC; Bamberg, 2013a, b). The SSBC assumes an implementation intention between behavioral intention and behavior. We administered a web survey in Hokkaido, Japan (n = 312). A quota sampling method was used, and we obtained 312 valid responses. The results revealed that a) the implementation intention was the strongest predictor of adopting energy-saving facilities, b) behavioral intentions did not predict adoption directly but did so indirectly through the mediation of implementation intentions, and c) demographic factors such as type of dwelling and presence of homemakers also predicted the adoption of energy-saving facilities, while household yearly income had no effect. These results suggest that the SSBC model, which was initially developed for habit change, is applicable to and useful for adopting expensive energy-saving facilities.

**Key Words :** energy-efficient facilities, self-regulated stage model of behavioral change, implementation intention

## INTRODUCTION

Various strategies for the efficient use of energy have been promoted globally as measures against climate change. The Paris Agreement adopted at COP21 requires a further reduction of greenhouse gas emissions by the member states of the United Nations, including developing countries[1)], and more efficient use of energy is required. In Japan, energy efficiency has been promoted mainly in the industrial sector, where energy consumption in 2018 was reduced to 84% that of 1973. However, in the household sector, energy consumption increased to 1.9 times that of 1973 levels[2)]. In Hokkaido, where this study was conducted, energy consumption is greater than the average for Japan, and more than half of consumption is used for heating in winter[3)]. Thus, Hokkaido is a region that has the potential to save more energy in the household sector. The climate characteristics of Hokkaido that are linked to household energy consumption are similar to those of North to Central Europe, Canada, and the northern part of the United States.

As promoting energy-saving actions is vital, energy-efficient approaches are recommended (IPCC, 2011). One of the most important approaches to promoting saving energy in the household sector and dealing with climate change is by introducing energy-efficient facilities and thereby reducing the amount of energy necessary for living, as well as using non-fossil energy. Therefore, this study focused on the adoption of expensive energy-efficient facilities for household use, such as a solar power generation system, a high-efficiency hot-water supply system, and a fuel cell battery.

Despite the significance, only a few studies have examined the psychological determinants of the

* School of Humanities and Human Sciences, Hokkaido University

** Jyukankyo Research Institute Inc.

adoption of expensive energy-efficient facilities compared to studies examining the demographic factors, while many studies have examined the psychological determinants of day-to-day energy-saving behaviors (cf. Kastner *et al.*, 2016). One reason is that there are financial difficulties to be addressed in adopting such facilities. Psychological determinants are considered to have relatively less impact on the adoption of this technology because, arguably, demographic factors such as household yearly income and type of dwelling ultimately determine these decisions. Costanzo *et al.* (1986) showed that demographic factors, such as income and owning or not owning one's dwelling, have a greater effect on the decision to adopt such facilities than psychological factors. It is reasonable to think that adopting such facilities requires a certain level of income, and adoption is difficult in a housing complex even if the residents as individuals have definite intentions. However, this study demonstrates that psychological variables determine the adoption of expensive energy-efficient facilities if an appropriate model is applied, although demographic factors are important. The purpose of this study is to identify the psychological and demographic factors that determine the adoption of expensive energy-efficient household facilities, applying a stage model of self-regulated behavior change (SSBC; Bamberg, 2007; 2013a; 2013b).

As for the model of pro-environmental behaviors, the theory of planned behavior (TPB; Ajzen, 1991) has often been applied to pro-environment behavior studies. This model describes behavioral intention, that is, intention about a specific behavior, as the direct determinant of a target behavior. Although the TPB model is applicable for many pro-environment behaviors, it has been pointed out that, under the condition of the behavior being difficult to execute, the association between behavioral intention and actual behavior becomes weaker (Kaiser *et al.*, 2007; Armitage *et al.*, 2001) and the strength of association between behavioral intention and actual behavior is not stable (Kaiser *et al.*, 2009). The introduction of expensive energy-saving facilities is difficult to put into practice. Therefore, behavioral intention alone would not be able to explain behavior.

A factor used to explain behaviors that have a gap between behavioral intention and the actual behavior is the implementation intention, which is aroused when particular requirements are satisfied (Gollwitzer, 1999). An example of the development of the implementation intention is creating a specific action planning that defines when, where, and how to behave in a certain circumstance. A model that explains pro-environmental behavior using the implementation intention is the stage model of Bamberg (2013b) used in this study.

**Self-regulated stage model of behavioral change**

The SSBC (Bamberg, 2013b) explains the process of behavioral change, which suggests four qualitatively different stages for changing from a past habituated behavior to a new habituated behavior. The SSBC proposes that it is possible to shape a new habituated behavior by determining the tasks to work for in each stage. This model presumes that the three intentions move to the next stage; from goal intention to behavioral intention, from behavioral intention to implementation intention, and from implementation intention to behavior.

In the first stage, namely, the pre-decisional stage, a goal intention is formed, which is the preparational willingness to achieve a goal but without a concrete procedural plan to achieve it. The pre-decision stage corresponds approximately to norm activation theory (Schwartz *et al.*, 1981). Hence, the goal intention is shaped by variables such as awareness of consequences and the obligation to fulfill personal norms. In the second stage, namely, the pre-actional stage, behavioral intention is shaped. The pre-action stage almost corresponds to the TPB (Ajzen, 1991). That is, behavioral intention for a specific behavior is shaped by the attitude toward a set of choices and perceived behavioral control. In the third stage, namely, the actional stage, the implementation intention that facilitates enacting the new behavior in a specific situation is shaped

(Gollwitzer, 1999). To foster the implementation intention, an action plan should be crystallized in which individuals concretely develop a plan to perform a new behavior in a specific situation. In other words, action planning is the capability of devising a plan of when, where, how, and in what situation to execute the new behavior in a practical context. Finally, in the fourth stage, namely, the post-actional stage, a new habit has taken root through adopting the new behavior.

The SSBC was initially applied to transport behavior (Bamberg, 2007, 2013a, 2013b; Bamberg *et al.*, 2011), and then it expanded to energy-saving behavior (Nachreiner *et al.*, 2015). The SSBC has been developed mainly to find appropriate intervention measures of habit change. However, the SSBC has the advantage of handling a process of decision-making that takes place over quite a long time; from shaping a goal that is often ambiguous to establishing a concrete behavioral plan. Klöckner (2014) expanded the SSBC into a decision-making process related to purchasing electric vehicles, instead of habit change. Klöckner *et al.* (2017) also applied it to decision-making with promotion and prevention factors for efficiency upgrades in the household, such as thermal insulators and windows. Similarly, the current study applies the SSBC to the adoption of expensive energy-efficient facilities such as photovoltaics, solar boilers, and high-efficiency boilers.

Decision-making for purchasing expensive facilities takes a long time, and an accumulated deliberate decision has a strong influence before the final decision is reached. Even if there may be the influence of feelings and intuitive factors, these are unlikely to be strong effects. Accordingly, the implementation intention of when and under what conditions one moves into action is important. Besides, not only perceived behavioral control, which goes along with the evaluation of the difficulty of execution, but also action planning, which concretely defines under what conditions and how one can move to execute, is needed. For these reasons, it is reasonable to apply the SSBC to explain decision-making in the adoption of expensive facilities.

The original SSBC (2013b) indicated that goal intention is formed by an awareness of consequences, perceived responsibility, negative affect, salient social norms, personal norms, anticipated emotions in goal progress, and perceived goal feasibility. As for the associations among the factors forming goal intention, SSBC based on the value-belief-norm theory (Stern, 2000; Stern *et al.*, 1999) and the norm activation model (Schwarts 1977; Schwarts *et al.*, 1981; Steg *et al.*, 2010), which have been fully investigated and obtained robust results in many studies, while no disproof was offered. Since the validity of the factors related to the formation of goal intentions -- particularly emotion, perceived responsibility, and perceived goal feasibility -- has proved robustly, there is no room for obtaining new findings. In contrast, relationships among implementation intention, behavioral intention, and behavior are still underdeveloped because not many studies have targeted it, and only a few empirical data were provided. Moreover, no study exists that applied the SSBC to adopting expensive energy-efficient household facilities. Hence, this study focused on the function of implementation intention in the adoption of the facilities rather than clarifying the formation of goal intentions.

Including too many variables deteriorates the quality of responses and the reliability of the model testing. The number of questionnaire items should be narrowed down instead of aiming full model test. Actually, Bamberg (2013a) used not all items in testing the model. The survey items should be selected along with the research focus. Because the focus of this study is not the formation of goal intention, redundant variables were trimmed away to assure the validity of model testing: emotion, perceived responsibility, and perceived goal feasibility were omitted, while covering awareness of consequences, salient injunctive norms, and the feeling of obligation to one's personal norms.

Both attitude and perceived behavioral control are the determinants of behavioral intention, but the current paper dealt with only perceived

behavioral control. As attitude can be substituted goal intention (Hirose, 1994), the term goal intention was used instead of attitude. Action planning, cognitive planning, and maintenance self-efficacy are determinants of implementation intention, but we only dealt with action planning.

**Demographics associated with adoption and intentions**

It is necessary to consider demographic factors related to the adoption of energy-efficient facilities. First, household yearly income should be the largest factor because introducing expensive energy-efficient facilities such as a solar power system requires a certain level of household yearly income. Second, the type of dwelling is also an important factor. In detached houses, people can place expensive energy-efficient facilities at their discretion. In contrast, in multiple-dwelling buildings, individuals cannot decide by themselves and need to obtain the owners' permission. Moreover, the owner of an apartment building can decide by himself or herself, but lessees cannot place expensive energy-efficient facilities without agreement. We also examined whether gender, age, and occupation have any effect since these variables are often used in social surveys.

The purpose of this study was to examine whether the adoption of expensive energy-efficient household facilities can be explained by the SSBC. In particular, we examined the connection between implementation intention and behavior. We also examined to what extent household yearly income and owning a house, which are considered salient to regulating the adoption of energy-efficient facilities, affect adoption, and we compared these factors with psychological variables to determine which have more effect. Furthermore, we exploratorily examined demographic factors that affect adoption apart from the above factors. The initial model is shown in Figure 1.

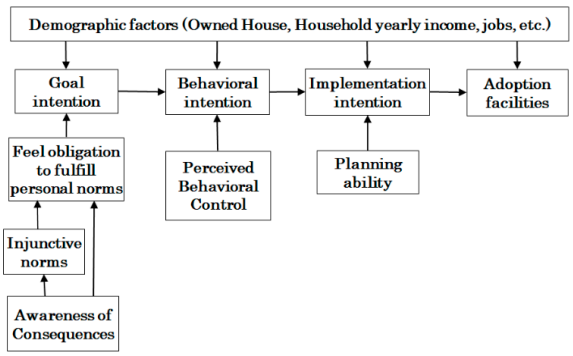


**Figure1 The initial model**

## 1. METHODS

### 1.1 Data collection and sampling design

We conducted a web-based questionnaire survey of individuals 20–79 years old living in Hokkaido (with a population of approximately 4 million) using a survey company's web monitor. We used the quota sampling method to extract targets.

First, we calculated the population structure of Hokkaido by gender and age based on the national population census (Table 1). Then we allocated samples to a total of around 300 respondents, and

**Table 1 Distribution in the population**

| Age | | Population | | Total |
|---|---|---|---|---|
| | | Male | Female | |
| 20-29 | n | 262,663 | 262,369 | 525,032 |
| | % | 6.3% | 6.3% | 12.7% |
| 30-39 | n | 338,125 | 341,733 | 679,858 |
| | % | 8.2% | 8.2% | 16.4% |
| 40-49 | n | 361,914 | 380,175 | 742,089 |
| | % | 8.7% | 9.2% | 17.9% |
| 50-59 | n | 342,537 | 365,910 | 708,447 |
| | % | 8.3% | 8.8% | 17.1% |
| 60-69 | n | 400,580 | 455,540 | 856,120 |
| | % | 9.7% | 11.0% | 20.6% |
| 70-79 | n | 276,213 | 358,920 | 635,133 |
| | % | 6.7% | 8.7% | 15.3% |
| Total | n | 1,982,032 | 2,164,647 | 4,146,679 |
| | % | 47.8% | 52.2% | 100.0% |

**Table 2 Distribution of obtained sample**

| Age | | Sample | | Total |
|---|---|---|---|---|
| | | Male | Female | |
| 20-29 | n | 20 | 20 | 40 |
| | % | 6.4% | 6.4% | 12.8% |
| 30-39 | n | 25 | 26 | 51 |
| | % | 8.0% | 8.3% | 16.3% |
| 40-49 | n | 27 | 29 | 56 |
| | % | 8.7% | 9.3% | 17.9% |
| 50-59 | n | 26 | 27 | 53 |
| | % | 8.3% | 8.7% | 17.0% |
| 60-69 | n | 30 | 34 | 64 |
| | % | 9.6% | 10.9% | 20.5% |
| 70-79 | n | 21 | 27 | 48 |
| | % | 6.7% | 8.7% | 15.4% |
| Total | n | 149 | 163 | 312 |
| | % | 47.8% | 52.2% | 100.0% |

finally, we obtained 312 valid samples after screening the invalid responses (Table 2).

### 1.2 Measures

#### 1) Adoption of energy-efficient facilities

In the questionnaire, first, we asked if respondents had already adopted any of these four household energy-efficient facilities: photovoltaics[4], solar boilers, high-efficiency boilers, and co-generation boilers.

#### 2) Implementation intention and the relevant items

For the actual stage, we measured the implementation intention and planning ability for energy-efficient facilities, referring to the items developed for purchasing expensive vehicles (Klöckner, 2014), and modified them to suit the energy efficient facilities. As for implementation intention, respondents chose the answer closest to their situation, choosing between "I will implement this facility in the near future," "I will implement this facility someday," and "I will not implement this facility," responding about facilities that the respondents have not yet adopted.

As for planning ability for applying facilities, respondents chose from a 5-point scale (1 = strongly disagree to 5 = strongly agree) for each question of these three items: "I know whom I should ask about adopting energy-efficient facilities," "I know how much and how long it takes to adopt energy-efficient facilities," and "I know how to get subsidies for adopting energy-efficient facilities."

#### 3) Behavioral intention and the relevant items

We referred to previous studies, which had executed comparative studies and established both Japanese and English versions (Ando *et al.*, 2007; Ando *et al.*, 2010; Ando *et al.*, 2014), for preparing the items for behavioral intention, goal intention, and the relevant items.

As measures of the pre-actional stage, we measured behavioral intention and perceived behavioral control concerning adopting energy-efficient facilities such as photovoltaics and co-generation boilers to the respondents' household, using a five-point scale from 1 (I do not think so at all) to 5 (I think so very much).

Behavioral intention was measured by two items: "I have an intention to adopt energy-efficient facilities" and "I intend to adopt energy-efficient facilities in my home." Perceived behavioral control was measured by two items: "It is easy to adopt energy-efficient facilities in my home" and "I am capable of adopting energy-efficient facilities."

Scores for behavioral intention and the relevant factors were calculated based on the means of the items.

#### 4) Goal intention and relevant items

As measures of the pre-decisional stage, we measured goal intention, awareness of consequences, an injunctive norm, and a feeling of obligation to fulfill personal norms by using a five-point scale for each item from 1 (I do not think so at all) to 5 (I think so very much).

Goal intention was measured by two items: "I have an intention to perform energy-saving behavior for reducing the environmental burden" and "I want to change my lifestyle, which includes energy-saving behaviors."

The following variables were measured by two items. Awareness of consequences was measured by "Energy issues are serious" and "Energy saving is an issue to be addressed imminently." The injunctive norm was measured by "Most people think that we should exercise energy-saving behavior" and "Energy-saving behaviors are required in our society." Feeling of obligation to fulfill personal norms was measured by "Regardless of what other people do, my values oblige me to attain energy-saving goals" and "I should exercise energy-saving behaviors for the solution of energy issues."

Scores for goal intention and the relevant factors were calculated based on the means of the items.

#### 5) Demographics

In addition to the above, we obtained demographic information, including gender, household yearly income, occupation, household size, type of dwelling (detached house or apartment house), own house or not (owned or rental), years of residence, and age.

## 2. RESULTS

### 2.1 Characteristics of demographics

Table 3 summarizes the demographic characteristics of the respondents. The mean age was 50.30 (SD = 15.95), and the mean household size was 2.56 (SD = 1.06). Approximately half of all respondents earned less than 2 million yen (about $20,000) per year. In terms of dwelling types, 60% of participants owned their own homes. Concerning occupation, the majority of samples were regularly employed, and one quarter of them were homemakers.

According to the above results, we used each demographic variable for analysis as follows. Gender was coded as a dummy variable, for which the standard category was male (0 = male, 1 = female). Household size was treated as a 5-point scale (1 = one person, 5 = five or more than five people), and household yearly income was treated as a 6-point scale (1 = under 2 million yen, up to 6 = above 10 million yen). As for home ownership and dwelling types, dummy variables were set, of which the standard category was the rental house (0 = rental house, 1 = owned house) and apartment house (0 = apartment house, 1 = detached house). For occupation, we prepared three dummy variables: full-time dummy, retired dummy, and homemaker dummy.

**Table 3 Demographic characteristics of sample**

| Variable | n | % | Variable | n | % |
|---|---|---|---|---|---|
| *Gender* | | | *Household size* | | |
| Male | 149 | 47.8% | 1 (one person) | 49 | 15.7% |
| Female | 163 | 52.2% | 2 (two persons) | 118 | 37.8% |
| *Age* | | | 3 (three persons) | 83 | 26.6% |
| 20–29 | 40 | 12.8% | 4 (four persons) | 51 | 16.4% |
| 30–39 | 51 | 16.4% | 5 (above five persons) | 10 | 3.2% |
| 40–49 | 56 | 18.0% | *House owned* | | |
| 50–59 | 53 | 17.0% | Yes (owned house) | 188 | 60.3% |
| 60–69 | 64 | 20.5% | No (rental house) | 122 | 39.1% |
| 70–79 | 48 | 15.4% | *Dwelling type* | | |
| *Household yearly income* | | | detached house | 176 | 56.4% |
| 1 (0–2M yen) | 150 | 48.1% | apartment house | 134 | 43.0% |
| 2 (2–4M yen) | 78 | 25.0% | *Job* | | |
| 3 (4–6M yen) | 42 | 13.5% | Full time | 99 | 31.7% |
| 4 (6–8M yen) | 9 | 2.9% | Homemakers | 81 | 26.0% |
| 5 (8–10M yen) | 3 | 1.0% | Part time | 50 | 19.0% |
| 6 (above 10 m | 2 | 0.6% | Retired | 42 | 13.5% |
| | | | Self employed | 21 | 6.7% |
| | | | Student | 8 | 2.6% |
| | | | Others | 11 | 3.5% |

### 2.2 Adoption of energy-efficient facilities, implementation intention, and scale construction of them

Table 4 shows the respondents' status of adoption of four facilities. No respondents adopted solar boilers or co-generation boilers. Relating to photovoltaics and high-efficiency boilers, less than 5% of all households had already adopted each of these. From these results, we created an index of adoption if respondents had adopted one or more types of the four facilities, i.e., "1" was marked if the respondents had adopted at least one type of facility, and "0" was marked if they had adopted no such facilities.

Next, we had the respondents who had not adopted any facilities choose one of three options ("I will implement this facility in the near future," "I will implement this facility someday," or "I will not implement this facility") for each facility. The results showed that less than 20% of all respondents answered "I will implement this facility in the near future" or "I will implement this facility someday" for any facility (Table 5).

**Table 4 Respondents' status of adoption of four facilities**

| Facilities | | have already adopted | have not adopted |
|---|---|---|---|
| Photovoltaics (PV) | n | 4 | 308 |
| | % | 1.28% | 98.72% |
| Solar boilers | n | 0 | 312 |
| | % | 0% | 100% |
| High-efficiency boilers | n | 15 | 297 |
| | % | 4.81% | 95.19% |
| Cogeneration boilers | n | 0 | 312 |
| | % | 0% | 100% |

**Table 5 Respondents' status of implementation intention of four facilities**

| facilities | | I will implement this facility in near future | I will implement this facility some day | I will not implement this facility | total |
|---|---|---|---|---|---|
| **Photovoltaics (PV)** | n | 3 | 48 | 257 | 308 |
| | % | 0.97% | 15.58% | 83.44% | 100% |
| **Solar boilers** | n | 1 | 29 | 282 | 312 |
| | % | 0.32% | 9.29% | 90.38% | 100% |
| **High-efficiency boilers** | n | 4 | 60 | 233 | 297 |
| | % | 1.35% | 20.20% | 78.45% | 100% |
| **Cogeneration boilers** | n | 0 | 32 | 280 | 312 |
| | % | 0% | 10.26% | 89.74% | 100% |

As the responses to implementation intention were extremely skewed, we coded "0" if they answered "I will not implement this facility," and coded "1" if they answered "I will implement this facility someday" or "I will implement this facility in the near future." Then, the sum of the score of four items was used to the scale of implementation intention, ranging from 0 to 4. Table 6 shows the means and standard deviations (SDs) for the adoption of facilities and implementation intention obtained by the above calculation. In the following analysis, we used a logarithmic converted score of implementation intention.

### 2.3 Construction of scales of psychological variables

The simple mean scores of the relevant items were counted as the scales to each psychological variable for each response. Then, the means scores and SDs of the scales were calculated as the whole sample (Table 7). Cronbach's alpha coefficients were calculated to check the reliability of the scales, and all scores revealed sufficient coefficients (αs >.7), representing that the scales were reliable (Table 7). As for goal intention and the relevant items, means were greater than 3 (neutral point), while for items relating to behavioral intention and implementation intention, means were less than 3.

**Table 6 The mean and SD for the adoption of facilities and implementation intention**

| Variable | Mean | SD |
|---|---|---|
| Adaptation of facilities | 0.05 | 0.23 |
| Implementation intention | 0.62 | 1.09 |

### 2.4 Demographic factors associated with adopting facilities and the intentions

Prior to testing the model, we conducted multiple regression analysis using a stepwise method to choose which demographic factors to use in the model, in which demographics were treated as independent variables and adoption and the three intentions as dependent variables. The results showed that homeownership and being a homemaker or not had significant effects on adoption (Table 8). Regarding dwelling types, rental houses or owned houses had a significant

**Table 7 Construction of scales of psychological variables**

| Variable | Questions | α | Mean | SD |
|---|---|---|---|---|
| Awareness of consequences | Energy issues are serious<br>Energy saving is an issue to be addressed imminently | 0.89 | 3.88 | 0.83 |
| Injunctive norm | Most of people think that we should do energy saving behaviour<br>Energy saving behaviours are required in our society | 0.81 | 3.88 | 0.77 |
| Personal norm | Regardless of what other people do, my own values oblige me to attain energy saving goal<br>I should do energy saving behaviours for solution of energy issues | 0.85 | 3.75 | 0.82 |
| Goal intention | I have an intention to do energy saving behaviour for reducing environmental burden<br>I want to change my lifestyles that includes energy saving behaviours | 0.89 | 3.63 | 0.88 |
| Perceived behavioural control | It is easy to adopt energy-efficient facilities in my home<br>I am capable of adopting energy-efficient facilities | 0.77 | 2.33 | 0.93 |
| Behavioural intention | I have an intention to adopt energy-efficient facilities<br>I intend to adopt energy-efficient facilities in my house | 0.85 | 2.83 | 0.98 |
| Action planning | I know who should I ask about adopting energy-efficient facilities<br>I know how much and how long it takes to adopt energy-efficient facilities<br>I know how to get subsidies in adopting energy-efficient facilities | 0.74 | 2.67 | 0.94 |

α: Cronbach's alpha coefficient, represnting the reliability of the scale.
SD: standard deviation.

**Table 8 Results of multiple regression predicting adoption and the three intentions**

| Variable | Goal intention (β) | Behavioural intention (β) | Implementation intention (β) | Adopting facilities (β) |
|---|---|---|---|---|
| Gender | | | | −.13 † |
| Age | .18 ** | | −.12 † | |
| Household size | −.12 † | | | |
| Household yearly income | | | | |
| Owned house | | .11 † | .22 ** | .19 ** |
| detached house | | | | |
| Fulltime | | | | |
| Retired | | | | |
| Homemakers | .13 * | | | .17 * |
| $Adj.R^2$ | .07 | .01 | .04 | .09 |
| $F$ | 7.76 *** | 3.50 † | 6.16 ** | 10.10 *** |

note:†p < .10, *p < .05, **p < .01, ***p < .001
coefficients were standardized

effect on adoption; however, having a detached house or apartment house did not have a significant effect. When we treated implementation intention as a dependent variable, homeownership and age had significant effects. When we treated behavioral intention as a dependent variable, only homeownership had a significant effect. When we treated goal intention as the dependent variable, age and being a homemaker or not had significant effects, and household size was marginally significant. Other demographics such as household yearly income, full-time job, and retired job were omitted in step 2, as they did not have significant effects on adoption and the three intentions. However, R-square was small overall, which suggested that demographic variables explained adoption or three intentions very little.

Besides, concerning the correlation between independent variables (Table 9), the correlation between gender and being a homemaker (r = −.55) and the correlation between homeownership and having a detached house or not (r = .63) was strong.

### 2.5 Testing the model

On the basis of the above results, we created an initial model and tested its fitness. In the initial model, in addition to psychological variables assumed in the stage model, we added demographic variables such as age, gender, household size, homeownership, and homemaker, which proved to be significant in the above stepwise multiple regression analysis. Although household yearly income was proven to have no

**Table 9 Correlations between demographics**

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| 1 Gender | −.03 | .03 | .08 | .10 | .01 | .42*** | .26*** | −.55*** |
| 2 Age | | −.32*** | .32*** | .23*** | −.03 | −.20*** | .46*** | .11 |
| 3 Household size | | | .15 | .24*** | .36*** | .04 | −.26*** | .10 |
| 4 House owned | | | | .63*** | .23*** | −.06 | .15** | −.05 |
| 5 Detached house | | | | | .18** | −.01 | .06 | -.03 |
| 6 Household yearly income | | | | | | .24*** | −.25*** | .08 |
| 7 Full time | | | | | | | −.31*** | −.47*** |
| 8 Retired | | | | | | | | −.23*** |
| 9 Homemakers | | | | | | | | |

**Table 10 Correlations between psychological variables**

| | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|
| 1 Adoption | .289*** | .136* | .03 | .10 | .181** | .141* | .167** | . 146** |
| 2 Implementation Intention | | .284*** | .466*** | .210*** | .287*** | .240*** | .198*** | .199*** |
| 3 Action Planning | | | .524*** | .476*** | .204*** | .117* | .111* | .08 |
| 4 Behavioural Intention | | | | .554*** | .317*** | .254*** | .174** | .205*** |
| 5 Perceived behavioural control | | | | | .09 | -.02 | -.09 | -.08 |
| 6 Goal Intention | | | | | | .770*** | .623*** | .629*** |
| 7 Personal norm | | | | | | | .714*** | .669*** |
| 8 Injunctive norms | | | | | | | | .625*** |
| 9 Awareness of consequences | | | | | | | | |

significant influence in the above analysis, we input it into the initial model since the analysis aimed to compare the effects of psychological factors with demographic factors, particularly household yearly income that the previous study had regarded as significant (Costanzo *et al.*, 1986). Table 10 summarizes the correlations between psychological variables used in the model testing.

We conducted a path analysis using the structural equation model (SEM) to examine the applicability of the SSBC. We used the goodness-of-fit index (GFI), the adjusted goodness-of-fit index (AGFI), Akaike's information criterion (AIC), and the root mean square error of approximation (RMSEA) as fit indexes for the model. We employed the maximum likelihood method as a parameter estimation method in the analysis.

The results indicated that household yearly income had no effect on intentions and adoption, but homeownership, gender, and being a homemaker or not had effects on adoption. Age and homeownership were also associated with the implementation intention significantly. No demographic variables were significantly associated with either goal intention or behavioral intention.

Then we created a modified model with the highest compatibility (Figure 2) after deleting paths that were not significant in the initial models. Results testing the modified model indicated that the model fit improved (Table 11).

The results indicated that, as for demographic factors, homeownership, gender, and being a homemaker or not were associated with adoption, and the implementation intention was the strongest determinant of adoption. Behavioral intention and perceived behavioral control had effects on action planning. Implementation intention was determined by behavioral intention as well as the demographic factors age and homeownership. Perceived behavioral control and goal intention determined behavioral intention. Awareness of consequences had an effect on injunctive norms and personal norms, and personal norms had effects on goal intention.

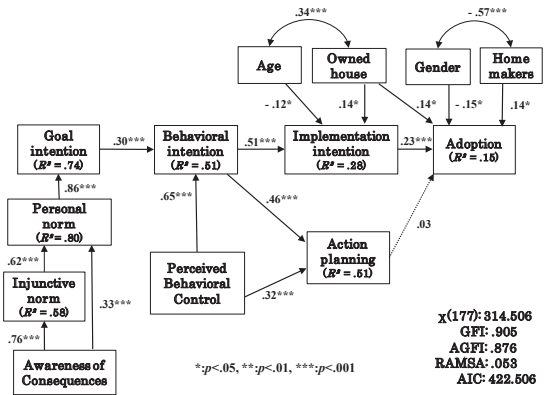


**Figure 2 Results of structural equation model about modified and final model**

## 3. DISCUSSION

This study conducted a web-based survey to examine the psychological and demographic factors that affected the process of adopting energy-efficient facilities applying the SSBC. The results indicated that implementation intention had the largest effect on adopting energy-efficient facilities. On the other hand, behavioral intention was not directly associated but indirectly associated with adoption via implementation intention. These results imply that, even though behavioral intention shapes behavior, it cannot be put into practice unless a specific plan is made for adoption. Accordingly, these findings can be regarded as showing that it succeeded in demonstrating the usefulness of the application of the SSBC.

However, the question remains why the stage model was appropriate for this study. One reason is that adopting energy-efficient facilities requires a long process of consideration: one must come up with an idea for saving energy, to begin with (goal intention), then think about adopting energy-efficient facilities (behavioral intention), and finally start considering concretely (implementation intention). As this requires a long

**Table 11 Model fit indexes of initial model and modified model**

| Model | $\chi^2$ | *df* | *P* | GFI | AGFI | AIC | RMSEA |
|---|---|---|---|---|---|---|---|
| Initial | 359 | 213 | <.001 | 0.85 | 0.81 | 645 | 0.078 |
| modified | 315 | 177 | <.001 | 0.91 | 0.88 | 423 | 0.053 |

time for action (or coming to a decision), the idea of the stage model was useful and applicable.

For the results that behavioral intention did not have a direct effect on adoption, it is explained the difficulty of the behavioral domain. Kaiser *et al.* (2009) pointed out that the strength of the relationships between behavioral intention and behavior was inconsistent and unstable. They proved that the behavioral difficulty moderated the strength of the relationship: the more difficult the behavior, the less correlated between behavioral intention and behavior. In accordance with the findings by Kaiser *et al.* (2009), it is reasonable that the association between behavioral intention and adoption was very low in our results because the difficulty is extremely high in purchasing energy efficient facilities. These facts cement the justifiability of applying SSBC instead of TPB in the case of this study.

Demographic factors, such as homeownership, gender, and being a homemaker or not, were associated with adoption. Surprisingly, household yearly income did not affect either adoption or intentions. These results suggest that an adequate income does not always lead people to try to adopt energy-efficient facilities. The possible reason that household yearly income did not affect adoption is that the goal of contributing to reducing global climate change by taking action to adopt energy-efficient facilities has not been created sufficiently in Japan, even among those who have a high level of income.

Costanzo *et al.* (1986) observed that homeownership is a significant demographic factor determining the adoption of energy-efficient facilities. It is not surprising that people cannot install energy-efficient facilities according to their judgment if they live in rented accommodation. Being a homemaker promoted the adoption of energy-efficient facilities, possibly because such individuals spend much time at home and are sensitive to energy expenditure and household facilities in their homes.

Homeownership and age had effects on implementation intention. For those who live in rented accommodation, it is hard to plan concrete action. Beyond the effect of age, because a great deal of time is required to recover the investment costs of expensive energy-efficient facilities, people imagine purchasing such facilities less as they get older.

On the other hand, demographic factors did not have effects on behavioral intention and goal intention at all, which implies that behavioral and goal intentions can be enhanced regardless of demographics.

However, a counter-argument can be raised that the skewed distribution led demographics to have less impact on the whole. The distribution was indeed extremely skewed for both the adoption and implementation intention. However, implementation intention was the strongest determinant of adoption after treated logarithm transfer. On the other hand, household yearly income, which did not necessarily follow a normal distribution but a monotone decreasing distribution form, was not related to any intentions. By contrast, implementation intention was affected by behavioral intention, of which distribution was normal. Therefore, the results of this study cannot be explained by the skewed distribution alone. Above all, the results of SEM represented a good fit despite such distribution forms for some variables. After all, it would be reasonable to conclude that the effects of demographics were limited.

However, few people adopted energy-efficient facilities in reality, and only a few people had a firm implementation intention. Given that the participants in this study reflected the population, it is necessary to implement interventions enhancing goal intention and behavioral intention. This study did not intervene. The SSBC has an implication when interventions corresponding to each stage are carried out. It would be worth implementing concrete interventions on the basis of the results of the study and examine the effects. Together with the discussion above, it is suggested from the results testing the SSBC model that, although the final behavioral act of actual adoption is limited by demographic factors, there is still a possibility that enhancing the goal

intention for saving energy and the behavioral intention to adopt energy-efficient facilities is effective for promoting adoption, even those of not meeting the demographic requirements. However, this study did not specify the stage at which each of the individuals is by a stage assignment scale (Bamberg, 2007), which was conducted in some studies using the SSBC. Henceforth, the formulation of a more detailed intervention will be possible by checking individuals' stages with the aid of such a scale.

Nevertheless, we have to admit to some limitations. This study only took up the behavior whereby individuals adopt energy-efficient facilities in their homes. Collective investment in the whole community was not dealt with. In Japan, incentives, such as a subsidy for individuals, are institutionalized; however, there is no system to encourage collective investment, as in some European countries. It is generally thought in Japan that the energy supply should be provided as a public service by the local government or by the private sector; therefore, the idea that citizens, consumers of energy, provide energy by themselves may not take root easily. In this study, we did not cover this, but in the future, it is necessary to study the correspondence to individuals' behavior by comparing the systems of each country. We should be careful of the differences in each country's system in explaining individuals' behavior, ensuring that SSBC is universal for studying interventions that promote behavioral change.

Moreover, we extended the SSBC, which was initially developed for habit change, as a model for decision-making about purchasing expensive facilities. However, there are differences; changing habits requires becoming conscious of automatic processes and unfreezing them, while decision-making about purchasing expensive facilities does not require such unfreezing. On the basis of these differences between habit change and decision-making, further consideration of the range in which the SSBC is applicable is needed.

## CONCLUSIONS

Promoting energy-efficient facilities in households is vital, particularly in Hokkaido as energy consumption is great. Because such facilities are expensive, demographic factors have been thought to be the primary factors. However, this study demonstrated that household yearly income was poorly associated with the decision-making for adopting the facilities. Alternatively, we applied the SSBC. The results of this study revealed that implementation intention had the largest effect on adoption, while behavioral intention had an indirect effect on adoption through implementation intention. These results implied that, even though behavioral intention shapes behavior, it cannot be put into practice unless a specific plan is made for adoption. The findings of the current study hopefully contribute to developing intervention measures for the promotion of adopting the energy-efficient facilities stage by stage on the basis of the SSBC.

This study did not investigate the actual markets. In practice, it takes a long time until deciding to purchase these facilities. Further study is required to examine following the decision making process in the actual setting and to explore the efficient intervention strategies.


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### NOTES

[1] UNFCCC.int (12/12/2015 updated) COP21: Adoption of the Paris Agreement. <https://unfccc.int/resourcedocs/2015/cop21/eng/l09.pdf>, 01/09/2021 referred.

[2] Agency for Natural Resources and Energy (06/05/2020 updated) Japan's Energy White Paper 2020. <https://www.enecho.meti.go.jp/about/whitepaper/>, 01/09/2021 referred.

[3] Ministry of the Environment (03/26/2021 updated) shows

that Hokkaido is the largest energy consumption area per household in Japan. <http://www.env.go.jp/earth/ondanka/ghg/kateiCO2tokei.html>, 09/05/2021 referred.

[4] Ministry of the Environment (03/2020 updated) showed that the potential of adopting solar PV in Hokkaido is the second largest in Japan. <http://www.renewable-energy-potential.env.go.jp/RenewableEnergy/report/r01.html>, 09/05/2021 referred.

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