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CASE STUDY OF FEED-IN TARIFF PERSONAL CARBON ALLOWANCE

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ABSTRACT

Since the Great East Japan Earthquake, Japanese energy and climate problems have reached a critical junction that requires an innovative energy and environmental policy. The idea of a Personal Carbon Allowance (PCA) system, which has been under discussion in the United Kingdom, is one of the innovative policies with the potential to solve related issues in Japan. The authors are proposing a Feed-in Tariff PCA (FIT-PCA) as a suitable policy for Japan to encourage citizens to manage CO₂ emissions in their daily personal lives and to improve their attitudes towards global environmental issues. In the psychological model we developed to study behavioural changes arising from the use of a PCA system, one assumption was that the experience of living with a FIT-PCA would stimulate loss aversion, goal setting, eudaimonia and pro-environmental life style changes. We conducted a simulation for six months with the cooperation of 30 households to investigate the validity of the model, monitor changes in energy reduction behaviours and encourage more responsible attitudes towards global environmental issues.

KEYWORDS

Personal carbon allowances, PCAs, Feed-in tariff, Climate policy, Energy policy, Pro-environmental behaviour

1. INTRODUCTION

In the industrial sector of Japan, reduction of CO₂ emissions towards the realization of a low-carbon society has been progressing. However, this has not been the case in the household sector. Under the Kyoto protocol, Japan pledged to reduce its CO₂ emissions by 6% of the 1990 levels (Kyoto protocol base year) by 2012. To reach this goal, the Japanese government encouraged greater use of nuclear energy because more than 80% of greenhouse gases in Japan are from CO₂ emissions from energy sources (Ministry of Environment, 2012) and nuclear energy does not emit CO₂ when generating electricity. However, the Great East Japan Earthquake and the following accident at the Fukushima Dai-ichi Nuclear Power Plant significantly damaged public trust in the safety of nuclear power (Ministry of Economy, Trade and Industry, 2012). Therefore, nuclear energy can no longer be relied on so heavily. Other renewable energies such as solar, wind, geothermal and biomass are still under development, but they cannot replace conventional thermal and nuclear energy because of their instability and inefficiency. It has become necessary to change our energy policy dramatically, for example, introducing an innovative energy policy such as a carbon tax that imposes an economic burden or constraint on CO₂ emissions in our daily personal lives, because the indirect CO₂ emissions from the residential sector have increased and are responsible for approximately 15% of total emissions (Greenhouse Gas Inventory Office of Japan, 2013).

However, reduction of CO₂ emissions from energy use is not only driven by concerns about environmental and energy problems (Steg, 2008). Steg argues that one of the barriers to fossil fuel energy conservation is the lack of motivation from either low prioritization or high costs of energy savings. For example, people are far more likely to conserve water in the kitchen, which has lower costs and requires little effort, than reducing their car use, which would have greater financial and lifestyle costs. Social norms and environmental concerns play important roles in motivation because they intervene in the activities of energy use (Lindenberg and Steg, 2007).

Personal Carbon Allowance (PCA) systems are authorized by policies that allow the government to distribute and manage rights of citizens to emit a certain amount of CO₂ (Hillman, 1998). Parag and

Strickland (2009) argue that PCAs will operate the mechanisms of economic behaviours, carbon perceptions and social norms. Social norms are generated by community, neighbourhoods, virtual communities and networks. Therefore, such norms do not work well with people who do not belong to communities (Parag and Strickland, 2009). This vulnerability of social norms is not daunting to the authors because Steg (2008) argues that norms that promote energy conservation are not generated only by social commitments. Biel and Thøgersen (2007) have demonstrated that situational factors such as salient needs and actions, benefits and costs, framing (market/non-market), behaviour of others and communications influence the formation of norms in response to social dilemmas. Therefore, the authors are more optimistic than Parag and Strickland (2009) about generating social norms by implementing PCAs. In each case, as a non-economic effect, PCAs are expected not only to encourage people to reduce CO₂ emissions in their personal lives but also to improve their environmental attitudes (Fawcett, 2010).

PCA systems have been studied mainly in the UK. Since the Japanese government has no experience with introducing CO₂ emission management systems, it is difficult to adapt UK research results directly to Japan. To solve this problem, the authors propose implementing a Feed-in Tariff PCA (FIT-PCA) suitable for Japan that was modelled after the idea of the German feed-in tariff rule of electricity trading (Huenteler et al., 2012) where the government purchases and sells the remaining allowances at a fixed price. This procedure can avoid low motivation for CO₂ emissions management caused by price instability in conventional PCA systems and encourages investment in housing equipment for reducing CO₂ emissions for easier future energy management planning. To investigate public acceptance and problems of implementing a FIT-PCA, the authors conducted a questionnaire survey (Kitamura et al., 2012). The results indicated a 60.5% support rate for FIT-PCAs compared with a down-stream carbon tax. In addition, informing the general public about average CO₂ emissions affects people's attitudes on energy consumption. However, it is not yet clear whether introducing a FIT-PCA system will have significant effects on promoting pro-environmental attitudes and behaviours. In conducting this study on FIT-PCAs, we will examine these effects based on a psychological model which assumes that the activities of working with the PCA will promote pro-environmental behaviours through the mechanisms of loss aversion, goal setting and eudaimonia (the highest human state of well-being and prosperity).

2. FEED-IN TARIFF PERSONAL CARBON ALLOWANCE (FIT-PCA)

2.1 FIT-PCA proposal

The PCA systems studied in the UK and Nordic countries allow citizens to trade their allowances between themselves or in the market. These individually negotiated allowance deals greatly affect the price management for CO₂ emission credits. In addition, the lives of the people who use a lot of energy may be burdened when the price becomes high. Further, when prices become low, motivation to reduce energy consumption and CO₂ emission may get discouraged. This instability may deter the development and improvement of pro-environmental attitudes and behaviours generated by managing one's own CO₂ emissions. In addition, policies like downstream carbon taxing create a direct economic burden on consumers that has not yet existed in Japan. To solve these problems, the design of the FIT-PCA in this study is based on the principles of simplicity, effectiveness and fairness.

Simplicity

FIT-PCA mechanisms must be comprehensive and customer interaction procedures must be simple. Because the ideas of imposing a constraint on CO₂ emissions is relatively new and the current emission trading system is applied only to companies, at present, the concept is unfamiliar to the Japanese public.

Effectiveness

FIT-PCA should be effective for the citizens to improve their pro-environmental attitudes and behaviours. This is the main purpose of this policy. It is also expected to positively influence solutions for other social issues because its affected fields can be broad.

Fairness

The FIT-PCA should not cause a feeling of unfairness as it would be applied to all kinds of people regardless of age, number of family members, location and climate in residential areas or style of housing. All of these variables affect the amount of CO₂ emissions. A fair FIT-PCA system needs compensatory rules to reduce any unbalance caused by such variables.

2.2 Rule details

2.2.1 System flow

Figure 1 shows the basic flow of a FIT-PCA system.

- (i) The government distributes a free personal carbon allowance (PCA) to each citizen periodically and equally. The PCA represents rights to produce a certain amount or level of CO₂ emissions from energy consumption in their daily personal lives. The government decides the quantity for the next year's PCA allowances based on data from the previous year. For CO₂ management, the government should set the amount of the PCA allowances lower than the cost for the average amount of CO₂ emissions per person per year.
- (ii) People would redeem their PCA credits as they purchased or consumed energy such as electricity, town gas, LP gas, gasoline, light oil and heating oil, which originate from fossil fuels. CO₂ emissions from electricity generation are calculated by the indirect coefficient.
- (iii) If a person did not have enough PCA when purchasing energy, they would have to purchase the difference for a fixed price. A fee would be required to purchase PCA credits.
- (iv) People would be able to sell their excess PCA credits back to the government for a fixed price if they did not need it. A fee would not be required for the disposal of PCA credits. A price difference between buying and selling units increases awareness of the loss of purchasing in comparison with selling PCA units, which is one goal of the management of a PCA.

In this system, people would manage their CO₂ emissions through their energy consumption with the expectation that not only would they reduce their energy consumption and CO₂ emissions, but also that pro-environmental attitudes and behaviours would be fostered.

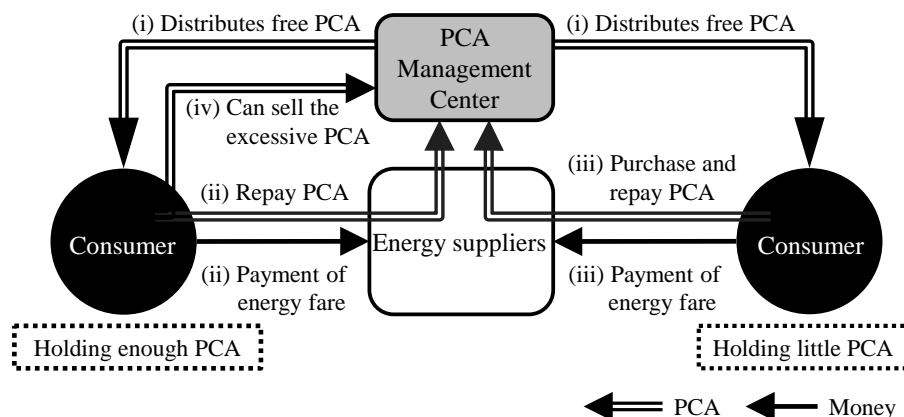


Figure 1. Flow of a FIT-PCA system.

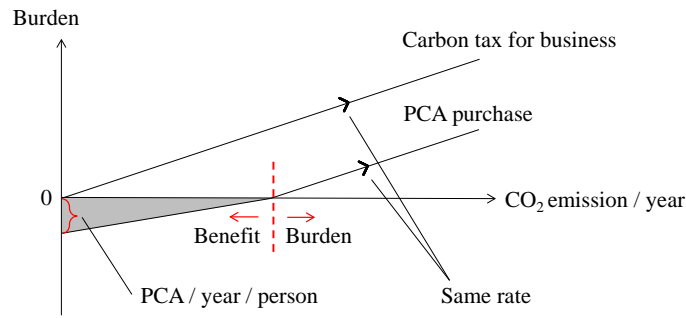


Figure. 2 Rate of burden or benefit in FIT-PCA.

2.2.2 PCA distribution amount and period

At the beginning of each month, the monthly PCA allowance would be deposited in each of the individual PCA accounts equally and without charge. The amount would be one-twelfth of an annual amount as determined based on the annual average of CO₂ emissions per person. The account units could be retained for twelve months including the distribution month (banking system). Any PCA account residual balance that exceeded twelve months would expire and disappear from the account. This rule would allow the government to prevent reduced effectiveness in PCA management for the next fiscal year.

PCA distributed to children would be managed by their parents or protectors. The transfer and integration of PCA to members in the same household would be allowed because the energy consumption in their daily personal lives can be best managed by household unit.

2.3 Prerequisite

To effectively implement a FIT-PCA system, the problem of carbon leakage must be solved. This happens most commonly when a PCA is redeemed and it cannot be determined whether the CO₂ was from personal usage or usage in business activities, especially in the case of self-employed people. Therefore, when the government introduces a FIT-PCA system, it will require a downstream carbon tax for CO₂ emissions from business activities to be introduced at the same time. Figure 2 shows the rate of downstream carbon tax and PCA. The rate of the downstream carbon tax should equal the cost of purchasing the PCA. In this system, self-employed people could apply their personal PCA allowance to both their private lives and their business activities; however, they would have to pay the same amount of money when the CO₂ emissions exceed their personal PCA balance.

In Japan, they have data from a residential basic book system (Ministry of Internal Affairs and Communications, 2012). Using this data and an advanced information system such as an IC card system, it would be relatively easy to develop the infrastructure for a FIT-PCA system.

2.4 Psychological model of FIT-PCA

To determine whether or not using a FIT-PCA encourages eco-friendly behaviours and attitudes, this study has modelled its psychological effects as shown in Figure 3. This model is based on development of loss aversion, goal setting, eudaimonia and self-perception.

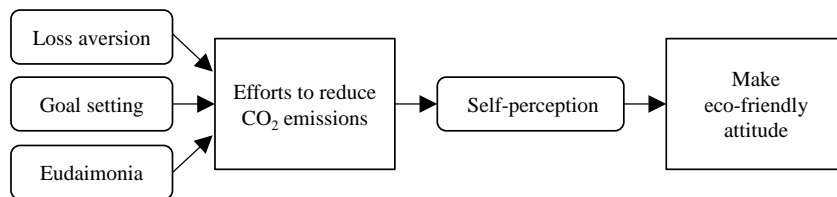


Figure 3. Psychological model of FIT-PCA.

Loss aversion

The concept of loss aversion is borrowed from Kahneman's prospect theory (1979). It refers to the strong tendency to avoid losses compared with the desire to make a profit. These tendencies can be influenced by price or length of time. Although the cost for the PCA is not expensive in the FIT-PCA, the authors expect that loss aversion will still play an important role in improving CO₂ management.

Goal setting

Locke (1968) claimed that setting goals affects motivation and performance. In the FIT-PCA system, the amount of distributed PCA allowance is set on the basis of the average CO₂ emissions from daily personal living. Therefore, the following effects can be expected.

1. Rational target: The target performance is better if there is a difficulty. However, it requires a rational reason.
2. Clear goal: A clear and specific goal can foster high motivation.
3. Effect of feedback: When feedback is combined with setting a target goal, motivation improves.

Eudaimonia

The Greek word 'Eudaimonia' is associated with Aristotle and implies the highest human state of well-being and prosperity (Waterman, 1993). A person experiences eudaimonia when they feel that they are living well in society. In the study of FIT-PCA, the authors expect that people who make an effort to reduce CO₂ emissions will feel eudaimonia.

Self-perception

Bem claimed that people develop their attitudes, beliefs and other internal states by observing their own behaviours (1972). Therefore, in the study of FIT-PCA, participants may develop new attitudes by observing their own efforts to reduce CO₂ emissions. Moreover, they may perceive their own behaviours regarding global environmental issues. This expectation could also be explained by cognitive dissonance theory.

3. A CASE STUDY OF FIT-PCA

3.1 Purpose and overview

This study examined whether using a FIT-PCA system could improve attitudes and behaviours to reduce CO₂ emissions. The case study has been conducted for six months with thirty cooperative households to investigate how they changed their energy saving behaviours and their attitudes on global environmental issues in a simulated FIT-PCA system. Figure 4 shows an overview of the procedures in this case study using a web system to manage virtual PCA accounts. The participants could view information about their PCA balances and bar graphs of their average CO₂ emissions over time. The basic activities were:

1. The participants input their household energy consumption data into the web system where they paid for energy.
2. They checked their CO₂ emissions and PCA balances.
3. They answered a questionnaire once a month on changes in their attitudes and behaviours.
4. The above 1–3 was repeated for each of the six months of the study (July–December 2012).

In this study, the reward to be paid to the participants varied based on how they traded their PCA allowance to realize the best economic effects. To examine the effects of loss aversion, the participants were divided into two PCA price groups, 1 or 10 JPY/kg CO₂.

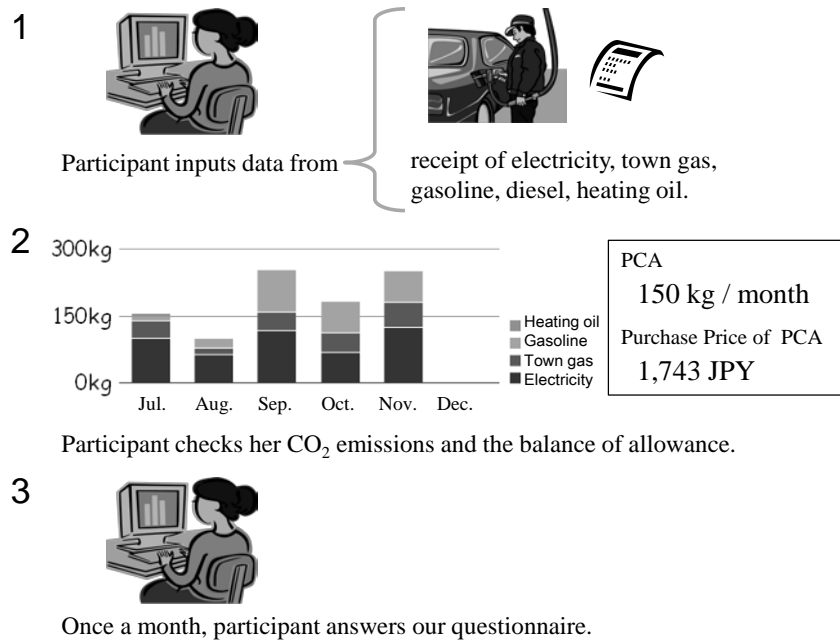


Figure 4. Overview of case study activities.

3.2 Methods

3.2.1 FIT-PCA account inventory (FAI) design

Case study participants can understand their balance of CO₂ emissions and PCA of the month by inputting the amount of their consumed energy to FIT-PCA account inventory (FAI). In this case study, the amount of PCA which distributed to the participants was set 150 kg- CO₂/month. It is because the average of CO₂ emissions by Japanese household per capita is 167 kg-CO₂/month approximately (Greenhouse Gas Inventory Office of Japan, 2012) and the distributed PCA should be a little lower than the average to promote their CO₂ emissions reduction. The following is a calculation of CO₂ emissions G in FAI.

$$G_i = \frac{p_i c_i E_i}{n} \quad \dots\dots\dots(1)$$

Where p is the proportion of energy use in their household against their business, c is the emission factor by energy source, E is the energy consumption, n is the number of people per household and i is the type of energy. Table 1 shows the CO₂ emission factors of energy (Ministry of Environment, 2006).

Table 1. CO₂ emission factors by energy types

Type of energy	CO ₂ emission factor
Electricity [kWh]	0.559 [CO ₂ -kg/kWh]
Town gas [m ³]	2.23 [CO ₂ -kg/m ³]
Gasoline [l]	2.32 [CO ₂ -kg/l]
Light oil [l]	2.58 [CO ₂ -kg/l]
Heating oil [l]	2.49 [CO ₂ -kg/l]

3.2.2 Questionnaire

The questionnaires were completed at the beginning of each month. In the questionnaire, there were questions about each element of the FIT-PCA psychological model and any changes in attitude towards global environmental issues. The respondents answered each question on a five point Likert scale for later quantitative analysis. In addition, a sixth choice of 'do not know' was provided for questions that may be difficult to understand for some respondents. Because the study is ongoing, interviews with the participants will be conducted at the end of the study to gather details of any perceived psychological changes. The questions about each element were as follows:

Loss aversion: 'Do you want to reduce monetary loss by using your PCA as much as possible?'

Goal setting: 'Do you know how much your household should reduce CO₂ emissions?'

Eudaimonia: 'Do you think that behaviours that lower your carbon emissions improve your way of life?'

Self-perception: 'Is the purpose of your efforts to contribute positively to global environmental issues?'

3.3 Results

This case study started in the middle of July 2012. At the time of writing this paper, the study is still in the experimental period. This section will report the current results.

3.3.1 Differences in loss aversion due to PCA price

To determine whether or not loss aversion was triggered at different price points in a PCA, the participants were divided into two groups of 1 JPY/CO₂-kg and 10 JPY/CO₂-kg as the cost of their PCA. There was no significant difference between the answers of the 1 JPY/CO₂-kg group and the 10 JPY/CO₂-kg group on loss aversion, i.e. 'I want to reduce loss by purchasing energy through my PCA as much as possible'. Table 2 verifies this result using an independent t-test. Therefore, in this case study, it was found that loss aversion was not affected by the difference in price for PCA. This result increases the feasibility of developing a FIT-PCA system because it would be easier to obtain public acceptance when introducing a low priced FIT-PCA.

Table 2. Results of t-test showing the difference of loss aversion between 1 JPY/CO₂-kg and 10 JPY/CO₂-kg groups

Questionnaire period	Group	mean value	SD	t -statistic	df	Two-sided P value
Early August, 2012	1 JPY	4.07	1.14	-0.33	27	0.74
	10 JPY	4.20	0.94			
Early September, 2012	1 JPY	4.26	0.79	0.91	28	0.36
	10 JPY	3.93	1.16			
Early October, 2012	1 JPY	4.06	1.16	-0.59	28	0.55
	10 JPY	4.27	0.59			
Early November, 2012	1 JPY	4.33	1.04	0.21	28	0.84
	10 JPY	4.26	0.70			
Early December, 2012	1 JPY	4.07	1.07	-0.37	27	0.71
	10 JPY	4.20	0.77			
Early January, 2013	1 JPY	3.93	1.28	0.29	28	0.77
	10 JPY	3.80	1.20			

Question: Do you want to reduce the loss by purchasing PCA as much as possible?

Answer uses a Likert scale and the choice of 'do not know'. 1: No, 5: Yes

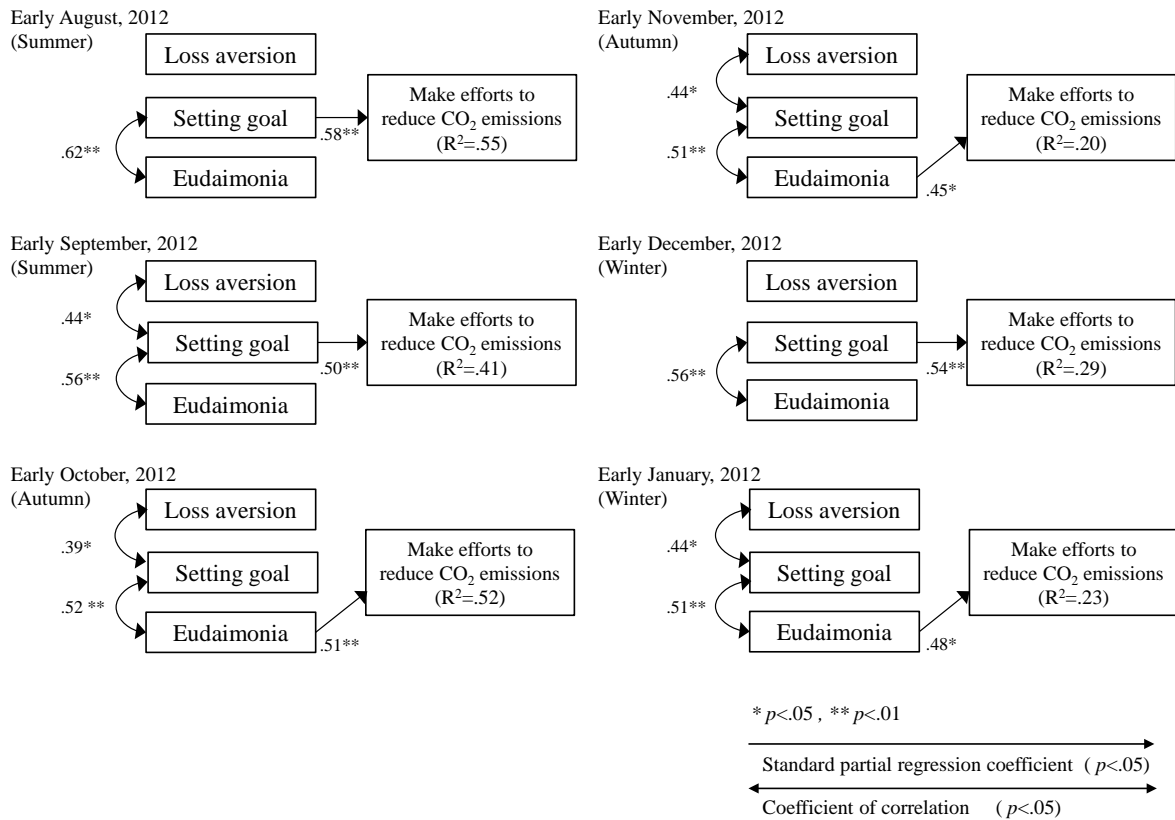


Figure 5. Path diagrams of the FIT-PCA psychological model.

Table 3. The number of the participants who perceived their own behaviours in connection with the global environment

Questionnaire periods	Make efforts to reduce CO ₂ emissions [n]	Perceive their own attitude to global environment issues [n]
Early August, 2012	8	4
Early September, 2012	10	6
Early October, 2012	10	6
Early November, 2012	11	7
Early December, 2012	9	8
Early January, 2012	6	5

3.3.2 Validation of the psychological model of the study of FIT-PCA

In order to examine whether FIT-PCA has led to the participants' efforts to reduce CO₂ emissions by the loss aversion, the goal setting and the eudaimonia as shown in Figure 3, a multiple regression analysis was made. Figure 5 shows the path diagram based on the results. As shown in the figure, it was found that the efforts to reduce CO₂ emissions has significantly affected by the goal setting or the eudaimonia.

Table 3 shows the number of the participants who perceived their own attitude to global environmental issues. This result shows the people who made efforts to reduce CO₂ emissions tended to perceive their own attitudes to be eco-friendly. Table 4 shows the changes of the attitudes to the environment which are their risk perception, effectiveness and responsibility attribution. This result shows their attitudes to global environmental issues have been improving compared with before the case study.

Table 4. Changes in attitudes towards the environment
(People who had perceived their own attitude towards global environmental issues in this case study)

Attitude	Questionnaire period	Mean value	SD	df	t -statistic
Risk Perception	Before case study	1.66	1.09	8	2.26*
	After case study	2.37	0.833		
Effectiveness	Before case study	1.22	0.441	8	2.00*
	After case study	1.89	0.928		
Responsibility attribution	Before case study	3.00	1.07	7	1.69
	After case study	2.13	0.991		

* $p < .05$

3.3.3 Typical cases

These statements are typical participants in this study who improved their eco-friendly attitudes and some who did not make any effort to reduce their CO₂ emissions.

Case 1: A participant who improved her eco-friendly attitudes.

This participant was a 60-year-old woman who lives with three family members in Kyoto, Japan. She is a typical example of people who improved their eco-friendly attitude in this study. Figure 6 shows the CO₂ emissions from her household over time. She has a car, but the railway is available near her house. Her house has a floor heating system. Before this case study, she reported having a highly positive environmental attitude. She was satisfied upon seeing the low emissions indicated in this graph for the summer and autumn months. However, in the winter months, when the CO₂ emissions began to exceed her PCA allowance of 150 kg., she began to encourage her family to use energy saving behaviours. In an interview, she reported that her efforts to reduce CO₂ emissions in the summer and autumn were motivated by eudaimonia. However, during winter, she said her motivation changed to loss aversion as she experienced the occurrence of loss.

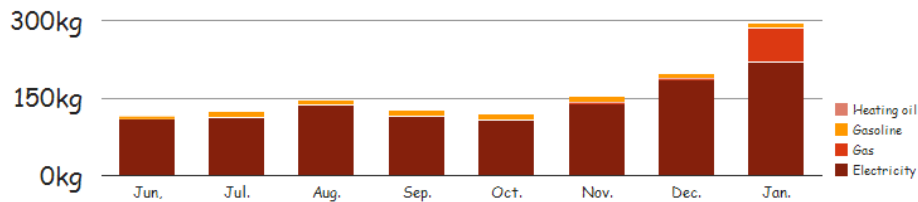


Figure.6 Case 1 - CO₂ emissions over time.

Case 2: A person who did not make an effort to reduce CO₂ emissions.

This participant is a 37-year-old woman who lives with five family members in Shiga, Japan. She is a typical example of people who did not make any efforts to reduce CO₂ emissions in this case study. Figure 7 shows the CO₂ emissions from her household over time. She has two little children. The family has three cars. Although they have a solar panel to provide some energy for their house, they use heating oil in the winter. She reported having a low level of environmental concern before participating in this study. The CO₂ emissions in her household were also low in the summer and autumn months. She reported that she did not increase her efforts to reduce energy consumption during winter because the health of her two little children is a higher priority; and they need the additional warmth provided by the heating system, which uses heating oil. Another participant who reported not making efforts to reduce CO₂ emissions stated there was a member of that household who needed long-term health care at home.

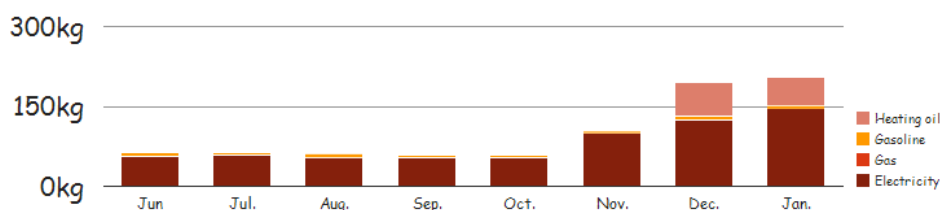


Figure.7 Case 2 - CO₂ emissions over time.

3.4 Discussion

The study participants had to input the numerical values of their energy usage into the FAI. However, in a real FIT-PCA system, such input would not occur. We believe that some of the participants experienced this case study like having an environmental household account book. This description was given by some participants during their exit interviews. This study aimed to measure changes in behaviours as a result of psychological effects induced by using the FIT-PCA system. One finding was that keeping participants informed of the status of their PCAs in an effective method was necessary as reinforcing feedback. It was revealed that goal setting had a large influence on CO₂ emission reduction behaviours according to the analysis of the psychological model. With the development of communication technology, the government should be able to effectively communicate the real time state of the PCAs in the future. Presently, methods to keep users informed of their PCA status are limited. Therefore, it is necessary to generate conversations about information presentation methodology in the study of FIT-PCA systems. Unfortunately, the same information may lower some people's motivation to reduce household CO₂ emissions when they have greatly exceeded their distributed PCA allotment. Furthermore, it is necessary to examine ways to mitigate unfairness in the system, especially as it relates to differences in climate and public transportation systems in different residential areas. Further study is also needed on how to manage the support of people with long-term home health care needs.

4. CONCLUSION

The authors developed a psychological model for reactions to using a FIT-PCA system and validated it through a six-month case study conducted with thirty cooperative participants. This model included principles of loss aversion, goal setting, eudaimonia and self-perception. Participants reported that goal setting and eudaimonia led them to increase their efforts to reduce CO₂ emissions. Furthermore, there was a tendency to express that their CO₂ reduction behaviours were based on their global environmental attitudes. This is likely due to their self-perceptions. At the end of the case study, six participants reported that they perceived their own behaviours as connected to the global environment. Interviews with participants who did not make an effort to reduce CO₂ emissions revealed that they had reasons that were of higher priority than their PCA management. Therefore, the potential for a successful FIT-PCA system depends, to some extent, on the way in which information is presented and how the workings of the system are explained. Future studies of FIT-PCA systems should include the analysis of a range of scenarios to match the range of patterns of people's daily lives.

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