

PUBLIC PERCEPTION ON HYDROGEN INFRASTRUCTURE IN JAPAN

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ABSTRACT

A public survey was conducted in March 2015 in Japan asking public awareness, knowledge, perception and acceptance regarding hydrogen, hydrogen infrastructure and fuel cell vehicle adopting the same key questions contained in the public surveys conducted six and seven years ago. Changes in answers between two different times of survey implementation were analyzed by comparing results of current survey to those of the previous surveys. Regression analyses were conducted and revealed influence of respondents' awareness, knowledge and perception about hydrogen, hydrogen infrastructure and fuel cell vehicle on their acceptance on hydrogen station. We found a large increase in the awareness and relatively a small improvement on knowledge on hydrogen energy, hydrogen infrastructure and fuel cell vehicle from the previous surveys. In contrast we did not find much changes in perception of risk and benefit perception on hydrogen society and hydrogen station and public acceptance of hydrogen infrastructure. Through the regression analyses we found large influences of negative risk perception of hydrogen itself and technology of hydrogen station and perception of necessity of hydrogen station on public acceptance of hydrogen station and the small influence of time background on the acceptance. Through the results of analyses, implications to public communication in building public infrastructure are presented.

1.0 INTRODUCTION

1.1 Background and objective

With the commercialization of fuel cell vehicles to begin in 2015, building hydrogen infrastructure is in need, to prepare a new society where hydrogen becomes familiar as a fuel in our daily life. As seen in nuclear power, public perception and acceptance of hydrogen and its utilization and supply technology are considered as an important factor for hydrogen penetration in the future. However, hydrogen utilization is an emerging technology to public, therefore, current status of its public acceptance is still unknown. It should also be noted that technology's public perception and acceptance may be influenced by the trend and incidents of the time. Such examples include the Hindenburg disaster back in 1937, and the hydrogen explosion at the Fukushima nuclear plant in 2011. This study conducts analysis on current status and historical changes of the public perception and acceptance of hydrogen infrastructure. The results will help facilitate communications, when promoting hydrogen use all over the nation in the future.

1.2 Literature review

Research on social acceptance of hydrogen and its utilization technology has been active outside Japan. Academic approach of such research is categorized to two main types; economic approach and social-psychological approach. The former conducts research on social acceptance from

economic perspective, mainly by the method of consumer survey of devices and equipment, focusing on “willingness to pay” survey for fuel cell vehicles and such, in order to give suggestions for policymakers and/or marketing field, while the latter analyses social acceptability and risk-awareness of facility locations, such as those of hydrogen stations and pipelines, to give suggestions in communications and discussions on facility location decisions, not from the perspective of economics. When using the above two approaches simultaneously in one research, social-psychological approach is adopted as the main, using economic approach partially.

Preceding studies outside Japan can be briefly summarized as follows; acceptability of utilization technology (for Fuel Cell Vehicle, hereafter it is called FCV) is very different from that of hydrogen infrastructure [1]. Previous social-psychological studies show positive response for FCVs from almost every people in survey, whereas such positive results are not apparent in questions about hydrogen station locations. For example, in the previous quantitative survey conducted in UK, a positive attitude to hydrogen station was seen in 25% of the respondents, however, 59% requested more information, and negative attitude was found in 9% [2]. Preceding qualitative research also shows both negative and positive attitudes and no strong objection [2, 3].

On the other hand, only a few studies have been conducted in Japan on these issues. The most comprehensive and large-scale research are the two surveys conducted by NEDO and Mizuho Information and Research Institute, using quantitative method (questionnaire for respondents to answer). These two take social-psychological approach with questionnaires, partially adopting economic approach as well. In their 2007 research [4], respondents were asked to show their attitudes to the introduction of fuel cell public transportation buses, installation of hydrogen stations (hydrogen sales at gas stations) and hydrogen pipeline construction. According to the results, 65% showed positive attitude to fuel cell buses, and 3% negative. For hydrogen stations, 52% positive and 11% negative, while 36% positive and 19% negative for hydrogen pipeline construction. The research in 2009 [5] also suggests that consumers’ trust on hydrogen supply and utilization system is the key to the public acceptance. Those survey results were not based on the respondents’ experience, however, because they were the general public without the real experience of using hydrogen utilization facilities.

2.0 METHODOLOGY

2.1 Implementation of the public surveys

This study conducted a public survey on awareness, knowledge, perception and opinion on hydrogen and fuel cell technologies across Japan, taking social-psychological approach, to analyze social acceptance of hydrogen and fuel cell technologies quantitatively. The survey was designed to compare the results of the two preceding large public surveys conducted by NEDO, using the same questions in the questionnaires of those surveys as key important questions in our questionnaire.

The survey was conducted in March 2015 using Internet panel. The advantage to use Internet panel is that it is relatively easy to obtain a large sample in a short time. While there is disadvantage that the sample is not always representative from the population even conducted random sampling because the original panel of Internet survey firm itself consists of voluntary participants. The basic data of implementation and the characteristics of the sample on the survey as well as those on the preceding surveys are shown in Table 1.

Table 1. The basic data of implementation of the surveys and the characteristics of the samples

	2008	2009	2015
Survey period	February 2008	October 2009	March 2015
Survey area	Across Japan	Tokyo area	Across Japan
Survey method	Random walk	Random walk	Internet
Sampling method	Two stage stratified sampling	Stratified sampling	Stratified sampling
N	1,188	800	3,133
Response rate	50.9%	51.4%	17.5%
Average age	49.0	48.1	45.4
Percentage of Female	51.0%	50.3%	50.1%
Average years of education	13.1	13.4	14.1

2.2 Analytical method

We used cross tab to compare the results of current survey to those of the previous surveys. To find influences of respondents' awareness, knowledge and perception about hydrogen, hydrogen infrastructure and fuel cell vehicle on their acceptance on hydrogen station, we used stepwise regression method to include / exclude variables adopting 0.05 for inclusion and 0.10 for exclusion in the significance level of F statistics.

3.0 ANALYSIS

3.1 Awareness

Compared to other energies including renewables and secondary energy, the awareness about "hydrogen energy" is not high (see Figure 1). About 32 % of respondents know about hydrogen as energy in 2015. It is much lower than those of nuclear energy, solar energy and wind energy, which are more than 80%. However, compared to 2008, percentage of those who know about hydrogen energy has increased by 12 points from 20%.

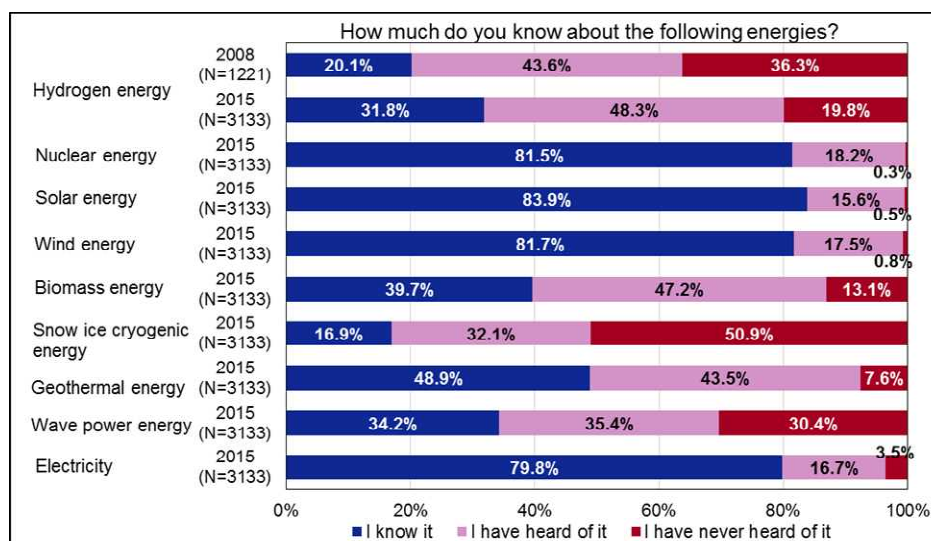


Figure 1. Awareness of renewable energy and secondary energy

In terms of fuel cell technology, awareness is much increased from 2008 to 2015 especially on FCV. More than one third know FCV and 89% have heard of it (see Figure 2). Even the awareness of hydrogen refilling station is about the same level of that of household fuel cell system in spite that most of public have never seen real hydrogen refilling station and household fuel cell systems which have been in the market since 2009 and about hundred thousands of household fuel cell system has sold so far.

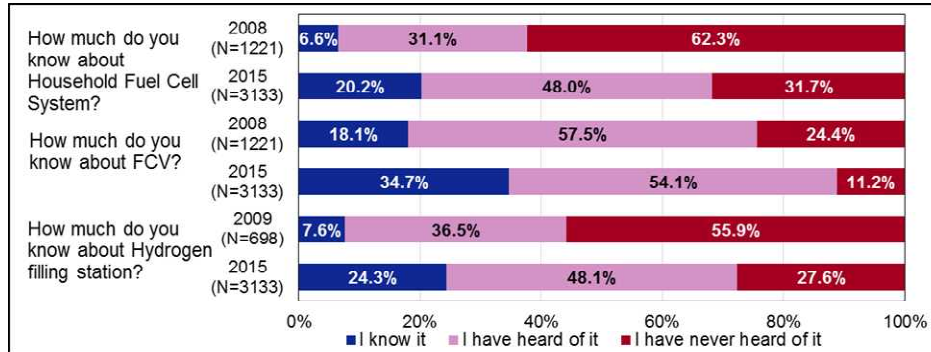


Figure 2. Awareness of household fuel cell system, FCV and hydrogen station

3.2 Knowledge

We gave the questions asking knowledge about hydrogen properties and relevant knowledge such as harmful or not; lighter than air or not; smell or not; flammable or not; and necessity of other energy to produce hydrogen. For all the questions, the correct answers are increased from 2008 and 2009 slightly (see Figure 3). This can be influenced by recent upsurge of the argument about the hydrogen society in the media or difference in the characteristics of the sample of two surveys. Except for the knowledge about hydrogen as the secondary energy, majority of respondents have correct knowledge about property of hydrogen.

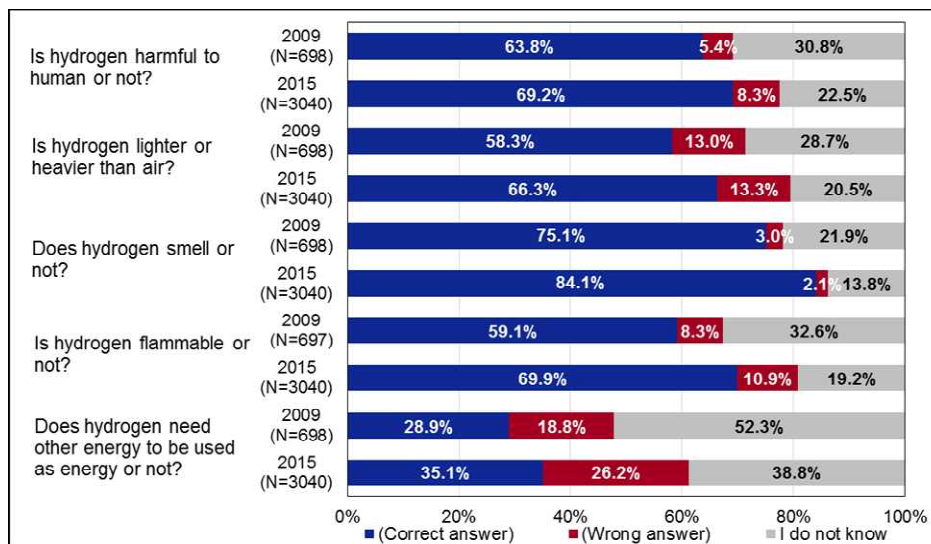


Figure 3. Correct / incorrect knowledge on hydrogen (properties and other issue)

As for fuel cell, we asked respondents how fuel cell works to produce electricity by two questions. We find the correct answers have increased from 2009 to 2015 slightly (see Figure 4). In contrast of knowledge on hydrogen property, still the majority of respondents do not know how fuel cell works correctly in 2015.

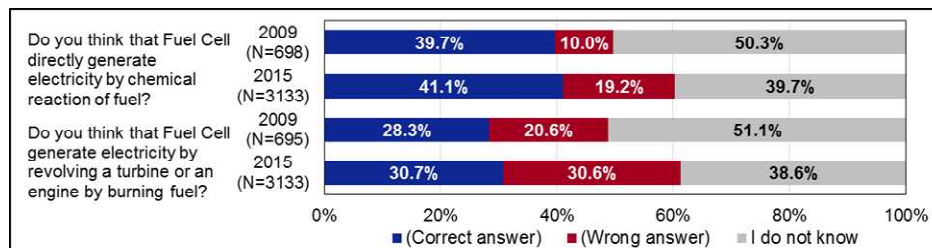


Figure 4. Correct / incorrect knowledge of fuel cell

3.3 Perception

We gave respondents questions related to future hydrogen society, asking “If we utilize more hydrogen energy, we do not have to rely on fossil fuel”; “If we utilize more hydrogen energy, we can solve global warming and air pollution”; and “Hydrogen is dangerous when we use it in dairy life”. The questions were created based on opinions collected in focus groups conducted before designing questionnaire in 2008. Through all the three questions, we found respondents show more neutral perception, decreasing optimistic perception about reducing dependency on fossil fuel and about solving global warming by utilizing more hydrogen energy (see Figure 5). At the same time, respondents’ perception that hydrogen is dangerous when we use it in dairy life is decreased. This can be the influence of concrete discussion on pro and con of hydrogen society in mass media. A typical criticism on promoting hydrogen energy is that hydrogen is currently made from fossil fuel so that it would not reduce CO₂ emission much.

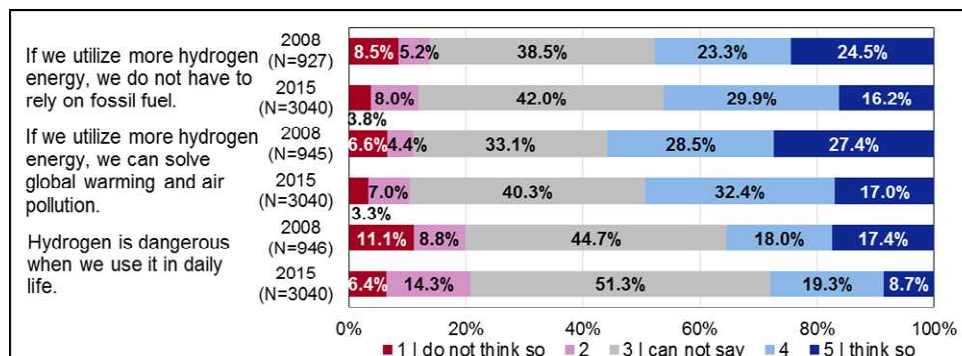


Figure 5. Perception relevant to hydrogen society

We gave respondents questions related to hydrogen stations. The questions were created based on opinions collected in focus groups conducted before designing questionnaire in 2009. As for the opinion “Hydrogen itself at hydrogen refilling station makes us worried” and “Technical reliability at hydrogen refilling station is low”, the tendency of the answers is not much changed from 2009 to 2015 (see Figure 6). About 40-50% of respondents took the neutral position for those questions. As for the opinion “We do not know what kind of accidents would happen”, the strong agreement on the opinions was decreased but more than half of the respondents supported the opinion in 2015. As for the opinion “Hydrogen refilling station is needed for society from now on”, agreement on the opinions was decreased significantly but still more than half of the respondents supported the opinion.

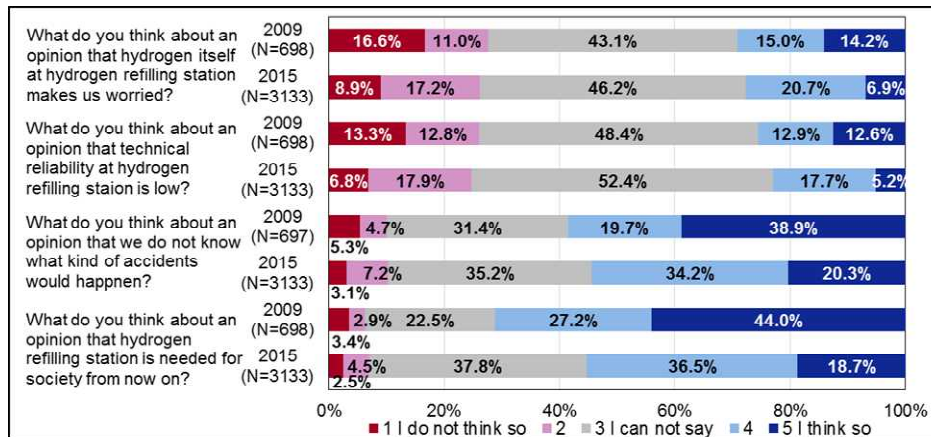


Figure 6. Perception relevant to hydrogen station

3.4 Acceptance

To assess acceptability of future hydrogen infrastructure, we asked opinions on three hypothetical cases that “if a bus company in your community will introduce fuel cell buses”; “if gas station near your house will start to sell hydrogen”; and “if new hydrogen station will be built near your house”. As for the fuel cell bus introduction, the positive opinion decreased slightly (see Figure 7). For hydrogen station, 52% of respondents showed positive opinion for starting to sell hydrogen in the nearest gas station and 44% of respondents showed positive opinion for locating new hydrogen station near the respondents’ house in 2015 but the percentages are not increased from 2009.

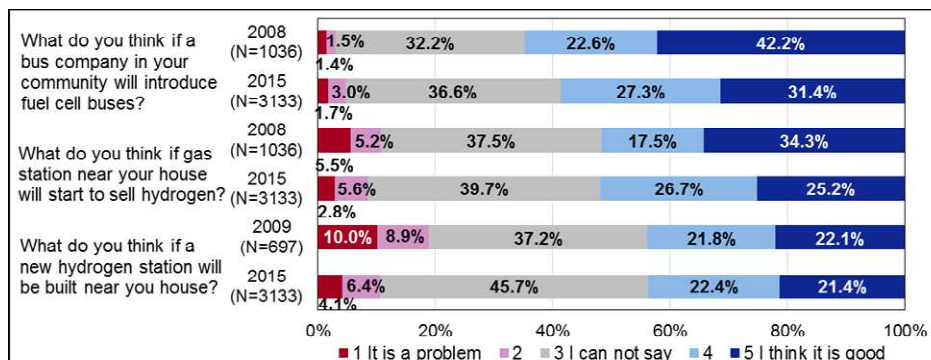


Figure 7. Potential acceptance of hydrogen station and fuel cell bus operated near respondents’ house

To find what kind of respondents’ characteristics and what kind of perception concerning to hydrogen, fuel cell and hydrogen infrastructure influenced the acceptance of locating hydrogen station near respondents’ house, we conducted the regression analyses using the answers to the question “what do you think if new hydrogen station will be built near your house?” as the dependent variable and endogenous variables that answers to questions on perception and opinion about hydrogen, fuel cell and hydrogen infrastructure in the questionnaire. For the questions asking knowledge on hydrogen itself and hydrogen and fuel cell technology, we created knowledge index by counting the number of correct answers to the questions and put it in the regression as an independent variable. In addition, we adopted a dummy variable of survey year coding year 2015 as 1 and other year as 0 to detect an effect not explained by endogenous variables but by the context of survey year. The result of the regression is shown in Table 2. The adjusted R-squared is 0.302 indicating the regression shows decent fit but still a large part is not explained by the regression.

When we look at size of standardized coefficients and significance level of independent variables, we realize the negative risk perception of hydrogen represented by the opinion “hydrogen itself at hydrogen refilling station makes us worried” and perception of technical reliability of hydrogen station represented by the opinion “technical reliability at hydrogen refilling station is low” made a negative effect and the perception of social necessity of hydrogen infrastructure represented by the opinion “hydrogen refilling station is needed for society from now on” made a positive effect on acceptance of new hydrogen station at 0.1% significance level.

As smaller effects, we see respondents’ favour of science and new technology such as “society should adopt new technologies as much as possible”, image of "science experiments" for hydrogen, opinion “we should utilize more renewable energies as soon as possible” and tendency to “take some risks if there is something that you really want” made a positive effect at 0.1 - 1% significance level. In addition, perception “FCV and Household Fuel Cell System are dangerous” made a negative effect at 1% significance level. As for the dummy variable of survey year 2015, we find relatively large positive effect of the context of the year 2015. In terms of knowledge index of hydrogen and fuel cell technology, the coefficient was not significant.

We also conducted a regression with the same dependent variable using only exogenous variables that are objective characteristics of respondents such as gender, age and educational level and 2015 dummy variable. Then we find only gender (female) variable and 2015 dummy variable are significant at 1% level and the fit of the regression (the adjusted R-squared) is very low (0.008).

In summary, we find negative large effect of negative risk perception on hydrogen and hydrogen and fuel cell technology and positive large effect of recognition of necessity of hydrogen infrastructure on acceptance of hydrogen station near respondents’ house.

Table 2. Result of regression analysis using endogenous variable in the surveys

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	2.895 **	.213		13.609	.000
What do you think about an opinion that hydrogen itself at hydrogen refilling station makes us worried?	-.275 **	.026	-.277	-10.698	.000
What do you think about an opinion that hydrogen refilling station is needed for society from now on?	.162 **	.025	.145	6.403	.000
Do you think that society should adopt new technologies as much as possible?	.112 **	.027	.088	4.078	.000
What do you think about an opinion that technical reliability at hydrogen refilling station is low?	-.131 **	.027	-.121	-4.938	.000
If we utilize more hydrogen energy, we do not have to rely on fossil fuel.	.078 **	.030	.074	2.585	.010
Does hydrogen make you imagine "science experiments"?	.082 **	.023	.073	3.531	.000
Do you think that FCV and Household Fuel Cell System are dangerous?	-.079 **	.024	-.072	-3.240	.001
Do you think that we should utilize more renewable energies as soon as possible?	.013 **	.005	.056	2.741	.006
Do you take some risks if there is something that you really want?	.070 **	.023	.065	3.099	.002
If we utilize more hydrogen energy, we can solve global warming and air pollution.	.077 *	.032	.070	2.413	.016
What do you think about an opinion that smell at hydrogen refilling station is uncomfortable?	-.058 *	.025	-.051	-2.332	.020
Do you think that a primary cause of global warming is ozone layer depletion?	.021 *	.009	.049	2.390	.017
Do you trust in newspaper articles?	-.051 *	.024	-.043	-2.101	.036
Dummy Year 2015	.320 **	.064	.107	4.978	.000

Dependent Variable: What do you think about an opinion that new hydrogen station will be built near you house?

*: Significant level below 5% **: Significant level below 1%

4.0 CONCLUSION

A public survey was conducted in March 2015 in Japan asking public awareness, knowledge, perception and acceptance regarding hydrogen, hydrogen infrastructure and fuel cell vehicle adopting the same questions contained in the public surveys conducted six and seven years ago. We found a large increase in the awareness and relatively a small improvement on knowledge on hydrogen energy, hydrogen infrastructure and fuel cell vehicle from the previous surveys. In contrast we did not find

much changes in perception of risk and benefit perception on hydrogen society and hydrogen station and public acceptance of hydrogen infrastructure. Through the regression analyses we found large influences of negative risk perception of hydrogen itself and technology of hydrogen station and perception of necessity of hydrogen station on public acceptance of hydrogen station and the small influence of time background on the acceptance. The results indicates the awareness and knowledge of hydrogen energy, FCV and hydrogen station has been increased due to a lot of publicity from the mass media, which was pointed out in recent focus group survey. However the perception and acceptance of hydrogen energy and hydrogen and fuel cell technology have not been improved by the media publicity meanwhile the majority of public are still rather neutral or favorable to them. This can be interpreted as the quality of perception and acceptance has changed, that is, the favorable prejudice to hydrogen energy and hydrogen and fuel cell technology has changed to a little more rational support to them.

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REFERENCES

1. Roche M.Y., Mourato, S., Fishedick, M., Pietzner, K. and Viebahn, P., Public attitudes towards and demand for hydrogen and fuel cell vehicles: A review of the evidence and methodological implications, *Energy Policy*, **38**, 2010, pp.5301-5310.
2. O'Garra, T., Mourato, S. and Pearson, P., Public acceptability of hydrogen fuel cell transport and associated refuelling infrastructures (Flynn, R. and Bellaby, P. Eds.), Risk and the public acceptance of new technologies, Palgrave Macmillan, Basingstoke, UK, 2007, p.126-153.
3. Ricci, M., Bellaby, P., and Flynn, R., What do we know about public perceptions and acceptance of hydrogen? A critical review and new case study evidence, *International Journal of Hydrogen Energy*, **33**, No.21, 2008, pp. 5868-5880.
4. Mizuho Information and Research Institute, Nenryoudenchi, suiso ni kansuru shakaijuyouseichousa (PEFC, Hydrogen's social acceptance research) (in Japanese), 2009.
5. Mizuho Information and Research Institute, Suiso shakaijuyousei ni kansuru chousa (Hydrogen's social acceptance research) (in Japanese), 2008.