sustainability

MDPI

Article

How Knowledge about or Experience with Hydrogen Fueling Stations Improves Their Public Acceptance

Shunichi Hienuki [1,*], Yoshie Hirayama [2], Tadahiro Shibutani [1], Junji Sakamoto [1], Jo Nakayama [1] and Atsumi Miyake [1]

1 Institute of Advanced Sciences/Center for Creation of Symbiosis Society with Risk, Yokohama National University, Yokohama 240-8501, Japan; shibutani-tadahiro-bj@ynu.ac.jp (T.S.); sakamoto-junji@okayama-u.ac.jp (J.S.); nakayama.jo1829@mail.u-tokyo.ac.jp (J.N.); miyake-atsumi-wp@ynu.ac.jp (A.M.)

2 Yokohama LCA Environmental Education Laboratory, Yokohama 220-0012, Japan; hirayama@xx.em-net.ne.jp

* Correspondence: hienuki-shunichi-sh@ynu.ac.jp; Tel.: +81-45-339-3776

Received: 30 September 2019; Accepted: 8 November 2019; Published: 12 November 2019

Abstract: Hydrogen, which is expected to be a popular type of next-generation energy, is drawing attention as a fuel option for the formation of a low-carbon society. Because hydrogen energy is different in nature from existing energy technologies, it is necessary to promote sufficient social recognition and acceptability of the technology for its widespread use. In this study, we focused on the effect of initiatives to improve awareness of hydrogen energy technology, thereby investigating the acceptability of hydrogen energy to those participating in either several hydrogen energy technology introduction events or professional seminars. According to the survey results, participants in the technology introduction events tended to have lower levels of hydrogen and hydrogen energy technology knowledge than did participants in the hydrogen-energy-related seminars, but confidence in the technology and acceptability of the installation of hydrogen stations near their own residences tended to be higher. It was suggested that knowledge about hydrogen and technology could lead to improved acceptability through improved levels of trust in the technology. On the other hand, social benefits, such as those for the environment, socioeconomics, and energy security, have little impact on individual levels of acceptance of new technology.

Keywords: hydrogen energy; advanced science and technology; technology acceptance; general public; acceptability model; technology experience; technology assessment; dissemination activities; energy management; energy policy

1. Introduction

Hydrogen is attracting attention as a next-generation energy source; it is also a useful option for creating a decarbonized society [1]. In Japan, the Ministry of Economy, Trade, and Industry organized "the Council for a Strategy for Hydrogen and Fuel Cells" with members collected from private companies and academic experts in December 2013. Based on their discussions, a "Strategic Road Map for Hydrogen and Fuel Cells" was compiled in June 2014 (and was then revised in 2016 and 2019) [2,3]. The first "Renewable Energy and Hydrogen Related Ministers' Meeting" was held in 2017, and the "Basic Hydrogen Strategy" was formulated in the second meeting. According to the current roadmap, a comprehensive direction and vision towards the 2030 goal—which the public and private sectors should share—has been developed, targeting a final hydrogen-based goal in 2050. This roadmap aims for 40,000 fuel cell vehicles (FCVs) to be domestically driven by 2020, but the number of FCVs launched was only 2824 by September 2018 [4]. Although there are several factors necessary for the penetration of FCVs, the most important issue relates to facilities for the adequate installation of hydrogen stations (HSs) for hydrogen refilling.

On the other hand, when innovative science and technology are introduced into society, their credibility greatly affects social acceptance; the introduction of hydrogen energy technologies such as FCVs and HSs is no exception. Until now, hydrogen energy has been used in a limited range for industrial purposes; however, since the fuel cells and FCVs that are currently expected to be introduced will be used in peoples' everyday lives, the public will be expected to use new technologies that are fully unfamiliar. Regarding HSs, discussions about their safety compared to gas stations [5,6] or current laws and regulations have shown that the serious risks can be managed [7].

The provision of information and experiences related to technology is a means to improve public awareness and acceptance [8,9]. For example, test drive experiences of electric vehicles have proved to be useful for greatly changing the introductory barriers and technology recognition, and it has been reported that providing public experiences of technology is also a useful strategy [10–12]. Such information provision and experiences have been shown to be particularly effective for ordinary people who are not yet widely familiar with the technology [13]. Also, Buhler et al. [10] reported that it is more effective for people to experience some of the technology in their actual lives rather than for them to simply obtain information about the technology.

Various studies have been conducted on the social recognition and acceptability of hydrogen energy. Environmental concerns and the reliability of the technology have been shown to be important factors for accepting hydrogen energy [14,15]. Moreover, it has been shown that economic efficiency is more important than environmental friendliness, assuming that reliability and safety are guaranteed [16]. Previous studies have generated hypotheses about the causal relationship between the receptivity of an HS and the psychological factors based on the norm activation model [17] and the theory of planned behavior [18]; they also analyzed survey results conducted on Dutch citizens in 2010 [19]. The main factors supporting HSs were personal norms, positive emotions about HSs, and the perception of the effects of HSs, while those that led to rejection of HSs were personal norms, negative emotions, and corporate credibility (distrust). The influence of problem recognition (environmental problems and energy security) on acceptability, which is proposed in the norm activation model [17], was not clearly seen. Huijts et al. [20] reanalyzed the same survey results by adding sociodemographic factors and the distance of survey takers to an HS. The results showed that the psychological factors (expectations for environmental protection and social effects) influenced acceptability more than the added factors and distance.

The 2015 Japan Internet Panel Survey [21] was conducted with the aim of comparing the risks, benefit recognition, and acceptability of HSs and fuel cell technology with those of two previous studies [22,23] conducted in 2008 and 2009, before FCVs had been launched. It was shown that the recognition and knowledge of the technology were improved; however, there was no change in the recognition of risks and benefits or the acceptability. In order to find the determinants of HS acceptability, they performed a multiple regression analysis with the "acceptability for setting up an HS near my home" as a dependent variable. The results suggested that negative risk perception (anxiety and distrust of technology) resulted in negative effects, while awareness of the social need for hydrogen facilities had a positive impact. A general understanding of the need for science and new technology were also slightly influential, while there was no impact from knowledge about the technology.

Ono et al. [24] investigated the acceptability of installing hydrogen refilling facilities in the existing gasoline stations and showed that "fear", one of the risk awareness factors, was the most influential factor as an independent variable contributing to acceptability. Based on this finding, they further investigated the impact of the provision of risk information on the acceptability of HSs as a measure to reduce fear [25]. Their study suggested that the acceptance of a new HS setting near their homes was relatively lower before information provision but was improved by providing quantitative information about the risk. The acceptability of installing hydrogen refilling facilities in existing gasoline stations was high, even when there was no information provided, but it tended to decrease once information was provided. This seems to be due to the recognition of a higher risk than expected before information provision. In the case of owning FCVs, the acceptability of installing a new HS near the survey respondent's home tended to increase.

Martin et al. [26] investigated the FCV awareness of FCV test drive participants in 2009. Eighty percent of the participants had good impressions, and they were generally ready for the drive range requirement, such as a relatively longer distance to HSs and the mileage limits for refilling. It was shown that awareness of hydrogen energy and its safety after a test drive was also improved. Hardman et al. [27] also investigated test drive participants' evaluation of FCVs in comparison with gasoline cars and compared the findings with a similar evaluation on existing electric cars. The samples were so-called "early adopters", categorized as members of the younger generation with high incomes and higher education. They chose environmental performance, fuel efficiency, and performance as the advantages of FCVs and the shortage of HSs and the price of the vehicle as the disadvantages. Compared to electric cars, the running distance and refilling time were positively evaluated, but the operational and initial costs were thought to be disadvantages. On the other hand, they were not significantly dissatisfied with the safety or reliability. This can be explained as a release of receptive disorder by suppression of "negative emotion", which is one of the influences of the psychological factors that Huijts et al. [19] had noted.

In addition, it has been pointed out that the results of questionnaire surveys targeting the general public with little knowledge about technology may be barriers in decision-making [28]. Various initiatives for the general public have been carried out to improve social awareness of hydrogen energy, and in Japan, there are also initiatives such as exhibitions of FCVs and test drive events. Therefore, it is necessary to clarify what kinds of technical information and experiences are effective for improving public awareness and acceptability. In this paper, we focused on the effect of initiatives that aim to promote awareness of hydrogen energy technology, thus investigating the acceptability of the technology by participants at several hydrogen energy technology introduction events.

2. Materials and Methods

2.1. Survey Questions

We asked respondents about FCVs, hydrogen energy, and HSs. The questions about vehicles regarded their perception, degree of environmental and socioeconomic benefits, and energy security effect. For hydrogen, subjective knowledge, safety, and explosion risk were questioned. For HSs, the questions were about perception, safety, risk of accident, willingness to use, and acceptance for nearby installation as an FCV owner or nonowner. Table 1 summarizes the questions. The answers for the questions are ratings with scales from 1 to 5 or 1 to 4, representing opinions that range from absolutely negative (1) to absolutely positive (4 or 5). In order to improve the ease of response, we asked that FCVs be compared to internal combustion engine vehicles and that HSs be compared to regular gas stations. As an FCV is very expensive compared with a gasoline vehicle, economic considerations that users might have (e.g., about vehicle and fuel purchase costs) were excluded from the questionnaire.

2.2. Sample

In this study, we focused on the impact of hydrogen energy technology introduction events on citizen acceptance. In order to compare and analyze this effect, a questionnaire survey was conducted at environmental/energy events held in the study region, and a questionnaire survey was conducted at seminars on hydrogen energy (symposiums and research report meetings). The former was a group comprised of general citizens with technical experience who participated in environmental/energy events (Exp), and the latter was a group who had knowledge of participating in seminars related to hydrogen energy (Know).

A point to note about the survey is that it did not include those who responded with no knowledge about hydrogen energy or technology. In general, in order to measure the impact of lectures and experiences, the "groups that were affected" and the "groups that were not" are compared; however, in the case of new technologies such as hydrogen energy, the general public's response with low knowledge may not be appropriate. Therefore, this study compared the two groups of the general public who have technology experience (Exp) and people who are engaged in work related to hydrogen energy, the environment, and energy technology (Know).

The survey period was from September 2016 to December 2017. The total number of respondents was 860, and the number of valid responses was 540 (Table 2).

Table 1. Summary of survey questions.

Question		Scale	Code
Fuel Cell Vehicle (FCV)	Subjective Knowledge	4	VK4
	Environmental Benefit (comparison with gasoline vehicle)	5	VE3
	Socioeconomic Benefit (comparison with gasoline vehicle)	5	VS3
	Energy Security (comparison with gasoline vehicle)	5	VP3
Hydrogen (H_2)	Subjective Knowledge	5	HY1
	Perceived Safety	5	HY2
	Perceived Explosion Risk	4	HY3
Hydrogen Station (HS)	Subjective Knowledge	5	ST1
	Perceived Safety (comparison with gas station)	5	ST2
	Perceived Risk of Accident (comparison with gas station)	5	ST3
	Attitude toward Use	4	ST4
	Acceptability for Nearby Installation (Vehicle Owner)	5	AS1
	Acceptability for Nearby Installation (Nonowner)	5	AS2

Table 2. Characteristics of the sample (N = 540).

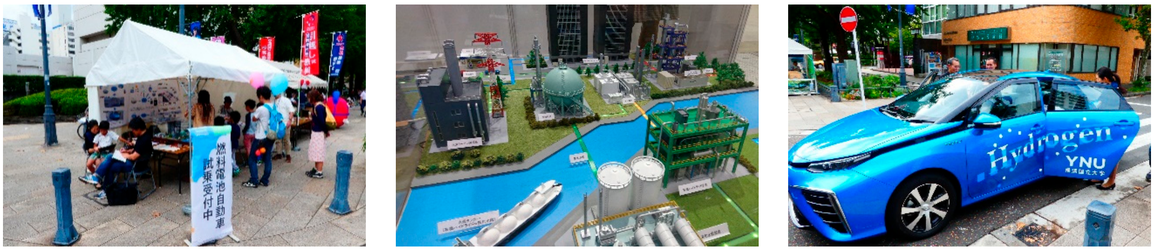
Age Distribution		Gender	
<19	16	Male	423
20–29	36		
30–39	80		
40–49	103	Female	55
50–59	99		
60–69	86		
70–79	39	Unknown	62
>80	9		
Unknown	72		
Total	540	Total	540

2.2.1. Environmental Energy Event for the General Public

At the environmental/energy events held by the local community, we prepared the content that would allow the general public (Exp, N = 184) to learn and experience hydrogen energy and technology (Figure 1a). Environmental/energy specialists and students were responsible for explaining the content.

The content consisted of five parts:

- Explanation of hydrogen energy, technology, and hydrogen refilling stations
- Explanation of hydrogen energy society by models (Figure 1b)
- Video of filling the FCV with hydrogen at the HS
- Water electrolysis and fuel cell kit demonstration
- FCV trial driving or ride (Figure 1c)



(**a**) (**b**) (**c**)

Figure 1. Example of a hydrogen energy system demonstration: (**a**) content overview, (**b**) energy system demonstration, and (**c**) fuel cell vehicle (FCV) trial driving or ride.

Each component of the content was based on actual conditions and scientific evidence as much as possible and did not explain whether the technology itself is good or bad. Respondents answered the questionnaire after experiencing all or some of these contents. Content and questionnaire surveys were conducted face to face, and respondents were able to ask questions at any time.

The poster presented hydrogen energy, fuel cells, features of HSs, hydrogen life cycle (from manufacturing to use), and safety measures for each type of technology. In addition, the video introduced how the FCV was filled with hydrogen at the HS with sound (mechanical sound, voice of the staff, etc.). The fuel cell kit produced hydrogen by electrolysis using electric power produced by solar power and ran a toy FCV with hydrogen; however, although respondents had experienced at least one of the above types of content, the difference in content was not taken into account in the aggregate analysis.

2.2.2. Hydrogen Energy Seminar

We conducted a survey targeting participants at seminars related to hydrogen energy and project research report meetings (Know, N = 356; Table 3). Many of the participants in these seminars were government workers, business operators, academics, and engineers who have more specialized knowledge than the general public about hydrogen energy and technology. The questionnaire was distributed along with the materials on the day of the seminar and collected after the seminar.

Table 3. Hydrogen energy seminar.

Data	Title
4/2016	The 6th Yokohama Hydrogen Energy Council Seminar—Toward the Realization of a Clean Energy Society—Seminar held via industry–government–academia collaboration
7/2016	Cross-Ministerial Strategic Innovation Program (SIP) Energy Carrier Public Symposium 2016
10/2016	Workshops attended by members of Japan Society for engineering
10/2016	The 7th Yokohama Hydrogen Energy Council Seminar—Toward the Realization of a Clean Energy Society—Seminar held via industry–government–academia collaboration
12/2016	Yokohama National University, Center for Creation of a Symbiosis Society with Risk, 5th Symposium "Considering the Effectiveness and Challenges of Risk Methods"
4/2017	The 8th Yokohama Hydrogen Energy Council Seminar—Toward the Realization of a Clean Energy Society—Seminar held via industry–government–academia collaboration
7/2017	Cross-Ministerial Strategic Innovation Program (SIP) Energy Carrier Public Symposium 2017
10/2017	The 9th Yokohama Hydrogen Energy Council Seminar–Toward the Realization of a Clean Energy Society—Seminar held via industry–government–academia collaboration SIP Energy Carrier Public Symposium 2017

3. Results and Discussion

3.1. Average Score and Response Ratio

The analysis was divided into a group of the general public (Exp) who had technical experience via environmental/energy events and a group (Know) who already had knowledge related to hydrogen energy. Figure 2 shows the aggregated results and average values for each Exp and Know group.

Question		Scale	Code	Group	Average
Fuel Cell Vehicle (FCV)	Subjective Knowledge	4	VK4**	Exp	3.83
				Know	3.27
	Environmental Benefit (comparison with GV)	5	VE3	Exp	4.22
				Know	4.15
	Socio-Economic Benefit (Comparison with GV)	5	VS3	Exp	3.83
				Know	3.81
	Energy Security (Comparison with GV)	5	VP3**	Exp	2.60
				Know	2.87
Hydrogen (H_2)	Subjective Knowledge	5	HY1**	Exp	4.41
				Know	4.08
	Perceived Safety	5	HY2	Exp	2.79
				Know	2.78
	Perceived Explosion Risk	4	HY3	Exp	1.68
				Know	1.74
Hydrogen Station (HS)	Subjective Knowledge	5	ST1**	Exp	3.76
				Know	2.70
	Perceived Safety (Comparison with Gas Station)	5	ST2	Exp	3.05
				Know	2.99
	Perceived Risk of Accident (Comparison with Gas Station)	5	ST3	Exp	2.77
				Know	2.88
	Attitude to Use	4	ST4	Exp	3.77
				Know	3.65
	Acceptability for Nearby Installation (Vehicle Owner)	5	AS1*	Exp	3.19
				Know	3.40
	Acceptability for Nearby Installation (Non-Owner)	5	AS2	Exp	2.58
				Know	2.75

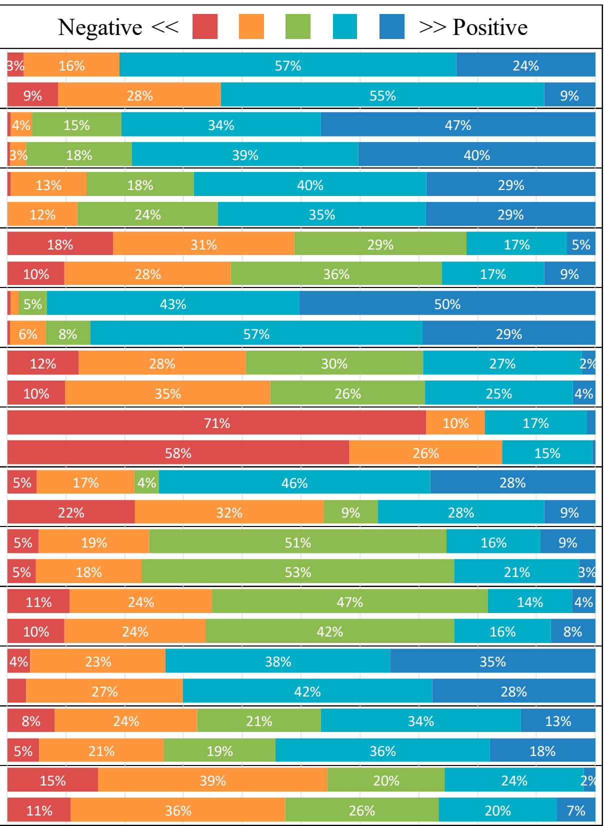


Figure 2. Overall results for each survey question answered. **, *: significance of the difference between Exp and Know, ** < 0.01, * < 0.05.

Regarding the knowledge of FCVs (VK4), hydrogen (HY1), and HSs (ST1), more than 60% of the respondents answered that they were more positive than the average value. The answers for FCVs (VK4) and HS knowledge (ST1) was higher for Know (significant probability of 1%).

Regarding the acceptability of HSs, there was a difference in the response tendency depending on whether the person owned an FCV (AS1) or not (AS2). It can be inferred that, if an FCV is owned, the FCV must be filled with hydrogen at the same frequency as the existing gasoline vehicle, making people more receptive to the concept in the context of everyday convenience. Both average scores were higher; that is, there was a tendency to be more willing to accept among the general public (Exp) who experienced the content than people with a certain level of knowledge.

As for the FCVs, many people answered positively about the environment (VE3) and social economy (VS3) performances compared to gasoline cars; however, with respect to energy security (VP3), the proportion of negative responses was larger than that of the positive responses, and 30% of the intermediate responses were in either group. This was presumed to be caused by the make-up of the Exp group. The first was the explanation of hydrogen raw materials from the viewpoint of the life cycle. A poster showed that hydrogen is produced not only from renewable energy but also from fossil fuels. Second, as one of the hydrogen projects, the hydrogen society model (Figure 1b) showed that hydrogen is produced using overseas renewable energy and coal use, and it is then transported to Japan.

As for hydrogen safety (HY2), the proportion of negative, intermediate, and positive respondents was almost the same in the Exp and Know group, while the proportion of slightly positive responses was higher in the Know group; however, over 70% of all the groups understood the possibility of a hydrogen explosion (HY3).

Regarding the safety of HSs (ST2) and accident damage (ST3), the intermediate values accounted for half, and the positive and negative responses were 30% and 20%, respectively. In other words, as a general trend among respondents, there were many people who thought that HSs and gas stations have the same levels of safety.

Nonetheless, over 70% of both groups had a positive response to the question of whether to use HSs. As for the acceptability of HSs, about half of the respondents who owned FCVs gave positive responses. Therefore, from these response trends, we can determine that people understand that there is a certain risk regarding the possibility of explosion and the safety of the technology, but there is a good chance that the technology will be accepted as a whole.

3.2. Factor Analysis

Exploratory factor analysis was conducted with 13 questionnaire items. In order to achieve better model fit, 2 of the 13 items were excluded. As a result, four latent variables were extracted, and the cumulative contribution rates of those four to the HS acceptability model were 63.7% for Exp and 67.0% for Know (Table 4); however, when we examined the contents of the items that showed an uneven distribution of scores, we excluded the environmental and socioeconomic items of FCVs. Therefore, these two items were excluded here, and 11 items were included in the subsequent analysis.

Table 4. Factor loading of observed variants (question scales).

(a) Exp					**(b) Know**				
	TT	**KH**	**AHS**	**ASB**		**TT**	**KH**	**AHS**	**ASB**
α*	0.747	0.546	0.766	0.388	α*	0.781	0.644	0.788	0.530
ST2	***0.732***	−0.050	0.048	−0.066	ST2	***0.802***	0.021	−0.056	0.080
ST3	***0.715***	−0.102	−0.054	0.056	ST3	***0.767***	−0.145	−0.091	−0.101
HY2	***0.699***	0.021	−0.007	0.075	HY2	***0.565***	0.096	0.109	0.028
ST4	***0.478***	0.160	0.043	−0.065	ST4	***0.523***	0.107	0.183	0.002
ST1	−0.099	***0.822***	−0.032	0.019	ST1	−0.047	*0.916*	−0.064	0.021
VK4	0.141	***0.622***	−0.012	0.016	VK4	0.055	***0.555***	0.032	0.009
HY1	−0.077	***0.259***	0.183	−0.019	HY1	−0.037	***0.480***	0.003	−0.091
AS1	−0.011	−0.052	***1.008***	0.036	AS1	−0.067	−0.003	***0.942***	0.031
AS2	0.130	0.153	***0.516***	−0.015	AS2	0.063	−0.036	***0.700***	−0.053
VE3	−0.036	−0.005	−0.032	***0.651***	VE3	−0.019	−0.050	−0.010	***0.819***
VS3	0.077	0.037	0.086	*0.387*	VS3	−0.006	−0.011	−0.006	***0.439***
Contribution (%)	29.401	14.198	11.466	8.628	Contribution (%)	31.670	13.238	12.753	9.311
Cumulative contribution (%)	29.401	43.599	55.065	63.693	Cumulative contribution (%)	31.670	44.908	57.661	66.971
Correlation to TT		0.204	0.614	−0.089	Correlation to TT		0.435	0.574	0.119
Correlation to KH			0.209	−0.063	Correlation to KH			0.351	0.057
Correlation to AHS				−0.010	Correlation to AHS				−0.008

* Cronbach's α value.

The first factor consisted of four items: station perceived safety (ST2), perceived risk of accident (ST3), hydrogen perceived safety (HY2), and attitude toward use (ST4). We named this factor the trust of technology (TT). The second factor consisted of three subjective types of knowledge (ST1, VK4, and HY1); the name of this factor was knowledge about technology. The third factor consisted of two HS acceptability items (AS1 and AS2), which was called the acceptability of a nearby location of an H_2 station. The fourth factor consisted of FCV environmental (VE3) and socioeconomic benefits (VS3): anticipation of social benefit (ASB).

The correlation between factors in both the Exp and Know groups tended to be similar. First, it should be noted that the ASB factor had no correlation with the other factors. This suggests that the environmental and socioeconomic benefits of FCVs have little to do with the acceptability of HSs. TT was highly correlated with AHS (acceptability of nearby HS). This shows that the reliability of the technology is important as a factor to accept the HSs. Also, TT had a weak correlation with KH (0.204 and 0.435, respectively), and this correlation was slightly higher in the Know group than in the Exp group. This shows that knowledge about hydrogen energy and technology is necessary for the reliability of the technology; however, this trend also shows that the more specialized Know group is more relevant.

Furthermore, a weak correlation can be confirmed between KH and AHS. This shows that knowledge about energy and technology is related to the acceptability of the HSs, although it has less impact than technology reliability does.

3.3. H_2 Station Acceptability Model

The latent variants were applied to a structure equation model. All paths in the model were significant. ASB could not be incorporated in the model. The model showed that AHS is positively affected by TT and that KH may indirectly affect ASH (Figures 3 and 4). The TT influence of the Exp group on AHS (β = 0.71) was stronger than that of Know (β = 0.61).

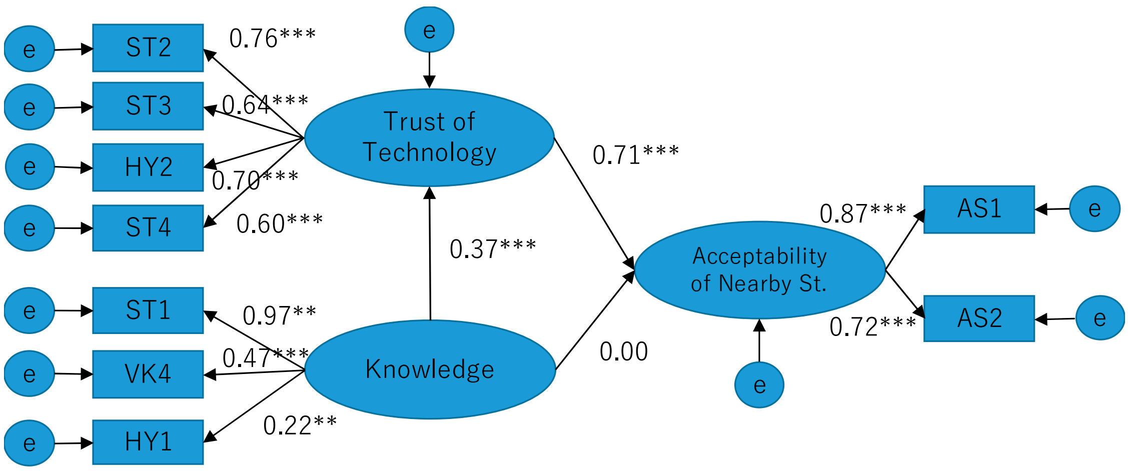


Figure 3. H_2 station acceptability model (Exp): goodness of fit (GFI) = 0.960, adjusted goodness of fit index (AGFI) = 0.929, root-mean-square error of approximation (RMSEA) = 0.044, normed fit index (NFI) = 0.927, and comparative fit index (CFI) = 0.961.

The result implies that the reliability of the technology is most important for the acceptability of HSs, and the reliability of the technology is influenced by knowledge about hydrogen energy and technology. It also shows that knowledge is not directly related to the acceptability of HSs and that it is important for people to use that knowledge to recognize the reliability of technology.

Exp and Know had slightly different relationships with the three factors. Exp had a 0.71 regression weight for the reliability of technology and the acceptability of HSs, which was slightly larger than the value of 0.61 for Know. This indicates that the general public group has a slightly greater impact on the acceptability of technology reliability than does the professional group. On the other hand, the relationships between the reliability of knowledge and technology were 0.37 and 0.42, respectively, and there was no difference between the two groups other than the relationship between reliability and acceptability. When combined with the results of the factor analysis, it is presumed that the expert group had a slightly stronger relationship between knowledge and technical reliability.

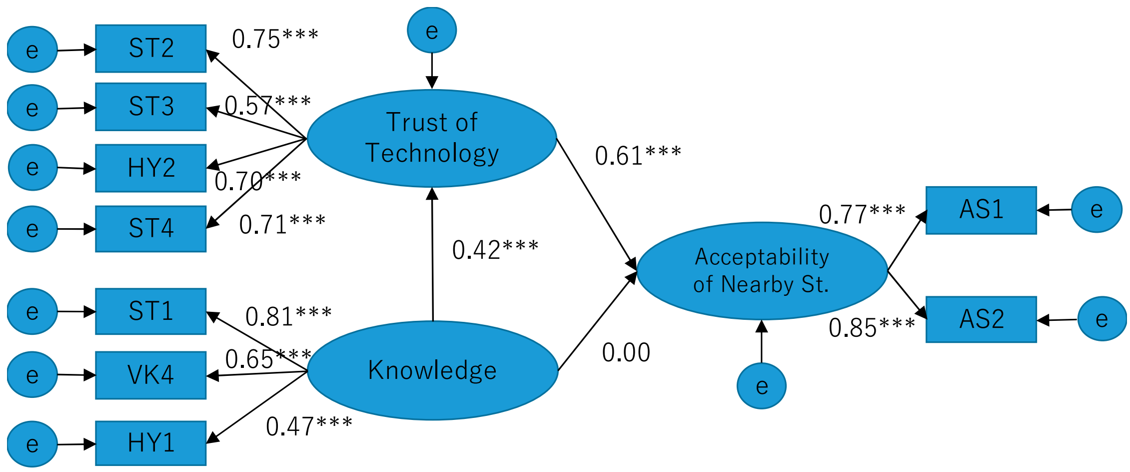


Figure 4. H_2 station acceptability model (Know): GFI = 0.960, AGFI = 0.928, RMSEA = 0.043, NFI = 0.926, and CFI = 0.961.

Next, we focused on the items that were made up the individual factors. First, we modeled that ST1, VK4, and HY1 were induced from KH, and the hydrogen station (ST1) was a good fit in both groups. The regression weights for the three observation variables for KH were well balanced in Know, and in Exp, the weight to SH1 was high and the weight to HY1 was low. This indicates that there is strong knowledge about the technology that citizens use or accept rather than about the characteristics of hydrogen energy.

The relationship between the factors that make up TT and the four items ST2, ST3, HY2, and ST4 was very similar between the two groups; however, for the use of the HSs (ST4), Exp had a regression weight of 0.60, which was slightly less than that of Know, which was 0.71. This indicates that the relationship between the attitude about using HSs and the reliability of the technology was slightly smaller for the general public than for a group of experts.

Factors AS1 and AS2 that made up AHS were both greater than 0.70; however, the magnitude of the relationship between AS1 and AS2 was reversed between the two groups. As can be inferred from the results of the factor analysis in Table 3, members of the general public group were less likely to accept HSs when they did not own an FCV, in comparison with the professional group. This study did not cover the economics at the individual level when using FCVs or hydrogen stations; however, convenience for everyday life is important when discussing the acceptance of HSs. On the other hand, the group of experts may feel that they are more conscious of contributing to society by accepting the HSs than is the group of ordinary citizens, even if they do not own FCVs.

3.4. Contribution to Hydrogen Energy Policy

Many energy policies related to hydrogen energy often appeal to the improvements in environmental performance and energy security. Certainly, FCVs contribute to solving urban air pollution because they emit only water when driving compared with gasoline vehicles. In addition, if hydrogen can be produced using electricity derived from renewable energy, it can be expected to contribute to reducing CO_2 emissions; however, these points do not greatly contribute to improving the general public's acceptance of hydrogen energy. Rather, it is important for policy makers and industries to explain how technology and safety measures as well as regulations are implemented.

As the survey results show, the general public considers the safety and risks of HSs to be comparable to those of gas stations; however, it was also recognized that hydrogen could explode, and it was suggested that such risks could not directly lead to hesitation of use. In other words, peoples' understanding of certain risks related to hydrogen energy and technology may also lead to improved acceptability.

Policy makers and industries provide opportunities to share this information with citizens. In order to increase the effect, active participation of the general public is important; however, it is not easy for them to show interest in technologies in the diffusion stage that have little direct impact on the lives of citizens. Against this backdrop, for example, as one measure, it may be effective to explain hydrogen energy and its technical mechanisms, risk, and safety when obtaining or renewing a driver's license. This is because approximately 75% of the Japanese hold a license and are obliged to take a course to renew their license once every few years [29]. By using this opportunity, there is a possibility that it can contribute to improving the acceptance of hydrogen by society as a whole by improving the acceptability of individuals.

4. Conclusions

According to the analysis results, participants of technology introduction events tended to have lower levels of both hydrogen and hydrogen energy technology knowledge than did participants in the hydrogen-energy-related seminars, but their trust in technology and acceptance of the installation of HSs near their residences seemed to be higher. This outcome may suggest that exposure to hydrogen technology leads to trust in the technology, thereby leading to acceptance. Knowledge of the technology should facilitate trust in it. The social benefits, such as environmental, socioeconomic, or energy security advantages, should not affect individuals' acceptance of the technology, even if they positively evaluate these advantages.

Some issues remain following this study. The first regards the measurements of things such as knowledge, perceived safety and risk, and attitude. In our survey, respondents replied subjectively due to the limitations of the questionnaire. Therefore, even if the same answer was selected, there may have been differences among them. Also, this study did not include the economic benefits of individual living levels. This is because the current hydrogen station construction and FCV purchase costs are higher than those of the existing technology. Previous studies have shown that safety and economics are important in terms of infrastructure and individual values [30]. In addition, although this study built an acceptability model for HSs, it could not deal with the relationship between consciousness and actual behavior and the continuity of knowledge and technical reliability through experience. We plan to conduct another survey when environmental and social conditions change in the future, after which we will compare its results with the results of the present study.

Author Contributions: Conceptualization, S.H. and Y.H.; Data curation, S.H., J.S., and J.N.; Formal analysis, S.H. and Y.H.; Funding acquisition, T.S. and A.M.; Investigation, S.H., Y.H., J.S., and J.N.; Methodology, S.H. and Y.H.; Project administration, T.S. and A.M.; Resources, S.H., T.S., and A.M.; Software, S.H. and Y.H.; Visualization, S.H. and Y.H.; Writing—original draft, S.H. and Y.H.; Writing—review and editing, S.H. and Y.H.

Funding: This work was supported by the Council for Science, Technology, and Innovation (CSTI) through its cross-ministerial Strategic Innovation Promotion Program (SIP), "Energy Carrier" (funding agency: Japan Science and Technology Agency (JST) and "Next Urban Lab Program" at Yokohama National University.

Acknowledgments: We are thankful for the cooperation of Yokohama National University's Green Hydrogen Research Center for questionnaire surveys at seminars and events.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. NEDO (New Energy and Industrial Technology Development Organization). *Hydrogen Energy White Paper*; NEDO: Omiya-cho, Japan, 2015; pp. 89–100.
2. Strategic Roadmap for Hydrogen and Fuel Cells, Japan Ministry of Economy, Trade and Industry. Available online: https://www.meti.go.jp/press/2018/03/20190312001/20190312001-1.pdf (accessed on 10 July 2019).
3. Outline of the Strategic Roadmap for Hydrogen and Fuel Cells. Japan Ministry of Economy, Trade and Industry. Available online: https://www.meti.go.jp/english/press/2019/pdf/0312_002a.pdf (accessed on 10 July 2019).

4. Daiwasoken Consulting Report. Daiwa institute of Research, February 2019. Available online: https://www.dir.co.jp/report/consulting/other/20190222_020637.pdf (accessed on 10 July 2019).
5. Sakamoto, J.; Nakayama, J.; Nakarai, T.; Kasai, N.; Shibutani, T.; Miyake, A. Effect of gasoline pool fire on liquid hydrogen storage tank in hybrid hydrogen–gasoline fueling station. *Int. J. Hydrogen Energy* **2016**, *41*, 2096–2104. [CrossRef]
6. Nakayama, J.; Kasai, N.; Shibutani, T.; Miyake, A. Security risk analysis of a hydrogen fueling station with an on-site hydrogen production system involving methylcyclohexane. *Int. J. Hydrogen Energy* **2019**, *44*, 9110–9119. [CrossRef]
7. Tsunemi, K.; Kihara, T.; Kato, E.; Kawamoto, A.; Saburi, T. Quantitative risk assessment of the interior of a hydrogen refueling station considering safety barrier systems. *Int. J. Hydrogen Energy* **2019**, *44*, 23522–23531. [CrossRef]
8. Jennings, P. New directions in renewable energy education. *Renew. Energy* **2009**, *34*, 435–439. [CrossRef]
9. Duan, H. The public perspective of carbon capture and storage for CO_2 emission reductions in China. *Energy Policy* **2010**, *38*, 5281–5289. [CrossRef]
10. Bühler, F.; Cocron, P.; Neumann, I.; Franke, T.; Krems, J.F. Is EV experience related to EV acceptance? Results from a German field study. *Transp. Res. Part F Traffic Psychol. Behav.* **2014**, *25*, 34–49. [CrossRef]
11. Jabeen, F.; Olaru, D.; Smith, B.; Braunl, T.; Speidel, S. Acceptability of Electric Vehicles: Findings from a Driver Survey. In *Shaping the Future: Linking Research, Policy and Outcomes*; Australasian Transport Research Forum: Perth, Australia, 2012.
12. Burgess, M.; King, N.; Harris, M.; Lewis, E. Electric vehicle drivers' reported interactions with the public: Driving stereotype change? *Transp. Res. Part F Traffic Psychol. Behav.* **2013**, *17*, 33–44. [CrossRef]
13. Bögel, P.; Oltra, C.; Sala, R.; Lores, M.; Upham, P.; Dütschke, E. The role of attitudes in technology acceptance management: Reflections on the case of hydrogen fuel cells in Europe. *J. Clean. Prod.* **2018**, *188*, 125–135. [CrossRef]
14. Achterberg, P.; Houtman, D.; van Bohemen, S.; Manevska, K. Unknowing but supportive? Predispositions, knowledge, and support for hydrogen technology in the Netherlands. *Int. J. Hydrogen Energy* **2010**, *35*, 6075–6083. [CrossRef]
15. Hickson, A.; Phillips, A.; Morales, G. Public perception related to a hydrogen hybrid internal combustion engine transit bus demonstration and hydrogen fuel. *Energy Policy* **2007**, *35*, 2249–2255. [CrossRef]
16. Mourato, S.; Saynor, B.; Hart, D. Greening London's black cabs: A study of driver's preferences for fuel cell taxis. *Energy Policy* **2004**, *32*, 685–695. [CrossRef]
17. Schwartz, S.H. Normative Influences on Altruism. In *Advances in Experimental Social Psychology*; Berkowitz, L., Ed.; Academic Press: New York, NY, USA, 1977; Volume 10, pp. 221–279.
18. Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [CrossRef]
19. Huijts, N.M.A.; Molin, E.J.E.; van Wee, B. Hydrogen fuel station acceptance: A structural equation model based on the technology acceptance framework. *J. Environ. Psychol.* **2014**, *38*, 153–166. [CrossRef]
20. Huijts, N.M.A.; van Wee, B. The evaluation of hydrogen fuel stations by citizens: The interrelated effects of sociodemographic, spatial and psychological variables. *Int. J. Hydrogen Energy* **2015**, *40*, 10367–10381. [CrossRef]
21. Itaoka, K.; Saito, A.; Sasaki, K. Public perception on hydrogen infrastructure in Japan. *Int. J. Hydrogen Energy* **2017**, *42*, 7290–7296. [CrossRef]
22. Mizuho Information and Research Institute. *Suiso shakaijuyousei ni kansuru chousa [Hydrogen's Social Acceptance Research]*; Mizuho Information and Research Institute: Tokyo, Japan, 2008. (In Japanese)
23. Mizuho Information and Research Institute. *Nenryoudenchi, suiso ni kansuru shakaijuyouseichousa [PEFC, Hydrogen's Social Acceptance Research]*; Mizuho Information and Research Institute: Tokyo, Japan, 2009. (In Japanese)
24. Ono, K.; Tsunemi, K. Identification of public acceptance factors with risk perception scales on hydrogen fueling stations in Japan. *Int. J. Hydrogen Energy* **2017**, *42*, 10697–10707. [CrossRef]
25. Ono, K.; Kato, E.; Tsunemi, K. Does risk information change the acceptance of hydrogen refueling stations in the general Japanese population? *Int. J. Hydrogen Energy* **2019**, *44*, 16038–16047. [CrossRef]
26. Martin, E.; Shaheen, S.A.; Lipman, T.E.; Lidicker, J.R. Behavioral response to hydrogen fuel cell vehicles and refueling: Results of California drive clinics. *Int. J. Hydrogen Energy* **2009**, *34*, 8670–8680. [CrossRef]

27. Hardman, S.; Chandon, A.; Shiu, E.; Steinberger-Wilckens, R. Cunsumer attitudes to fuel cell vehicles post trial in the United Kingdom. *Int. J. Hydrogen Energy* **2016**, *41*, 6171–6179. [CrossRef]
28. Assefa, G.; Frostell, B. Social sustainability and social acceptance in technology assessment: A case study of energy technologies. *Technol. Soc.* **2007**, *29*, 63–78. [CrossRef]
29. Cabinet Office. Number of License Holders. Available online: https://www8.cao.go.jp/koutu/taisaku/h30kou_haku/zenbun/genkyo/h1/h1b1s2_3.html (accessed on 27 September 2019).
30. Hienuki, S.; Noguchi, K.; Shibutani, T.; Saigo, T.; Miyake, A. The Balance of Individual and Infrastructure Values in Decisions Regarding Advanced Science and Technology. *Sustainability* **2019**, *11*, 3385. [CrossRef]