

## COMMUNITY ACCEPTANCE OF NUCLEAR POWER GENERATION IN JAPAN AND RELEVANT INFLUENCING FACTORS

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### ABSTRACT

The Japanese government has recently set an ambitious target to reduce its CO<sub>2</sub> emissions by expanding renewables and nuclear power plants (NPPs). Perception about nuclear power, however, has always been an issue in Japan. This research reports the results of a survey regarding public acceptance of NPPs in three community groups and associations with some of its influencing factors. The samples are taken from one site near a plant under construction (Kaminoseki), another near a plant in operation (Hamaoka) and one without plants nearby (Kyoto). Among the findings, the preference to expand nuclear power was 28 percent, while that to decrease it was 11 percent. In addition, the community acceptance may shift from 28 to 65 percent in a special case of constrained acceptance. People living near the planning and the consumption sites had the highest acceptance rates and the least polarised view towards NPPs expansion. Among the analysed factors of influence, "Inclusion in the decision process" had significant correlation with both cases of acceptance ( $\tau_b=0.22$ ). Some measures to improve community acceptance before plans for NPPs expansion are included as recommendations.

**Keywords:** Community Acceptance; Public Acceptance; Nuclear Power; Japan; Energy

### 1. INTRODUCTION

Over the past three decades despite considerable efforts have been directed towards evaluating alternatives to reduce the accumulation of greenhouse gases, Global warming still remains one of the most serious threats for humanity. Several governments have failed to comply with their own previously set targets, making such collaborative efforts perhaps the most multifaceted problem to conciliate in our current society. In some cases, action have delayed to the point of having the first serious implementation programs just now, long after having commitments for abatement greenhouse gases signed. Such an example is Japan, where the government has set targets to limit its CO<sub>2</sub> emissions just recently. The Japanese goal is to reach 25% and 80% of their 1990 annual emission levels by 2020 and 2050 respectively (Japanese Cabinet, 2010). After a 13 year period of emissions increase since their signature to the Kyoto Protocol, this measure, if effective, will have a direct implication on the power production because the

relationship between energy fuels and greenhouse gases is highly correlated, and today 66% of electricity in Japan is produced from fossil fuels (Takase and Suzuki, 2011).

In that prospective scenario, the only options available to substitute fossil fuels in the electricity mix in Japan are renewables or nuclear power, but each technology has own advantages and disadvantages. Some forms of renewable energy seem to have large physical and economical potentials, however constraints related to their generation pattern and land required for deployment could limit their growth, particularly to a scale sufficient enough to fill the void left by fossil fuel substitution (MacKay, D., 2009). On the other hand, increasing the share of nuclear energy would be an effective measure to cut down greenhouse gases, but the constraints related to nuclear fuel, nuclear waste management and the perception of risks related to nuclear power generation have created distrust towards its expansion among the public. An urgent question, therefore, is how the prospective energy system would be like, particularly for countries like Japan without own resources. In case there is full deployment of renewables, how likely is nuclear energy to remain in the agenda and how much power production would be needed by 2020 and 2050? If policy still aims towards nuclear energy, the most pressing issues would be its risks compared to other power generation forms and the way these are conveyed to the public (risk communication).

Under this context, social acceptance assessments are one way of analysing factors involved with the perception of risks of nuclear power among social groups. According to Wustenhagen et al. (2007) social acceptance is a broad concept which includes socio-political, community and market dimensions. Community acceptance can be defined as acceptance from local residents and governments towards nuclear power plants (NPPs). In Japan, over the past years some reports have been published concerning community acceptance of NPPs (Onisawa et al, 1986; CPRO, 2009) however, none has attempted to understand the concept focused on the difference between locations and in association with any influencing factors. In CPRO (2009) for example, using a stratified two-stage sampling, the Japanese government survey 1,850 individuals about their opinions on nuclear power focusing on the general

perception of the public. No reference was found, however, to understand community acceptance in association to influencing factors, despite the sample could have potentially studied differences among the population it covered. Such an approach could shed some light on what is the main barrier for the accurate conveyance of those risks to the public. The aim of this paper, therefore, is to obtain the level of community acceptance from local residents to NPPs, to analyse statistical relationships to four factors that may influence that score, and to explore the shift of that acceptance when respondents are faced with a renewable-constrained scenario. This study has focused on three community groups to identify differences between locations related to each stage of a nuclear power project: a settlement near a plant under construction, another near a plan under operation and a last one without plants nearby (a consumption centre).

## 2. METHODOLOGY

### 2.1 Questionnaire structure

All necessary data for the analysis was structured in a questionnaire divided in three major sections:

First: Overall Acceptance

- The perception about expansion of NPPs.

Second: Influencing factors

- Factor 1: Knowledge about NPPs advantages (Knowledge).
- Factor 2: Quantity of information received, sources and trust over it (Information).
- Factor 3: Motivation to know more about NPPs (Motivation).
- Factor 4: Inclusion in the stakeholders' decision making process (Inclusion).

Third: Constrained Acceptance

- The preference for NPPs or fossil fuels expansion if renewable' growth was constrained to a certain limit.

The questionnaire was structured in the following way: Overall Acceptance obtained by enquiring about the willingness to expand, maintain or reduce nuclear power through a question in a 4 point scale; Knowledge by asking individuals to select advantages of nuclear power they know from four options: "generation at high efficiency", "CO<sub>2</sub> emissions reduction" and "reduce reliance on fossil fuels"; Information through a question in a scale from 1 to 5, enquiring how much information have they received from the power company, the government, NGOs and the mass media; Trust, by asking to score from 1 to 10 the reliance on each of the information they have received; Motivation by asking if the respondent would like to know more about nuclear power; Inclusion, through a question in a 5 point Likert scale asking how much would respondents agree on to say their opinion has been listened in the project; And finally, Constrained Acceptance through a question asking respondents to choose among expansion of fossil fuels or NPPs if more energy was needed but renewable energy

could not be used beyond a limit because of land or other physical constrains.

### 2.2 Locations:

As introduced before, our sample was selected from locations near each of the stages related to a nuclear power generation project: planning, operation and consumption. For the planning stage we have selected Kaminoseki-cho in Yamaguchi prefecture where a NPP project is under construction by the Chugoku Electric Co. For the operation one, we selected Hamaoka-cho in Shizuoka Prefecture with Chubu Electric's Hamaoka NPP in operation nearby since the early 90's. And finally, for the consumption stage, we selected Kyoto with no NPPs in its vicinity.

### 2.3 Analysis:

From the three sites a total of 140 answered questionnaires were collected in January 2011: 60 from Kyoto and 40 from Kaminoseki and Hamaoka respectively.

For the analysis, the values were used in the following way: For the variable Knowledge answers were treated as ordinal dummy variables (yes and no), Information, Trust and Inclusion were aggregated as ordinal dummy variables (Low and High), Constrained Acceptance as an ordinal dummy variable as well, and Overall Acceptance as a three-scale ordinary variable (decrease, maintain and expand).

To reveal differences among the answers of the three sites, we conducted a one-way ANOVA (analysis of variance), and to analyse the difference between factors and acceptance: X<sup>2</sup> tests of independence for significance and Kendall's tau correlation coefficient ( $\tau_b$ ) for the strength of association.

## 3. RESULTS AND DISCUSSION

### 3.1 Community acceptance towards nuclear power

In the complete sample, the preference to expand nuclear power generation was 28 percent, while that to decrease NPPs was 11 percent. There were 19 percent of respondents without a clear preference and the highest percentage in the sample was from those who wished to maintain the current power plants working (42 percent). Figure 1 summarises these results.

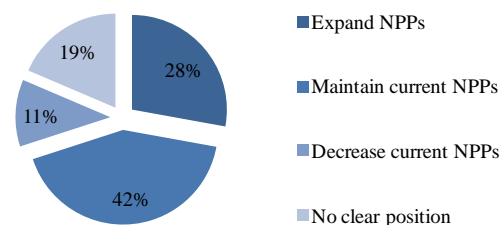


Figure 1 Preference percentage regarding the future of nuclear power plants (NPPs) in Japan.

In contrast to a report by the Japanese government (CPRO, 2009), there was a considerably larger share of nuclear power “advocates” (28% to 9.7%), slightly fewer “opponents” (11% to 16%), and considerably fewer respondents willing to maintain the current NPPs working (42% to 70.3%).

The sample took slightly more questionnaires from regions close to the power plants, where the preference to expand NPPs might be thought as more positive. Despite citizens living nearby these regions have to accept the risks of NPPs, economical or labour benefits associated to the power plants could influence a positive response towards expanding nuclear power. To determine if this difference is related to that hypothesis, the following section is devoted to analyse the preference in each of the three selected sites.

### 3.1.1 Regional Differences

According to the  $X^2$  test of independence, there was a significant ( $P < 0.001$ ) regional difference of preference towards NPP expansion compared to the overall results. Fig 2 shows how the planning and operation stage had a different pattern of preference to the overall scores, while the consumption centre was more similar.

The preference to expand NPPs concentrated in places without plants in operation (Kyoto and Kaminoseki) while the lowest rate was found in Hamaoka. In addition, these two regions not only contained the largest percentage of advocates but also the smallest of “opponents”, suggesting that the views towards NPPs were positive in general and less polarised. In these regions, however, the results exhibit the largest share of “sceptics”, respondents without a clear position towards NPPs. This is true particularly in Kaminoseki with 30 percent of such respondents, and double the percentage of Kyoto.

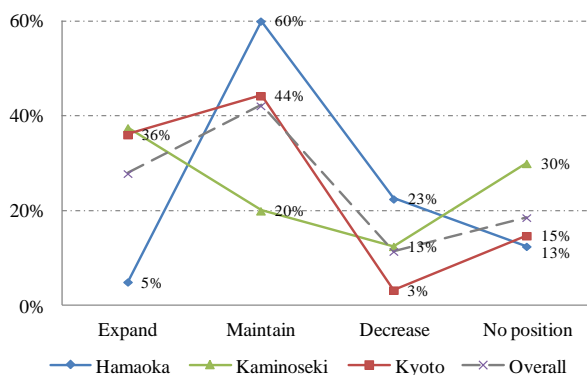


Figure 2 Preference percentages regarding the future of nuclear power plants (NPPs) in Japan by region.

Hamaoka, on the other hand, exhibited the lowest percentage of sceptics in addition to its largest percentage of people who prefers to keep the current power plants working. Based on this, we can say despite the population

around Hamaoka have received benefits associated with a large scale power generation project, their views towards nuclear energy is not as positive as supposed. This fact contrasts with the belief that places with “successful” projects bear higher acceptance scores, and regions close to projects under planning bear lower ones. On the contrary, in Hamaoka “opponents” are the largest and “advocates” the lowest. Constant contact with a “successful” project does not necessarily influence positively the standpoint of citizens towards it.

Finally, another major difference between regions was the percentage of those wanting to maintain the current plants. Kyoto was the closest to the overall scores while Kaminoseki was half of that and Hamaoka 20 percent more.

In summary, places without NPPs in operation scored the highest acceptance towards NPPs expansion but also the highest level of scepticism. Scepticism was highest in the place close to an NPP but without previous experience of their future performance. Previous experience with a “successful” project, however, may not necessarily influence positively the standpoint of citizens towards expanding NPPs.

### 3.2 Community Acceptance under a Renewables-Constrained Scenario (Constrained Acceptance).

The scores of community acceptance of NPPs may change when individuals are asked to decide among expansion of fossil fuels or NPPs under a hypothetically renewable-constrained future. Table 1 shows a summary of the preference between nuclear and fossil fuels expansion when renewable energy expansion in Japan is limited to a certain percentage. In this table, we can see that there was a shift from 28% to 65% of the respondents choosing to expand NPPs. This result suggests that when renewables cannot supply the energy needs, several respondents are ready to avoid environmental impacts from fossil fuels by adopting a more positive position towards NPPs expansion.

Table 1 Preference shift under a renewables-constrained future.

Overall Acceptance	Constrained Acceptance			TOTAL
	Expand Fossil Fuels	Expand NPPs	No answer	
Decrease	6 (38%)	9 (56%)	1 (6%)	16
Maintain	17 (29%)	35 (59%)	7 (12%)	59
Expand	1 (3%)	34 (87%)	4 (10%)	39
No position	5 (19%)	13 (50%)	8 (31%)	26
TOTAL	29 (21%)	91 (65%)	20 (14%)	140

In a more careful analysis, however, we can also see that the number of strong opponents to NPPs was rather high (21%), structured mostly from those that changed their view from wishing to maintain NPPs to strong opposition. In contrast, those who changed their view towards NPPs expansion

came not only from respondents wishing to maintain current NPPs, also from “sceptics” and “opponents”.

### 3.2.1 Constrained Acceptance Regional Difference

The shift of acceptance was not similar for all the regions. Hamaoka had the best scores reaching 84% of acceptance and acceptance in Kaminoseki was the lowest (see Figure 3). According to an ANOVA, however, this difference is not statistically significant.

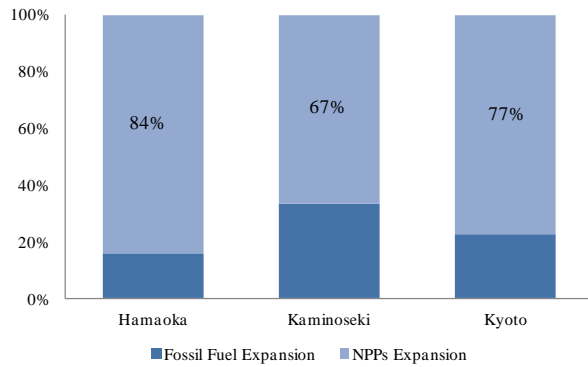


Figure 3 Preference for future power generation expansion in Japan by region.

The following section will concentrate on those factors that may influence the scores to accept or reject expansion of NPPs.

## 3.3 Factors Influencing Community Acceptance

### 3.3.1 Factors Influencing Overall Acceptance

Among the factors analysed, only two had significant correlation with *overall acceptance*:

- Trust on information received from the mass media.
- Inclusion in the decision process.

The  $X^2$  tests and  $\tau_b$  correlation results are summarised in table 2.

These results show that Knowledge about any of the advantages from NPPs had no association with higher acceptance to build new NPPs and except for mass media, the same was found for information. The association between acceptance and trust in mass media information, however, was in fact quite weak and negative, i.e. those who trusted more in such information showed lower acceptance to expand NPPs. By assuming that the information those respondents received had had a neutral standpoint; those who have trusted it more would have gained more arguments to decide that NPP expansion is unacceptable. A reasonable argument for lower acceptance to NPPs by trusting more on the information received. If, on the other hand, that information had had a negative standpoint, respondents would have directly being influenced on their opinion towards NPPs. In any case, the association seems to be a weak predictor for acceptance based on the  $\tau_b$  correlation coefficient.

Finally, inclusion in the decision process is the only factor positively associated with acceptance of NPPs. As expected, the role of the respondents in the decision process is relevant for accepting to have more similar projects. Despite the association was too weak to be a good predictor it showed certain association.

Table 2 P values from  $X^2$  tests and  $\tau_b$  correlation coefficients between factors and acceptance.

Factors	Overall acceptance		Constrained Acceptance	
	P	$\tau_b$	P	$\tau_b$
(1) Knowledge about advantages				
a. Generate electricity at high efficiency	0.89	0.02	0.90	0.00
b. Reduce CO2 emissions	0.34	0.12	<b>0.00**</b>	<b>0.26</b>
c. Reduce the reliance on fossil fuels	0.90	0.03	0.23	0.11
(2) Information received				
a. Company Trust	0.32	0.09	<b>0.02*</b>	<b>0.21</b>
b. Government Trust	0.54	0.09	<b>0.00*</b>	<b>0.32</b>
c. NGOs Trust	0.89	0.04	0.10	0.15
d. Mass media Trust	0.77	0.02	0.06	0.17
e. Mass media Trust	0.45	0.11	0.32	0.09
f. Mass media Trust	0.37	0.11	0.90	0.01
g. Mass media Trust	0.07	-0.18	0.37	0.08
h. Mass media Trust	<b>0.01**</b>	<b>-0.2</b>	0.14	0.14
(3) Motivation to know more about NPP				
	0.17	0.09	0.11	0.15
(4) Inclusion in the decision process				
	<b>0.00**</b>	<b>0.10</b>	<b>0.02*</b>	<b>0.22</b>

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

### 3.3.2 Factors Influencing Constrained Acceptance

By taking the score of *constrained acceptance* as the maximum reachable acceptance level for NPPs expansion, three factors had significant associations with it:

- Knowledge about CO<sub>2</sub> emissions reduction capabilities of NPPs.
- Company's information and trust on it.
- Inclusion in the decision process.

Contrary to overall acceptance, table 2 shows how knowledge about one nuclear power advantage was significantly associated with higher levels of constrained acceptance. This was the ability to reduce CO<sub>2</sub> emissions of NPPs. This could also mean, however, that those who knew CO<sub>2</sub> emissions can be reduced with NPPs did not choose fossil fuels as an option for future power expansion, because constrained acceptance only allowed for these two options.

As for the quantity and reliance on the information received from the power company both had significant effects to constrained acceptance. Moreover, both seem to have a positive relationship from the data in Table 3. This

contingency table shows that among strong opponents to NPP expansion (fossil fuel expansion), the cases with “high” information levels were much less than those of nuclear advocates. Similarly, the trust on this information was sensible to the amount of information received from the proportions in each group: (0% among opponents and 72% among advocates).

Table 3 Quantity and trust on information from the power company by constrained acceptance groups: (A) Group with preference for fossil fuel expansion (B) Group with preference for Nuclear Power Expansion

Constrained Acceptance					
Trust	(A) Fossil fuels expansion		(B) NPP expansion		Total
	Low	High	Low	High	
	Quantity				
Low	23 (28%)	2 (2%)	45 (54%)	13 (16%)	83
High	4 (11%)	0 (0%)	7 (19%)	26 (70%)	37

Finally, inclusion also had significant association to constrained acceptance, a pattern that not only remained from the overall acceptance analysis but slightly strengthened with the correlation with constrained acceptance.

In conclusion, while reliable information from companies in particular seemed partially important in the process of building acceptance towards expansion of NPPs, the factor that had more relevance was inclusion in the decision making process. In any case the factors analysed in this paper had weak associations that could not be taken as strong predictors for the community acceptance of NPPs.

### 3.4 Recommendations

This section is aimed to briefly discuss some measures to improve community acceptance before NPPs expansion.

The first measure is to disclose information regarding risks of plants and safety measures. Despite increasing information from the companies has little effect on acceptance towards NPP expansion, the trust on the project may be increased and there may be a multiplicative effect for both factors, which had moderate correlation with acceptance.

One strategy for such purpose is to enhance the interaction between stakeholders through regular contact with community leaders, to allow for the creation of campaigns to clarify doubts regarding risks of plants and their safety measures. And to include environmental advantages of NPPs in comparison to other technologies from a life-cycle perspective. These measures would not only improve the quantity and quality of the information, but also the

inclusion in the decision process. Furthermore, they should be aimed locally to create stronger social bonds in the community (Yamano et al., 2008).

Finally, enhancing acceptance of NPPs using these strategies should not exclusively focus on regions with new projects. It should specially include those regions that already have plants in operation. Based on the conclusion from the regional constrained acceptance, the best places to expand NPPs seemed to be locations with previous “successful” projects. However, in real acceptance scores these had the highest preference to both: just maintain the current NPPs and decrease them. This means such places have not had proper risk communication or inclusion campaigns and are currently not positive towards such projects. We suggest a restructuring of the strategy to disclose information in those places based on the recommendations before, because improving trust among all stakeholders seemed to bring considerable advantages in terms of possible favourable response from the citizens in these areas.

## 4. CONCLUSION

The preference to expand nuclear power generation (overall community acceptance) was 28 percent, while that to decrease it was 11 percent. There were 19 percent of respondents without a clear preference and 42 percent who wished to maintain the current NPPs working. By region, people living near the planning and the consumption sites had the highest acceptance and the least polarised view towards NPPs expansion. Those near the planning site, however, had the highest percentage of people without a clear preference (30%), and those near the operation site, had the highest percentage of answers to maintain the current plants (60%).

When individuals were set under a hypothetical renewable-constrained future, the overall preference to expand nuclear power generation shifted from 28 to 65 percent (constrained acceptance).

Among the analysed factors of influence, only “Inclusion in the decision process” had significant correlation with overall acceptance and constrained acceptance ( $\tau_b=0.22$ ). Other factors associated with acceptance were the “quantity of information disclosed by the Power Company” and “trust on it from the public” ( $\tau_b=0.21$ ,  $\tau_b=0.32$ ) and “Knowledge about CO2 emissions reduction capabilities of NPPs” ( $\tau_b= -0.2$ ).

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