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TRANSLATION: FUKUSHIMA NPP ACCIDENT RELATED

Public opinion changes after the Fukushima Daiichi Nuclear Power Plant accident to nuclear power generation as seen in continuous polls over the past 30 years

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ABSTRACT

In this study, the results of surveys conducted over the past 30 years were analyzed. The surveys include continuous opinion polls conducted by seven organizations, those conducted by eight news media one year after the Fukushima Daiichi accident, and those conducted by Institute of Nuclear Safety System (INSS) 14 times from 1993 to December 2011. The results were as follows: (1) negative opinions towards nuclear power generation (NPG) suggesting 'abolition or reduction,' which was 20%–30% over the past 30 years, increased to 70% from four to six months after the accident, when there was also much news about renewable energy. (2) Even after the accident, 60% regarded NPG as 'inevitable,' but many opposed future replacement or new construction of NPG facilities. (3) After the accident, recognition of the usefulness of NPG and concerns about electric power shortages in the near future remained unchanged, while anxiety and distrust toward NPG increased significantly. When considering power generation options, people now tend to focus on accident risks. (4) Nevertheless, people are neither aware of various possible problems caused by reducing NPG nor willing to accept a significant rise of electricity rates caused by the shift to renewable energy.

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Nuclear power generation; public opinion; continuous opinion polls; Fukushima Daiichi accident; anxiety; electric power shortage; power generation options; renewable energy; newspaper article database

1. Introduction

Since the Fukushima Daiichi Nuclear Power Plant accident (Fukushima Accident), the outcomes of public opinion polls on nuclear power generation (NPG) have been frequently reported. Such polls have been conducted almost monthly by newspaper companies, TV broadcasting companies, and news agencies, and they usually ask respondents their opinions of the Cabinet and political parties at the same time. These polls are conducted by the method of RDD (random digit dialing) via telephone. The questions are limited to a few in number and worded to get simple replies, because the respondents must answer the questions in a limited time (which controls the number of questions asked), and they must understand and answer the questions and choose options verbally. Although the questionnaires are prepared by different research companies, they are similar in nature. Actually the questions tend to settle into narrow arguments like 'Should the generating ratio of nuclear power be increased or decreased?' or 'Do you support or oppose restarting nuclear power plants?'

NHK (Nippon Hoso Kyoukai, Japan Broadcasting Corporation) has conducted 'public opinion polls on NPG and energy' several times [1] and Nippon Research Center conducted its own surveys four times and made them public [2]. The numbers of questions on

NPG in these surveys were more than those in regular surveys, but still not enough to get multilateral understandings of people's underlying opinions and to allow analysis of the responding patterns, because these surveys were conducted via telephone or they adopted an omnibus style conducted with questions gathered from multiple clients.

In order to identify the trends of public opinion after the Fukushima Accident, the data before the accident are necessary, but all of the surveys mentioned above were conducted after the accident. Questionnaires based on reminiscence try to measure changes before and after the Fukushima Accident using respondents' own evaluations [3], but the changes seem difficult to be grasped accurately.

On the other hand, it is useful to analyze the current situation relatively as part of a long-term trend, in addition to the comparison before and after the Fukushima Accident. For instance, how much did the 1986 Chernobyl Accident and the 1999 JCO Criticality Accident affect public opinion, or how differently did the Fukushima Accident affect it? In the past, multiple research companies conducted continuous surveys (continuous questionnaires) on NPG, but many of them have been discontinued so it is not possible to grasp the movement of people's preferences before and after the Fukushima Accident.

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Supplemental data for this article can be accessed [here](#).

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The Institute of Nuclear Safety System (INSS) to which the author belongs has regularly made surveys of people's awareness (public opinion) on NPG since 1993. This is one of the few surveys that has been continued following the Fukushima Accident, although it had not been started before the Chernobyl Accident. The INSS questions have uncovered wide ranges of feelings people have had on NPG, and some of the results of these surveys have been published as books and reports in journals and at academic society meetings [4–15].

Based on the points mentioned earlier, the goals of this report are: (1) to grasp the long-term trends of public opinion by gathering the results of surveys on the usage of NPG; (2) to analyze when trends changed by gathering the results of the surveys conducted by various media before and after the Fukushima Accident and classifying them in time order, and from that analysis to understand the magnitude of the change of trends by comparison with the long-term trends; and (3) to use data from the INSS continuous surveys to clarify how people's feelings on NPG have or have not changed because of the Fukushima Accident and to determine the underlying background of people's understanding of energy issues when choosing 'the reduction of nuclear-generated electricity'. The objective data of public opinion collected by social research methods would provide useful basic data to discuss energy policy.

2. Summary of public opinion polls conducted by many research entities

2.1. Regular surveys before the Fukushima Accident – from the late 1970s 'reducing or stopping NPG' was a minority opinion

The author collected serial published data on people's attitudes to NPG. As far as the author has obtained, the Asahi Shimbun (newspaper) asked about preference on

promotion of NPG from 1978 till 2002 and NHK asked whether to promote or to stop it from 1982 till 1998 [16]. These were not surveys which focused on NPG, but rather surveys that selected this topic for questions about awareness of various social issues. Over time, the methods which they applied changed from face-to-face surveys to telephone surveys.

The Japan Productivity Center (JPC) and the Research Council for Energy and Information Technology, Inc., (EIT) conducted surveys on NPG continuously for more than 10 years mainly around the 1990s [17,18]. The Institute of Applied Energy (IAE) started its surveys from 2003 [19]. The Cabinet Office, Government of Japan (CAO), conducted surveys of public opinion on NPG and energy saving, but the questions and their options for answers changed over time, probably because the CAO was not interested in analyzing changes in trends [20]. The surveys of these four entities gave three options: to promote NPG (to construct new plant(s)), to reduce the number of operating plants or to no longer use NPG (to stop and to decommission plants). The Japan Atomic Energy Relations Organization (JAERO) has also conducted surveys since 2007 [21]. They did not ask about the promotion and increase or decrease of nuclear power plants, so questions on the necessity of NPG were selected for analysis.

Supplemental online Table S1 summarizes results of each organization's surveys and the questions and answer options. The sampling method most of them adopted was sampling from the Basic Resident Register until 2006 when a change in the law made it difficult for persons other than government officials or the media to access the Register. The IAE adopted the assignment method and JAERO sampling was done from housing maps.

Figure 1 shows the trends of the ratio of total negative responses which are marked with \square summarized in Supplemental online Table S1. The percentage of no answer varied among the surveys. This might be caused

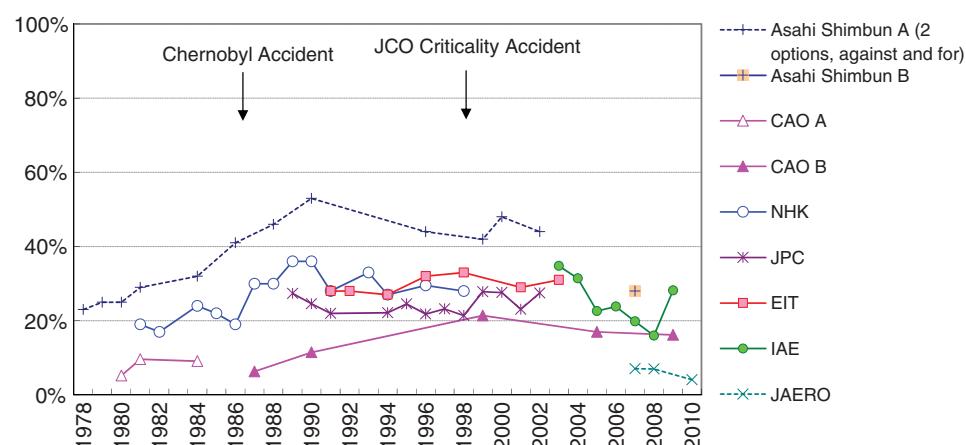


Figure 1. The long-term trends of negative opinions to NPG before the Fukushima Accident.

by differences in the questions and answer options. For example, in the case of self-completion questionnaires (mail method, placement method) options saying 'neither' or 'don't know' were given first among the answer choices. The percentage in surveys the four organizations carried out which combined 'reduce, decommission, stop, no longer use' answers, in other words, the percentage of clear negative opinions which excluded 'new construction, promote, status quo, neither, don't know' has been shifting between 20% and 30%. No big change could be recognized after the Chernobyl Accident and the JCO Criticality Accident. Looking at the results for Asahi Shimbun A showed the percentage exceeded 40%, but that might be caused by giving alternative options as for and against the promotion of NPG, not the utilization of NPG. The option of 'against the promotion' might include people who preferred the status quo but did not agree with promotion, and that could result in a higher percentage of negative answers. It is difficult to compare results rigidly because of the differences in questionnaires and research methods, but it seems the clear negative opinions to the utilization of nuclear power, like 'reduce, decommission, stop, no longer use' have consistently been minority opinions for 30 years before the Fukushima Accident.

Among the surveys which were conducted relatively closer to the Fukushima Accident, but still before it, Asahi Shimbun B published the results of its survey which asked the same questions as after the Fukushima Accident. It showed 28% of the respondents had the opinion 'reduce + stop' in 2007.

2.2. Surveys of public opinion made by the media after the Fukushima Accident – the opinion 'reduce, no longer use' skyrocketed to 70% in May to July 2011

Figure 2 shows the trends for every period of the percentage of respondents holding negative opinions, that is, 'reduce + no longer use' and 'against,' and those holding positive opinions to questions which included options of 'increase, main status quo, decrease, no longer use.' It also shows trends for questions asking whether persons are for or against the utilization of NPG. These surveys which were conducted by the media from April 2011 until May 2012 during 2 to 3 days centered on a weekend. If the average of the dates counted is more than 15, it applies to the last half of the month.

Because of differences in the contents of the questionnaires, leading sentences, sentences stating the options and so forth, the biggest percentage difference among them was about 10 percentage points. However, when replies were compared with those before the Fukushima Accident (Figure 1), the numbers were

close and the trends coincided. Most of these questions were asked within a survey of the Cabinet approval rating, and the similarity of the survey method, the construction of the questions and the answer options might cause the trends to coincide.

The percentages of respondents replying 'reduce + no longer use' in surveys conducted by NHK, FNN & Sankei Shimbun and Asahi Shimbun, all of which gave four answer options, were 41%–44%. As mentioned in Section 2.1, if the corresponding percentage relying 'reduce + no longer use' in the 2007 Asahi Shimbun survey, which asked almost the same question, was 28%, it might be presumed that there was a move of more than 10 percentage points to negative opinions during the first month after the Fukushima Accident. The percentage of respondents holding negative opinions moved to 57%–60% over the first half of May, which meant a very big increase in a short time. On 5 May, Prime Minister Naoto Kan requested Chubu Electric Power Co., Inc., to stop operation of the Hamaoka Nuclear Power Plant reactors because a big earthquake was likely to occur, and three days later the company decided to stop them. The percentage of people with negative opinions increased to around 70% in the last half of July and after that it was stable. Among the 70%, 20%–30% held the opinion to 'no longer use' nuclear power and remainder wanted a 'decrease.' That is, during the five months after the Fukushima Accident, the majority opinion moved from 'maintain status quo' to 'reduce' NPG.

2.3. The increased number of reports on renewable energies which overlapped the rapid growth of negative opinions

The increased number of reports on renewable energies could be pointed out as causing the rapid growth in the opinion of 'reduce + stop.' Supplemental online Figure S1 shows the trend for hit counts every half month in the G-Search database which included one of such phrases as 'renewable energies,' 'natural energy,' 'new energy,' 'solar photovoltaic (PV),' 'mega-solar,' and 'wind power' in the title or the body of the reports which were provided by the four biggest national papers and NHK. (Here 'NHK news' means only news reports and does not mean all news programs and educational programs.) The trend directions looked the same even considering the difference in the amount of the samples because the number of pages and recording criteria differed among the newspapers. There was a peak in the last half of May until the first half of July after the shut-down of the Hamaoka Nuclear Power Plant reactors. The period when public opinion was moving toward 'reduce NPG' overlapped the period when the number of reports about renewable energies was going up.

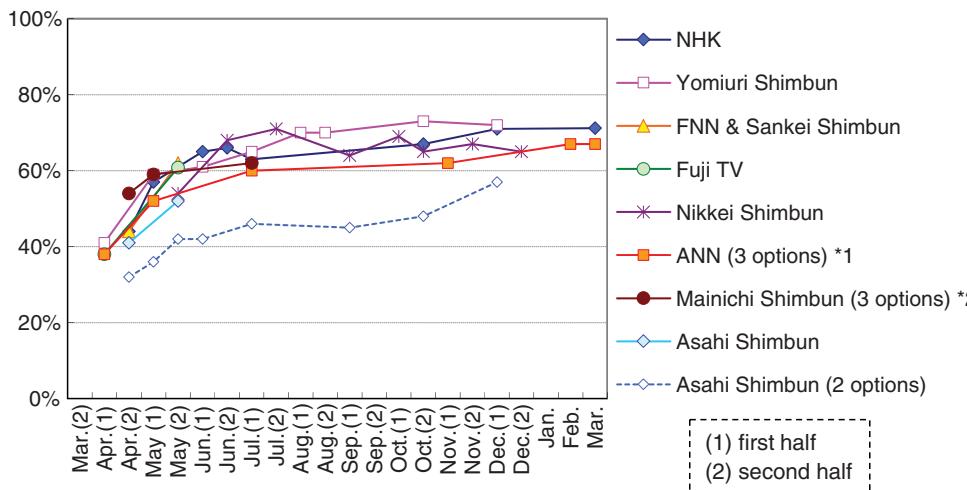


Figure 2. The transition of negative opinions to NPG after the Fukushima Accident.

3. Summary of INSS continuous surveys

In this section, the author looked at data from the INSS surveys to show people's attitudes toward NPG and their evaluation of its usefulness, their anxiousness and distrust of NPG, and their way of thinking about a desirable composition of power sources. Furthermore, the author considered how people recognize the problem and the burden accompanying the reduction of NPG by looking at additional questionnaires after the Fukushima Accident in order to clarify people's understanding of the facts when NPG is reduced.

3.1. Research and analysis method

3.1.1. General description of surveys

The INSS conducted regular surveys and spot surveys from 1993 until December 2012, 14 times in total. Among them, two surveys were conducted from 14 July to 8 August 2011 and from 2 to 26 December 2011, 4 months and 9 months after the Fukushima Accident, respectively. Supplemental online Table S2 shows the research period, the sampling method and the number of samples. All surveys were conducted among persons aged 18–79 years and living in the area where the Kansai Electric Power Co., Inc., distributes electricity,¹ and the placement method was applied. Among these surveys conducted in 1993 until 2005, several authors have published the results [5–12].

3.1.2. Survey items

The continuous surveys in the long term put value on repeating the same questions and finding trends; however, they must include new viewpoints because NPG has an aspect of current topics. Changes and additions of questions mainly in the regular surveys (in 1998, 2002, and 2010) were made in a cautious manner to ensure some continuity. In the spot surveys, the INSS measured the trend of people's awareness of

NPG by asking only whether they were acquainted with a recently occurring accident so as not to put too much emphasis on the accident. On the other hand, the surveys conducted after the Fukushima Accident asked people about their understanding of the facts of the accident and their concern about radioactive contamination in detail. The questionnaires after the Fukushima Accident were composed of questions on the Fukushima Accident itself and the sources of information about the accident, the perceptions of science and society, environmental awareness, understanding of the electricity supply and the selection of electricity sources, NPG, renewable energies, and the general awareness of society (reliance on other human being, superstitions, and so on). In this report, the author addressed opinions on three topics: (1) NPG, (2) the supply and demand of electricity and the selection of the electricity sources, and (3) renewable energies.

3.1.3. Ensuring the continuity of the time series surveys

Even if the questions, the answer options, and the orders of them are given in the same, the ways of doing the research, sampling methods and return rates may affect the results. As an example, when the Japan Productivity Center changed its research method from mailing to placement, the age of respondents changed significantly: replies increased 16 points to 42.9% from persons under 30 years old and they decreased by 19 points to 12.4% from persons over 60.² The Center researchers noted that the strict comparison among surveys was difficult [23]. Concerning regular surveys by the press, Suzuki [24] mentioned that Cabinet support rates differed among media surveys in their absolute value due to differences in the ways the research was carried out; for example, whether background information was given about reshuffling of the Cabinet, or whether to ask again if the respondents did not reply clearly, but the trends did not change among surveys, which

meant the media were managing their own surveys consistently. The consistency of the research method and contents as well as the collected sample size are all matters affecting the detection accuracy of opinion changes among continuous surveys.

In this respect, the INSS has made every effort not to change its research method generally. The research respondents had been chosen at random from the Basic Resident Register at places where its public viewing was allowed. However by the law amendment of 2006, with the exception of such as public institutions and universities, it became difficult to view the Basic Resident Register. After 2007, the survey applied the random route method, a kind of area sampling method. In the random route method, the researchers go to the sampling area and visit households at regular intervals. They ask the number of persons living there by age, and select an individual at even intervals. The 2007 survey was done with two different methods, the random route method and the method based on a digital map database of residents, and it was confirmed that there was no demographical distortion for both methods and the continuity with the past research looked good [25]. In addition to that, in 2010, the survey was done by the INSS with the random route method and by Hokuriku Gakuin University with the method based on the Basic Resident Register during the same period with the same questions and no statistical difference was confirmed between them [26].

3.1.4. The statistical significance test of percentage difference

The significance level is defined as 5% when comparing the responding rate and the test (Equation (1)) with the percentage difference mutually independent is applied. Because of the two-stage extraction by area and individual, the margin of sampling errors is set in the square root two of simple random sampling according to the literature [27,28],

$$|p_1 - p_2| \geq 1.96 \sqrt{2P(100 - P) \frac{n_1 + n_2}{n_1 n_2}} \quad (1)$$

$$P = \frac{n_1 p_1 + n_2 p_2}{n_1 + n_2}$$

where n_1 and n_2 are the volumes of sample; p_1 and p_2 are the responding rates among the samples (percentage).

3.2. Trends of people's attitude toward the utilization of NPG and its cause

3.2.1. The approval ratio dropped 30 percentage points but was 60%. The majority of respondents were against both new construction and replacement of aging nuclear power plants

For the utilization of NPG, respondents were given four options: 'I think it is good to utilize NPG though its safety should be taken into consideration'; 'I think it inevitable to utilize NPG in real life but I feel uneasy about its safety'; 'I think it is necessary to rely on other generation means which are safer than nuclear power, regardless of the cost or even if it causes destruction of the environment'; and 'I think NPG must not be utilized however hard our life becomes.' As for these options, it must be pointed out that the premise 'regardless ...' is too strong and the word 'inevitable' is inductive. Concerning this, other questionnaires were examined using 'however ...' and 'inevitable' and it was confirmed these wordings did not make much difference in the answers selected [4]. After the Fukushima Accident, it was expected that radioactive contamination would be the biggest possible destruction of the environment, but the INSS concluded that the long-term trend research was important and did not change the answer options.

As for the utilization, its trend has little connection with that of having anxiety or having distrust which is mentioned in Section 3.2.2. and was reported in the literature [4,8]. Figure 3 shows opinions on NPG utilization. Among respondents, around 10% replied it was 'OK to utilize NPG.' For positive opinions, most of which were passive choices, the percentage was moving around 70%, but it gradually went up against the

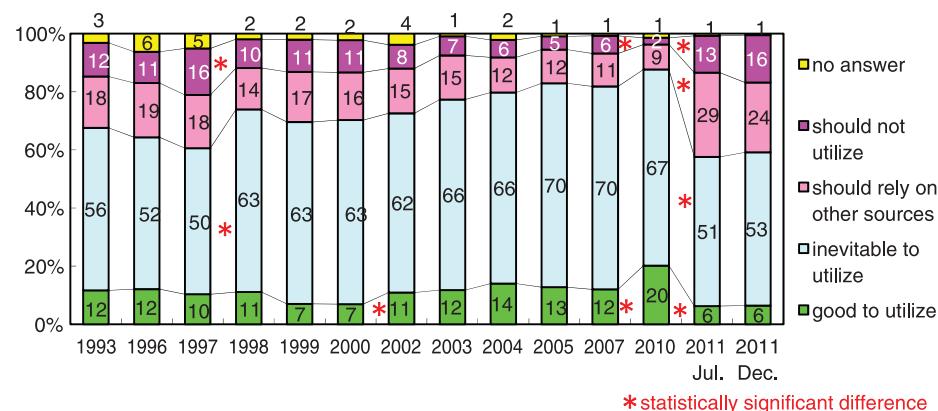


Figure 3. Opinions on the utilization of NPG.

background of a sudden rise in oil prices and the 'nuclear renaissance' so that it reached 87% in 2010. But four months after the Fukushima Accident, respondents choosing 'OK to utilize NPG' dropped to 6%, 'inevitable to utilize' dropped to 51%, 'depend on other ways of generation' rose to 29%, and 'should not utilize' rose to 13%. Significantly, opponents and supporters gained and lost 30 points, respectively. After the accident, however, the percentage of supporters was still more than that of opponents.

In the questions which asked about opinions for and against new construction of nuclear power plants (this data is available as Supplemental online Figure S2) and replacement of aging plants (this data is available as Supplemental online Figure S3), the number of answer options was cut from five to three in 2010. While a simple comparison might not be valid, the results before the cuts are shown for reference. As for the new construction, the majority held the opinion 'don't know' with 46%, and supporters and opponents were almost even. After the accident, the number of supporters was 10%, 17 points less, and that of opponents 59%, 32 points more.

As for the replacement, the explanation was given: 'In the future, some of the nuclear power plants will be out of service because they will have reached the end of their lifetime. If they are decommissioned, the electricity supplied by NPG will decrease by their generation capacity. Replacement means to construct nuclear power plants in order to replace the lost generation capacity' and the purpose of replacement was defined as keeping the present capacity of electricity generation, followed by the question. In 2010 the percentage of supporters was 49%, that of opponents 10%, and that for those choosing 'don't know' was 40%. After the accident, the percentage of supporters was 16%, 33 points less, and that of opponents 47%, 37 points more. Before the accident respondents holding the opinion that keeping the present electricity generation capability by nuclear power is unnecessary were in the minority, but after the accident they accounted for half and the majority opinion was reversed.

If the time when the number of opponents increased by 30–40 points is focused on, it corresponded with the time when the percentage of respondents holding the opinion 'decrease or no longer use' increased by around 40% in the research by the media mentioned in Section 2.2. On the other hand, the percentage of negative and opposite opinions had a difference. For the reason of high percentage, it can be considered that the option 'reduce,' which accounted for 40% of all negative answers in the present case and was 70% in the research by media, was based on the premise that the nuclear power plants will be utilized until zero operation, thus covering a very wide range. In some cases, respondents were not necessarily negative to utilization if they were considering when to stop NPG and what amount to reduce it by. As for the high percentage holding the positive opinion on 'utilization' in the INSS research, it can be considered that the questions were putting stress on the present rather than the future and answer options referred to the burden, rather than not to the use. As for the reason that the percentage of negative opinions to 'new construction' and 'replacement' accounted for 50%–60%, it can be considered that there was a neutral option 'don't know' which probably included some who leaned to the negative opinions. Concerning new construction and replacement, if respondents were not required to choose support or oppose, the fact should not be overlooked that the percentage of those who clearly chose or who could not judge was 30%–40%.

3.2.2. The percentages of opinions for feeling 'anxiety' and feeling 'distrust' were 30–40 percentage points more than ever seen before

People who felt 'very anxious' about nuclear accidents increased by about 10 points two months after the Monju Accident and after the JCO Criticality Accident, but returned to the same level one year after each accident (Figure 4). The feeling of anxiety increased slightly after the 2004 Mihama Nuclear Power Plant Accident and in 2007 two months after the Kashiwazaki-Kariwa Nuclear Power Plant was shut down for seismic safety

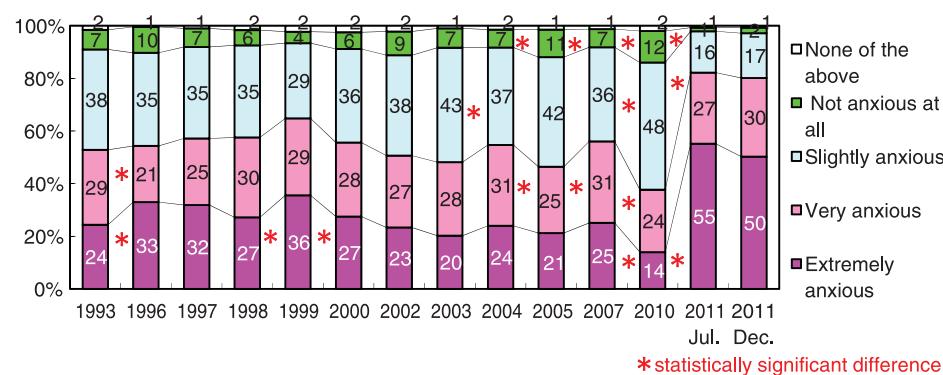


Figure 4. Have anxiety about accidents in nuclear facilities.

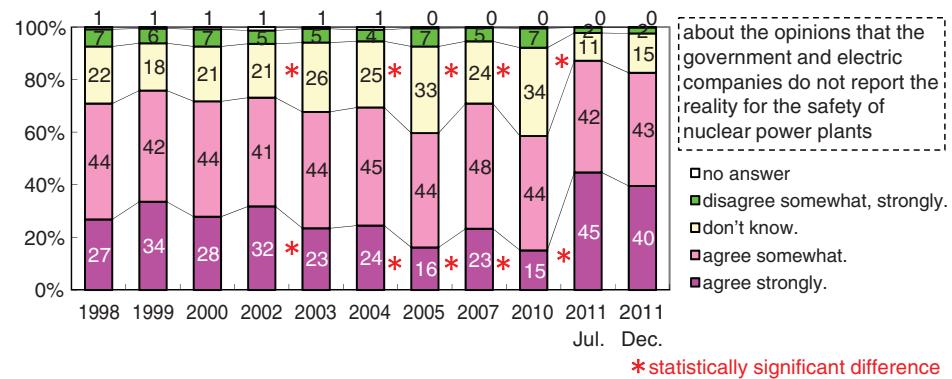


Figure 5. Distrust reported reality of the situation.

improvements following the Niigata-ken Chuetsu-oki (Chuetsu Offshore) Earthquake. When these opinion changes due to the aforementioned events were ignored, the persons having the feeling of being 'anxious' has gradually decreased since 2000 and in 2010 the percentage of persons choosing 'very anxious' fell to 14%. Four months after the Fukushima Accident, it increased to 55%, 41 percentage points more, which was the highest value ever reached, and the percentage of those who felt 'rather anxious' to 'very anxious' reached 82%.

Four months after the Fukushima Accident, a gender difference was seen for feelings of anxiety. The percentages of men feeling 'anxious' increased from 13% to 48%, 35 points more, and that of women increased from 15% to 61%, 46 points more, which was especially big. Nine months after the accident, feelings of anxiety for only women had decreased by 10 points. It was reported that anxious feelings changed easily for both men and women, and those of women changed widely [4,8], and the trend seen here proved these findings again.

The question concerning the feeling of distrust was added after the Monju Accident which raised the issue of a cover-up of an accident video: 'The government and electric utility companies do not report the reality about NPG safety.' Figure 5 shows opinions on distrust of reporting. In every survey, no more than 10% of the people chose 'I disagree strongly,' or 'I disagree somewhat,' and the people who answered they did not feel distrust were in the minority. From 2002 until 2010 the surveys asked people why they thought as they did. The author [9,12] reported that people gave two main reasons: 'because the government and companies had caused scandalous affairs before' and 'because the government and companies do not report the reality in other matters too; this is not just in nuclear matters' and she mentioned that the reasons reflected a general distrust in the government and companies in a sense. An international comparative report by Yoshino [29] stated that Japanese have a feeling of low confidence and pointed out that this influences the trend of their response (for example, neutral answers and negative answers). There might be a correlation with this

generally held low confidence and the thinking of the majority that the reality was not reported.

On the other hand, if the strong distrust of the opinion 'agree strongly' is focused on, over 30% held this opinion after the JCO Criticality Accident and in 2002 (two months after the Tokyo Electric Power Co., Inc., issue on falsification of inspection data) and it was higher by a few percentage points when it became known in 2007 that the Criticality Accident had occurred at Shika nuclear power plant in 1999. If these fluctuations due to the aforementioned incidents were ignored, the feelings of both distrust and anxiety had a downward trend and the percentage of respondents holding the opinion 'agree strongly' dropped to 15% in 2010. However, four months after the Fukushima Accident, it rose to 45%, 30 percentage points higher, and it was unprecedentedly high.

Concerning the Fukushima Accident, two points were criticized very much: the late report of the meltdown (made on 13 May 2011) and the failure to quickly announce the predicted diffusion of released radionuclides made using SPEEDI (System for Prediction of Environmental Emergency Dose Information) which would have led to quicker evacuation of residents. The fact that a severe accident had actually happened gave the people a feeling of distrust, that is, they had not been told the reality of the safety of NPG.

3.2.3. The percentage with favorable opinions of NPG usefulness dropped slightly

As for the usefulness of NPG, even in the survey conducted four months after the Fukushima Accident the percentage of respondents choosing the options 'very useful' and 'useful' was 27%, while 'extremely useful' reached 51%; overall, NPG was considered to contribute to the stable electrical energy supply (this data is available as Supplemental online Figure S4). After the government prevented the nuclear power plants which had stopped for regular maintenance at the time of the Fukushima Accident from restarting without stress tests and ordered all those operating at the time to stop when they reached the next scheduled maintenance and also

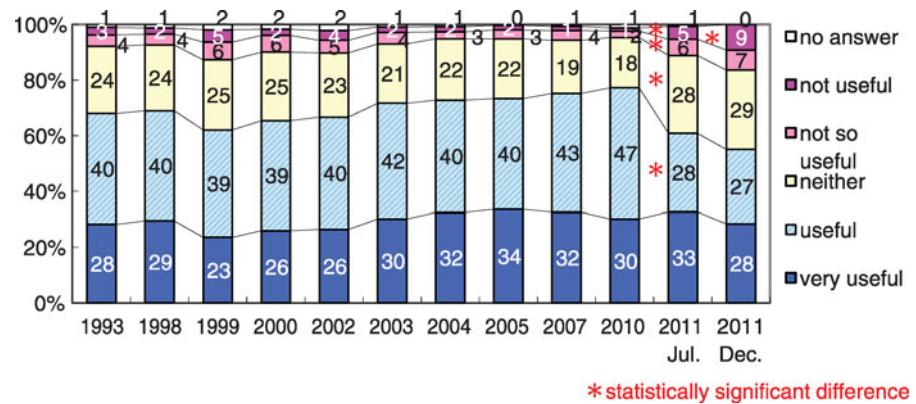


Figure 6. Opinions about how useful NPG is to Japanese society and daily life.

not restart without the stress tests, requests to save electricity were announced; however, the percentages for opinions on the contribution to the stable supply of electricity did not change with any significant difference. Other than this, the opinion percentage on the usefulness of NPG as a countermeasure to global warming did not change with any significant difference in comparison with before the accident.

Regarding the general usefulness of NPG as described in Figure 6, 'very useful' and 'useful' for society and a comfortable life were selected by 77% of respondents in 2010, by 61% four months after the Fukushima Accident, and 55% nine months after it, 22 percentage points less. However, the option 'neither' accounted for 30% and the number of people who chose not useful remained around 10%. In the survey by NHK (conducted from 16 to 18 March 2012), almost the same question was asked 'Do you think NPG is useful to our society and life today?' but without the neutral answer choice. The answers and percentages choosing them were: 'very useful' 22.1%; 'useful to some extent' 56.0%; 'not so useful' 11.9%; and 'not useful at all' 3.8%. Those who totally denied the usefulness of NPG accounted for the same level as in the INSS surveys.

3.2.4. Recognitions that saving electricity is generally easy and anxiety about the electricity supply 10 years in the future is small

When people were anxious about the electricity shortage during the peak usage period of summer, the July 2011 INSS survey asked people whether a 15% reduction of electricity use in their household could be achieved. The answer 'It can be achieved if you only try not to waste it' was given by 30%; 'I feel a little bit inconvenient or less comfortable, but it can be achieved' was given by 45%; 'I feel it is very inconvenient or tries my patience, but it can be achieved' was given by 14%; and 'It cannot be achieved' was given by 11%. The percentages were the same concerning the amount of electricity saving during one month, not just at a limited

peak time. Percentages did not change in December when people had already experienced electricity saving in the summer. Saving electricity in households was recognized as generally easy.

When the capacity of electricity generation 10 years in the future was considered, the percentage of respondents that answered 'enough' was 20%; 'a little anxious about capacity' was 60%–70%; and 'very much anxious that it cannot be supplied' was less than 10%, and these percentages have been stable until the last INSS survey in December 2011 (this data is available as Supplemental online Figure S5). In 2003 when customers of the Tokyo Electric Power Co., Inc., experienced an electricity shortage and in 2007 when the Kashiwazaki-Kariwa Nuclear Power Plant reactors had to be stopped after the Nigata-ken Chetu-oki Earthquake and it caused an electricity shortage issue in the metropolitan Tokyo area, the respondents choosing the answer 'enough' concerning the generation capacity 10 years in the future decreased with a statistically significant difference. Even in the Kansai area after the Fukushima Accident, electricity saving with a target number was requested, but the level of the anxiety about the supply did not change in comparison with the past.

3.3. The composition of electricity sources desired by people and the change in criteria of electricity source selection

3.3.1. Reducing fossil fuel use as well as NPG use and relying on renewable energies 10 years in the future

Looking at the question asking the reasons to support NPG, regardless of before and after the Fukushima Accident, the answer 'a stable supply with well-balanced sources and diversity of electricity sources' was chosen by around 60% of the respondents and its support was more than 20 percentage points higher than for other answers. Single answer options could not explain what respondents would consider to be the desired composition of electricity sources. Therefore, this

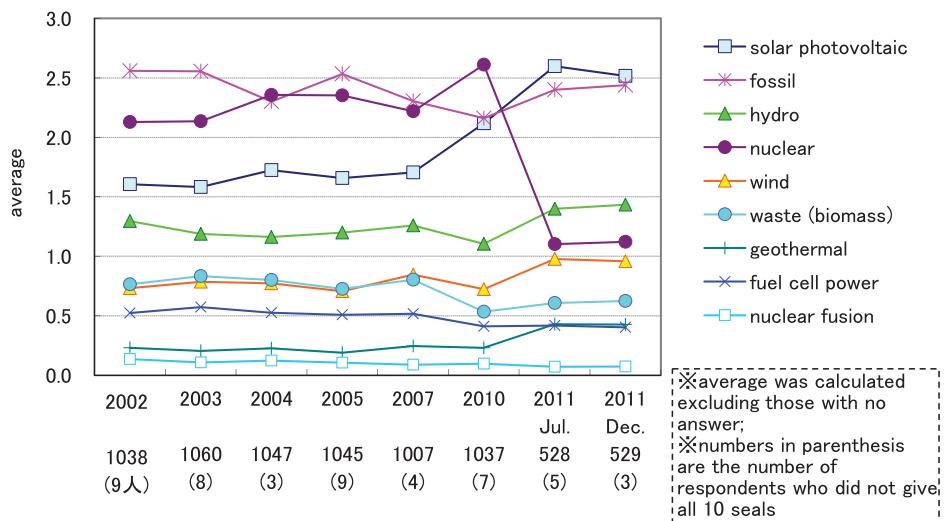


Figure 7. Desirable composition of electricity sources 10 years in the future.

survey question was done using the method of giving a seal (a paper sticker).³

The procedure was as follows. The merits and demerits of each power generation method, actual generating records, and standard generating production per unit were shown. The actual ratio of generation currently, for example, six seals for fossil, three seals for nuclear, and one seal for hydro was given. Then people were asked: 'How do you think the seals should be given in Japan 10 years in the future for a good composition of power generation methods? One seal is equivalent to 10%. Put the seals on each generation method according to the percentage that you think is best.' (There are various opinions concerning merits or demerits, the Appendix in the Supplemental online material describes these and readers are referred there.)

The average percentage of seals given to the nuclear generation method was 26% even in the 2010 survey when it was most affirmed, although that was lower than 30% which was the value shown as the example of the current composition (Figure 7). After the Fukushima Accident it declined to 11%. On the other hand, that for solar power increased from 21% to 26%, for hydro from 11% to 14%, for wind power from 7% to 10%, and for geothermal from 2% to 4%. The percentage for the four renewable energies was over 50%. The percentage for fossil fuel power generation in 2010 should be noted: it increased from 22% to only 24%. The average percentage for fossil fuel power generation before the Fukushima Accident was less than half compared to 60% given currently for the example and even after the accident when the reliance on the fossil fuel was increased in real life. Such an outcome might have resulted from the wording of the question saying 'hopeful' which extracted the answer based on desire rather than feasibility. People thought it was better to reduce the reliance on fossil fuel power generation and replace nuclear energy with combinations of various renewable

energies for the future, even in as short a time as 10 years later.

However, when the aforementioned outcome is analyzed, it must be taken into account that (1) the electric power generations by coal, oil, and natural gas were grouped into one method, fossil fuel; (2) renewable energies were given as five separate generation methods; and (3) the minimum percentage that could be assigned was 10% (that is, one seal). But when looked at from another viewpoint, even thinking about future generation methods in real life, it might be thought that the rich variety of renewable energy led people to expect a greater proportion for them among all electricity generation methods.

3.3.2. The criteria to select the energy source were changed to weigh accident risk

Concerning the criteria for the selection of the generation source, six options were shown as the important viewpoints when utility companies generate electricity and respondents were asked to give as many seals out of 10 according to importance as they thought. Supplemental online Figure S6 shows those six options and an example of giving the seals. How many options they thought were important and how much was the difference among them depended upon the respondents. If they put more seals on one specific option, they had to put fewer seals on others. The choice contains a trade-off element. Because this question has been asked continuously since 2002, the criteria for the selection of the power generation method are not necessarily best for today's choice. For example, 'a lower electricity charge by generation cost reduction' was the viewpoint based on electricity deregulation which was introduced at that time, but from today's viewpoint, it is better to amend as 'to choose the generating method using whatever necessary means to lower generation cost.' However, if this

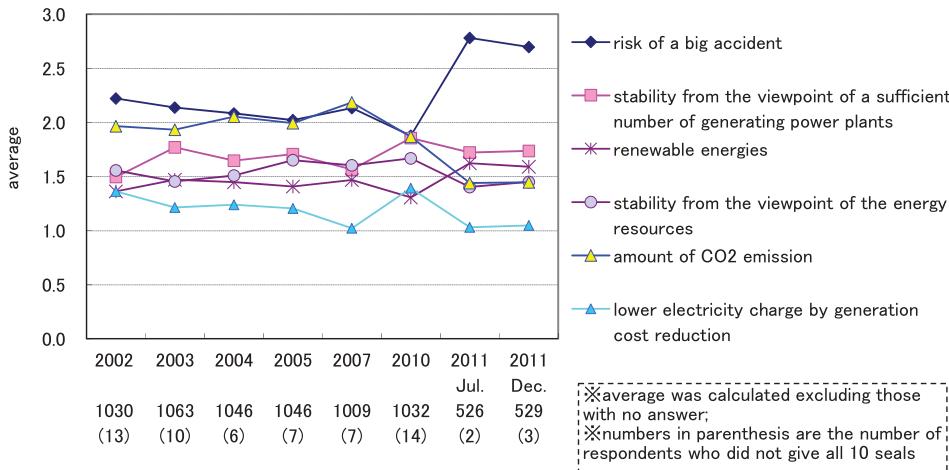


Figure 8. Important considerations for the utility companies in generating electricity.

amendment is made, it cannot be clear whether the difference in the opinions occurred because of the change in the respondents' criteria or to the change of the question, then the newer INSS surveys did not amend it.

In this question, a few respondents took a simple strategy which allocated seals intensively to one or two viewpoints, while more than 80% scattered them over more than four options. This represents the respondents' sense of balance [4]. If the trend of the average number of seals allocated is examined, 'the risk of a big accident' and 'the amount of CO₂ emission' were thought important until 2007 (Figure 8). After the Fukushima Accident, that of 'the risk of a big accident' went up from 1.9 seals to 2.8, and the difference between that of other viewpoints expanded. After 2010 those favoring 'the amount of CO₂ emission' dropped down and received an average of 1.4 seals. In addition, the survey period in 2010 was just before the Cancun COP16 Conference, at which Japan opposed the requirement to reduce the CO₂ emissions for developed countries only.

Though this was a period when electricity saving was required because some nuclear power plants were not in service due to maintenance work and electricity was in short supply, the sense of importance described by 'stable supply from the viewpoint of a sufficient number of generating plants' was not rising in people's minds. This coincided with the scenario mentioned in Section 3.2.4: anxiety about the capacity of the electricity supply 10 years in the future was not going up.

Along with the option on 'the amount of CO₂ emission,' the options of 'a lower electricity charge by generation cost reduction' and 'stable supply from the viewpoint of energy resources' were going down in popularity, too. The opinion 'a lower electricity charge by generation cost reduction' increased in popularity a little in 2002 when liberalization of the electricity supply market was progressing and in 2010 just after the economic downturn caused by the Lehman Brothers' crash, but it still had the lowest level of support among the six

choices. In Section 3.4.2, the argument is made as to whether regarding this point not an important means for accepting the raise in electricity charges.

Supplemental online Figure S7 shows the distribution of the seals when the responses to the energy sources were divided into two groups, that is, the supporting group and the opposing group based on opinions to the utilization of NPG (Section 3.2.1). Before the Fukushima Accident, among the supporting group the options 'the stable supply from the viewpoint of energy resources' and 'the stable supply from the viewpoint of a sufficient number of generating power plants' were regarded as important, and among the opposites 'the risk of a big accident' and 'renewable energies' are. After the Fukushima Accident, among the supporters the opinion 'the stable supply from the viewpoint of a sufficient number of generating power plants' and among the opposites 'the risk of a big accident' and 'renewable energies' were regarded as more important and the difference between them became clearer. The opposing group following these criteria to choose the generating methods had been the minority (11%) before the Fukushima Accident but increased to 40% after it. As mentioned in Section 2.2, this coincided with the fact that in the period when public opinion on NPG moved to 'reduction,' the media actively reported on renewable energies.

Among both supporting and opposing groups, the opinions for 'the amount of CO₂ emission' and 'a lower electricity charge by generation cost reduction' were regarded as less important after the Fukushima Accident. The amount of CO₂ emission and the electricity charge, which are important aspects of energy policy, were of relatively less concern and the trend became more prominent that people's attitude on NPG was decided by whether they thought it was important to increase the use of renewable energies to avoid the risk of a big accident or maintain the stable supply with a sufficient number of generating plants.

3.4. Understanding the facts behind the trend for the opinion 'to reduce nuclear power generation'

3.4.1. Respondents do not think it will cause issues

When the surveys conducted by the media were looked at, the affirmative attitude to the opinion 'to reduce the NPG step by step and to not use it in future' accounted for 70%–80%. (For instance, surveys were conducted on 14 and 15 April 2012 by the Asahi Shimbun and on 10 and 11 March 2012 by the Nihon Yoron Chosa Kai.⁴) In order to investigate people's understanding of the facts about the effects from reducing NPG, the INSS asked two questions in July and December 2011. First, the introduction was given: 'There is a forecast that the following issues will or will not occur if NPG is reduced. What do you think about this?' Next, the respondents were required to choose one option from the following three for each of eight issues: 'I think it will occur'; 'I have no idea'; and 'I don't think it will occur' (this data is available as Supplemental online Figure S8).

For all eight issues about 10% chose 'I don't think it will occur' and the number of respondents who had confidence that there was no problem was small. In December, the percentage of respondents with the opinion 'The electricity rate will go up' was 77%, and that of 'The supply of electricity will be unstable' was 53%; both were over 50%. People had a rough image that there were direct effects on daily life.

On the other hand, the percentage of respondents thinking 'international conflicts on natural resources will occur' was 44%, and that of 'The amount of CO₂ emission will increase' was no more than 35%. As mentioned in Section 3.3.1, people expected that the amount of electricity generated by nuclear and fossil fired power plants would decrease drastically and that of renewable energies would increase generally in the next 10 years. If NPG was reduced and there was a direct move to renewable energies which are produced domestically and emit no CO₂, there would be no problem from the viewpoint of conserving natural resources and preventing global warming. People possibly thought that they would 'switch the energy source from nuclear power to renewable energies' without a clear recognition of the transitional period requiring substitution by fossil fuel fired power generation when they thought about the issue of 'reducing NPG'.

As for the influence on the quality of life, the percentage of respondents with the opinion 'Comforts of daily life or the standard of living will decrease' was less than 30%. For the influence on the economy, the percentage of respondents saying 'jobs will be lost due to factories moving overseas' was 38% and that for 'Japan's competitiveness in world markets will weaken and the Japanese economy will go down' was 29%. For the economic influence, more men in their 40s and 50s, who are the main actors in economic activities, held those two opinions, but strong anxiety could not be observed.

Because the shift of factories overseas and weakening of international competitiveness are caused by other elements like currency exchange rates, and they also depend on the markup rate of electricity charges and shortages in the electricity supply, the economic influence is not always thought to be connected directly with reducing NPG as a simple cause and effect. For the economic influence, it might be necessary to explain the difference between fluid effects like exchange rates and static effects which are fixed for a long term.

The opinion 'The local economy and people's lives in regions where nuclear power plants are located will be harder' was chosen by 41% in the July 2011 question and by 30% in the December one and they were significantly different. In the months between these two surveys, local governments with nuclear power plants in their prefectures were adopting cautious attitudes that they would not accept the restart of the nuclear power plants if the National Government would not accept their requirement such as making new safety regulations. People might have thought by this movement that local people did not hope for the restart of the plants, and it might have given the impression that there would be harmful effects on the local economy if nuclear power plants would not be restarted.

3.4.2. The acceptable increasing rate of electricity charges due to the use of renewable energies is small

The timeframe and the magnitude of reduction of NPG will determine whether there will be problems. The INSS survey asked about the time frame as: 'If we no longer use NPG, we will shift to renewable energies like wind power and solar power as much as possible and the National Government will push this strategy as a national energy policy. How long do you think it will take for this to come true?' The options respondents could choose from and the results were: 'within 5 years' 3%; '10 years' 24%; '15 years' 16%; '20 years' 37%; and '30 years' 15%. People who thought the condition 'to promote renewable energies aggressively as an energy policy' would be achieved in as short a term as 10 years did not exceed 30%; when percentages for all opinions up to those who thought 20 years would be necessary were added together, the result was 80%. People seemed to think that it could not be achieved in a short term and it would take much time to shift from NPG to renewable energies.

Renewable energies cost more than the existing methods of power generation and in order to promote and spread them, and the feed-in tariff system was started in July 2012 to promote them. Consumers were worried about the burden of higher electricity bills if the amount of purchased electricity is going up rapidly because the purchase cost will be added to consumers' electricity bills. Then the INSS survey asked 'How much will you accept in additional payments for electricity when the cost to promote renewable energies like wind

power and solar power are included in your electricity bill?' Looking at Supplemental online Figure S9 which summarizes answers given in July four months after the Fukushima Accident, it can be seen the responses were concentrated on the least markup range among the options, that is, less than 10%. The phrase 'less than' 10% does not necessarily mean a person accepts a 10% markup. If the percentage answering 'I cannot accept any markup' that accounts for 60%. As mentioned in **Section 3.4.1**, people had an image that the reduction of NPG meant the electricity charge would go up, but they had little awareness that a big markup of the electricity bill cost would be needed to promote wind power and solar power. If Supplemental online Figure S9 is broken down by opinions on the utilization of NPG; but even the group who chose the option 'to rely on other methods of power generation' (I think it is necessary to rely on other generation means which are safer than nuclear power, regardless of the cost or even if it causes destruction of the environment) did not have high acceptance for the markup to promote renewable energies. This suggested that although people may say 'regardless of the cost,' they chose the option to rely on other methods of power generation than nuclear power without thinking they would pay the additional cost by themselves. As mentioned in **Section 3.3.2**, respondents did not think it was important to lower the electricity charge through reduction of generation cost as their criterion for electrical power generation. However, that they did not think it was important does not mean that they think there is no other way regarding cost or that they think it is all right if the electricity bill goes up. This suggests that they chose the methods of power generation without serious consideration of the generation cost or electricity charge.

3.4.3. The trend on the view of NPG worldwide was reversed

Supplemental online Figure S10 summarizes INSS findings when respondents were asked whether they thought the amount of NPG throughout the world would go up or go down. The percentage of respondents who thought it would go up 'rapidly' and 'a little' was 16%, 40 percentage points less than before the Fukushima Accident, while those who thought it would go down was 65%, representing 41 percentage points more. People's understanding of the world trend in NPG was turned around in only five months from the thinking in 2010.

In 2010 the Japanese government set a policy of exporting infrastructure systems as one of its growth strategies and provided support to receive orders for construction of nuclear power plants by other countries. On the other hand, in Germany and Italy movements to abandon NPG were reported. It can be thinkable that such difference of situation between Japan and other

countries made a big change of people's understanding of the facts for the world trend.

If the relation between the idea of increasing or decreasing NPG and the opinions on its utilization as shown in Supplemental online Table S3 is examined, they had a significant difference at the 1% level in the test of independence, the percentage opposing utilization was 18% for the group who thought 'NPG will increase rapidly,' 31% for those who thought 'increase a little,' 31% for 'stable,' 40% for 'decrease a little,' and 64% for 'decrease rapidly'; furthermore the association were rather strong. The same was said in the survey 9 months after the Fukushima Accident. People's understanding of the world trend might affect their decision-making on the utilization of NPG because they thought the world trend was evidence for the feasibility of no longer using NPG.

In the surveys there were questions in which the reasons for opposing NPG were given and respondents could choose as many options as they wanted that they thought were reasonable. There was one option saying 'the world trend is toward no longer using NPG.' The percentage who chose this had never reached 20% since 1993, and after the Fukushima Accident it did not exceed 25%. Among many opposing reasons related to danger, the reason because it is a world trend was taken as showing the individual lacked an opinion and found it relatively hard to make a choice.

3.4.4. As for the possibility that NPG can be utilized well, the opinion 'I cannot judge' still accounted for 60%

In order to ask about the basic understanding of the relationship between the NPG and people's lives, the INSS surveys asked the rather vague question: 'Do you think that nuclear power can be utilized well without having bad effects on people and the environment?' And respondents were required to choose one off three options, 'Yes, it can'; 'I have no idea'; and 'No, it cannot.' Findings are summarized in Supplemental online Figure S11.

Since 1993, the percentage of respondents choosing 'Yes' was always around 20%–30% and that of 'No' reached around 60%. It seems that people have tolerated the use of nuclear power with some anxiousness that it would possibly have a bad effect on people and the environment but they could not clearly say 'Yes' because there was a risk of accidents or the issue of radioactive wastes even before the Fukushima Accident.

After the Fukushima Accident, the percentage of respondents thinking 'I have no idea' accounted for 60% and that of 'No' went no more than 22%. The opinion denying the use of nuclear power was held by a minority and the basic understanding of the relation between NPG and people's lives was unchanged in contrast to the anxiety about accidents and distrust and opinions on NPG utilization.

4. Summary and considerations

In this report, the author examined the results of seven surveys conducted regularly for about the past 30 years and eight public opinion polls conducted for one year after the Fukushima Accident by the media and 14 surveys conducted regularly by the INSS to clarify the major public opinion trends on the utilization of NPG and their causes, and people's inconsistent consciousness underlying the opinion trend which prefers 'the reduction of the NPG.'

4.1. Public opinion before the Fukushima Accident

Before the Fukushima Accident, in the periods immediately following the Chernobyl Accident and the JCO Criticality Accident as well as periods of no accidents or incidents, the percentage of respondents with a 'clearly opposing opinion' which included 'reducing, abolishing, stopping, no longer using NPG' and 'excludes maintaining the status quo,' ranged around 20%–30%. In the INSS surveys, the opposing opinions claiming 'rely on other generation methods,' or 'should not use it,' went around 10%–20%, too. These surveys confirmed that opposing opinions had been the minority for a long period before the Fukushima Accident.

Looking at the INSS surveys which have been conducted since 1993, negative opinions to NPG utilization were declining slowly in the 2000s. Though anxiety about nuclear power and distrust went up for a time after the JCO Accident or the Mihama Unit 3 Accident, it had a declining trend in the long run. The author [12] analyzed the trend of the degree of understanding of the facts about the accidents and problems which happened from 1993 until 2005, and pointed out that the degree of recognition of these issues had decreased rapidly but the degree of recognition of the Chernobyl Accident had remained high. Based on this finding, one of the possible reasons why the percentage of respondents holding negative opinions had decreased in the 2000s was that there had been no big accident like Chernobyl. Other reasons might be the steep rise of oil prices in this period, the requirement to reduce CO₂ emission and the effect of the 'nuclear renaissance' movement.

The opinion on anxiety about the nuclear power and distrust in the 2010 INSS survey had declined much more than in the 2007 survey. The Japanese economy was sluggish at that time because of the drop in exports due to the high yen rate and Japan had been surpassed by China in GDP. The export of nuclear power plants was included as one of the infrastructural industries in the National Governments' growth strategy. People had the idea that the amount of NPG worldwide had been increasing in the 2010 survey. Though not discussed further in this report, there were some people at that time who thought it was undesirable that the amount

of NPG would go up, although 70% of the respondents answered that Japanese activity overseas in the field of nuclear power was hopeful. The percentage who thought that the managers of nuclear power plants were 'excellent experts' rose.

Before the Fukushima Accident, although survey respondents had an anxiety about the safety, they accepted the NPG utilization and reluctance to it was fading out.

4.2. Public opinion after the Fukushima Accident

Looking at the surveys conducted by the media, the percentage holding negative opinions like 'to reduce, to abolish, to stop and no longer use' increased rapidly during May to July 2011 and accounted for 70%, and after that, it remained steady. On May 6, Prime Minister Kan requested all the Hamaoka Nuclear Power Plant reactors be stopped because the 'probability of a big earthquake was high,' and three days the Chubu Electric Power Co., Inc., decided to accept the request. Analysis of a newspaper article database showed that there were many reports about renewable energies in this period of a rapid increase in persons holding this opinion. In fact, INSS's July 2011 survey showed the trend for opponents to weigh renewable energies with the criteria of choosing electricity sources. These affected the big change of the public opinion on NPG.

INSS's July 2011 survey showed that 60% of respondents accepted NPG, mainly answering 'it is inevitable,' which was a 30 percentage points decrease compared to before the Fukushima Accident. As for the new construction and replacement of aging plants upon which the future situation will depend, those with a supporting opinion represented 10%–20%, and those opposing, 50%–60%, which clearly showed that they intended 'to reduce NPG' in agreement with the media research.

Analyzing people's awareness about what their opinion on the utilization of nuclear power is based on showed that anxiety about the future energy supply had not gotten stronger, though that was at the time when the target amount of electricity saving, as a countermeasure to the electricity shortage caused by not being able to restart the nuclear power plants, was discussed, and people thought that the electricity saving was rather easy. They recognized that the issue of electricity supply could be solved if operation of nuclear power plants was stopped and anxiety on the future supply might not have been aroused. However, those with the opinion that NPG was useful for the stable supply did not get become fewer. Those with the opinion of usefulness to society and life did not become fewer, either. In contrast to the trend that the awareness mentioned earlier changed very little, the anxiety about nuclear power and distrust got much higher than that experienced after accidents in the past. The following relationship for the criteria to choose the electricity sources was recognized.

If people weighed the accident risk and renewable energies, they decided not to favor the utilization of NPG, and if they weighed the accident risk and the stable supply of electricity, they decided to accept NPG. In summary, the big change in public opinion on the utilization of NPG can be explained by the change of people's criteria to choose the energy sources: they weighed the accident risk in their opinions because their anxiety about safety rose after the Fukushima Accident.

Through the analysis of the 2003 survey, the author [9,10] reported that in spite of nuclear power plants being stopped due to the Tokyo Electric Power's data falsification issue and the shortage of electricity supply in the metropolitan Tokyo area, in the free description column respondents did not point out the problem of the supply side, but rather the waste of electricity and electricity saving which they thought was needed in their daily life, that is, over-demand. People's awareness in their daily life that 'they consume more electricity than they need' possibly made them think demand should be controlled in the case of a shortage of electricity.

4.3. People's understanding of the facts behind the opinion 'to reduce the utilization of nuclear power generation'

The respondents who expected the reduction of NPG would lead to more CO₂ emission and cause environmental issues were small in number. The reason may be that they did not clearly imagine the substitution by the fossil fuel power generation. In fact, for the composition of energy sources 10 years in the future, people said it was desirable to decrease fossil fuel use as much as possible. If so, however, the quick shift to renewable energies without fossil fuel power generation was not premised, either. Those who thought it feasible to shift from nuclear power to renewable energies in 10 years were the minority, and they had little desire to accept the great markup of electricity charge for that shift, either. In the innovative strategy for energy and the environment [31] illustrations were made for ways of electricity saving, demand peak control by smart technology, promotion of energy saving capability of home electric appliances, introduction of energy saving machines, and increased thermal insulation of buildings. At the same time, the strategy said that realizing these measures required consumers to share some cost for the capital investment and to change their consumption activities. If the shortage of electricity supply is not compensated for with a substitutive energy source but with demand control, then economic activities and daily life, which are based on today's level of electricity consumption, are possibly restricted to some extent, but the percentage of respondents who thought it influenced the economy and quality of life was small. The respective considerations deeply connected with 'reduce NPG' in the aforementioned surveys can hardly be realized at

the same time and they are contradictory as a whole if they are held on the very restricted presumption 'taking a long time and reducing as much as possible are not obstacles.' It does not seem that these respondents understood the downside of reducing NPG nor does it seem that they decided by looking at all aspects of the issue. After the Fukushima Accident, people's image of the NPG world trend was reversed: before, they widely thought 'NPG will increase' but after, they came to believe 'NPG will decrease.' The decision to abandon NPG by Germany and Italy had possible impacts on the Japanese inclination 'to reduce NPG.'

4.4. Concluding remarks

After the INSS survey of December 2011, which this article reported on, through 'the national discussion on the choice of energy and environment,' the government published its policy of no NPG by the 2030s in March 2012. The point of argument in the media moved to whether to reduce NPG to zero and by what time to reduce it to zero. However, the percentage holding the opinions 'reduce NPG to zero immediately' or 'stop it soon' was small as seen in the NHK survey of 30 November to 2 December 2012 and the Asahi Shimbun survey of 1–2 December 2012. Provided that it will be reduced to zero in the future, the utilization of NPG will continue for some period. Discussion on these issues must continue in the future, and include for example, how to achieve the energy best mix including renewable energies or how to utilize NPG, by checking how people will decide the matter supposing that they know the downsides in both cases of utilization and no utilization. The author hopes to contribute to the discussions by continuing the INSS surveys which have accumulated data for over 20 years and by providing these data in comparison with those of public polls.

Notes

1. There were regional differences of opinion gaps among surveys after the Fukushima Accident; for example, it was reported that in the Tohoku area, especially Fukushima Prefecture, there were more negative opinions than in the other areas in of Japan [22].
2. However, when using the random route method, collected samples tended to be 'fewer in the younger group and more in the elderly group'; there might be some causes for the remarkable age bias.
3. This method is called the Glass Marble Method and marbles are given by respondents in a personal interview [30]. Refer the said supplementation of the question in the Appendix in the Supplemental online material provides as for the details of the method.
4. Nihon Yoron Chosa Kai is a nationwide organization conducting public opinion surveys, and consists of Kyodo News Service and 38 of its member companies (regional and local newspapers). Kyodo News Service prepares articles about the survey results and provides them to the member companies.

Disclosure statement

No potential conflict of interest was reported by the author.

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