公益社団法人 日本経済研究センター
Japan Center for Economic Research

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Top Priorities: Address Spent Nuclear Fuel and Surplus Plutonium Issues.
Use of Nuclear Energy through 2050 Should Remain On Table.

As energy policy shapes up to become a major point of contention in the next general elections, the government has changed course in favor of abandoning nuclear energy. The Energy and Environment Council on September 14 worked out an “Innovative Strategy for Energy and the Environment”, the central pillars of which are to abandon reliance on nuclear power plants within the 2030s, promote energy conservation and rapidly expand use of renewable energy. The plan outlines six issues to be addressed if these pillars are to be realized.

Key Points

(1) **Disposal of spent nuclear fuel key to nuclear-free future:** If all nuclear power stations are taken off line, it will no longer be possible to pass on spent fuel by shipping it to the reprocessing facility at Rokkasho in Aomori Prefecture. The premise in doing so is that such fuel will be reused, and that reason will no longer exist. Facilities need to be built at nuclear power stations for temporary storage of spent fuel generated, and since deciding on a permanent disposal site is the premise for such temporary storage, that decision must be made. The government and the electric power industry should begin the process now.

(2) **Use existing facilities to deal with surplus plutonium:** Continued holding of plutonium by Japan can only raise fears of possible diversion to nuclear weapons. Consideration should be given on an exceptional basis to finishing the plutonium fuel nuclear facility at Omamachi in Aomori Prefecture now under construction until the fuel is used up, but on the understanding that either the operator will pay premiums for insurance against severe accidents or the plant will be placed under state management. Consideration might be given to using the existing reprocessing facilities to process contaminated water resulting from the Fukushima accident.

(3) **The government and private sector should maintain nuclear technology for reactor decommissioning and decontamination purposes:** It will be necessary over the long term to retain researchers and engineers to work in the decommissioning of existing nuclear plants and in cleaning up the Fukushima Daiichi accident. The government and private sector should consider a policy of jointly establishing a nuclear energy central control organization and, while building cooperative ties with the United States, maintain nuclear energy technology.

(4) **Secure stable supplies of fossil fuels through Trans-Pacific Partnership:** Instead of buying the fossil fuels needed to replace nuclear energy on the expensive spot market, secure supplies of U.S. shale gas and similar fuels under long-term agreements. The U.S. is disposed to provide such gas to countries with which it has free trade agreements, and thus Japan should express its readiness to join the Trans-Pacific Strategic Economic Partnership Agreement (TPP) without delay.

(5) **Promote greater energy conservation and strengthen power grid, as through frequency standardization:** The government has set a total electric power output (i.e., consumption) conservation target of 10% (versus 2010 levels), but this target should be raised to 20%. Wider and more extensive use of smart grids would make it possible not merely to boost consciousness on the demand side but would enable users to control consumption as supply-demand and price conditions vary. Effort should also be made to improve the transmission grid as by standardizing the frequencies between east and west Japan to make power sharing possible nationwide.

(6) **Consider economic conditions in timing of final nuclear shutdown:** Taking all nuclear plants offline by 2030 will greatly increase dependency on renewable forms of energy, particularly solar power generation, which is two to three times more expensive in terms of generation costs than such forms as wind or geothermal. The result will be higher energy costs. Even if the total nuclear shutdown policy itself remains unaltered, allowing some scope in its timing would make it easier to cope with changes in resource prices or uncertainties about global warming. A flexible approach that allows for possible continued reliance on nuclear energy to 2050 should therefore be considered.

1. Disposal of spent fuel key to nuclear-free future

Once total abandonment of nuclear power is the goal, it is only a matter of time until the nuclear fuel cycle policy must end. Reprocessing of spent nuclear fuel at the Rokkasho plant in Aomori Prefecture becomes unnecessary, and Aomori Prefecture would no doubt ask the government and the power company to transport the spent fuel now being held there back whence it came. It is critical that urgent steps therefore be taken to build temporary storage facilities to hold the spent fuel on a temporary basis pending final disposal. A “Recycle Fuel Storage Center” capable of holding 3,000 tons will begin operating in the Mutsu City from the autumn of 2013, but whether it will actually be able to operate is an open question. There is about 17,000 tons of spent nuclear fuel in Japan presently, and if the spent fuel sent overseas for reprocessing is also taken into consideration, the total would amount to just less than 25,000 tons accumulated thus far. Considering the total energy generated as of the 2030s, when all nuclear plants are to be shut down (approximated as the total nuclear power plant output in FY2010 *x* 20 years ÷ 2), it is likely that another 10,000 tons of spent nuclear fuel

will be produced (for a total of just under 30,000 tons). Efforts should be made to address this situation by building temporary storage facilities within the sites for nuclear power plants nationwide to hold the spent fuel.

Fig. 1: A Nuclear Power Plant Cannot Operate When Its Storage Pool Is Full

(Usable period in the case of the spent nuclear fuel returned from the processing facility in Aomori)

Electric power company	Nuclear power station/Number of plants	FY storage capacity to be reached	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Hokkaido	Tomari/ 3	2025	■	■	■	■	■	■	■	■	■	■	■	■						
Tohoku	Onagawa/ 3	2017	■	■	■	■														
	Higashidori/ 1	2027	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
Tokyo	Fukushima Daiichi/ 2	2012																		
	Fukushima Daini/ 4	2012																		
	Kashiwazaki-Kariwa/ 7	2014	■																	
Chubu	Hamaoka/ 3	2016	■	■	■															
Hokuriku	Shiga/ 2	2026	■	■	■															
Kansai	Mihama/ 3	2015	■	■																
Chugoku	Takahama/ 4	2015	■	■																
Shikoku	Oi/ 4	2016	■	■	■															
Kyushu	Shimane/ 2	2014	■																	
	Ikata/ 3	2016	■	■	■															
	Genkai/ 4	2012																		
	Sendai/ 2	2022	■	■	■	■	■	■	■	■	■									
J-Power	Tsuruga/ 2	2016	■	■	■															
	Tokai Daini/ 1	2013																		

Source: Japan Atomic Energy Commission

Meanwhile, it will also be necessary by 2030 to select a final disposal site for the spent fuel, which becomes “nuclear waste.” (If not reprocessed, the spent fuel itself is highly radioactive nuclear waste.) Lack of progress on this decision would very likely hamper construction of temporary storage facilities. Moreover, the highly radioactive nuclear waste already sent to Britain and France will be returned to Japan.[1] Whether one wishes to promote or to abandon nuclear energy, the present generation is not entitled to shift the adverse consequences arising from its use of nuclear energy onto future generations. And if one advocates a change of policy back to promotion of nuclear energy, securing of a final disposal site will be indispensable. Incidentally, the U.S. Nuclear Regulatory Commission (NRC) in early August decided not to approve construction of any new nuclear power plants until the NRC itself had decided on a new policy regarding the temporary storage and final disposal of spent nuclear fuel.

According to the existing framework for deciding on a final disposal site, local governments make proposals to host the sites, but one alternative might be adopting the Swiss approach, under which a number of candidate sites within Japan would be chosen from the viewpoint of scientific safety, after which the need to build the site could be explained to local citizens. In Finland, where a final disposal facility is under construction after the site was selected, nearly twenty years were required to choose the location, so the government and industry should act as soon as possible.

[1] Radioactive waste remaining from spent fuel after recovery of usable uranium and plutonium is generally described as “nuclear waste” in Japan.

2. Use existing facilities to deal with surplus plutonium

Economy, Trade and Industry Minister Yukio Edano on September 15 made it clear to Aomori Prefecture that the government would maintain support for construction of the Omamachi plant and reprocessing facility, but some reason for the construction and the facility should be given which is consistent with the no-nuclear policy.

The reason that Edano expressed approval for building the Omamachi nuclear plant and continuing reprocessing was that any sudden abandonment of the nuclear fuel cycle facility and the nuclear plant would adversely affect employment and have major economic consequences in Aomori Prefecture.[2] Consideration should be given to the need to ease the economic damage as through construction of new renewable energy or thermal power plants in the prefecture. In addition, the Fukushima Daiichi nuclear accident produced some 200,000 tons of highly contaminated water, and a huge facility will be necessary to process this. The Rokkasho reprocessing plant is a commercial plant which also has facilities capable of turning the highly radioactive waste (nuclear waste) generated from the reprocessing into vitrified radioactive waste. Consideration could be given to turning the Rokkasho plant into a facility to process highly radioactive water.

Japan now has some forty-five tons of plutonium within and outside the country. Failure to deal with it will raise concerns over its possible diversion for use in nuclear weapons. Thus consideration should be given either to burn this plutonium in the UK or France or to complete, on an exceptional basis, the plutonium fuel reactor now being built in Aomori Prefecture's Omamachi by J-Power to use the fuel. In that case, the facility would have to remain in operation for forty years and would therefore have to be given exceptional treatment with respect to the nuclear-free target year of 2030s. This exception would be strictly for the purpose of dealing with the surplus plutonium. Incidentally, the Omamachi plant is capable of burning just under four times the amount of plutonium compared to conventional light water reactors, and the local government has already given its agreement to the burning of plutonium. It could help to ease the economic impact on Aomori Prefecture if the reprocessing plant and the Omamachi plant were redesigned as facilities specifically intended to process contaminated water and, by burning plutonium, to prevent nuclear proliferation.

If the Omamachi plant is completed and started up, however, the premiums for insurance against severe accidents should be calculated, with the premiums being paid by J-Power. If that is not feasible, the plants could be placed under state management, with J-Power being commissioned to operate the facilities while the state assumed full liability for any severe accidents.

An effective method of carrying out the processing of radioactive water and the burning of surplus plutonium at the reprocessing facility would be through a "nuclear energy central

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[2] According to the Asahi shimbun, the prefecture received 240 billion yen in power plant site subsidies over FY1981–FY2011 and businesses within the prefecture received 510 billion yen in orders related to the nuclear fuel cycle facility over FY1985–FY2010.

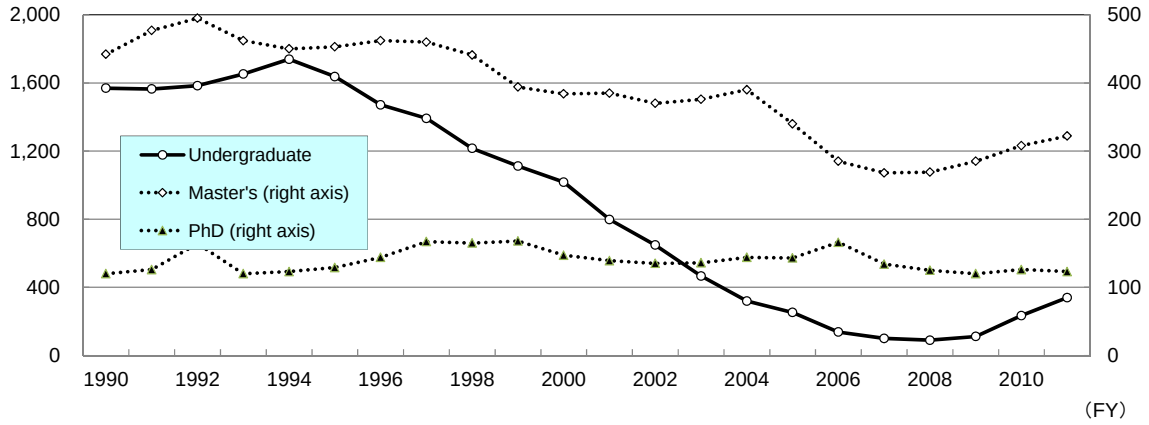
control organization," as mentioned below.

3. The government and private sector should maintain nuclear technology for reactor decommissioning and decontamination purposes

Even if the decision has been made to completely abandon nuclear energy by 2030, it will still be necessary to secure researchers and engineers over the long term in connection with the decommissioning of existing reactors and the cleanup of the Fukushima Daiichi plant. It would not be feasible, however, to rely on power companies in this regard. Once abandoning nuclear power has been designated as a national policy, energy companies will no longer have an incentive to maintain or hire researchers or engineers for their nuclear power divisions, which will no longer be sources of revenue for them. Under the jurisdiction of Nuclear Regulation Authority (NRA), which was launched on the 19th, a "nuclear energy central control organization" should be set up through which the government and private sector can cooperate in the decommissioning of reactors and the handling of accidents so the work of winding down nuclear facilities can be affected in a coordinated fashion. The present Japan Atomic Energy Agency (JAEA) should then be reorganized and folded into the central control organization. It should, as it were, play the key role in the strategy of withdrawing from nuclear energy and ensure that researchers and engineers at power companies and the government are not lost. One proposal is that it should assume jurisdiction over private sector power plants, reprocessing plants and other nuclear fuel cycle facilities, with the income from sale of electricity being allocated to research and development in reactor decommissioning and accident cleanup work. The Nuclear Decommissioning Authority (NDA) of the UK operates under this kind of structure, so it could serve as a model.

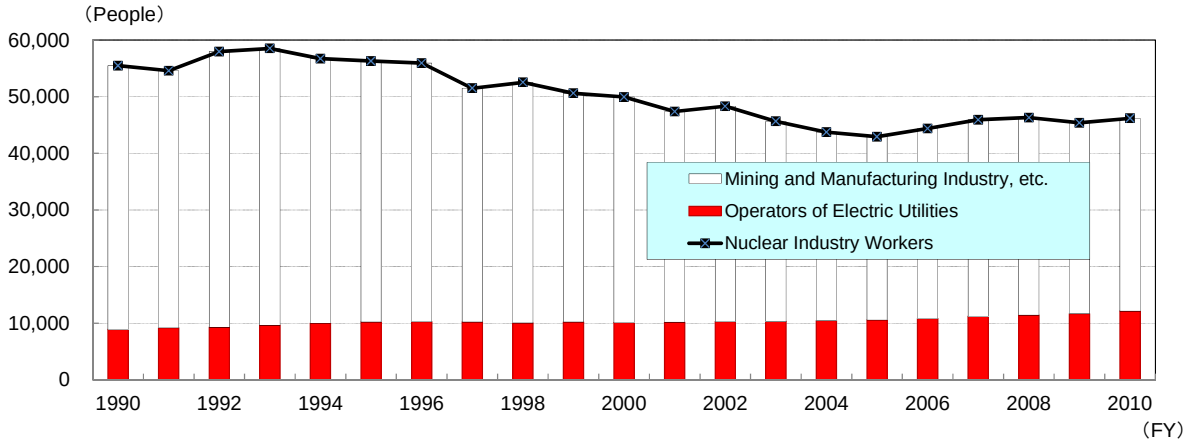
Japan should consider joining hands with the United States to establish and maintain an international body for research and development. In Europe, for example, the European Atomic Energy Community (EURATOM) maintains four research facilities in Italy, Germany, Belgium and Holland, and Japan might join with the United States and perhaps South Korea in considering ways to jointly maintain nuclear energy technology. The media has reported that the Americans are concerned about Japan's policy of abandoning nuclear energy, one reason being the fear that Japan would no longer possess nuclear plant construction technology. There are about a hundred nuclear power plants in the United States, and since the Three Mile Island accident in 1979, no new construction of nuclear plants has been approved, while many plants are aging. Japanese construction technology is needed to help maintain the U.S. plants. Thus if Japan and the United States cooperate in technology development, both countries would be able to maintain technology relating to nuclear plant construction. The Japan Atomic Energy Commission (JAEC) could be reorganized into an expert organization providing advice on matters such as basic policy to the central control organization.

Fig. 2: Number of Students Studying Nuclear Science and Engineering



Source: School Basic Survey, Ministry of Education,Culture,Sports,Science and Technology

Fig. 3: Trend on Workers for Nuclear Industry



Source: Industrial survey on Nuclear Power Generation 2010, Japan Atomic Industrial Forum, Inc.

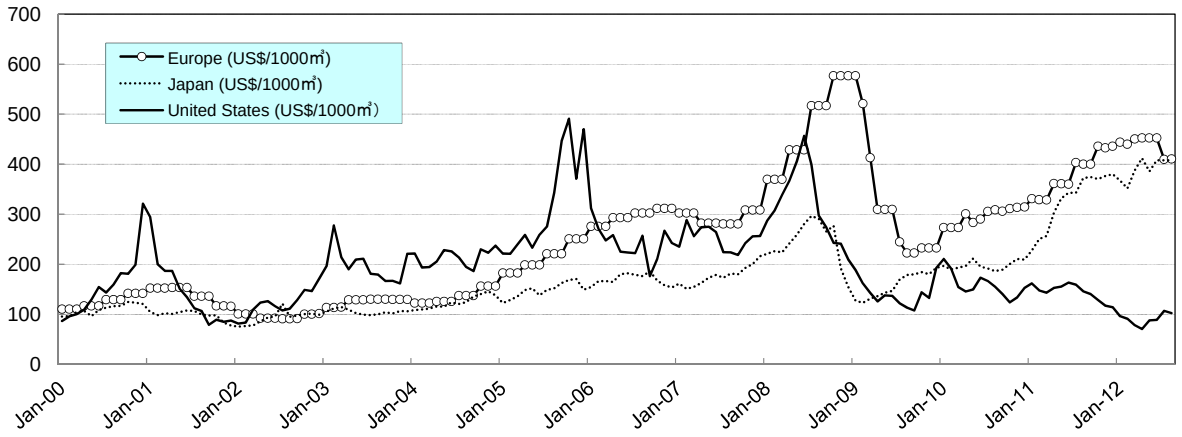
The knowledge and know-how relating to plant decommissioning and decontamination or safety enhancement which the nuclear power central control organization could obtain would be extremely valuable whether used in maintaining nuclear energy or in abandoning it. It could conceivably become part of the export industry. For this reason too, securing a core group of research and development personnel will be critical.

4. Secure stable supplies of fossil fuels through Trans-Pacific Partnership

Given the loss of confidence in nuclear energy, it may be impossible to restart any nuclear plants at all. Creating an environment in which stable operation of nuclear plants through 2030 is possible will be difficult until a stable government is in power. It may impossible to bring any nuclear power plants back online even in 2013 as well. For the time being, relying on thermal power will be the only option. Thus rather than buying natural gas

and oil in the high-priced spot market, Japan should quickly establish a system to secure such fuels as shale gas from the United States under long-term agreements. Japan is paying about 18 dollars for liquefied natural gas on the spot market but could procure U.S. shale gas for twenty to thirty percent less, according to energy industry sources.

Fig.4: Liquefied Natural Gas Prices in the United States, Europe and Japan



Source: IMF

Having entered into a free trade agreement with the United States, South Korea has been granted license to receive exports and is scheduled to begin imports from 2017. Japan is pursuing negotiations at the government and private level in hopes of beginning imports from 2016, but there is some doubt as to whether the United States will approve exports to Japan very soon since Japan has not expressed its intention to join in negotiations for the Trans-Pacific Strategic Economic Partnership Agreement (TPP). In principle, the United States is granting export approval to those countries which have entered into the TPP. Thus Japan should express its intention soon to join TPP negotiations in order to open the way to import U.S. shale gas and shale oil as early as possible.

5. Promote greater energy conservation and strengthen power grid, as through frequency standardization

The government's Innovative Strategy for Energy and the Environment aims by 2030 to achieve energy savings of 10% in terms of total electric power output (i.e., total consumption) compared to levels prevailing prior to the Fukushima Daiichi accident. However, we believe this target could probably be raised to 20%. According to the Federation of Electric Power Companies of Japan, electric power consumption this summer was down 10% from the summer of 2010, which was particularly hot. System peak load was also about 11% lower, as it turns out. Although electricity conservation efforts were made at the corporate and household levels, the fact that this was achieved in the short term on the demand side alone shows that even greater conservation could be achieved if innovative power consumption

technologies such as smart grids are also used in the future.

In the Higashida district of Kitakyushu City, for example, smart grid verification tests have been carried out with support from METI by the city, together with companies such as Nippon Steel Corporation, IBM Japan, Fuji Electric and Yaskawa Electric. It was found that power consumption could be reduced by 10% by varying electricity rates for 230 households and fifty businesses by about five-fold in accordance with power supply and demand conditions.

The control room at the power-saving management facility in Higashida district, Kitakyushu, Fukuoka Prefecture

Sample of a monitor that enables home users to visualize their electricity usage

Credit: Courtesy of JCER

Displays installed in homes made it possible to notify households of electricity rates a day before based on weather forecasts and other data. By increasing “visibility,” the system encourages households to conserve diligently. If smart grids are exploited, there would be even further room to conserve energy, as by adjusting electricity usage in accordance with electricity rates or supply and demand. Such technical innovations and their wider use could hold substantial promise for power conservation by homes and offices.

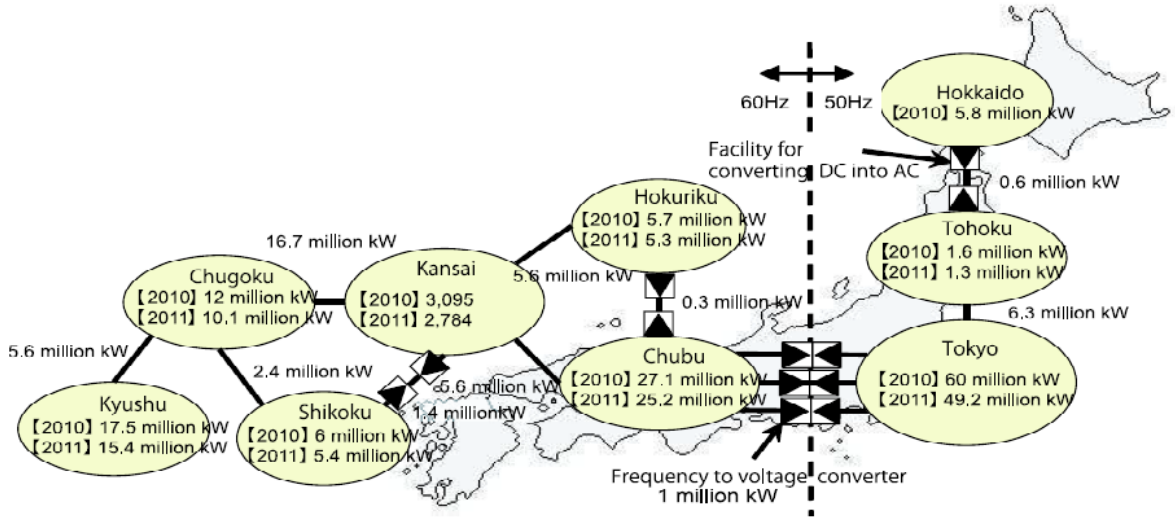
One point must be born in mind, namely the need to standardize the various devices used in connection with smart grids. For the system to gain wide popularity, it is critical that the smart meters and home terminals be usable in connection with any power company. Rather than having the major power companies supply and install meters and home terminals, it would accelerate the popularity and technical advancement of the devices if consumers could themselves freely choose and buy them, or use their PCs like telephone or internet services .

It will also be necessary to improve the power grid. Each of the power companies in Kyushu, Shikoku, Chugoku, Kansai, Chubu, Hokuriku (western Japan) can to one extent or another share power with each other, and the same is true for the power companies in Tohoku, Tokyo (eastern Japan except Hokkaido). But because eastern and western Japan uses different frequencies, only 1 million kW can be shared between them. And although the frequencies used by Hokkaido Electric and Tohoku Electric are the same, the submarine power grid capacity is only 600,000 kW. The government is thinking of spending a total of 5.2 trillion yen

by 2030 to strengthen the power grid as a means of stabilizing the electric power system with a view to promoting wider use of renewable energy, which are inconsistent. It should therefore standardize frequencies to make it possible to share power throughout the nation. There are fears that a future Nankai Trough mega-quake could affect a wide region, with power plants incurring damage. A single unified nationwide power grid is therefore necessary to protect against such natural disasters.

Since frequency standardization will cost a total of 10 trillion yen, there are many in the government and the electric power industry who believes it is unrealistic. However, joint efforts by the government and the private sector to digitalize broadcasting, combined with repurchasing of TV sets by users over a ten-year period, made it possible to achieve full digitalization even though many believed it would be impossible. The investment expenses incurred by the power companies in connection with frequency standardization could be financed by passing them on through electricity rates, for example. (The total cost of the nuclear fuel cycle is 19 trillion yen, but it has gone ahead because the cost is added to electricity rates.)

Fig.5 Regional Alliances among Electric Power Companies



Source: Agency for Natural Resources and Energy

6. Consider economic conditions in timing of final nuclear shutdown

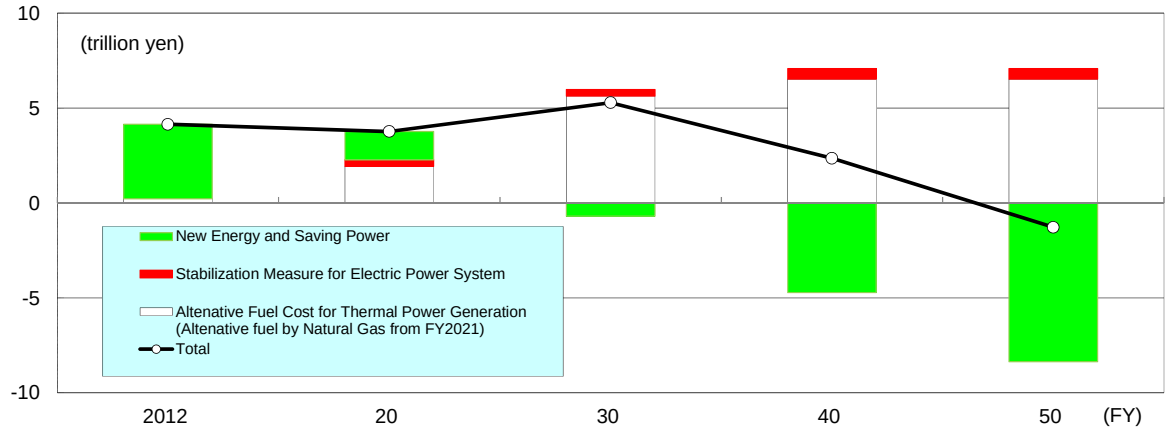
The pillar of the governments' energy policy is expanding use of renewables in place of nuclear energy, but it is unclear how high the cost of measures to promote them will rise. The feed-in tariff (FIT) scheme was launched from July, but some observers fear that the costs will grow rapidly. The costs through FY2030 should therefore be estimated. In doing so, however, it should be born in mind that these costs should be considered together with the impact of savings on fossil fuels made possible by the use of renewables. Moreover, the effectiveness of

the FIT scheme as a means to promote wider use of renewables should be reviewed every five years.

Figures 6-1 and 6-2 present estimates of the "net expense" for abandoning nuclear energy. This net expense is calculated by subtracting (i) the amount of savings arising from replacing fossil fuel with renewables from (ii) the cost of investment in renewables and the increased fossil fuel cost arising from the greater use of thermal generation in place of nuclear. Figure 6-1 anticipates complete abandonment of nuclear energy by 2030 in accordance with the government's Innovative Strategy for Energy and the Environment. As of 2030, renewable energy is projected to supply 30% of Japan's electric power. Figure 6-2 assumes that the target year for abandoning nuclear energy will be 2050 and is taken from our report of July 25, 2012, "Retaining Nuclear Plants after 2030: Four Conditions."[3]

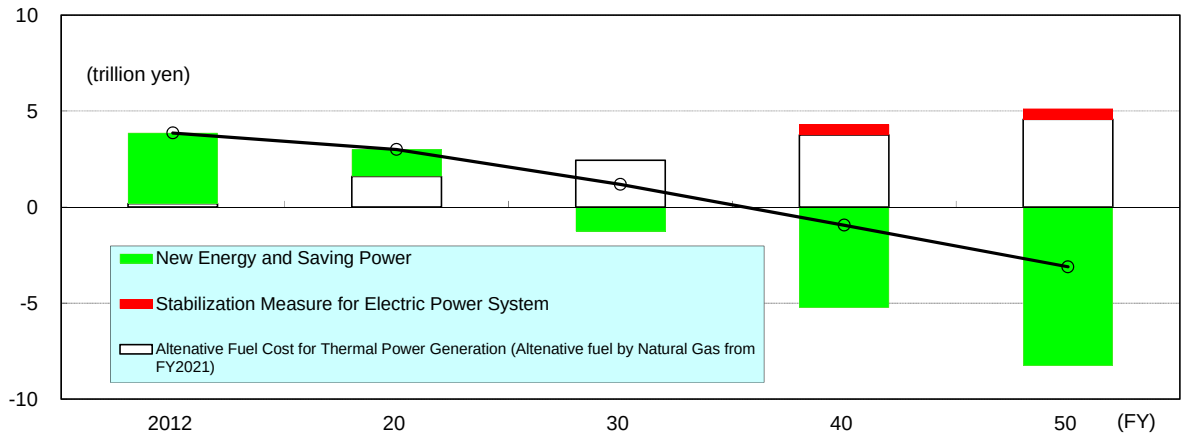
We will dispense with a detailed explanation here but will note that under a scenario of going nuclear-free by 2030 (Figure 6-1), a rapid growth in reliance on renewables will mean greater investment in renewables (with the investment cost being recouped through the FIT scheme and borne by consumers). Since this will exceed the amount of savings arising from reduced use of fossil fuels, it will be in the 2040s before the net expense finally turns negative. If renewables are to account for 30% of the energy mix through 2030, Japan will be much more dependent on solar power generation, the cost of which is two to three times higher than that of wind or geothermal generation. Generation costs will therefore be expensive. Under the scenario presented in Figure 6-2, nuclear generation will be reduced at a slower pace, so it would be possible to adopt renewables more slowly as well (20% by 2030 and 30% by 2050). In both cases, consistency with global warming policy is not taken into consideration, but in fact abandoning nuclear energy and promoting renewables will be closely tied up with targets for reducing greenhouse gas emissions. Future detailed consideration of how to reconcile these three issues will be necessary.

Fig. 6-1: Pure Cost of Power Generation with Saving Power (Zero Nuclear Power in 2030)



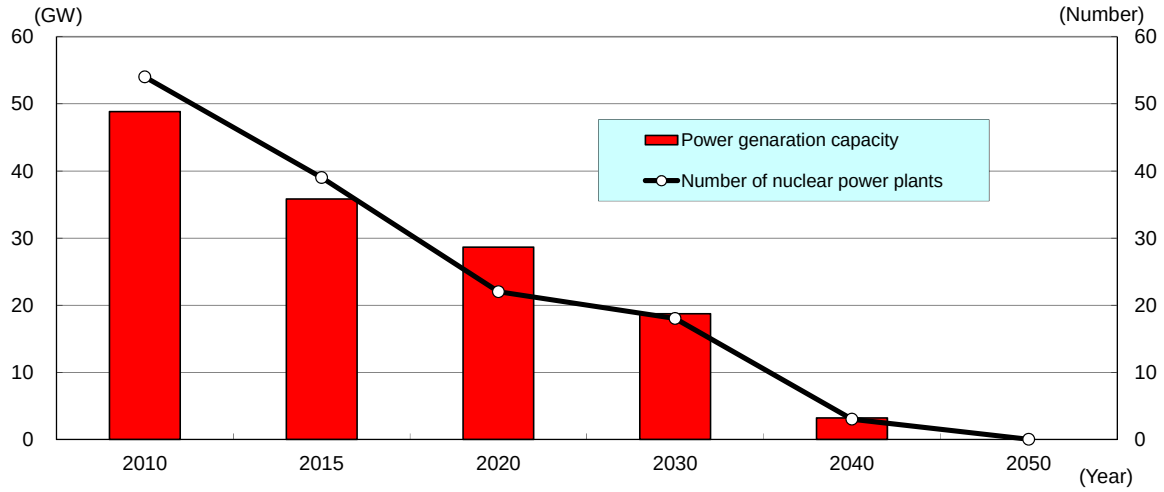
[3] [FOOTNOTE: http://www.jcer.or.jp/eng/research/pdf/pe(jcer20120725)e.pdf

Fig. 6-2: Pure Cost of Power Generation with Saving Power (Zero Nuclear Power in 2050)



According to the forty-year rule announced by the government, any nuclear power plant reaching forty years in service will be decommissioned, any plants to be restarted will require safety approval from the Nuclear Regulatory Authority (NRA), and no new construction of nuclear plants will be approved. Under this rule, the number of nuclear power stations will still not fall to zero by 2050, as indicated in Figure 7.

Fig. 7: Zero Nuclear Power Plants in 2040 without New and Additional Plants



Since it will be impossible to reduce the number of nuclear power plants to zero by 2030 under the forty-year rule alone, measures such as compensating electric power companies may become necessary. Considering the uncertainties surrounding factors such as the cost of abandoning nuclear power, it may be wise to keep 2050 on the table as an alternative target year for complete abandonment of nuclear power. Even if the eventual goal of becoming completely nuclear free itself remains unchanged, retaining some flexibility in regard to the timing would likely make it easier to mollify the impact on the public livelihood and business activities caused by changes in resource prices or uncertainties regarding the problem of

global warming.

If relinquishing dependence on nuclear energy by 2030 is to be achieved, these six conditions will unavoidably have to be addressed in detail. Abandoning nuclear power will definitely reduce the risk of nuclear disasters. However, it is also certain that costs must be paid regardless of the means used to substitute other energy sources for nuclear. These proposals have not addressed what the impact will be on the structure of Japanese industry, so in upcoming reports, we will analyze the impact which abandoning nuclear energy will have on Japanese industry, whether favorable or unfavorable.

Proposals: Kazumasa Iwata (JCER President) and Tatsuo Kobayashi (Principal Economist). Estimates regarding renewable energy are based on our 38th Medium Term Forecast for the Japanese Economy (http://www.jcer.or.jp/eng/pdf/m38.pdf).

Note of Appreciation

As Japan Center for Economic Research does not specialize in amassing knowledge regarding the nuclear power industry or nuclear energy, we have, in the course of completing our reports, obtained advice from many experts in the government and the electric power industry. Owing to the nature of the issues, it has not been possible to credit these sources, so we take this opportunity to express our deepest appreciation for their assistance.

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