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NUCLEAR POWER IN JAPAN  
--THE VISION, THE REALITY,  
THE PREDICAMENT--

Tatsujiro Suzuki

Massachusetts Institute of Technology  
MITJP 91-11

Center for International Studies  
Massachusetts Institute of Technology



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Tatsujiro Suzuki

Visiting Scientist, The Center for Energy Policy Research  
Massachusetts Institute of Technology

## INTRODUCTION

Japan's nuclear power program is considered one of the most successful in the world. As of December 31, 1990, there were 39 commercial reactors in Japan with 31.5 GWe of total capacity, the fourth largest in the world. There are 11 units (10.8 GWe) now under construction and three (3.5 GWe) in the planning stage. All of them are expected to come into operation by early in the next century, making Japan's nuclear capacity close to 45 GWe. Nuclear power supplied 26.1% of Japan's total electricity needs in 1990,<sup>1</sup> and probably will become the largest source of electricity by the year 2000. Since 1982, the average capacity factor has been consistently higher than 70%, which is among the best in the world.<sup>2</sup>

Despite this impressive record, Japan's nuclear power program still has to overcome many obstacles if its original "vision" is to be realized. As with all other nuclear power programs in the world, this vision is "energy independence through establishment of an indigenous nuclear fuel cycle and plutonium/breeder economy." However, the reality of high political and economic costs to achieve these ambitious goals has forced most nations to scale down or delay their nuclear programs. Japan's nuclear program retains its original goal and is now on the verge of full-scale commercialization of plutonium use. Can Japan still achieve its goal? How much political and economic risk does Japan have to take? Do the benefits outweigh these risks? What are Japan's policy options? These are the questions that this paper addresses and tries to answer to help in solving the predicament the Japanese nuclear program now faces.

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<sup>1</sup>. *Atoms in Japan*, February 1991.

<sup>2</sup>. The world average capacity factor in 1988 was 67%; so far, this has never exceeded 70%.

## THE VISION

Interest in nuclear power in Japan originated in 1952, when the U.S. Occupation ended and the ban on nuclear research was lifted. In December 1953, U.S. President Dwight Eisenhower made his famous "Atoms for Peace" speech; this boosted Japanese interest significantly and legitimized Japan's efforts to move forward. The first nuclear budget was submitted in 1954, and Japan's Basic Atomic Energy Law was enacted in 1955. This law is based on three fundamental principles--independent, civilian, and open--as proposed by the Science Council. The Japan Atomic Energy Commission (JAEC), established in 1956, serves as an advisory organ to the prime minister. At the end of 1956, the JAEC issued its first "Long-Term Plan for the Development and Utilization of Atomic Energy," which called for the development of a fast breeder reactor (FBR). FBRs, which produce more plutonium than they consume, use limited uranium resources most efficiently and could eventually allow Japan's nuclear program to become "self reliant." For Japan and other countries, too, FBRs became the common ultimate goal in the early days of nuclear development. But they are particularly important for Japan, which has virtually no domestic energy resources, including uranium.

In 1966, the JAEC issued a key report,<sup>3</sup> which determined the course of nuclear power development. The report reaffirmed the development of the FBR as Japan's primary goal, and, more importantly, it called for the establishment of a complete indigenous fuel cycle. The development of a domestic enrichment and spent fuel reprocessing capability, both of which have always been politically sensitive because of their potential for nuclear proliferation, was decided upon. The report also recommended developing an advanced thermal reactor (ATR)<sup>4</sup> as an "intermediate" reactor until the FBR became fully commercialized.

The Power Reactor and Nuclear Fuel Development Corporation (PNC), a semi-governmental R&D organization, was established in 1967 to serve as the main organization to develop advanced reactors (FBRs, ATRs) and all fuel cycle capabilities, except for light water reactor (LWR) fuel, which was being supplied by private companies.<sup>5</sup> It should be

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<sup>3</sup>. Japan Atomic Energy Commission, "Doryokuro Kaihatsu no Kihon Houshin ni Tsuite (Concerning the Basic Course of Reactor Development)," 1966.

<sup>4</sup>. ATR is a heavy water reactor developed by Japan. It uses slightly enriched uranium or plutonium as fuel.

<sup>5</sup>. There is another nationally funded research institute, Japan Atomic Energy Research Institute (JAERI), which was set up in 1956. JAERI's main function is to undertake basic research, such as safety, radiation science, and nuclear fusion. JAERI is also involved in high-temperature gas-cooled reactor development.

emphasized here that the importance of the JAEC 1966 plan and the establishment of PNC was a break from the common pattern of technology importation, and this was the first strong commitment by the Japanese government to develop "indigenous" technology.

Japan's nuclear budget increased significantly once PNC was established. Before 1967, the budget growth was moderate (¥9 billion in 1960 to ¥12 billion in 1965), but the budget reached ¥40 billion in 1970, and then grew six-fold in 10 years (¥247 billion in 1980) and 10 times in 20 years (¥410 bill in 1991). The development of advanced reactors, although there were significant delays as seen in most other nuclear programs, has proceeded rather smoothly and made steady progress. In 1977, the first experimental FBR (JOYO, 100 MWth) started operation. A prototype ATR (FUGEN, 165 MWe) became critical in 1978, and both JOYO and FUGEN have exhibited high performance. Currently, a prototype FBR (MONJU, 280 MWe) is under construction and is expected to start operation in 1992.

One of the most critical components of this development plan is, however, to "close" the fuel cycle, i.e., to reprocess spent fuel and recover plutonium and uranium which can be recycled into reactors. Thus, "reprocessing-recycle" is the cornerstone of the Japanese nuclear program and remains the basic strategy outlined by JAEC's latest long-term plan in 1987. The accomplishment of the entire vision can be threatened if the reprocessing-recycling option is in doubt. And this is the critical gap that Japan may have to face between the vision and the reality. At the same time, other important factors could also make accomplishing the vision more distant and difficult than originally thought.

## THE REALITY

### *Foreign Dependence*

Despite the original plan, Japan's nuclear program has remained highly dependent on foreign countries, and will remain so for the foreseeable future.

In its 1956 long-term plan, JAEC recommended importing already commercialized reactors until FBRs were fully developed. In 1957, JAEC announced the decision to import a Calder Hall type gas-cooled reactor (GCR), developed by the U.K., as the first commercial power reactor in Japan. The decision was welcomed by the utility industry, which needed the rapid introduction of new power sources in order to meet growing demand. The GCR

was chosen mainly because it uses natural uranium and thus does not require enrichment. The Japan Atomic Power Co. (JAPCO), a consortium of the utility industry (80%) and government (20%), was established to own and operate the reactor.

Soon after the decision to import the GCR, however, the U.S. announced a new policy to guarantee a supply of enriched uranium to fuel U.S.-developed light water reactors (LWRs). Encouraged by this policy and by optimistic cost estimates, Japan's utility industry decided to import LWRs as its main reactor types. In 1965, JAPCO decided to import boiling water reactors (BWRs), and Tokyo Electric Power Co. (TEPCO) followed suit soon thereafter. The Kansai Electric Power Co. selected pressurized water reactors (PWRs) instead.<sup>6</sup> Since then, all Japanese commercial reactors have been either PWRs or BWRs, and the Japanese commercial nuclear program has been highly dependent on the U.S.

Enriched uranium was supplied exclusively by the U.S., which virtually monopolized the market until the late 1970s. Currently, more than 60% of Japan's enriched uranium comes from the U.S. LWR technologies all came from the U.S., and Japanese vendors still have licensing agreements with U.S. vendors.<sup>7</sup> This high dependence on the U.S. has resulted in significant American political influence over the Japanese nuclear program.

Foreign dependence is not only on the U.S. Japan has had to import all its natural uranium, mainly from Australia, Canada, and South Africa. The first reprocessing plant owned and operated by PNC was built based on French technology. Even for the next reprocessing plant in Rokkasho-mura, the main process design came from France. Since Japam lacked sufficient reprocessing capacity, the utility companies decided they would have to depend on the U.K. and France for reprocessing services, and this eventually created the plutonium shipment problems described below.

Despite its high foreign dependence, nuclear power is regarded as a "semi-domestic" energy source in Japan, mainly because of its long-term technological potential for making Japan less dependent on foreign sources. Even under the most optimistic scenario,

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<sup>6</sup> . The typical pattern by which Japanese utilities have introduced new power plant technologies is for the first plant to be supplied by foreign vendors, while Japanese vendors become the licensee of the foreign vendor and learn the technology through the first project. The Japanese vendor can then be the prime contractor from the second plant on. Nuclear power technologies followed this pattern also.

<sup>7</sup> . The contents of the agreements have been changing to reflect the technological developments made by Japan, and thus now are more equal in terms of technical cooperation.

however, foreign dependence is likely to remain high until well into the next century, far beyond what was originally foreseen.

### *Economic Constraints*

In the early days of nuclear power, the cost of nuclear electricity was believed to be much less than other conventional power sources. In the 1970s and '80s, however, it became apparent that the economics of nuclear power were not as attractive as originally expected. In particular, the costs of FBRs and the reprocessing-recycling option became so high that strong commercial interest evaporated rapidly.

In Japan, electricity from nuclear power is still considered the cheapest among the various power sources. But its competitive edge is apparently narrowing, and the nuclear industry is under strong pressure to improve LWR economics.

Under these circumstances, the nuclear industry faces an increased burden for FBRs and their associated fuel cycle activities. As in many other countries, the cost of FBR development in Japan has escalated dramatically. The original estimate of the prototype FBR (MONJU) was only ¥36 billion (in current value) in 1967. This increased to ¥400 billion in 1979 and rose to ¥600 billion in the early 1980s. The utility industry's share of the burden, which was ¥60 billion in 1979, is now ¥110 billion. The next FBR, called the demonstration reactor, is supposed to be built by early in the next century. The government has already suggested an "increased role of the private sector" in funding the next demonstration plant, meaning that the utility industry would bear most of the construction cost. However, there is no clear commitment from the utilities at present, even though the conceptual design study has just been completed. It is now widely believed that FBRs will not be commercially competitive until at least 2030.

The Japanese reprocessing-recycling policy could cause more serious economic problems. The utility companies in Japan, with some funding from other nuclear industry companies, established a commercial reprocessing company, Japan Nuclear Fuel Service (JNFS), Inc, in 1980. JNFS decided to build an 800 ton/year reprocessing plant, one of the largest in the world, in Rokkasho-mura in Aomori Prefecture in Northern Japan. Its construction cost is now estimated to be more than ¥1 trillion, far exceeding any other power plant project. In addition, if plutonium is to be recycled, it has to be fabricated as mixed oxide (MOX) fuel. Since there is no dedicated MOX fuel fabrication facility in Japan, if recycling is to be fully

implemented, Japan needs to invest in a new fabrication plant.<sup>8</sup> And because of the high fabrication cost of MOX and the stable price of uranium, MOX fuel is unlikely to be competitive with uranium fuel. The planned reprocessing-recycling business, thus, is likely to place a significant economic burden on the utility industry.

### *International Politics*

Economics is only part of the picture. The Japanese government and nuclear industry believe that the current reprocessing-recycling program will bring long-term benefit in improving the energy security of Japan. In theory, recycling of plutonium can reduce uranium requirements by about 30%, and FBRs could increase uranium resources by 50 to 100 times. Thus, there are certain benefits in this reprocessing-recycling policy, in particular considering the uncertain future of energy availability. In reality, however, the short-term benefits in energy security are not likely to be so large as originally expected.

Even under the most aggressive plutonium use program, Japan can only reduce its uranium requirements by less than 10% by 2010.<sup>9</sup> This could be even less if the program moves more slowly than expected.

Japan's nuclear program is heavily influenced by U.S. policy. U.S. enrichment policy can influence Japan's nuclear fuel prices and import practices. More importantly, through its bilateral Agreement on the Peaceful Use of Nuclear Energy, Japan needs U.S. "prior consent" if Japan wants to either reprocess or transport nuclear fuel abroad. Until the agreement was revised in 1988, this "prior consent" was given on a "case-by-case" basis, i.e., Japanese utilities had to go through a complex approval process for each shipment of spent fuel. This political constraint had a real impact on Japan's reprocessing program.

In April 1977, President Jimmy Carter announced his nuclear non-proliferation policy, by which he proposed to abandon commercial reprocessing and plutonium use. This policy directly affected the operations of Japan's newly completed Tokai reprocessing facility. After intensive negotiations as well as changes in the U.S. Administration's policy, Japan now can operate the facility at full capacity. In addition, the new agreement, which became effective in 1988, now has a "30 year advance consent" clause instead of "case-by-

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<sup>8</sup>.The utilities are planning to fabricate MOX fuel in Europe for the time being. This may require new investment in Europe also, however, if full-scale recycling is implemented.

<sup>9</sup>.See Berkhout, Suzuki, and Walker, MITJP 90-10, p. 15.

case" prior consent. This significantly reduces political uncertainties and is a political breakthrough for the Japanese nuclear program.

Even under the new agreement, however, the U.S. still has significant influence over the Japanese nuclear program, through Congressional actions as well as potential changes in Administration policy. So uncertainty cannot be eliminated entirely as long as Japan imports enriched uranium from the U.S. and relies on LWRs, which are American-licensed technology. The latter may be more important for the longer term. Even if Japan secures all of its nuclear fuel from non-U.S. sources, if fuel is burned in U.S.-licensed reactors (as all Japanese LWRs are), the U.S. can still control end-use under the bilateral agreement.

Reprocessing contracts with the U.K. and France make this relationship more complex. Both the U.K. and France have nuclear weapons and are members of EURATOM. The U.S. and EURATOM have an agreement on the peaceful use of nuclear energy. Japan has separate agreements with the U.K. and France. Uranium suppliers, such as Australia and Canada, also have separate agreements with Japan. Through all these agreements, then, numerous countries have some influence over Japan's back-end deployment.

Finally, there are various international regulations, involving risks of nuclear proliferation, controlling nuclear activities. The Nuclear Non-Proliferation Treaty (NPT) is the basic international norm by which peaceful programs must function. Japan signed the NPT in 1970 and ratified it in 1977. Under the NPT, all nuclear facilities in non-nuclear weapon states have to be under International Atomic Energy Agency (IAEA) safeguards, which means the IAEA inspects the facilities to make sure the nuclear materials involved are not diverted. There are other important regulations, such as the London Suppliers' Guidelines, which control export and technology transfer of certain nuclear technologies, and the International Convention on Physical Protection of Nuclear Material, which became effective in 1980 and is designed to prevent theft or unauthorized diversion of nuclear materials.

After the Indian nuclear explosion in 1974, which used plutonium recovered from a civil research reactor, political sensitivity on civil plutonium and its associated fuel cycle activities increased significantly. Carter's non-proliferation policy, which is mentioned above, reflected such sensitivity. This sensitivity remains high and could intensify, considering the fact that the U.S.-U.S.S.R. strategic arms negotiation may make steady

progress in the coming years, and this could reduce the world's military stockpile of plutonium.

All these international political constraints were not originally envisioned. Ironically, the more Japan relies on plutonium, the more its nuclear program will be affected by international politics. This is the basic dilemma Japan now has to face.

### *Domestic Politics*

Japan's tragic experiences in Hiroshima and Nagasaki are believed to be the roots of Japan's so-called "nuclear allergy." It is true that Japan's strong anti-nuclear "weapon" feeling can be explained adequately by that. But Japan's growing anti-nuclear "power" movement has other roots, since the majority of the general public has supported civilian nuclear power development despite the Hiroshima-Nagasaki background.

In the early days, nuclear power was generally welcomed by the public. In particular, the first oil crisis of 1973 helped to promote the development of nuclear power. As reducing dependence on imported oil became a top priority in the national energy policy, the general public in Japan was made well aware of the need to develop alternative energies including nuclear power. At that time, the anti-nuclear movement was relatively limited to the local populations around the power plant sites. The government introduced new laws, that is, the "three basic laws to promote electric power development." These laws created special accounts to fund economic development in regions where power plants are located. Compensation to local fishermen was the utilities' key instrument to win consensus from the local community. The Communist and Socialist Parties helped organize an anti-nuclear movement, but they proved more effective in their anti-weapon campaign. The local governments received tremendous economic benefits through accepting power plant projects. The laws were not limited to nuclear power, but were most useful in siting nuclear plants.

The TMI accident in 1979 increased the general public's concerns over nuclear safety. Local negotiations became more difficult, and lead times from the planning the start of

construction became unacceptably longer.<sup>10</sup> But, mainly due to the second oil crisis, the general public still supported nuclear power.

The 1986 Chernobyl accident changed the nature of the anti-nuclear movement significantly. Food contamination in Europe aroused the attention of the general public, in particular housewives and consumers. Popular anti-nuclear activists undertook very effective campaigns criticizing the safety of Japanese nuclear power plants. A series of live public debates on nuclear power were held on nationwide TV as well as locally. A nationwide campaign to submit a petition for a "nuclear moratorium" to the national Diet collected more than three million signatures, even though it fell short of the goal of 10 million. These movements were all new to the anti-nuclear movement in Japan. Now, the anti-nuclear movement in Japan is more grass-rooted, urbanized, and is no longer limited to local siting issues.

### *Impact of Recent Nuclear Accidents*

After a couple of years of strength, the anti-nuclear movement in Japan has somewhat subsided recently. However, two nuclear accidents in 1989 and 1991 could help spur its revival. It is important to assess the potential impact of these accidents on Japanese nuclear program in order to foresee its future directions.

The first accident was in 1989 at TEPCO's nuclear power plant site in Fukushima, which is about 200 km north of Tokyo and one of the two largest nuclear power plant sites in Japan. There are now 10 nuclear power plants on two sites in Fukushima (six on site #1 and four on site #2). All of them are owned and operated by TEPCO, the largest utility company in Japan and the largest investor-owned utility in the world. On January 7, 1989, operators at the the Fukushima #2-3 unit (BWR, 1100 MWe) shut down the reactor manually because of strong vibrations in a recirculation pump. TEPCO soon found that the pump was partially destroyed and that broken pieces had flowed into the reactor vessel. No injuries or radioactive releases were reported.

Although the accident was not believed to be "technically serious," it raised social and political concerns. The key facts that concerned the public were: (i) the operators were

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<sup>10</sup>. In some cases, such as the Maki and Shiga nuclear plants, it took more than 10 years before the utilities could submit their official plans to the Electric Power Coordinating Council, which officially authorizes plant construction plans.

aware of the vibrations six days before the accident and continued operations despite the warning signal; (ii) TEPCO originally thought the incident was minor and did not think the broken pieces could get into the reactor vessel (which could reduce the flow rate of cooling water and/or could damage the nuclear fuel); and (iii) TEPCO did not report the accident to MITI and the local governments immediately. The Fukushima site had been considered the best model of a successful relationship between a utility and the local community. Unfortunately, however, both the government and TEPCO now believe this accident may have created serious "mistrust" between the public and the nuclear industry.

After an intensive investigation, MITI concluded that the causes of the accident were (i) improper welding of the pump component and (ii) misjudgment of operators who continued to operate the plant despite the warning signal. Although MITI and the Nuclear Safety Commission issued approval to restart the plant in July 1990, TEPCO waited until it could reach consensus with the local government. Fukushima #2-3 was reopened in November 1990, after almost two years of clean-up, safety examination, and intensive negotiations with the local government.

Three months after the restart of Fukushima #2-3, a more serious accident occurred at another key site. On February 9, 1991, an emergency core cooling system (ECCS) was activated for the first time in Japan at the Mihama-2 nuclear power plant (PWR, 590 MWe). This plant is owned and operated by the Kansai Electric Power, Co., the second largest utility in Japan. The Mihama site is located in the Wakasa Bay area, which is about 100 km north of Osaka, the second largest city in Japan. The area has 11 nuclear power plants, nine of which are owned and operated by Kansai Electric Power.

A tube cut was found in one of the steam generators (SGs) at Mihama-2. This had caused about 20 tons of water to leak from the primary loop (radioactive) to the secondary loop (non-radioactive). First, it was reported that there was no radioactive leak, but it was later found that a small amount (about 10% of annual emissions) of radioactivity had been released to the environment. This was the first Japanese nuclear accident which resulted in an abnormal radioactivity leak to the environment. There were no injuries, and no impact on public health is foreseen.

The preliminary results of MITI's investigation suggest that anti-vibration bars (AVBs) were not properly installed on the steam generator, as specified by the design. Excessive vibration due to insufficient support resulted in material fatigue, which eventually ruptured

the tube. The position of the AVBs was not subject to annual inspection; thus, their improper installation was not noticed. MITI ordered all PWR owner utilities to inspect their steam generators and AVBs, and Kansai Electric later found that AVBs at Takahama-2 unit were also improperly installed. The unit was shut down immediately. It is expected to take more than three years to replace the steam generator.

The media treated this incident as "the worst nuclear accident in Japan." Nuclear critics and anti-nuclear activists immediately assailed the nuclear industry and the government, claiming that they were right and industry wrong in assessing the real danger of steam generators. The utility industry and MITI have insisted that detailed annual inspections could prevent such accidents. Now, nuclear critics say, that claim has lost its credibility. Local governments also expressed their concerns. First, the mayor of Mihama complained that he received the accident information one hour 44 minutes after the incident. The Fukui Prefectural government, which has been a strong supporter of nuclear power, asked MITI to reexamine the inspection regulations.

There are certain facts that should be noted about the above two accidents. They are: (i) TEPCO and Kansai are Japan's two largest utility companies, and each is the leader of its PWR/BWR owner's group; (ii) human error and management failure are the common causes of the accidents; and (iii) two local governments considered most favorably disposed towards nuclear sites are now openly expressing their "dissatisfaction" about the way the utilities handled the accidents. Considering these facts, the accidents could influence the fundamental relationship between the nuclear industry and the general public, in particular local politics.

What are the long-term implications of these two accidents for the future?<sup>11</sup> The most important one will be the added difficulty of finding new sites for nuclear projects. All the on-going nuclear projects are at sites selected before the Chernobyl accident. No new sites for any nuclear projects have been successfully secured since then. Even on-going projects, like Rokkasho-mura, could be significantly affected. Although the pro-nuclear incumbent governor was re-elected in the recent Aomori election, the majority (56%) of the vote was for anti-nuclear or skeptical candidates. The future of the Rokkasho project is, thus, still

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11. A short-term impact will be on electricity supply this summer. The reserve margin is becoming dangerously low, and closing two or more nuclear plants could well mean an electricity shortage depending on demand this summer. See "Japan Faces Possible Summer Electricity Crunch," *The Wall Street Journal*, April 4, 1991.

uncertain. According to MITT's latest Long-Term Energy Outlook published in 1990, about 40 new nuclear plants are to be built by 2010. This goal had been thought unrealistic by many experts; now it seems almost impossible.

Another important impact is on the credibility of the government and the nuclear industry. The general public is already skeptical about Japan's nuclear programs. According to the latest government poll published on December 23, 1990,<sup>12</sup> 90% of the public feels "uneasy" about nuclear power, and 46% thinks that nuclear power in Japan is "not safe," though the majority (65%) still believes nuclear power is necessary. When asked which information source is reliable, TV/newspapers and scholars/experts are cited as more reliable than the government or utilities. Thirty-one percent of the respondents say information about the accidents from the authorities is not sufficient. And, finally, the groups who are in favor of an increased role of nuclear power dropped below 50% (48.5%) for the first time (it was 57% in 1987), while those who oppose such an increased role reached more than 40%.

## THE PREDICAMENT

### *Plutonium Surplus and Plutonium Shipment*<sup>13</sup>

Since the immediate prospect of a plutonium economy has faded, most nations have delayed and downsized their reprocessing programs. Some of them, such as the U.S., have abandoned reprocessing. Japan is no exception. The first commercial scale reprocessing plant (800 tons/year, 1998 completion) was delayed and downsized from its original plan (1200 tons/year, 1990 completion). However, Japanese commitment to its reprocessing-recycling remains firm, unlike most other nations.<sup>14</sup>

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<sup>12</sup> *Atoms in Japan*, January 1991, pp. 24-31, and *Nihon Keizai Shimbun*, December 24, 1990.

<sup>13</sup> See the detailed discussion in F. Berkhout, T. Suzuki, and W. Walker, "Surplus Plutonium in Japan and Europe: An Avoidable Predicament," *The MIT Japan Program*, MITJP 90-10, September 1990, and "The Approaching Plutonium Surplus: A Japanese/European Predicament," *International Affairs*, Vol. 66, No. 3, pp 523-543, Summer, 1990.

<sup>14</sup> For example, while Germany also maintains its official reprocessing policy, it has already abandoned construction of its domestic commercial reprocessing plant (although this is mainly due to political opposition), and has reexamined the alternative options to reprocessing. France has also published two independent reports suggesting reexamination of reprocessing options. Sweden, Italy, Canada and the U.S. have chosen not to reprocess spent fuels.

Japan, along with some European countries, made contractual commitments to both the U.K. and France to build and utilize the two nations' large new reprocessing plants (THORP and UP-3) during the '70s and '80s. Both plants were also delayed, but UP-3 has recently been completed and THORP is close to completion. If all the contractual commitments are honored, THORP and UP-3 will produce roughly 90 tons of plutonium between now and 2003 or so, out of which 36 tons are for Japan.<sup>15</sup> And the Tokai reprocessing plant will produce about five tons by 2000.<sup>16</sup> The Rokkasho plant will start operations in the late 1990s, and its cumulative production by the year 2010 will be 60-70 tons. Thus, the total cumulative supply by 2010 will be 100-110 tons. On the other hand, according to the latest government report, the R&D demand for plutonium (used by FBRs and ATRs) will be, at most, 40 tons by 2010.<sup>17</sup> Consequently, the "surplus" (i.e. the difference between production and R&D needs) could be 60-70 tons. The current Japanese plan is to recycle such "surplus" plutonium into existing LWRs.<sup>18</sup> But, as described above, such large-scale recycling could bring significant economic penalties to the utilities. Thus, it is possible that full-scale recycling may not take place as planned.

The need to ship plutonium is another important predicament. As described above, domestic plutonium production may not be sufficient to supply all R&D needs before the Rokkasho plant starts operations. Nevertheless, the plutonium belongs to Japan and thus has to be shipped to Japan eventually. But plutonium shipment from Europe to Japan is an extremely sensitive operation in terms of its impact on international politics. Japan realized this political sensitivity when it shipped 253 kg of plutonium from France in 1984. Because of strong concerns over the potential risks of terrorist attacks or thefts, the shipment was escorted by the French and U.S. navies. The new agreement of 1988 and its subsequent implement agreement also added new safeguards and physical protection

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<sup>15</sup>. The quantity expressed here is "total plutonium," which includes non-fissile plutonium, such as Pu 238, Pu 240, and Pu 242. International regulations are based on total plutonium amount. The quantity of fissile plutonium, such as Pu 239 and Pu241, varies depending on the status of spent fuel, but roughly 70-80% of total plutonium in the spent fuel is fissile. Source: Frans Berkhout and William Walker, "Spent Fuel Policies and Plutonium Recycle in Western Europe: The Non-nuclear Weapon States," Paper for submission to Energy Policy (Draft), January 1991.

<sup>16</sup>. After 2000 or the start up of the Rokkasho plant, the Tokai plant will be used for R&D purposes; thus, its production rate will be substantially lower (0.2 tons/year or less).

<sup>17</sup>. It is estimated at around 30 tons of fissile plutonium by 2010. Thus, the total plutonium amount will be roughly 38 to 42 tons. The numbers are from the interim report published by an ad hoc experts group on nuclear fuel recycling, Atomic Energy Commission of Japan. The numbers are provisional, and the actual numbers may vary. (*Asahi Shimbun*, March 18, 1991)

<sup>18</sup>. The above report suggests that about 53 tons (fissile) of plutonium can be used in LWRs by 2010, i.e., can be used in four units (1000MWe class) by the late 1990s, and in 12 units by 2005 or so. (*Asahi Shimbun*, March 18, 1991)

requirements for plutonium shipments; this was, in fact, the most difficult part of the negotiation. Under the current agreement and the commitment made by the U.S. Administration, the U.S. still "maintains the right to suspend its consent [to reprocessing and Pu shipment] in order to prevent a significant increase in the risk of proliferation or threat to its national security."<sup>19</sup> In addition, the U.S. Congress could raise opposition or could even block the shipment. Although plutonium shipment is in principle approved by "30 year prior consent," its implementation is by no means an easy task.

Plutonium shipments are also a domestic political problem for Japan. Sending the Self-Defense Force (SDF) as a military escort overseas is politically too risky, as it could violate the spirit of the Constitution's Article 9 and could provoke political opposition among Asian countries. Instead, Japan has decided to build a dedicated escort ship owned and operated by the Maritime Safety Agency. Defense experts and right-wing politicians argued that the SDF was better suited to this mission. Although the Government's policy is now clearly set, it is still possible that the debate could be revived if the situation changes.<sup>20</sup>

It is also reported that the utility industry plans to ship plutonium as MOX fuel fabricated in Europe rather than in powder form. The utility industry hopes that this will result in relaxed safeguards and physical protection requirements since, technically, it would be more difficult to divert plutonium from MOX fuel.<sup>21</sup> International regulations, however, do not distinguish plutonium in MOX from plutonium as powder, and it is unlikely that the requirements will be eased. MOX fabrication in Europe is also opposed by a group that favors domestic fabrication of MOX fuel.

### *Spent Fuel Storage and Waste Management*

Currently, Japanese reactors produce roughly 500 tons of spent fuel annually. Spent fuel is stored at reactor sites for short periods of time and then shipped to the reprocessing plants. Through 1988, about 5,000 tons of spent fuel were generated and about 3,000 tons were shipped to reprocessing plants in Japan (only 400 tons) and Europe (about 2,700

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<sup>19</sup>. John C. Whitehead, Deputy Secretary of State, Letter to Chairman Fascell, Committee on Foreign Affairs, House of Representatives, May 26, 1988.

<sup>20</sup>. Prime Minister Kaifu acknowledged in a closed Cabinet meeting that the shipment plan could, if necessary, be the subject of future discussion. *Asahi Shimbun*, Dec. 20, 1989.

<sup>21</sup>. *Nihon Keizai Shimbun*, March 18, 1991.

tons). Current estimates by MITI show that, by the year 2001, about 17,000 tons of spent fuel will have been generated. Considering the additional new capacity at Rokkasho-mura (3,000 tons of storage and 800 tons/year reprocessing), there will be adequate storage capacity.<sup>22</sup>

But, if the Rokkasho plant is delayed, storage capacity could be tight. Especially some older plants, which have smaller storage capacity may face a shortage of space. Technically, it is easy to expand the storage capacity, through re-racking as well as transfers to a larger storage facility. But this could be difficult politically. Agreements with local communities assume that spent fuel will be shipped out of the reactor site "in a short time." Building a dedicated centralized spent fuel storage facility could also be difficult since the local public may think it would become the final repository. This is a common problem for all nuclear programs worldwide. Alternative programs, such as dry cask storage on and off site, are commercially available. Many countries are already introducing such programs. But, in Japan, such alternative long-term fuel storage schemes have not been permitted because they undermine the need for reprocessing and they could provoke political opposition from local communities.

In addition, vitrified waste from the reprocessing of spent fuel will be returned from Europe soon. The Rokkasho plant also has the storage capacity for this returned waste. Currently, there is no specific plan to select a site for high-level waste (HLW) disposal in Japan. (A low-level waste disposal facility will be built in Rokkasho-mura, also.) There is a plan to build an "HLW waste engineering test center" in Horonobe in Hokkaido. However, the Governor of Hokkaido, a Socialist, opposes this plan and has delayed it. And finally, last year, the Hokkaido Diet voted against the project. Another plan proposed by PNC was also cancelled because of local opposition.<sup>23</sup> Waste management is emerging as a new political issue, and site selection will become increasingly difficult. Thus, if the Rokkasho plant is delayed, there could be no place to put returned HLW from Europe.

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<sup>22</sup>. MITI Nuclear Industry Division, March 1989. Quoted from NHK special report, "Ima Genshiryoku wo Tou (Nuclear Power Now)," August 1989.

<sup>23</sup>. Kamaishi mine, which is under threat of closure, was the candidate site. The local public submitted a petition not to accept the research facility, and the city diet adopted a resolution to that effect. *Asahi Shimbun*, November 13, 1989.

## *International Pressure*

Japan's international presence has risen dramatically in the last decade. International relations are becoming increasingly important policy components for Japan's decision-making process. Japan has now started to realize that its actions are not only inevitably affected by policies and events in other parts of the world, but will affect the rest of the world more than Japan has ever thought.

Intensified trade friction with the U.S., as well as with other countries, makes Japan an easy target for these countries' policy makers. Even if the policy is considered rational for Japan, it will create international criticism when it has a negative impact on other countries. In particular, pressure from the U.S. is becoming stronger than ever. Japan's recent lack of action and sensitivity toward the Gulf Crisis has surely increased the general dissatisfaction with Japan's attitude toward international issues.<sup>24</sup>

Increased environmental concerns may add another dimension to Japan's international predicament. Whaling has been a typical example, but other similar issues have been raised. Drift net fishing and import of endangered species and their products (e.g., ivory and turtles), are good examples of how Japan can be easily attacked by the international environmental community and is often forced to change its policies.<sup>25</sup>

Transportation of nuclear materials has already become a major political issue in Europe. Recently, the Dutch Government would not allow a Swedish ship transporting enriched uranium from Germany to Scotland into Rotterdam, due strong opposition by environmental groups.<sup>26</sup> It is not clear how environmental groups will behave when Japanese plutonium shipments leave England or France.

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<sup>24</sup>. According to the latest Washington Post-ABC poll, eight of 10 Americans say they either lost respect or their attitudes were unchanged in light of Japan's actions toward the Gulf War. The poll was conducted after the end of War. *The Washington Post Weekly*, March 18-24, 1991. p. 38.

<sup>25</sup>. See, for example, Keith Schneider, "U.S. Moves to Punish Japan for Trade in Turtles," *The New York Times*, March 21, 1991.

<sup>26</sup>. *The Economist*, January 19, 1991. p. 53.

Japan will be under increasingly strong international pressure to act responsibly and positively on any issues that could affect the rest of the world. The plutonium issue, in particular, sea shipments, will be certainly one of these, as Japan will be the only country transporting such large quantities of plutonium.

#### OPTIONS--SEARCHING FOR THE SOLUTION

Japan has to realize that its original "nuclear vision," i.e., the establishment of a self-reliant nuclear power system through early commercialization of breeder and plutonium use, will not be realized as expected, at least for the foreseeable future, even though it may be valid as a long-term goal. Nuclear power policy based on an unrealistic vision could be harmful. Large-scale plutonium use at present is no longer necessary. On the contrary, it could make the Japanese nuclear program more inflexible and susceptible to international politics. Eventually, it could threaten the entire nuclear program.

Economic and social conditions surrounding nuclear power have changed considerably in the last decade. Public concern over nuclear safety and waste management is increasing. International pressure to protect the environment and to prevent the proliferation of weapons of mass destruction (nuclear, biological, chemical) is also becoming stronger. Japan's priorities have to shift to reflect such changing social needs. The credibility of Japan's nuclear policy is eroding both domestically and internationally. The Atomic Energy Commission will soon start discussions to revise its long-term development plan, which is due in 1992, and this is an opportunity to reexamine that policy and search for alternative options.

### *Maintaining the FBR-plutonium option*

It is clear that commercialization of FBR-plutonium will not be realized in the near future. There is no need to rush full-scale use of plutonium. But this does not mean that Japan should give up its FBR-plutonium option. The best policy choice is to maintain this option until it is needed or to prepare for an uncertain future. This could be done through appropriate technological development programs without committing to large-scale use of plutonium.<sup>27</sup>

### *Reexamining the Reprocessing-recycling policy*

The best way to solve the plutonium surplus issue is to reduce the scale and delay the timing of reprocessing in order to match the need for plutonium. While maintaining the momentum of the reprocessing-recycling program, its scale and timing can be changed. The spent fuel storage plan has to be adjusted to a reduced reprocessing scheme.

### *Establishing A New Vision: Contribution to international society*

Japan's nuclear predicament is no longer only a domestic issue. Considering the fact that Japan will be the only non-nuclear weapon state to use such large amounts of plutonium, its actions cannot go unnoticed by the international community. Japan has to make policy decisions responsibly in this context. It will no longer be acceptable if Japan alone is arguing that plutonium is needed for its own energy security reasons.

Japan has both the technological and economic capability to contribute to international society in solving global energy problems and reducing proliferation risk. Introduction of the above two policies can be a good starting point. A *new vision* for Japan's nuclear policy should be established. This new vision should reflect changing domestic and international needs for nuclear power, and priority should be on three key issues: safety, waste management, and non-proliferation. Initiatives in the development of advanced nuclear technologies, which are safer, economical, and more proliferation-resistant, and

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<sup>27</sup>. See the detailed argument in T. Suzuki, "The Analysis of U.S. FBR R&D Program Dynamics to Maintain the Technological Capability," IFAC Energy Systems, Management, and Economics, Tokyo, Japan, 1989. pp. 429-434.

contributing to a waste management solution, could be good examples of such a new vision.

There are some encouraging new signs in Japan's non-proliferation policy, especially after the Gulf War. The following are several examples of these latest developments.

- (1) Japan is insisting that North Korea accept IAEA safeguards as a condition for resuming diplomatic relations.<sup>28</sup>
- (2) Japan decided to propose new rules to make the IAEA safeguard system stronger and more effective. One idea is to eliminate the condition of "consent" from host countries in order to enforce "special inspection" in "suspicious" countries.<sup>29</sup>
- (3) Japan decided to introduce four new guidelines to its Official Development Aid (ODA) policy. One of these is the status of mass destructive weapon programs in the recipient country.<sup>30</sup> For example, whether the recipient country is a signator of the NPT or not is one specific condition for ODA.<sup>31</sup>

Although it is still premature to assess the real significance of these policies, they may be interpreted as emerging signs of Japanese new willingness to contribute on an international level.

Combined with these foreign policy initiatives, a new nuclear policy could be well respected both domestically and internationally. A new vision based on these policy initiatives will serve Japan's interests as well as international ones better than the current programs.

Changing a policy has been considered by Japanese decision-makers to be a threat to the existing programs. It is true that consistency is one important element in making policy successful. But it should be noted that the credibility of Japan's nuclear policy will not be threatened by adopting such a new vision. It will be enhanced significantly as it reflects new needs and can reduce both economic and political risks. This is the way to sustain the consistency of the Japanese nuclear policy.

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<sup>28</sup>. Japan successfully forced China to accept IAEA safeguards as the condition for Japan-China Cooperation Agreement on Peaceful Use of Nuclear Energy in 1985. Now, Japan is requesting that China join the NPT. (see *Nihon Keizai Shimbun*, March 29, 1991)

<sup>29</sup>. *Asahi Shimbun*, March 29, 1991.

<sup>30</sup>. *Nihon Keizai Shimbun*, March 29, 1991. The other three conditions are: military expenditure, arms trade and level of democratization.

<sup>31</sup>. *Asahi Shimbun*, March 30, 1991.