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Japanese Energy Security and Changing Global Energy Markets:
An Analysis of Northeast Asian Energy Cooperation and Japan's Evolving Leadership Role in the Region

Nuclear Power Generation and Energy Security:
The Challenges and Possibilities of Regional Cooperation

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INTRODUCTION

The 20th Century is called the age of oil. It may be no exaggeration to say that the energy policies of the major advanced nations of the world have been virtually built around oil. Like a giant ship that is difficult to steer, long-term energy policies and the energy supply infrastructure based on these policies cannot be altered significantly even when the energy situation changes.

Nuclear power generation is similarly entrenched. It involves a very large industrial infrastructure, which includes mines, fuel processing, spent fuel storage, reprocessing, and waste disposal. Moreover, research and development requires huge investments and a long lead-time. So, once established, nuclear power generation is very hard to alter. This aspect has a most significant meaning in considering the role that nuclear power generation plays in energy security.

As of the end of 1998, there were 422 commercial nuclear power generation plants (358.49 kW) in operation in the world, accounting for about 16% of the world's electricity supply. However, it is expected that the number of new projects in North America and Europe will decline as plans for abolishing or early closure of nuclear power plants are increasing. This trend implies that nuclear power generation may be expected to have a smaller share in world electricity markets in the years to come.

On the other hand, Northeast Asia is the only region where nuclear power is expected to grow. Northeast Asian countries continue to pursue nuclear power generation to enhance energy security in the face of dwindling regional oil supplies. Since the oil crises of the 1970's, nuclear power generation has been playing a major role as an alternative energy, but there are many problems yet to be resolved for nuclear power generation to continue to contribute to energy security.

First, it should be recognized that many of the problems facing the nuclear power industry come from past policy decisions. In particular, the problems of spent fuel and radioactive waste are greatly affected by the decisions regarding the nuclear fuel cycle and the fast breeder reactors (FBR).

Second, as exemplified by the Chernobyl accident in the former Soviet Union and the critical accident in Tokai Village in Japan last September, such accidents, even one involving a small part of the system, can seriously affect the fate of other nuclear power projects. Such accidents affect social attitudes towards nuclear power, even spreading across national borders. Therefore, sufficient attention should be given to the technical risks and the effects they pose.

Lastly and perhaps most importantly, nuclear power's image is linked to its relationship with nuclear weapons. Nuclear power programs for civilian and military use are given clear distinction by law, but it is more difficult to give them technical distinction. The use and reprocessing of plutonium have posed the greatest danger of being employed for nuclear weapons.

The energy environment for the 21st Century is very opaque and uncertain. How can we cope with this uncertainty? What future role will nuclear power play? To answer these questions, it is necessary to weigh nuclear power's role as a relatively secure alternative to fossil fuels against its technical risks, lack of public acceptance and potential security role.

This paper considers Japanese nuclear power and energy security in section II, followed by the present status of nuclear power in Asia and its problems in section III. The paper concludes with policy recommendations for the future.

NUCLEAR POWER AND ENERGY SECURITY FOR JAPAN

The history of nuclear power development: In search of energy security

Ensuring the nuclear cycle and the fast breeder reactor (FBR), as the starting point: 1950s to 1960s.

Nuclear power development in Japan began with the 1953 historic speech "Atoms For Peace" by U.S. President Eisenhower at the United Nations. Immediately thereafter in 1954, the Atomic Energy Law was promulgated. This law provides for three principles (independent, democratic, and open) for the peaceful use of nuclear power in Japan. In 1956, the Atomic Energy Commission was organized, working out "Long-Term Plans for the Research, Development and Use of Nuclear Power"(hereinafter called "Long-Term Plans"). With the Atomic Energy Law stipulating that Prime Minister respects the advice of the Atomic Energy Commission, the Long-Term Plans to be made by the Atomic Energy Commission have been playing an important role in determining Japan's nuclear power policies. The Long-Term Plans are revised once every five years, having last been revised in 1994. Discussions for the next Long-Term Plans started in 1999.

The 1956 Long-Term Plans stated that: "… the basic policy dictates that the reprocessing of spent fuels be conducted in Japan as far as possible … Japan's effort to develop nuclear power shall aim to develop the fast breeder reactor (FBR) which is deemed to be the most suitable atomic reactor for Japan from the viewpoint of effective use of nuclear fuel resources."[1]

With Japan lacking in uranium, the decision to opt for the FBR was a logical decision, consistent with the prevailing worldwide trend of developing FBR given the limit to world's uranium supplies. By 1956, commercial nuclear power plants had already been in operation in the U.S. It was also been decided to introduce the light-water reactor (LWR) to be pursued simultaneously with development of the FBR. The introduction of these technologies from the

U.S. and the decision on the use of enriched uranium was to affect Japan's development of nuclear power in a significant way.

In 1967, recognizing that the effort to introduce the LWR was making steady progress, the Atomic Energy Commission announced a Long-Term Plan, which helped finalize the increasingly fast development of the FBR-nuclear fuel and a long-term commitment to it. The gist of the Long-Term Plan is as follows:

[1] Assuming the LWR as the major nuclear reactor for commercial use, Japan set a LWR development goal of 3,000 to 4,000 kW by 1985.

[2] As a nuclear reactor for independent development, the Advanced Thermal Reactor (ATR) was to be developed in addition to the FBR as an interim reactor until the FBR is in practical use.

[3] It was decided that, to establish a nuclear fuel cycle in Japan, concentration and reprocessing facilities would be built in Japan. Assuming that it would take some time for use of the FBR to become practical, a nuclear reactor "Monju" was to be constructed before a commercial nuclear reactor is built.

[4] The development of the FBR, the ATR, and the nuclear fuel cycle was made a national project to be pursued jointly by the private and public sectors. A special public-sector corporation "Power Reactor and Nuclear Fuel Development Corporation" (hereinafter called "PRNFDC") was created as the organization to realize this project.

It is generally believed that the plan was a political decision reached after having sufficiently examined Japan's energy situation and energy technologies. It was also true that the

Atomic Energy Commission sent a fact-finding mission to America and Europe the previous year and that as a result; it had ample knowledge of the current European nuclear power development. At that time, America, the U.K., and France each had an experimental fast breed reactor in operation and had decided to build the next-stage nuclear reactor. Therefore, Japan's policies were not necessarily made in light of Japan's own peculiar situation but rather were motivated by the desire to remain current in nuclear power development.

Another important development was the established of the so-called "dual system" where the responsibilities for research and development plans and commercial programs were divided between private industry and government institutions. At the time, the government (Atomic Energy Commission) was to develop basic policies and research and development plans. National research and development institutes (under the Science and Technology Agency) such as the PRNFDC and the Japan Atomic Energy Research Institute were to carry out these policies and plans. Nuclear power development was positioned as "a national effort." The responsibility of carrying out the nuclear power development was to be assumed by the private sector but research and development would be government-sponsored. These circumstances led to inner contradictions in Japan's nuclear power development.

The LWR having come to stay and the delay in the development of the nuclear fuel cycle

In the 1970s, the introduction of nuclear power generation began to accelerate. After the oil crisis in 1973, nuclear power became the "major electricity source as an alternative to oil." In 1974, "three electric power laws" were promulgated (the Law for the Neighboring Area Preparation for Power Generating facilities, the Electric Power Development Promotion Law, and the Electric Power Development Promotion Special Accounting Law).

Under these laws, electric power location subsidies were to be given to the municipalities (prefectures, cities and towns) that agreed to accept nuclear power generation and other large-scale power generation plants. The Electric Power Development Promotion Tax was incorporated into electricity bills to fund these subsidies. Nuclear power plants were to be given subsidies twice as high as coal-fired or oil-fired thermal power plants, providing a powerful financial incentive. Initially, the Electric Power Development Promotion Tax charged was 0.085 yen per kWh, and then it was raised to 0.30 yen per kWh in 1980. An electric power diversification account was added to fund alternative energy research. The tax was raised to the prevailing rate of 0.445 yen per kWh in 1983. This tax revenue was included in a special account to be shared almost equally between the Science and Technology Agency and MITI. The tax system under the "three electric power laws" ensures that subsidies and research funds play a major role in promoting Japan's policies of developing alternative energy to oil, especially nuclear power.

In recent years, however, these three laws have proven less effective in gaining new sites for nuclear power. Especially after the Chernobyl accident, the only site to be agreed on was in Totsu (in Aomori prefecture).

Although initial goals were not met, Japan saw its nuclear power development make steady progress in the 1970s and the 1980s. The number of nuclear reactors at existing sites has increased steadily through continued expansion since the late 1970s. Nuclear power has maintained itself in Japan as a low-cost, stable source of electric power, with the nine major electric power companies all owning nuclear power plants (some under construction) by the middle of the 1980s.

On the other hand, the development of the FBR and the nuclear fuel cycle has met with unexpected difficulties as compared with the commercial LWR. First, the operation of the experimental FBR "Jouyu" was delayed till 1997, and the fast breeder prototype reactor "Monju" was not completed in the 1980s. The "Monju" and the succeeding FBR programs will be discussed later at length. The ATR was expected to serve until the FBR is commercialized so the prototype reactor "Fugen" continued operation. By contrast, the demonstration reactor program experienced costly delays and was eventually cancelled due to rising costs in the 1990s. The processing experiment for the ATR and FBR plutonium fuel (uranium and oxide mixtures, to be called "MOX") has been making steady progress at the PRNFDC with the results matching those in America and Europe.

The PRNFDC had a pilot plant (90 tons per year) built in Tokai Village for the reprocessing of the LWR spent fuel but the operation was put on hold in the mid-1970s by the implementation of U.S. President Carter's policy of nuclear non-proliferation. After India's nuclear testing in 1974, the danger of converting civilian-use plutonium for nuclear weapons began to attract attention, prompting U.S. President Ford's announcement of a temporary freeze on reprocessing for civilian use. President Carter pushed this policy a step further, announcing an indefinite postponement of the commercialization of the civilian-use reprocessing/FBR. As a result, Japan's reprocessing plans, which required America's consent under a bilateral agreement, ran into a large barrier.

President Carter's policy of curtailing the reprocessing/plutonium was opposed by Japan and Europe, which were being brought into the International Nuclear Fuel Cycle Evaluation (INFCE). Japan was allowed to begin operating part of the reprocessing facilities at Tokai Village on condition that "Japan will not commit itself to second reprocessing facility." Subsequently, President Reagan helped to remove the ban on reprocessing temporarily, but the negotiations between Japan and the U.S. were most difficult, eventually leading to the revision of the Japan-U.S. Nuclear Agreement.

The new Japan-U.S. agreement was of utmost importance. It stipulated:

[1] <u>The introduction of comprehensive approval</u>: Under the old agreement, reprocessing and transportation of spent fuels across the border required U.S. approval on a case-by-case basis. Under the new agreement, programs agreed to in the appendix were to be approved collectively. As a consequence, it was expected that reprocessing and the use of plutonium could be carried out as Japan wished for the duration of the new agreement (30 years).

[2] <u>The introduction of increased U.S. influence (the pollution clause)</u>: Article 9 of the new agreement designates the scope of U.S. influence as "including nuclear substances burnt in a reactor using U.S. technologies," a more restrictive definition than before. Almost all the reactors in Japan are built using technologies licensed from the U.S., making it necessary that spent fuels of uranium or other fuels purchased from other countries than the U.S. still be put under U.S. control.

[3] <u>Intensified protection against nuclear substances in transportation</u>: When 253 kg of plutonium were being transported from France in 1984, a major issue of protection against nuclear substances in transportation was raised in the U.S. Congress. As a result, the new agreement provides for guidelines, making it necessary to get U.S. approval separately on a case-by-case basis.

Thus, the Japan-U.S. questions involving reprocessing showed that Japan's nuclear fuel cycle plans were linked to international politics. As a result of the long-standing Japan-U.S. negotiations, the comprehensive consent clause under the new agreement helped to significantly expand the degree of freedom of Japan's plutonium plans, but the inclusion of the pollution clause made it impossible to escape from the U.S. influence for some time.

Japan also pursued relations with European countries with nuclear capacity (especially U.K. and France). In the early 1970s, spent fuels were being generated in quantities that far exceeded Japan's reprocessing capacities. Japan needed to gain access to reprocessing facilities in other countries. Reprocessing contracts were made with COGEMA of France and BNFL of the U.K. under which the recovered plutonium as well as the high-level radioactive waste materials were to be returned to Japan. Meanwhile in the 1980s, domestic commercial reprocessing programs also emerged. In 1980, amendments to Japanese laws also made it possible for private-sector companies to do reprocessing. A private reprocessing company "Japan Nuclear Fuel Service Ltd." (now called Japan Nuclear Fuel Ltd.) was created. Japan's electric power companies were its major equity holders. The company agreed to locate a large commercial reprocessing plant (800 tons per year), a uranium concentration plant, and a low-level waste disposal facility at Rokkasho Village in Aomori prefecture. Still, Japan’s plants were producing spent fuels in quantities exceeding Japan's reprocessing capacity, prompting the policy for "partial reprocessing (partly interim storage)" introduced in 1987. Also, FBR programs in America and Europe, which began before Japan’s program, started to experience delays or even cancellations, making the economic feasibility of the use of plutonium increasingly uncertain.

Growing public doubts and the age of surplus plutonium: 1990s up to the present

In the 1990s, the climate for nuclear power development changed significantly, with the transportation of plutonium facing more-than-expected opposition not only from the U.S. but also from nations along the transportation routes. This opposition surprised Japan. It had committed to meet all the requirements according to international rules and bilateral agreements and also had made the necessary preparations. The opposition raised not only questions about transportation safety but also criticized Japan's plutonium policies and its nuclear power policies per se, even raising fear of Japan owning nuclear weapons.[4]

In answering these criticisms and fears, the Atomic Energy Commission announced a policy of "not choosing to possess any surplus plutonium," making the plutonium inventory known to the general public in an effort to improve transparency and trust. Satsuki Eda as the Minister of the Science and Technology Agency (also Chairman of the Atomic Energy Commission) in the Hosokawa coalition cabinet organized a "Session to Hear Opinions," trying to make the policy making process better known to the general public.

But in 1995, Japan's nuclear power policy was seriously affected by a sodium leakage accident at the "Monju" prototype FBR.

The ill-organized effort to deal with this accident, rather than the actual technical problems, led to doubts about the structure of the PRNFDC as the central organization to promote the FBR. PRNFDC disintegrated further with another accident in 1997 at the asphalt solidification facilities in the processing plant. These accidents left questions about Japan's FBR development effort.

In January 1996, the governors of Fukui, Fukushima and Niigata prefectures, the major prefectures where nuclear power plants are located, made a direct proposal to the Prime Minister entitled "Hoping to build a national consensus." Taking this opportunity, the Atomic Energy Commission made a policy statement "Toward building a national consensus," which covered: 1) increased disclosure of information, 2) "Atomic Roundtable Sessions" to air opinion and 3) discussion of the FBR and radioactive waste disposal issues at a meeting yet to be organized. The roundtable meetings and public meetings had moderators or chairmen who were non-experts from outside the industry. Critical opinions about nuclear power and the FBR were voiced at the sessions.

This effort was praised for its precedents for a new policy making process in Japan. But the domestic climate for nuclear power has not improved. For example, the proposal for a Tohoku Electric's planned nuclear power plant at Maki village was voted down by a majority of the village people voting in August 1996. Moreover, the critical JCO accident at Tokai village in September 1999 has helped create another big obstacle to nuclear power.

A recent report on nuclear power from the December 1997 people's meeting to discuss the FBR remains notable. The most remarkable outcome of the meeting was a declaration of nuclear power as "an effective future alternative to fossil fuels" and the statement that "In commercializing the FBR, flexibility must be used while ensuring safety and economy," which helped to cause a stir in the hitherto inflexible development effort[6].

While supporting a continuation of the FBR research and development effort, this proposal offered flexibility, which was contrary to the official policy of the Atomic Energy Commission. The decision (December 1997)[7] of the Atomic Energy Commission in response to this proposal indicated increased flexibility in carrying out the nuclear power programs by stating that "...considers the conclusion of the people's meeting to be appropriate. The commission will use flexibility in commercializing the FBR in respect of the development programs including the time of commercialization." This resulted in the virtual postponement of the demonstration reactors planned after the "Monju." A new development team was organized with the Japan Nuclear Cycle Organization (JNC), the successor to the disbanded Power Reactor and the PRNFDC. The new team will have to restart research and development effort for the commercialization of the FBR, potentially delaying the commercialization of the FBR until 2030 or later.

Delay in the development of the FBR has at least temporarily curbed demand in Japan for plutonium. As contracted processing of plutonium in Japan and Europe has progressed, plutonium inventory has increased from less than 1 ton in 1992 to 5 tons in Japan and 24 tons in Europe (France and the U.K.) in 1998 for a total of 29 tons[8]. The Japanese government, which wants to push the use of plutonium in order to deal with its own growing stock of plutonium, got Cabinet approval "on the current promotion of the nuclear fuel cycle.” Normally, a decision by the Atomic Energy Commission is a matter "to be reported to a Cabinet meeting," but in light of its importance, this decision was treated as a matter "to be approved by a Cabinet meeting." This decision included the following two important items.

[1] <u>The promotion of plu-thermal</u>: Recycling plutonium in the existing LWR is called "plu-thermal." The reprocessing contracts with Europe are expected to produce a total of about 30 tons of recovered plutonium, the only outlet for which at the moment is for the "plu-thermal". Of the opinion that all electric power companies

that operate any nuclear power plant may well employ the "plu-thermal" in turn, the Japanese government decided that the "plu-thermal" should be employed at ten to fifteen nuclear power plants by 2010.

[2] The storage of spent fuels: Spent fuels are being produced in quantities that far exceed the reprocessing capacity. This excess will continue even if the reprocessing plant at Rokkasho village opens as scheduled. Therefore, approval has been given for storage at facilities other than nuclear power plants.

Backed up by this Cabinet approval, the "plu-thermal" had been accepted by Fukui and Fuskushima prefectures and approved by MITI, and a decision was almost made for it to be commercialized within 1999. However, the September 1999 critical accident at Tokai village and the subsequent fabrication of the MOX data have helped to delay its employment considerably[9].

The Advisory Committee for Energy issued an interim report[10] in June 1998 on spent fuels storage after Cabinet approval. The report designated spent fuels as "recyclable fuel resources," emphasizing that they are an important energy resource and that they should be kept in "interim storage" until required for reprocessing. The report also proposed that the laws and regulations be amended to make it possible to store spent fuels at facilities other than nuclear power plants. Based on this report, the regulations on nuclear reactors and other related matters were revised, making possible commercial storage of spent fuels. This revision of the regulations helped to significantly increase flexibility involving the management of spent fuels by electric power companies. But here again, even after the storage pool (3,000 tons) of the reprocessing plant at Rokkasho village in Aomori prefecture was completed, the data on casks containing spent fuels were found to have been tampered with, significantly delaying the actual start of transportation of spent fuels. The candidate sites for the interim storage have not yet been announced. Since the lack of spent fuel storage capacity can force a nuclear power plant to discontinue operations, this issue, in a sense, should be recognized as most important for energy security.

Further, this issue is very closely related to the issue of high-level waste disposal. With reprocessing a precondition in Japan, vitrified waste of high-level radioactive materials from a nuclear power plant are specified as high-level waste. As a result, preference was first given to reprocessing, and the high-level waste disposal plans began with ensuring storage of vitrified waste of high-level radioactive materials. Despite the commissioning of storage capacities at Rokkasho village, final disposal plans have lagged behind the rest of the advanced nations. This adds further uncertainty to future nuclear power development in Japan.

The Atomic Energy Commission has been listening to public opinion by organizing public meetings to discuss the high-level wastes. But future prospects remain uncertain, with no specific plans in sight. According to the present plans, a high-level waste organization is to be created this year, but many issues remain to be resolved including location and funding.

Contribution to Energy Security

The fiction of domestic energy

Most obvious among the goals of energy security policy is the establishment of independent energy supply, or in other words, the establishment of domestic energy supply systems. As discussed earlier, since the beginning of Japan's nuclear power development effort, nuclear power has been regarded as almost domestic energy when the FBR is employed. Plutonium is essential as a major fuel for nuclear power generation. However, arguments that the use of plutonium is a precondition for energy security are wrong as a matter of fact. There are three paradoxes about plutonium that are important to understand.

(a) Paradox #1: The more plutonium used by a nation, the more the nation becomes influenced by international politics

Plutonium is produced in an existing nuclear reactor. Spent fuels contain about 1% of plutonium. Recovering this plutonium by "reprocessing" and re-using it as fuel is called the "fuel cycle". So, once the nuclear fuel cycle is established at home, nuclear power becomes almost an indigenous energy, and, moreover, if the FBR is commercialized, nuclear power becomes an inexhaustible domestic energy. This is the basic theory behind the pursuit of plutonium as the ultimate domestic energy source.

However, the reality is not so simple. The fact that plutonium can be used for nuclear weapons dictates that the use of plutonium by nations such as Japan be rigorously controlled by international law. As mentioned earlier, the use of plutonium by Japan is subject to the bilateral agreement with the U.S. and to various other international regulations and restrictions. Thus, if problems with any country’s plutonium use become an international issue, it can affect the restrictions imposed on Japan. In other words, the more a nation depends on plutonium for its nuclear power generation, the more that nation is influenced by international politics.

(b) Paradox #2: The more plutonium used, the less the value of plutonium in saving the uranium resource.

Uranium is an exhaustible resource. To save uranium as far as possible is essential, especially for Japan, which lacks uranium resources. As discussed earlier, the ultimate method of nuclear power generation is by a plutonium-based FBR. But even before the FBR is commercialized, a theoretical 20% to 30% saving of plutonium is believed to be possible by using the plu-thermal.

However, the reality is much more complex. First, the uranium resource is an exhaustible resource. Yet, geologically speaking, it is a relatively abundant resource. Judging from the figures recently published by the International Atomic Energy Agency (IAEA), there seems to be enough plutonium assured to meet demands for at least 50 years ahead[11.] If uranium in seawater is included, the resource is a huge one[12]. For now, uranium prices are depressed, leaving non-existent economic merit for the plu-thermal. When long-term resource savings are the goal, the plu-thermal will lose its value as an energy resource rather than helping to "reduce" plutonium. In the long-term, it will be more efficient to store away plutonium as spent fuel and recover it when employment of the FBR requires it. Consequently, the plu-thermal cannot be the most efficient method of saving uranium from a long-term point of view.

(c) Paradox #3: If use of plutonium for peaceful purposes is to make progress, there should be more stocks of plutonium available. On the other hand, nuclear disarmament and nuclear non-proliferation require efforts to reduce plutonium inventories.

The weapon-class plutonium used for nuclear weapons is a highly pure Pu239 90%, only 4 kg of which can make a nuclear explosion device. However, the nearly 200 kg of plutonium produced every year by a one-million-kWh nuclear reactor is a "low grade" Pu239 60% (called "nuclear reactor class plutonium") and is not used as a material for nuclear weapons. Therefore, it follows that civilian-use programs to make use of the nuclear reactor class plutonium will not pose such a nuclear proliferation risk as the critics maintain. Also, increased peaceful use of this material requires higher inventories, which will eventually be consumed as fuel and will not lead to worsened nuclear proliferation risks.

Nevertheless, in the international arena, this common sense is no longer acceptable. It has already been shown that even nuclear reactor class plutonium can make nuclear explosion devices, and the categories for international nuclear guidelines do not distinguish plutonium by its isotope components. As mentioned above, the international guidelines on plutonium aim to balance the supply and demand of plutonium, sustaining the momentum towards reduced inventories. Given the fact that the management and disposal of plutonium recovered in the U.S. and Russia becomes a most important issue for international security with the progress of nuclear disarmament, it will never be a welcome policy to produce more plutonium.

The above discussion will make it apparent that given the paradoxes of plutonium, the concept it will become Japan's ultimate domestic energy source contributing significantly to its energy security must be reconsidered.

Stable supply of uranium fuel and its contribution to the best mixes of energy sources

How should the role of nuclear power in Japan be evaluated? Discussion of this question comprises three main arguments: a) it reduces dependency on oil, b) it provides stability of supply, and c) it contributes to the diversification of energy resources. Nuclear power generation here does not necessarily assume the establishment of the nuclear fuel cycle, but means generation by the existing LWR using uranium of low concentration.

(a) Ability to reduce dependency on oil

Since the 1973 oil crisis, a top priority of the Japanese government's policies has been development of alternative energy sources to oil. Nuclear power has contributed significantly as an alternative to oil. Japan's dependence on oil for electricity generation declined from over 70% in 1973 to about 15% in 1998, mainly through the substitution of nuclear power along with natural gas for oil.

However, it is not certain that future increases in nuclear power generation will necessarily lead to oil replacement. According to Japan's future electricity supply plans, nuclear power's share of total power generation is expected to rise to 45% in 2010 from the present 35% while that of oil will only fall modestly (See Appendix, Figures 1-1, 1-2). In terms of total energy supply, nuclear power's share will increase to 17% in 2010 from 12% now (See Appendix, Figure 2). But nuclear power cannot be counted as an alternative energy for transportation, which is the largest use for oil, indicating that nuclear power's ability to reduce dependence on oil in terms of total energy has become less important than in the 1970s.

(b) Supply stability

In addition to its contribution as an alternative energy source to oil, nuclear fuel can be evaluated as one of the more stable sources of supply. Main points contributing to supply stability are relative abundance, resistance to supply disruptions and price stability.

i) Abundance of Uranium

It is argued that uranium exists abundantly in stable supply in contrast to oil when considering political factors. Major uranium suppliers include Canada, Australia, France and the U.K. (which receives uranium shipments from Namibia and South Africa for re-export). Proven reserves divided by annual production (R/P) are said to be good for more than 70 years, assuring sufficient quantities to last for the next 50 years. With prices and growth in demand recently depressed, however, new mines have not been developed. According to forecasts by OECD and the NEA, supply capacity may possibly go below demand in the next ten years, making supplies less secure. Japan has secured its needs until at least 2010 under long-term purchase contracts so there is no fear of short supply under normal circumstances.

(ii) Resistance to supply disruption

Historically, uranium has often been put under the control of the government as a strategic resource, and in some cases, state-owned companies are commissioned to handle sales and marketing (as is the case with COGEMA). This means that an abrupt individual government decision by a big uranium supplier can significantly affect the uranium market. As a matter of fact, in 1974 immediately after the nuclear testing by India, Canada chose to temporarily suspend exports of uranium due to concern for nuclear non-proliferation. The Canadian move did not directly affect Japan's procurement of uranium. Nevertheless, it had a significant psychological impact on Japan. Nowadays, in a move to address environmental protection and opposition from the aborigines, the development of Australian mines has been partly curtailed. Therefore, uranium is not truly an energy source that is free from political influence and potential disruption.

Yet, nuclear power generation is most resistant to the disruption of fuel supply. This resistance is due to the lead-time for fuel procurement that can be characterized as a feature of the nuclear power generation technology. It takes about two years to mine, concentrate, process, and charge a nuclear power plant with uranium. Even if procurement contracts should be disturbed, uranium fuel procured under old contracts will continue to arrive at the nuclear power plant for the next two years. Moreover, once the fuel is charged into the reactor, normally it does not need replenishment for up to one year, making it possible to use an average of half a year under normal operation. This lends credence to the idea that uranium offers strong resistance to the disruption of supply as compared with oil, which has a short lead-time and needs constant replenishment.

Furthermore, uranium has an energy density one million times that of fossil fuel, helping to making it easy and cheaper to store. According to the OECD, France maintains two to three years of uranium supplies in storage. Japan is said to hold similar amounts. This also explains the relatively calm response in coping with the unusual situation of the closure of processing facilities.

(iii) Fuel Price Stability

Finally, it should be noted that uranium prices are fairly stable. The biggest risk an oil crisis poses to Japan does not lie in the physical securing of the fuel itself but in abrupt fluctuations in price. Even LNG prices are directly affected by oil price movements since LNG contract prices are linked to international oil price levels. In contrast to oil prices, nuclear fuel costs have been relatively stable. During the oil crises, there were times when uranium prices soared. Nevertheless, uranium fuel costs account for less than 10% of total nuclear power generation costs. Thus, if uranium fuel prices were to double, nuclear power prices would only rise by 20%. A comparison of fuel costs in the past shows that nuclear power generation is relatively stable.

However, in years ahead with the number of new nuclear power plants decreasing and the average age of the nuclear power plants going up, the cost components for nuclear power generation will change, pushing its relative share of total fuel costs higher. Therefore, the stability of fuel cycle costs will be increasingly important in years to come.

(c) Contribution to Diversity

The degree of nuclear power's contribution to energy security can also be evaluated from the angle of diversification. To promote energy diversity, it is important for Japan to reduce its dependence on oil. For diversity of electric power supply sources, Japan's index is the highest in the world at 1.56 far exceeding the OECD average of 1.48. Japan enjoys a well-balanced mix of nuclear power, natural gas, oil, coal, and hydroelectric power. It will be important to continue maintaining the share of nuclear power as it is now (at 30% to 35%) in years to come. Conversely, the degree of energy diversity will most likely go down when nuclear power's share exceeds 40%.

Contribution to Better Environment

As the so-called 3Es (Energy, Environment, and Economy) are cited as goals of MITI's policies, environmental protection as well as energy security has recently been given serious consideration. As a non-fossil fuel that does not generate carbon dioxide, nuclear power is considered a trump card in reducing the globe-warming gases. The 1998 interim report of a Demand and Supply Sub-committee Meeting of the Advisory Committee for Energy says that for Japan to achieve its goals set forth in the December 1997 Kyoto Protocol, it will be necessary to increase nuclear power generation capacity to nearly 7,000 kWh from the present level of 4,500 kWh. This recommendation has led to an energy policy to "build new nuclear power plants". The most practical alternative to supplying the increase in demand with nuclear power is to supply more electricity by thermal power generation. This would require increasing LNG-fired thermal power generation. Without nuclear power, Japan would have to reduce demand for fuel in the transportation sector as well to achieve the goals of the Kyoto protocol. This could reduce economic growth by 1.2% to 1.7% and result in a loss of 730 thousand to 2,250 thousand jobs[15].

To be sure, increase in nuclear power generation in the past has contributed considerably to the reduction of carbon oxide generated in Japan. In the 1960-70s, dependence on fossil fuels (coal and oil in particular) was high, whereas partial conversion to natural gas and nuclear fuel helped to reduce Japan's unit quantity of carbon dioxide gas generated from 0.6kg CO_2/kwh (in the 1970s) down to 0.38kg CO_2/kwh (in 1998)[16].

However, the environmental gains to come from nuclear power will only be significant to the extent it replaces coal-fired generation capacity. Nuclear power meets most of the base load for the electric power sources already. Another major electric power source for the base load is coal-fired thermal power. If increased capacity of nuclear power goes as far as to replace coal, this will help to significantly reduce carbon dioxide emissions. But more recently, natural-gas-fired power generation is receiving attention as the most economic source since combined cycle gas turbine power plants, with their higher efficiency, are more cost-effective than coal-fired power plants. It is believed that LNG-fired power generation now used for the middle load can be used for the base load in future. In this case, carbon dioxide emissions will be reduced using coal-fired power generation for the middle load. Japan's electric power sector has already succeeded in curtailing carbon dioxide emissions to some extent, which indicates that emissions here will likely grow less than Japan's average in years to come.

Nuclear power has no use other than that of electric power generation and therefore can be of limited effectiveness in contributing to Japan's total primary energy supply. Given that expansion of energy use is likely to come mainly in the transportation sector, effective policies for energy security must focus on primary energy in general and the area of transportation in particular.

Nuclear Power Generation Issues: After the Tokai Village Accident

The JCO accident took place at Tokai village on September 30, 1999. It was the worst nuclear accident in Japan, having fundamentally shattered the trust of the Japanese people in the industry's management capabilities for nuclear power generation. It will doubtlessly affect Japan's nuclear power industry for years to come. Even before this accident, there were a huge number of unresolved issues to be addressed by Japan's nuclear industry. The industry needs to improve competitive performance, repair its public image and develop new ways to dispose of nuclear wastes and spent fuels[17].

In the nuclear industry where safety must come first, the pressure of deregulation and cost-reduction is being increasingly felt. This pressure contributed also to the Tokai village incident. In the years ahead, competition will increase with the deregulation or liberalization of the electricity market. In Japan, nuclear fuel is said to have an economic advantage over fossil fuels, but in the future, it may have to compete with the marginal cost competition from Independent Power producers (IPP) and even other nuclear facilities.

According to an assessment[18] conducted by the Central Research Institute of Electric Power Industry in awareness of these issues, costs of existing nuclear power plants are estimated to drop to 5.10 yen per kWh in 2010, from 7.23 yen per kWh in 1996. However, with new nuclear power plants alone, costs are estimated to be 9.93 yen per kWh in 2010, and 6.24 yen per kWh in the same year for existing and new plants combined (See Appendix, Figure 3 and 4). Further, a review of the cost components of nuclear power generation shows that the capital cost, which accounted for 49% of total costs in 1996, will drop to only 27% of total costs in 2010, and be as low as 9% for existing plants alone. On the other hand, the operation and fuel recycling costs will increase to 38% and 35% of total costs respectively by 2010 (See Appendix, Figure 5). These figures make it clear how important reduction of the operating and the fuel recycling costs as well the plant construction costs[19] is to the competitiveness of nuclear power.

The belief in a high degree of safety and trust in the Japanese nuclear power industry may have evaporated with the Tokai village accident. Until then, Japan's nuclear safety administration was convinced that "(serious) nuclear accidents will not happen". As this accident has shown, however, a stance that assumes "zero risk" (that is, just whether accidents will happen or not) is unrealistic. In other words, it is necessary to establish a "relative safety theory" which may well include safety discussions based on the theory of probability, comparisons of the benefits and the risks nuclear power offers, and comparisons between nuclear power and other energy sources. Some say that the Japanese people do not trust nuclear safety because of a lack of reasonable explanations. This accident has also shown that there is a lack of trustworthy risk information. A mechanism is needed that propagates information on the risks posed by modern science and technology. This will be most important for considering energy security.

To gain people's confidence, it will be necessary to review the regulation and administration of safety and also intensify voluntary restrictions by the nuclear power industry. It will be also necessary to secure risk management capabilities to deal with nuclear terrorism and sabotage.

Continuous operation of a nuclear power plant requires reliable storage and management of spent fuel. So far, the only sites to be considered have been within the power generation site and the reprocessing plant. Down the road, it will become essential to build so-called "interim storage facilities" since storage capacity is limited. Compared to other nuclear facilities, storage of spent fuel is very safe. It is not only economical but there are diverse storage choices, requiring less rigorous requirements than the nuclear reactor. Also, reprocessing and waste disposal schedules can be made flexible by using interim storage.

As mentioned earlier, the interim storage of spent fuel is considered to be of sufficient importance to require approval of the Cabinet. But the responsibility of creating such storage basically falls on the nuclear power industry itself. Given the importance of this issue to the future of nuclear power in Japan and energy security, Considering the importance this issue implies (secure operation of nuclear power generation) for Japan's energy security, however, the government should be more involved in the process.

There are several ways the government could support the construction of interim storage. Spent fuel, which is called a "recycle fuel resource" as a valuable energy reserve, may well deserve a national reserve, similar to the national oil reserve. To ensure secure operation of nuclear power plants and also to smooth the location of the private-sector interim storage industry, the government could make use of state-owned land for the storage of spent fuel. Specifically, a national reserve to last for about ten years (10,000 tons) would significantly reduce the load on electric power, making it unnecessary to do the burdensome reprocessing. A national tanker reserve for an emergency escape may also deserve consideration.

Another possibility would be for the Japanese government to consider participating in an international reserve. This can be done as part of nuclear non-proliferation and disarmament projects in the arena of international politics. An international reserve must be pursued between governments and through cooperation with international organizations and must be considered separately from the reserves to be pursued by the private-sector industries. Also, an international reserve should be meant for specific limited purposes.

It is likely at last that the "High-level Radioactive Waste Disposal Law" will be submitted to the 2000 Diet session. The law would create "Organization for the Modernization of the Atomic Power Generating Environment," which would be financed by an estimated 0.14-yen per kWh added to electricity bills to cover disposal fees. As discussed earlier, however, the growing competition in the electricity market can cause larger electricity bills to affect the electric power company adversely, making it still uncertain whether the whole disposal cost can be added to the electricity bills.

For Japan to establish the nuclear fuel cycle and to maintain its plutonium policies for years ahead, the international political climate towards non-proliferation must be considered. The May 1998 nuclear testing in India and Pakistan drives this point home. Increasing uncertainty about proliferation of nuclear material can adversely affect peaceful use of nuclear power. After an indefinite postponement in 1995, an international conference will be held to review the nuclear non-proliferation treaty. The conference will discuss many issues including ratification of the

CTBT. Japan should be active in nuclear nonproliferation.

The proper management and adequate disposal procedures for surplus plutonium are critical to civil nuclear energy programs. In non-proliferation policy, the management and disposal of plutonium removed in Russia and the U.S. may be top priority, but the reduction of civilian-use plutonium is no less important. A delay in the plu-thermal plans in Japan will increase further surplus plutonium. The timing of the opening and capacity size of the planned large reprocessing plant at Rokkasho village, which also will likely increase surplus plutonium, needs to be reconsidered. This reprocessing plant also may suffer from cost overruns[20]. It needs to be re-evaluated from the point of view of nuclear non-proliferation and economic viability.

In September 1998, the new atomic power round table conference began to discuss nuclear issues, including long-term nuclear power development and the utilization plan (the long-term plan) for the year 2000[21]. The government and the electric power industry seem to expect that this kind of process will help shape a consensus on nuclear power. However, it must be recognized that an open democratic process to build a consensus will not necessarily end up favorably for those who favor nuclear power. What is important is how such a forum can help alleviate the distrust people have in the policy making process. A "predetermined conclusion" would compromise the process and increase distrust. If a policy decision is to be based not on government-directed, top-down economic planning but on democracy and the market mechanism, such a decision making process will involve inherent risks. This point should be recognized as a social risk.

A major dilemma[22] will arise in forging energy strategy consensus in the years ahead. Energy security should be considered on a national level whereas democratic practice implies respect for the wishes of the inhabitants at a site to be affected. Cases will also arise where economic considerations will prevent the development of a specific energy resource from proceeding as planned. How far should a government go to provide compensation for the "uncertainties of democracy"? As far as nuclear power policies are concerned, is it not the time to reconsider the meaning and roles of Long-Term Plans in that perspective? Japan's nuclear power policies and even Japan's energy policies are basically characterized by the "carry-out-government-plans" formula. Isn't the real question that the consensus building process raises "Where does the government have to intervene?"

The JCO accident has put the consensus building process in a more difficult path. According to public opinion polls taken at Tokai village, 64 % of the inhabitants polled felt "safe" or "fairly safe" about nuclear power before the accident. This dropped sharply to 15% after the accident. Only 22% of the village people polled felt "in some danger" or "in danger" before the accident. This went up abruptly to 78% after the accident. As to the future of nuclear power, 52% before the accident answered, "should be promoted positively" or "should be promoted cautiously," which decreased to 32% after the accident. Those who favored "should remain as it now stands " dropped to 18% from 30% while those favoring "should be phased out over time" or "should be abolished immediately" increased sharply to 40% from 12%[23]. This outcome of the polls at Tokai village, which once had been most understanding of nuclear power, even immediately after the accident shows how difficult it will be to find future locations for nuclear power facilities.

The government and the electric power industry need to consider the possibility that there is little likelihood that nuclear power plans will go ahead as planned. This is one of the factors of the uncertain energy situation. Consequently, future nuclear power policies should have ample room for maneuvering and flexibility. To regain trust in nuclear power as an energy source requires fundamental change[24].

PROSPECTS FOR NUCLEAR POWER IN ASIA

The U.S. and Europe account for two thirds of the world's nuclear power capacity. Considering future growth of nuclear power generation, it is certain that the largest share of the world's total nuclear power capacities will shift to Asia. According to a recent survey, Asia accounts for less than 20% of the existing capacity, but about one third of the 46 nuclear power plants (38 million kWh) under construction and about 60% of the planned 46 nuclear power plants (34.49 million kWh) are located in Asia. Japan, Korea, China, and Taiwan account for 90% of the planned capacity increase in Asia. Will nuclear power in Asia really grow as expected? It surely will grow, but it may fail to materialize at the levels currently predicted.

China: Downward revision of the nuclear power plans and safety

To meet its rapidly growing energy demand, China, as the most populous nation in Asia, is expected to shift some of its energy sources from coal to nuclear power. Currently, a total of 12 nuclear power plants (10.7 million kWh) are under construction or are planned in China. This is the largest capacity in the world, exceeding that of Russia (11 plants, 8.96 million kWh) and of India (16 plants, 6.76 million kWh).

In June 1998, construction began on the No. 1 reactor of phase three of Tai Shan nuclear power plant to be built by AECL of Canada as the main contractor. This, along with the FRAMATOME reactor in Canton province and the Russian PWR (VVER-1000) in Shandong province, highlights the diversity of nuclear reactors China imports. In the future, China is planning to pursue the development of the PWR on its own.

Given these programs, China has the most promising prospects for nuclear power growth in Asia, but it is likely that given capital constraints, China will make a downward revision of its nuclear power development plans.

It was rumored that China National Economic Committee was going to review China's ninth five-year electric power development plan and also scale down its nuclear power development plan. China's electricity demand is growing at a low rate of 2.5% per year, with the GDP elasticity down to 0.53 from 0.81 in 1995. Its nuclear power development plan aiming at 20 million kWh in 2010 is considered difficult to achieve since only three power plants (2.26 million kWh) have been completed up to now. It is also believed that investment in modernization of China's power transmission lines deserves a higher priority than new generation capacity. It has been decided to break up the China National Nuclear Corporation (CNNC), which has been the central body for nuclear power development. Now that efficient management of the electric power business is considered important as a policy matter, it is fairly likely that China's investment in nuclear power generation will not go as smoothly as planned.

New information indicates that the July 1998 accident at the Tai Shan No.1 reactor was more serious than originally thought. Designed and built by China, this reactor has been suspended since last July, but the details of the accident have not been made public. According to a recent announcement, insufficient strength in the guidelines fitted to the lower part of the reactor for inserting the neutron sensor is considered to be responsible for the accident. It is said that 24 fitting bolts and nuts came off with the 24 guidelines or were otherwise damaged. These collided with one another and damaged nine of the 121 pieces of the nuclear fuel assembly. The report confirmed no radioactive leakage from the reactor, but the damage, if left as is, would get worse causing a critical situation.

Almost nothing has been made known about this accident. The China National Security Agency admits that the accident occurred. But other information has not been publicly released; it has never made any of the details known. It appears that MITI has some information on this accident through an information exchange agreement between the Chinese and Japanese nuclear authorities concerned, but details have not been disclosed to MITI as yet. With the Chernobyl accident, Russia learned that releasing information about the accident and quickly propagating was an important element in the process. The way China responded to its accident has left fears about the future of its nuclear power program

Korea and Taiwan: Privatization and spent fuel disposal as vexing issues

South Korea's nuclear power development has so far been proceeding quite smoothly. Its nuclear power generation as of 1998 is up as much as 16.3% to a record high of 89.7 billion kWh.

However, the recent economic crisis makes the future of the nuclear power industry uncertain. The Korean government (the Ministry of Commerce, Industry and Resources) in August 1998 announced the electric power development plan for its nuclear power for the years up to 2015. The nuclear power development plan was scaled down due to Korea's flat electricity demand projections. The 1995 plan called for 27 power plants (26.329 million kWh) to be completed by 2010 whereas the current plan aims at 25 plants (23.429 million kWh). It has also been decided to privatize Korea Electric Power Corporation and embark on a major restructuring of the electric power industry.

Nuclear power accounts for 41.7% of Taiwan's total power generation, up 9.4% from the previous year. The result so far is excellent, with the average utilization at 90.2%.

Prior to 1996, Taiwan's nuclear power share has been declining, from 24.5% in 1994 to 21.7% in 1996. To help increase nuclear power's share, Taiwan Electric has decided to build in Long Men, the site of its fourth nuclear reactor, two of the ABWR (1.35 million kwh) of Tokyo Electric's Kashiwazaki/Kariha type. Construction of the first reactor started in 1999 and operation is scheduled to commence in 2004. The second reactor is expected to be in operation in 2025. With its 1999 IPO, Taiwan Electric is to be fully privatized by June 2001. With a $15 billion capitalization, this privatization will be the largest among a series for state-owned companies in telecommunications and oil. Taiwan Electric Power will be split into power generation, power transmission, and power distribution divisions. This desegregation would greatly affect Taiwan's electric power policies and nuclear power for years to come.

The Korean and Taiwanese state-owned electric power companies that underpinned Asia's nuclear power development efforts are undergoing big changes. The trend will surely be to emphasize short-term profitability, making it harder to secure long-term investment funds required for the development of nuclear power development. A major unresolved issue for the two countries is nuclear waste and spent fuel.

South Korea had a low-level and a medium-level waste disposal plant that was planned at

Anmyondo and Myongdo. Both were cancelled. The plant in Anmyondo was cancelled in 1990 due to local opposition, and the facility in Myongdo was cancelled in 1995 because of an active fault discovered near the island. Subsequently, it was decided that the oversight responsibility for nuclear energy would shift from the Ministry of Science and Technology (MOST) to the Ministry of Commerce, Industry and Resources (MOCIR). At the same time, it was also decided to shift the responsibility for radioactive waste disposal from the Korean Atomic Energy Research Institute (KAERI) to the Korean Electric Power Company.

As of June 1998, Korea had 50,215 pieces of low and medium-level waste stored at nuclear power plants. This is expected to reach 98,048 pieces in 2010, 177,278 in 2025, and 257,078 in 2040. With the power plants storage capacity of less than 100,000 pieces, a quick response is necessary.

Spent fuel, which now totals 3,365 tons in South Korea, is expected to reach 4,632 tons in 2000, 11,083 tons in 2010, 23,389 tons in 2025, and 34,102 tons in 2040. With a power plant site storage capacity of only 6,589 tons, it is said that new capacity separate from the power plant sites is needed.

In September 1998, the MOCIR announced a new plan for low-level waste disposal plants and spent fuel storage facilities. The first phase of the plan calls for a 100,000-piece low-level processing plant and a 2,000-ton spent fuel storage facility, which will eventually be expanded to 800,000 pieces and 20,000 tons respectively.

Nuclear waste disposal is an issue in Taiwan as well. In particular, the agreement with North Korea to cooperate on low-level wastes is foundering for political reasons. In February 1998, Taiwan Electric Power selected six locations out of the 30 candidate sites for low-level waste disposal. In March, the Atomic Power Commission announced the "Declaration of Safe Management of Low-level Radioactive Wastes" which focuses on ensuring security, mandating Taiwan Electric Power to submit environmental and safety assessment reports.

Other Countries: India, Pakistan, North Korea, Indonesia and Vietnam

Nuclear power in Asia cannot be discussed without addressing the issues of North Korea and nuclear proliferation on the subcontinent.

The nuclear testing by India and Pakistan in May 1998 renewed nuclear fears of the Cold War era. In June 1998, India signed an agreement to import two VVER-1000 reactors from Russia. Pakistan's Chasnupp power plant (PWR, 325Mwe) supplied by China's CNNC is expected to commenced operations during 1999.

The Democratic People's Republic of Korea, North Korea, is suspected of having nuclear weapons. The light water reactor project of KEDO (Korean Peninsular Energy Development Organization) was agreed to in June 1998 with the condition that North Korea suspend its nuclear weapons program and the offered price of the two reactors is to be reduced from $5,18 billion to $4.6 billion. It was also agreed that Korea and Japan would shoulder $3.2 billion and $10 billion respectively. But, several issues with North Korea remain unresolved. These include rapidly changing development and instability such as the test firing of missiles, suspicious ships on the Japan Sea, and secret underground facilities.

Indonesia should also be mentioned as a country in Southeast Asia that has been pursuing nuclear power aggressively. Vietnam is also said to have begun discussing nuclear power for its future energy program. Indonesia completed feasibility studies to embark on nuclear power several years ago, but the financial crisis and political instability have delayed implementation. Also, the discovery of rich natural gas resources and the liberalization of the electric power business may have contributed to cooling of nuclear power prospects. Orders of nuclear power equipment are unlikely. Vietnam too completed nuclear power feasibility studies in November 1998. The country's electricity demand is forecast to increase to between 140 billion and 180 billion kWh by 2020. With Vietnam's conventional electric power sources (coal, gas, and hydropower) considered to be capable of only 100 billion kWh, the country may consider development of about 20 billion kWh of nuclear power to help reduce its dependence on imported electricity. This would require nuclear power generation capacity of 3 million kWh, for which Vietnam is expected to put the necessary facilities in place between 2010 and 2020.

Nuclear Power Cooperation in Asia

The concept of establishing an Asian nuclear power cooperation organization, ASIATOM, has been discussed often over the years. Asia should have a regional cooperation system similar to EURATOM. A review of Asia's nuclear power development shows that the situation is quite different from that prevailing at the time of EURATOM's establishment. The differences include: diverse development stages, historical antagonism between nations in the region, several nuclear countries or potential nuclear countries in the region, and many equipment suppliers besides the U.S. A suitable regional concept that meets the current requirements of nuclear power development is needed.

A multilateral organization would first start by addressing common issues involving increased civilian use of nuclear power. Its second mission could be to address nuclear non-proliferation in the region. The two can coexist, but also may also create conflicts. Many of the proposed conceptions for ASIATOM cooperation differ from each other. These differences pose great barriers to ASIATOM establishment.

Still, there are clear common interests especially in the areas of the management and storage of spent fuel and improved security. South Korea has proposed the establishment of an Asian Nuclear Security Counsel Organization but it has not found broad support.

A comparison of proposed ideas for nuclear power cooperation in Asia

	Security	PA	Industrial cooperation	Management of waste fuel	Waste	Local security measures	Pu management	Nuclear nonproliferation	Nuclear armament reduction
1	x		x	x	X	x		x	
2	x	x	x	x	X	x		x	x
3	x	x	x	x				x	
4	x		x(Concentrated)	x	X	(x)			
5	x		x						
6	x			x	x(R&D)			(x)	
7	x			x				x	
8	x	x	x	x	X			x	
9	x			x	X			x	
10	x			x	X	x	x	x	x
11	x			x	X	(x)	(x)	x	
12	x		x(R&D)	x	X		x	x	
13	x			x	X		x	x	
14	x			x	X	x	x	x	

Proposition

1. Hiroshi MURATA, 1997), 2. Kumao KANEKO, 1996, 3.Tokio KANO, 1995, 4.Takayoshi IMAI, 1995, 5.Takehiko SAKAIRI, 1997, 6.Noriyuki SUZUKI, 1996, 7. Kunihiko UEMATSU, 1997), 8. Atlantic Council (1997), 9.R.Manning (1996) 10.W.Dircks (1995) 11.J.S.Choi (1996) 12.Y.M.Choi (1996) 13. J.Carlson (1997) 14.KAIST (1997)

Source T.Suzuki and T.Tanabe, “Institutional and Policy Issues for Nuclear Cooperation Scheme in the Asia-Pacific Region,” Pacific Basin Nuclear Conference, Banff, Canada, May 1998.

Still the case of Japanese-Russian cooperation on denuclearization stands as an example of what could be accomplished if political will could be generated. In April 1993, Japan decided to extend to the countries former Soviet Union a total of $100 million (11.7 billion yen) of financial assistance to support denuclearization. Based on bilateral agreements with Russia, Ukraine, Kazakhstan, and Belarus, a cooperation committee was organized to discuss and determine how to share the funds for specific outlets. The major items of support to be offered and the details of the fund allocated as of the end of 1999 are given below.

- For Russia: 8.19 billion yen (70% of the total fund) for construction of nuclear materials storage facilities, construction of liquid low-level waste disposal facilities, and grants for equipment to deal with emergencies, etc.
- For Ukraine: 1.755 billion yen (15%) for the establishment of denuclearization management, grants for medical equipment, for nuclear weapons disposal staff, etc.
- For Kazakhstan: 1.17 billion yen (10%) for the establishment of denuclearization management, nuclear pollution cleanup in the neighborhood of Semipalatinsk nuclear testing site, etc.
- For Belarus: 0.585 billion yen (5%) for the establishment of denuclearization management, grants for equipment for the occupational training center for war veterans, etc.

In particular, a new agreement with Russia was reached in May 1999 whereby Japan extends the following cooperation as support for disarmament and non-proliferation.

i) Dismantling of nuclear submarines

For the dismantling of nuclear submarines in the Russian Far East, support for liquid low-level waste disposal facilities was made as part of the support mentioned above. This new agreement is to make the following surveys as a specific project to help further dismantle Russian nuclear submarines.

- Construction in Zvezda shipyard of a storage facility for spent submarine fuels and the project with Bolshoy Kamen and Smolyaninovo to reconstruct a railway line

- Dismantling of a submarine in Zvezda shipyard

- Remodeling of vessels to transport containers with spent nuclear fuel

ii) Military-to-civilian conversion of scientists

The International Science and Technology Center (ISTC) has already been set up in Moscow primarily to prevent the brain drain of Russian scientists and for military-to-civilian conversion of Russian scientists, having already giving support to as many as 23,000 scientists. Since the establishment of the ISTC, Japan has already provided grants amounting to $29 million. This is only 30% to 40% of what the U.S. and Europe have each contributed. Japan is thinking of intensifying its support in the future.

(iii) Management and disposal of surplus plutonium

Related to peaceful use of nuclear power, most attention has been given to support management and disposal of plutonium. Japan has ample experience especially with the technology of processing plutonium fuel (MOX fuel) and with the MOX burning in the FBR and the heavy water reactor. There are many areas where Japan can contribute technologically to Russia, which has less experience in these areas. Technical support here is appreciated as mutually beneficial as Russia may also offer opportunities for Japan to learn technologies for civilian use of nuclear technologies.

Japan has been extending to Russia and other nations of the former Soviet Union steady support for denuclearization. This exemplifies well Japanese contributions to civilian use of nuclear power and to enhancing security and environmental protection in the countries of the former Soviet Union. Two contributions deserve special attention. They are liquid low-level waste disposal facilities and cooperation in dismantled plutonium disposal .[26]

In December 1992, a Russian government commission announced its interim report on sea dumping of radioactive wastes in the Far East, having made sea dumping publicly known. Then, following requests from the Japanese government, Russia revealed that, between 1959 and 1992, radioactive waste was dumped into the sea in the North and the Far East. In 1993, the environmental group "Green Peace" declared that the Russian navy was still dumping radioactive wastes into the Japan Sea. Japan followed this with official protests to the Russian government.

In November 1993, a Japan-Russia Nuclear Weapons Disposal Committee decided to give financial support for waste disposal by using part of Japan's denuclearization support funds. At that time, Russia was hoping to have radioactive waste disposal facilities built, and it was agreed that they would be built on land. But, later, opposition from the inhabitants of the proposed site caused the Russians to change to sea sites, leading to another agreement in May 1994 for the construction of sea sites. In August 1994, an agreement was concluded between the Nuclear Weapons Disposal Committee and Russia's Ministry of Atomic Power to construct radioactive waste disposal facilities at sea.

However, in the course of bidding for this construction project, problems arose, blocking the smooth implementation of the project. First, there were discrepancies in the data relating to the wastes from Moscow and from Vladivostok, and considerable time was required to verify the data. Then, the Russian bidder with the lowest offer did not agree to the terms and conditions, giving rise to a second tender invitation. A consortium, which was the lowest bidder in the second tender, was told that the Russian side found it inconvenient to make internal adjustments and to accept the consortium. Thus, once more readjustments had to be made, so that finally the Tomen-B&W

consortium as the second lowest bidder won the contract in January 1996 by agreeing to use a Russian shipyard, designing firm, and subcontractors.

After the construction began, many things delayed the construction including contract amendments required due to changes in Russian laws, unpaid wages for Russian laborers, and difficulties involving adjustments to process documentation for the completion of the construction. Finally, the waste disposal facilities were completed in April 1998 and are now in trial operation.

Despite the delays, Japan should be praised for its substantial contribution to resolving the issue of dumping radioactive waste into the sea.

About 50 tons of dismantled plutonium from Russia is subject to management and disposal under an U.S.-Russian agreement. The April 1996 Moscow summit on atomic power safety agreed that G7 countries would extend support to Russia for plutonium disposal. Japan has continued to discuss the matter with Russia. Last year, the Russian Ministry of Atomic Power and the Japanese Nuclear Fuel Cycle Development Organization agreed that research and development be made jointly to burn dismantled plutonium by using the existing FBR BN600 in Russia. The details of this effort are:

- Phase zero (1999 - 2004): First, with the critical equipment (BHS-2) in Russia, nuclear physical experiments relating to the reactor core will be made using dismantled plutonium. Then, forming of the MOX fuel (vibro-packed fuel) using Russian processing technology and demonstration testing will be made. In 2000, the MOX fuel will be charged into the BN600 for data collection and calculations.
- Phase one (2000 - 2006): In concert with Russian and American experts, BN600 burning programs will be examined in detail and burning of 0.3 tons per year will be

attempted.

- Phase two (2002 - 2020): Drawing on the results up to Phase one, 1.3 tons per year of plutonium will eventually be burned. This phase may require financial support from other countries.

France and Germany are also working on projects for plutonium disposal, but have not yet reached the stage of burning the MOX fuel. This plan, if commercialized, would likely contribute a lot to the processing of Russian dismantled plutonium.

Separately, a new proposal has been made for disposal of Russian dismantled plutonium, using private-sector funds. This proposal calls for building a facility in the Russian Far East to dispose of the spent fuels kept by the electric power companies in Japan and other countries in East Asia. The profits from the storage service are to be used to pay for the cost of plutonium disposal[28].

Under the proposal, Japan and Russia would conclude a bilateral agreement, under which spent fuel storage facilities and a MOX processing plant would be built in the Russian Far East. Japan would finance the initial project. Russia would then convert dismantled plutonium to fuel at the MOX processing plant and sell it as fuel to Japan's electric power companies to be burnt in the commercial reactors in Japan. The spent fuel storage facilities store spent fuel from Japan's electric power companies for some period (50 years, for instance) under contract and also undertake storage of spent fuel from other countries when the terms and conditions are acceptable. They may also store spent fuel from dismantled Russian submarines. Finally, Japan's electric power companies can enjoy the services of spent fuel storage and MOX processing for a price at least equal to, or less than, the international price. If this merit is not realizable, an additional agreement may be considered whereby the Japanese government extends financial support (for instance, purchasing dismantled highly enriched uranium from Russia).

This plan makes it possible to secure the necessary funds for the construction in Russia of facilities to handle the MOX processing of dismantled plutonium. It can also contribute to spent fuel disposal for electric power companies in Japan, Korea and Taiwan. These facilities to be located in Russia will naturally be put under international security surveillance and can adopt the newest nuclear control and protection measures. Also, by ensuring these measures, this plan helps to significantly reduce the need for reprocessing in the Far East region, also enhancing the security of the region. Such a project could be regarded as a large driving force to work out a Japan-Russia Peace Treaty and will also help to reveal to the world the role Japan is playing for disarmament.

At the same time, it is equally true that there are many barriers that must be overcome before this idea can become reality. The first requirement is political stability in Russia. Ensuring the transparency of the use of the cooperation funds and intensifying protection against nuclear substances are also very important requirements. The cross-border movement of spent fuels requires revisions in the domestic and international laws, and multinational agreements as well. These make this project less easy to realize. This concept of international storage of spent fuel must have its pros and cons objectively evaluated while making its objectives for security very clear.

In Japan, nuclear power cooperation is discussed mainly from the viewpoint of "how to meet the rapidly growing energy demand in Asia." However, as nuclear testing by India and Pakistan has proven, nuclear power cooperation in Asia is also closely related to international security. To promote nuclear power cooperation, it is necessary to ensure a policy mix, which makes energy policy consistent with security. The following three policy measures should be considered:

a) Confidence building measures aimed to build trust (more dialogue, disclosure of information, transparency). Distrust still prevails among Asian nations. Between the U.S. as supplier and Asian nations as customer, there is a deep-rooted distrust about reprocessing and plutonium policies. In advancing nuclear power cooperation, the first thing to do will be to improve mutual trust. Specifically, trust building steps should include promotion of dialogue, not only at government-to-government level, but also among people, between research institutes, and through many other channels, more open information (at home and abroad as well), and increased transparency. In the long term, personal networks should be built, as is the case with the U.S.

(b) Technology used to make specific contributions to disarmament and nuclear non-proliferation. The technology for surveillance of nuclear testing is a case in point. Japan has high technologies that can be employed to contribute to disarmament and nuclear non-proliferation. One candidate area for such contribution is for dismantled plutonium disposal in Russia and the U.S. More active contribution by Japan to nuclear non-proliferation could turn distrust of Japan into respect for Japan. Japan should quickly work out programs that will enhance its international reputation.

c) Spent fuel policies, opportunities for specific cooperation projects (on safety) and their objective evaluation. A consensus should be reached on spent fuel policies and safety. It is high time to hammer out more specific and practical cooperation projects. Japan, the U.S., and South Korea should play a central role in developing practical cooperation projects. In doing so, it is important to clearly define the objectives and evaluation criteria.

CLOSING

Nuclear power has played a great role for energy security. However, it is unrealistic to think that nuclear power will suddenly create ample indigenous energy resources and freedom from the exhaustion of resources. It may be advisable for Japan to maintain the present level of dependence on nuclear power. But, for nuclear power to continue to contribute to energy security and to environmental protection, there are challenges that need to be met. Nations in North East Asia should cooperate to resolve issues of common interest.

Specific policy proposals on the issue of nuclear power are as follows:

1. Nuclear policy should be developed based on the propagation of scientific information and thoughtful analysis of nuclear power's role in promoting energy security.

As promising domestic energy sources, the FBR and the plutonium recycle cannot make significant contributions as realistic energy source options for sometime to come. Yet, it must be emphasized that existing nuclear power generation facilities are making sufficient contribution. Especially noteworthy among the contributions of nuclear power is supply stability. However, it must be noted that nuclear power requires a large industrial infrastructure and a long lead-time, and is rather inflexible. Also, the social risks of nuclear power technologies as exemplified by the "Monju" accident and the critical accident at Tokai village must be taken into account when evaluating energy security.

2. The target size for nuclear power generation should be based on its share of the total amount of electric power generated. The present share of about 35% is desirable from the standpoint of maintaining diversity and economy. It is advisable to maintain a share of 30% to 35% over time.

It is advisable to define the goals for nuclear energy in terms of its role in providing diversity to the mix of Japan's energy sources. To maintain diversity, it is not advisable or realistic to increase or reduce the present share. The Government needs to acknowledge that the present goal to construct 20 power plants by 2010 of 62 million to 70 million kWh will be impossible to realize given popular opposition.

3. Nuclear power policies should be part of a comprehensive policy for energy and the environment. It should be consistent with policy for the energy security, deregulation and anti-warming measures. Also, to ensure smooth implementation of nuclear energy policies, it is essential to make the policy making process more transparent and democratic.

Japanese nuclear policy has been shaped in the past primarily by the Long-Term Plans of the Atomic Power Committee. It has become clear that since the "Monju" accident, this policy decision-making process has failed to respond to the needs of Japanese society. Citizens near nuclear power facilities have developed a distrust of the government's policy judgment. The fair assessment of future nuclear power development can be ensured only through a more democratic and transparent decision making process. The government's role in nuclear energy development should be clearly defined. The dual system of "decided by the state, and operated by business" has distorted the current nuclear power policies. To make the most of the market economy after deregulation, government intervention should be limited to areas of possible market failure. As for nuclear power, such areas of government involvement may include safety regulations, nuclear nonproliferation, and, to some extent, spent fuel storage and waste management and disposal.

4. Concerning the possibilities of nuclear power cooperation in Asia, an international cooperation could be developed through specific projects that respond to common concerns for security, radioactive waste and spent fuel management, and nuclear nonproliferation.

Japan, South Korea, China, Taiwan, and other Asian countries share many common concerns with nuclear power. Forums where Asian countries can exchange candid opinions about these common issues are needed. Common issues include nuclear safety, radioactive waste and spent fuel management, and nuclear non-proliferation. Japan should propose specific projects to deal with these common issues, drawing on its experience in nuclear power cooperation it has been offering. Japan's support for Russia's nuclear nonproliferation effort stands as a concrete example of a successful initiative.

NOTES

1. The Japan Atomic Energy Commission, "The Long-Term Plans for the Research, Development and Use of Nuclear Power," September 6, 1957
2. The dual system was analyzed in detail by the book "The Social History of Nuclear Power: Its Japanese-style Development" by Hitoshi Yoshioka (Asahi Sensho, April 1999)
3. For the relationship between the Rokkasho Village Nuclear Fuel Cycle Plant Project and regional politics and economy, see "The Giant Regional Development Project and Its Outcome - the Mutsu Ogawara Nuclear Power Development Nuclear Fuel Cycle Plant" by Harutoshi Funahashi, Kouichi Hasegawa, Nobuko Iijima, the University of Tokyo Press, February 1998. They did not analyze the nuclear fuel cycle plant project from the standpoint of nuclear power policies, but focused their analyses on the failure of the project and how closely it was connected with the regional politics and economy.
4. For analysis of the international concern about Japan's plutonium polices, see "International Responses to Japanese Plutonium Programs" by E. Skolnikoff, T. Suzuki and K. Oye, Working Paper, MIT Center for International Studies, C/95-5, August 1995
5. The Power Reactor and Nuclear Fuel Development Corporation (Donen), Reform Examination Committee report, "Basic Direction of Donen's Restructuring", August 1, 1997. The opposing group published "The Monju Accident and Japan's Plutonium Policies: Proposals for Policy Changes" by Monju Accident Comprehensive Appraisal Council, Nanatsumori Shoten, December 10, 1997.
6. Report by Informal Advisory Council to Discuss FBR, December 1, 1997

7. Decision by the Atomic Energy Commission, "The Way Future FBR Development Should Be," December 5, 1997
8. IAEA INFCIRC/549, "Communication received from certain Member States concerning their policies regarding the management of plutonium," April 2000. Besides, 31.3 tons are estimated by Institute for Science and International Security (ISIS) ISIS Plutonium Watch, May 1999
9. According to the Nuclear Inspection Institute of the U.K. (NII) report, it came to light that BNFL of the U.K. had fabricated the inspection data in the processing of fuels including the MOX fuel for No. 3 and No.4 reactors of Takahama Nuclear Power plant of Kansai Electric Power of Japan. The Electric power company decided to discontinue using the fuel. It was found further that the data fabrication had been more extensive, spreading to wider scopes and longer periods, including the fuel for a German electric power company, and that nuts had been mixed in the fuel. NII maintains that there is problem about safety, but Kansai Electric Power has no definite schedule to make use of the fuel in question.
10. Interim report by MITI's Advisory Council for Energy, Subcommittee on Nuclear Energy, "Toward the realization of the interim storage of recycle fuel resources," June 1998
11. "Global Energy Outlook", Key Issue Paper No. 1, IAEA Symposium on Nuclear Fuel Cycle and Reactor Strategy: Adjusting to New Realities", Vienna, June 1997.
12. "Conversion of the nuclear fuel cycle" by Kazumi Doi, an article of Asahi Shinbun, February 18, 2000. Drawing on his long years of experience with uranium resource development at PNC (Donen), Mr. Doi maintains that "based on the outlook of the uranium resource, there is no need for nuclear fuel recycle."

13. The most noted scientific article on the possibility of converting the nuclear reactor class plutonium for weapons, is J.C. Mark, “Explosive Properties of Reactor-Grade Plutonium”, Science and Global Security, Vol.4, No. 1, 1993, pp. 111-128.
14. Andrew Stirling, “Diversity and Ignorance in Electricity Supply Investment,” Energy Policy, March 1994.
15. MITI's Advisory Council for Energy, Subcommittee on Nuclear Energy, "Basic stance for the choice of nuclear power,” June 11, 1998
16. Federation of Electric Power Company, “Electricity Review, Japan,” 1999.
17. "What to do with Japan's nuclear power: Proposals for the 21st century" edited by Kenji Yamaji, Study Group for the Future of Nuclear Power, Nikkan Kogyo Sha, 1998. The author of this paper also participated in this study group, which he finds to be a frank report on nuclear power policy matters.
18. Report by Central Research Institute of Electric Power Industry, "The cost structure of Japan's nuclear power generation and its future outlook,” Y98019, June, 1999
19. According to an estimate by the Advisory Council for Energy, Subcommittee on Nuclear Energy, the power generation cost of a new nuclear power plant as a 40-year lifelong average is 5.9 yen per kWh, much lower than before but increasing with the cost of operating management and nuclear fuel cycle.
20. The estimated total cost of Rokkasho Reprocessing Plant was up from the initial 840 billion yen to about 2 trillion yen. Its reprocessing cost is estimated to be about 1 yen per kWh.
21. The second nuclear power roundtable conference closed its activity in February 25, 2000 with its final proposals, which included: "Offer multiple choices with future nuclear power plans",

"the group to study the nuclear fuel cycle is to be continued", and "Set up a similar forum to discuss the nuclear power policies (temporarily called 'Nuclear Power Policies Communications Forum' from now.)"

22. On February 22, 2000, the governor of Mie prefecture urged that the Ashihama Nuclear power plant project, which had been being discussed over 37 years, be cancelled, and Chubu Electric Power agreed to cancel it. This is the first cancellation of a planned nuclear power location in Japan.
23. "Tokai-mura Polls 'the prevention of disasters and town building'", the PR Department, Tokai-mura, "Tokai" No. 659, February 16, 2000
24. Susan Pickket, "Over the walls of a nuclear power village: A Japan-U.S. comparison of the consensus building process", Energy Forum, February 1999, pp. 32-36
25. Ministry of Foreign Affairs, Foreign Policy Bureau, Scientific Affairs and Nuclear Energy Division, Arms Control and Disarmament Division data, also visit the ministry's home page
26. "Liquid radioactive waste treatment facility projects in Asia," by Ministry of Foreign Affairs, Foreign Policy Bureau, Scientific Affairs and Nuclear Energy Division, December 1999
27. A. Yamato, K. Aratani, “The Present Status of International Cooperation pertaining to Russian Surplus Weapons Plutonium Dispositions,” presented at the Second Annual JNC International Forum on the Peaceful Use of Nuclear Energy, February 21-22, 2000, Tokyo, Japan.
28. M. Bun, N. Numark, T. Suzuki, “A Japanese-Russian Agreement to Establish a Nuclear Facility for MOX Fabrication and Spent Fuel Storage in the Russian Far East”, Belfer Center for Science and International Affairs (BCSIA) Discussion Paper No. 98-25, Harvard University, November 1998. There is a very similar project, which the U.S. NGO

"Non-Proliferation Trust (NPT)" is negotiating with Russia's Ministry of Atomic Power.

Appendix

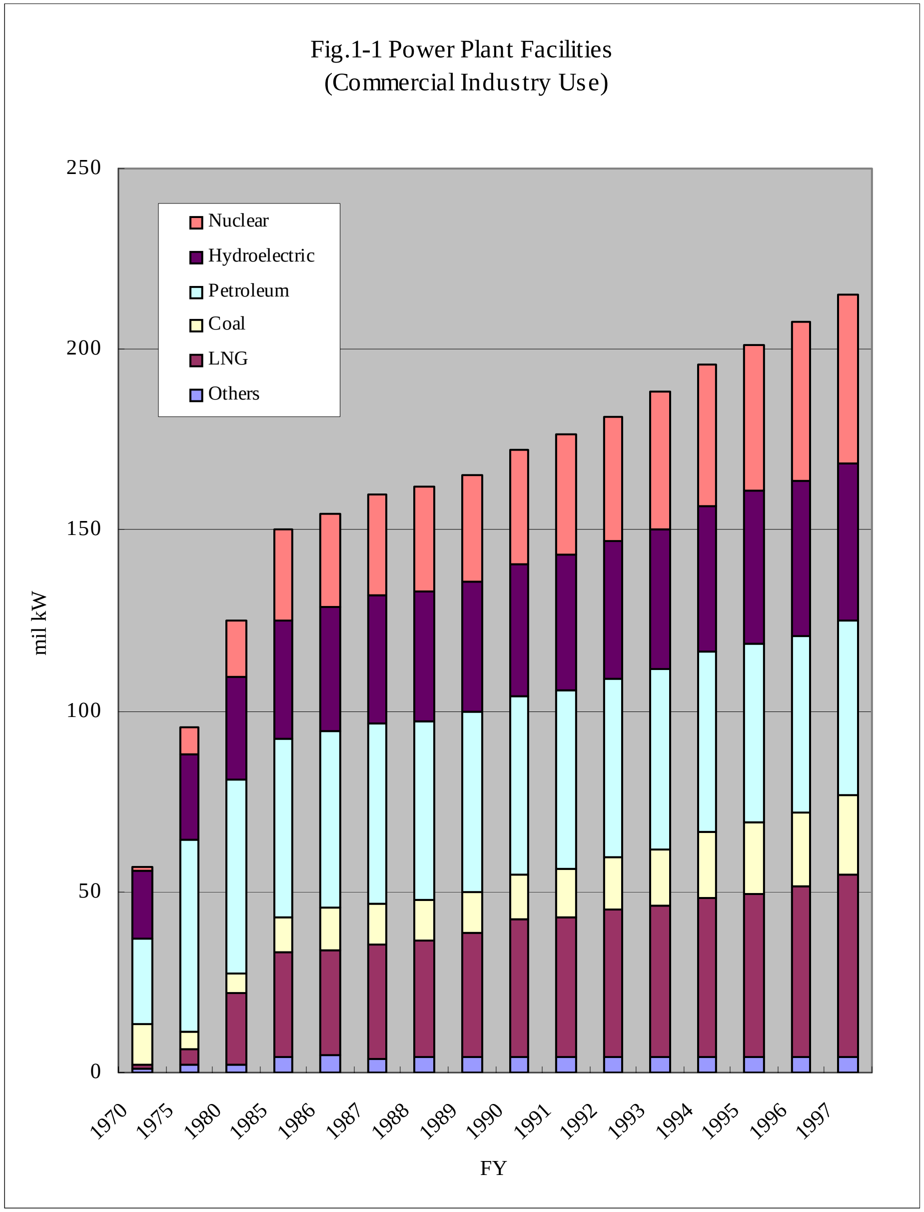
Fig.1-1 Power Plant Facilities
(Commercial Industry Use)
mil kW
0
50
100
150
200
250
Nuclear
Hydroelectric
Petroleum
Coal
LNG
Others
1970
1975
1980
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
FY

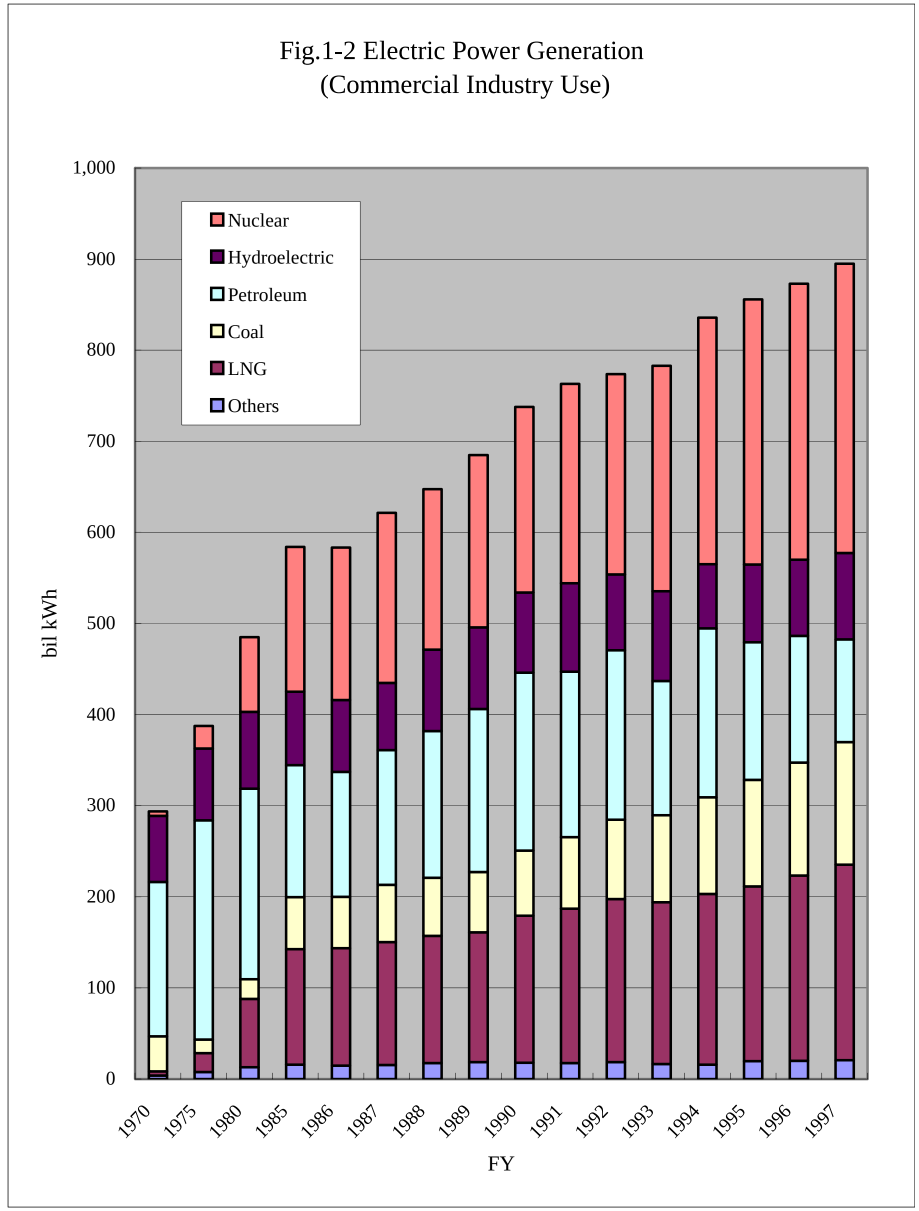
Fig.1-2 Electric Power Generation
(Commercial Industry Use)
bil kWh
0
100
200
300
400
500
600
700
800
900
1,000
Nuclear
Hydroelectric
Petroleum
Coal
LNG
Others
1970
1975
1980
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
FY

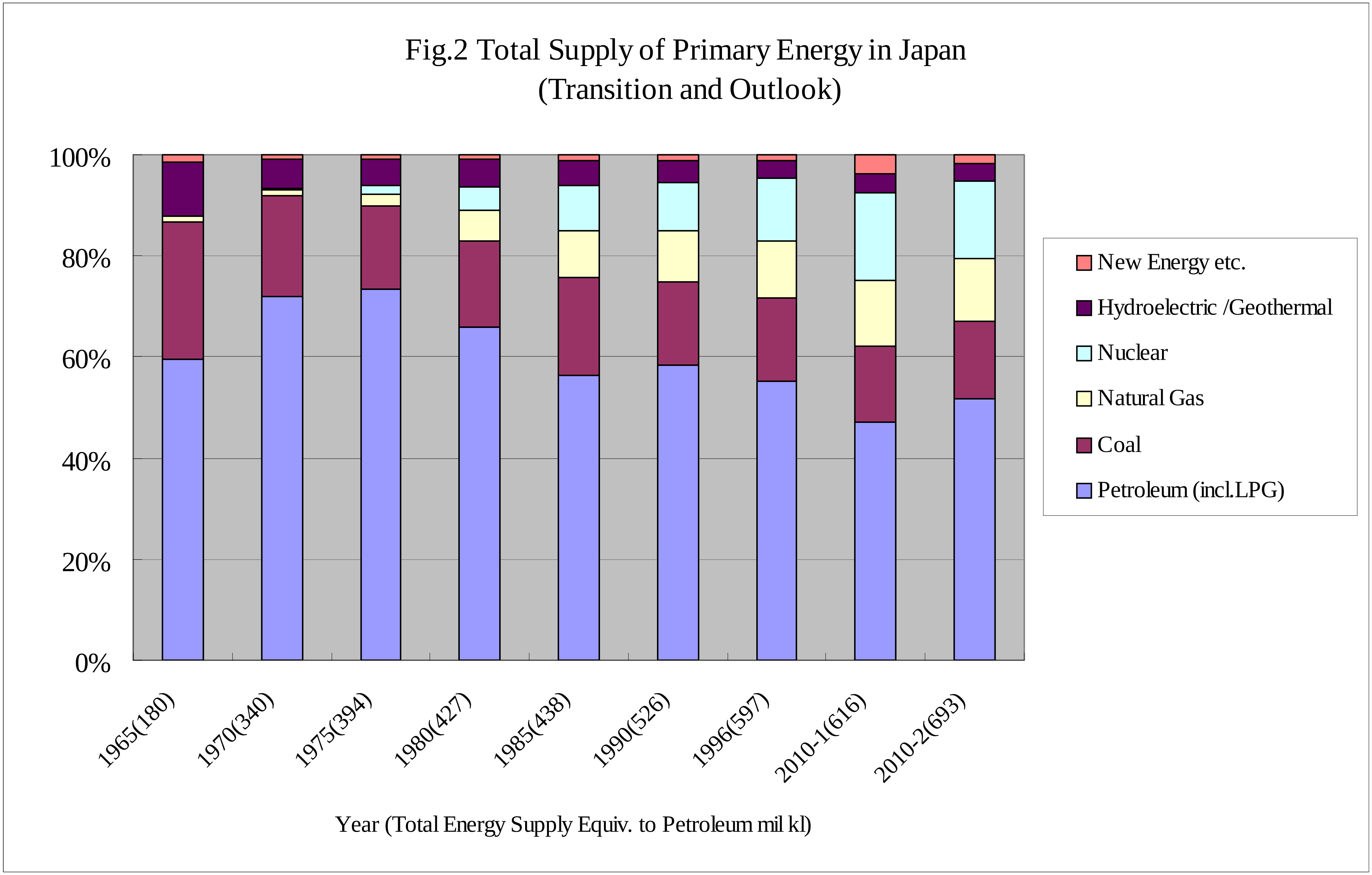
Fig.2 Total Supply of Primary Energy in Japan
(Transition and Outlook)
100%
80%
60%
40%
20%
0%
1965(180)
1970(340)
1975(394)
1980(427)
1985(438)
1990(526)
1996(597)
2010-1(616)
2010-2(693)
Year (Total Energy Supply Equiv. to Petroleum mil kl)
New Energy etc.
Hydroelectric /Geothermal
Nuclear
Natural Gas
Coal
Petroleum (incl.LPG)

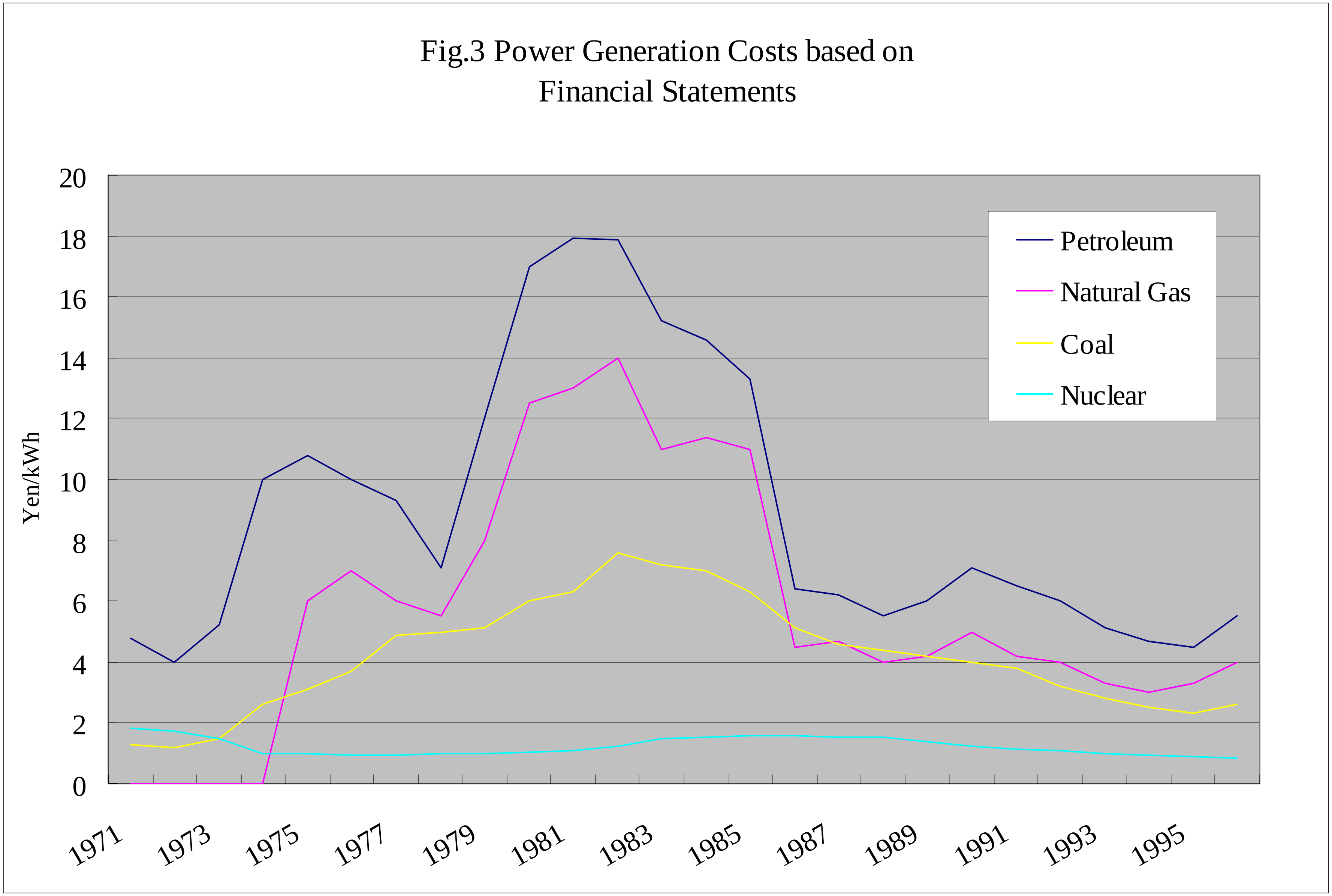
Fig.3 Power Generation Costs based on Financial Statements
Yen/kWh
0
2
4
6
8
10
12
14
16
18
20
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
Petroleum
Natural Gas
Coal
Nuclear

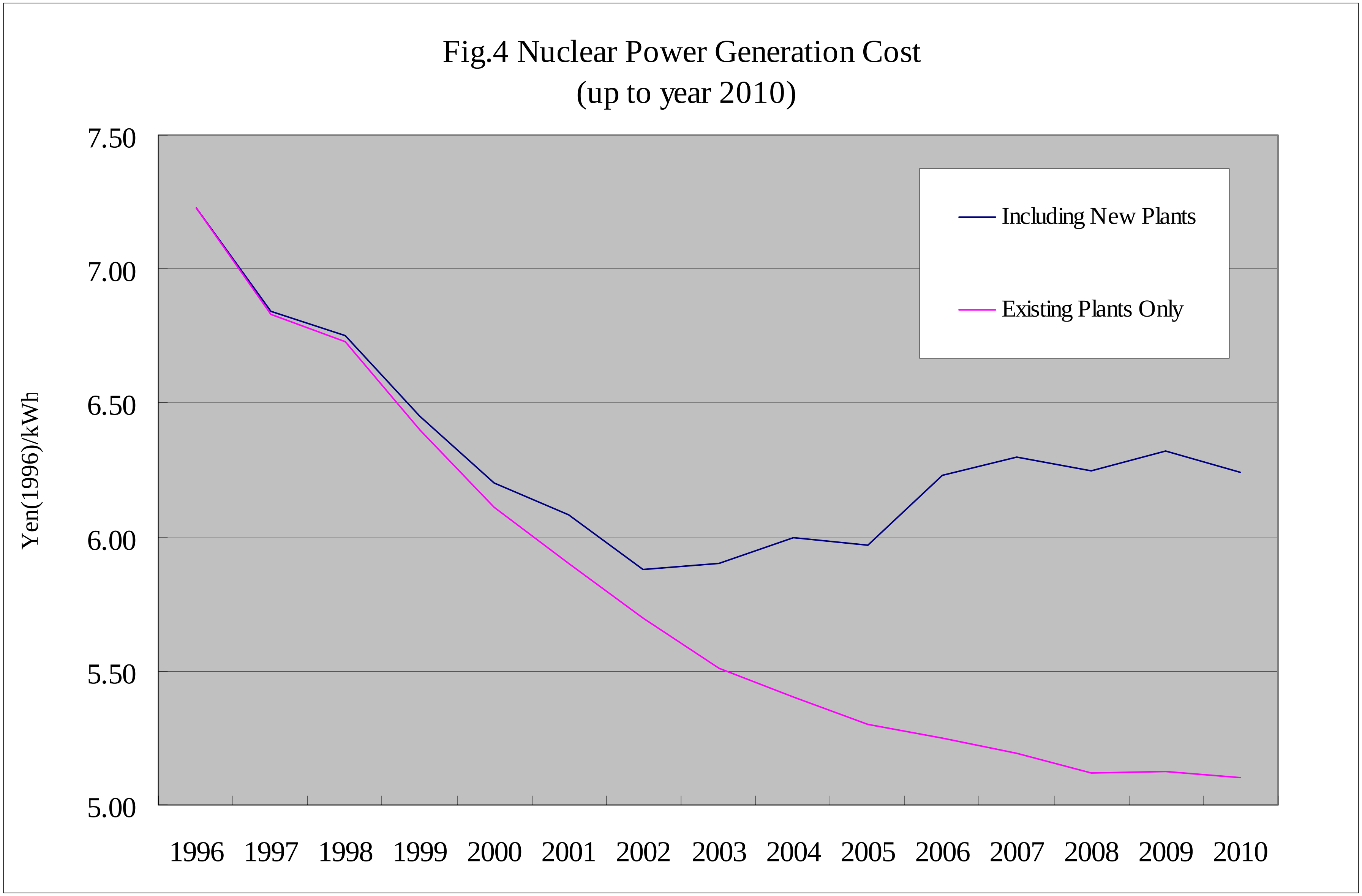
Fig.4 Nuclear Power Generation Cost
(up to year 2010)
7.50
7.00
6.50
6.00
5.50
5.00
Yen(1996)/kWh
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010
Including New Plants
Existing Plants Only

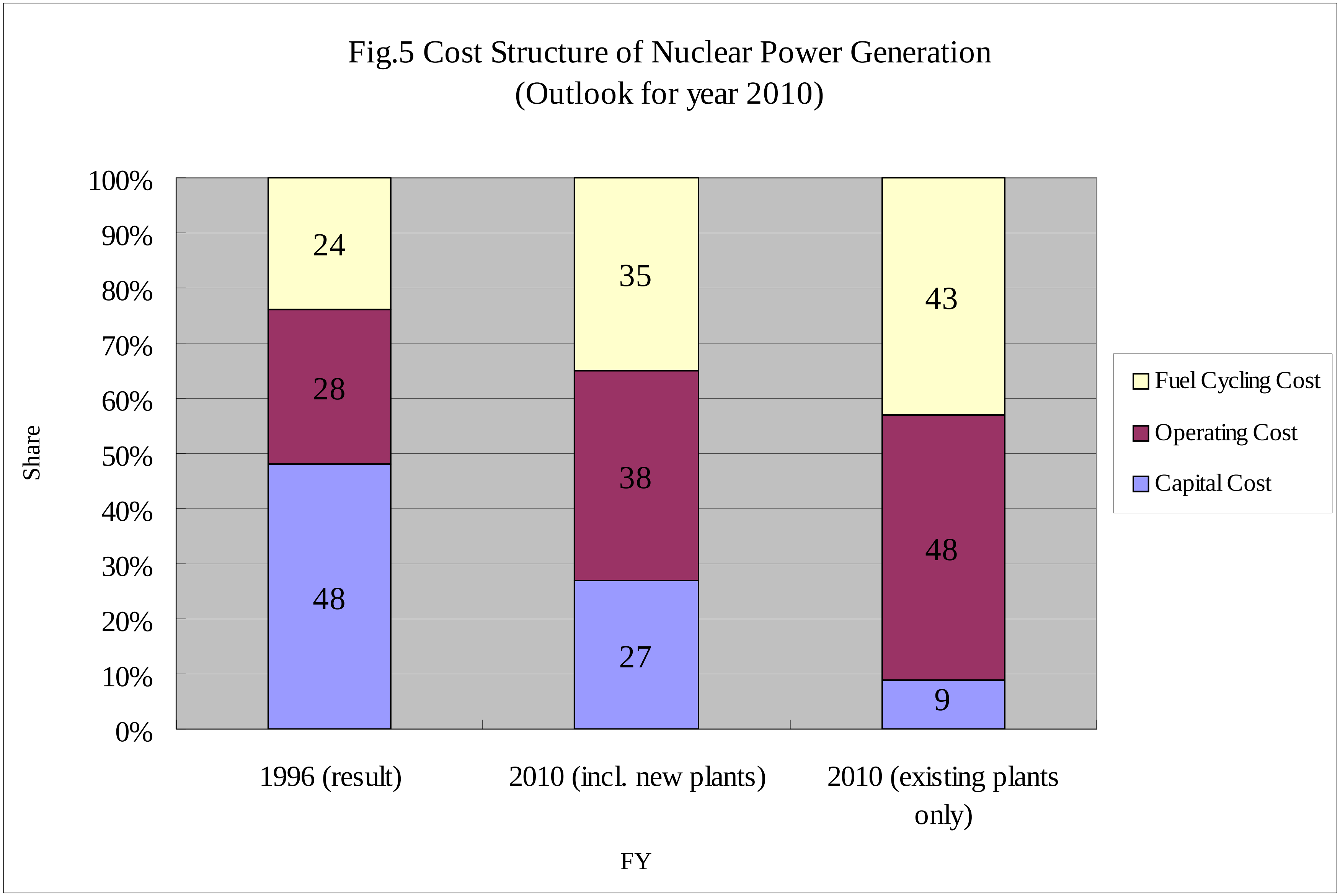
Fig.5 Cost Structure of Nuclear Power Generation
(Outlook for year 2010)
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Share
24
28
48
35
38
27
43
48
9
Fuel Cycling Cost
Operating Cost
Capital Cost
1996 (result)
2010 (incl. new plants)
2010 (existing plants only)
FY