Energy Security and the Role of Nuclear Power in Japan

Tatsujiro Suzuki
Senior Research Scientist,
Central Research Institute of the Electric Power Industry

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 require 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 played a major role as an alternative energy source, but there are many problems yet to be resolved for nuclear power 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 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.

HISTORY OF NUCLEAR POWER DEVELOPMENT IN JAPAN

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"). 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 the FBR given the limit to the world's uranium supplies. By 1956, commercial nuclear power plants had already been in operation in the U.S. It was also 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 FBR-nuclear fuel and a long-term commitment to it.

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 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 energy alternatives 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 until 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 (Advanced Thermal Nuclear Reactor) 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 PNC (the Power Reactor and Nuclear Fuel Development Corp) with the results matching those in America and Europe.

The PNC 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 of 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.

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 significantly to 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 capacities (especially the 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 not only raised 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. The 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 Tohoku Electric's planned nuclear power plant at Maki village was voted down by a majority of the village people 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 outcomes of the meeting were 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 efforts 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] The promotion of Pu-thermal: Recycling plutonium in the existing LWR is called "Pu-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 "Pu-thermal". Of the opinion that all electric power companies that operate any nuclear power plant may well employ "Pu-thermal" in turn, the Japanese government decided that "Pu-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, "Pu-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 implementation 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 significantly to 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 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 from 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 of 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 SECURIY

The fiction of domestic energy

Most obvious among the goals of energy security policy is the establishment of an 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%

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 Pu-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 assuredly to be enough uranium to meet demands for at least 50 years[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 Pu-thermal. When long-term resource savings are the goal, Pu-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 Pu-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 greater stocks of plutonium available. On the other hand, nuclear disarmament and nuclear non-proliferation require efforts to reduce plutonium inventories.

The weapons-class plutonium used for nuclear weapons is a highly pure Pu239 90%, only 4 kg of which can make a nuclear explosive 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 larger 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 explosive 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 that it will become Japan's ultimate domestic energy source and will contribute significantly to Japan's 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) nuclear power generation 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 the 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 temporarily to 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 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 maintain 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 a 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 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 730,000 to 2,250,000 jobs[15].

To be sure, increase in nuclear power generation in the past has contributed considerably to the reduction of carbon dioxide generated by 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 0.6 kg CO_2/kWh (in the 1970s) down to 0.38 kg 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 provides most of the base load for 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 significantly to 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 efficiencies, 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 only 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, and it 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 nuclear power generators may have to compete with the marginal cost competition from Independent Power Producers (IPPs) and even other nuclear facilities.

According to an assessment[18] conducted by the Central Research Institute of the Electric Power Industry on 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, Figures 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 will 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 also be 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 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 facilitate the siting of private-sector interim storage facilities, 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 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 Pu-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 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 on 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, suggests how difficult it is likely to be to find future locations for nuclear power facilities.

The government and the electric power industry need to consider the possibility that nuclear power plans will rarely 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].

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 cycle cannot make significant contributions as realistic energy source options for some time 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 the 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 the Institute for Science and International Security (ISIS). ISIS Plutonium Watch, May 1999.

9. According to a report by the Nuclear Inspection Institute (NII) of the U.K., 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 the 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 a safety problem, 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 the 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 the 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 discussed for 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

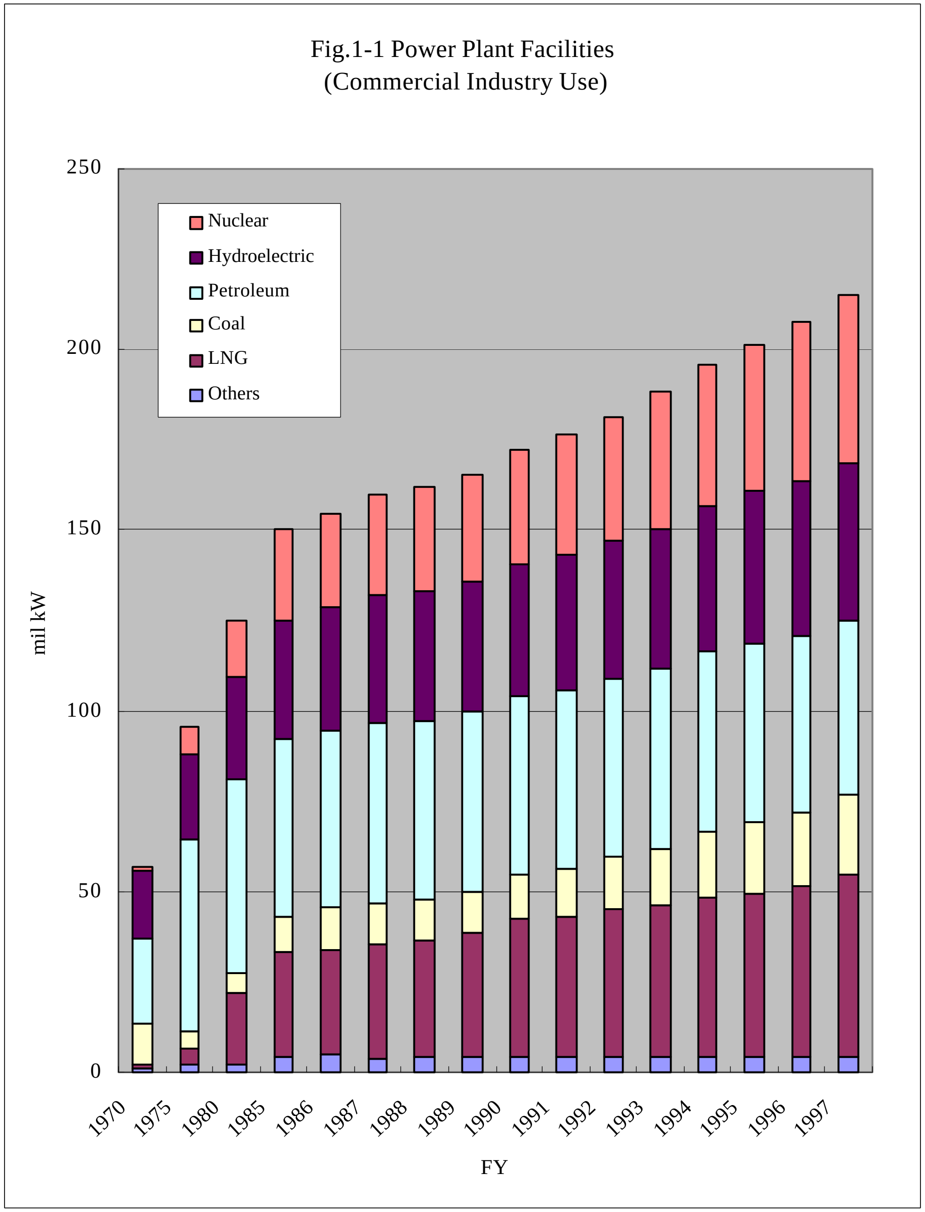
Fig.1-1 Power Plant Facilities
(Commercial Industry Use)
mil kW
0
50
100
150
200
250
Nuclear
Hydroelectric
Petroleum
Coal
LNG
Others
1970
1975
1980
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
FY

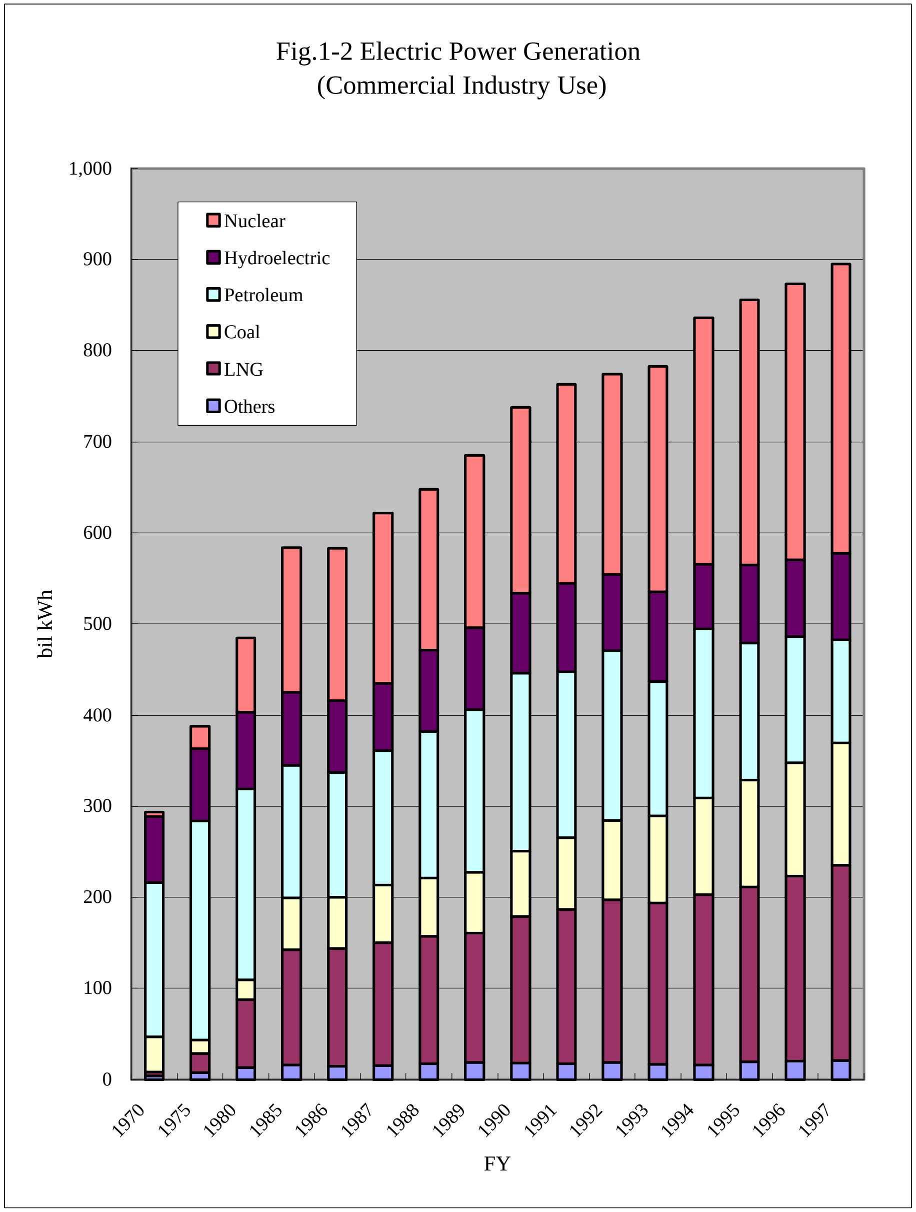
Fig.1-2 Electric Power Generation
(Commercial Industry Use)
bil kWh
0
100
200
300
400
500
600
700
800
900
1,000
Nuclear
Hydroelectric
Petroleum
Coal
LNG
Others
1970
1975
1980
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
FY

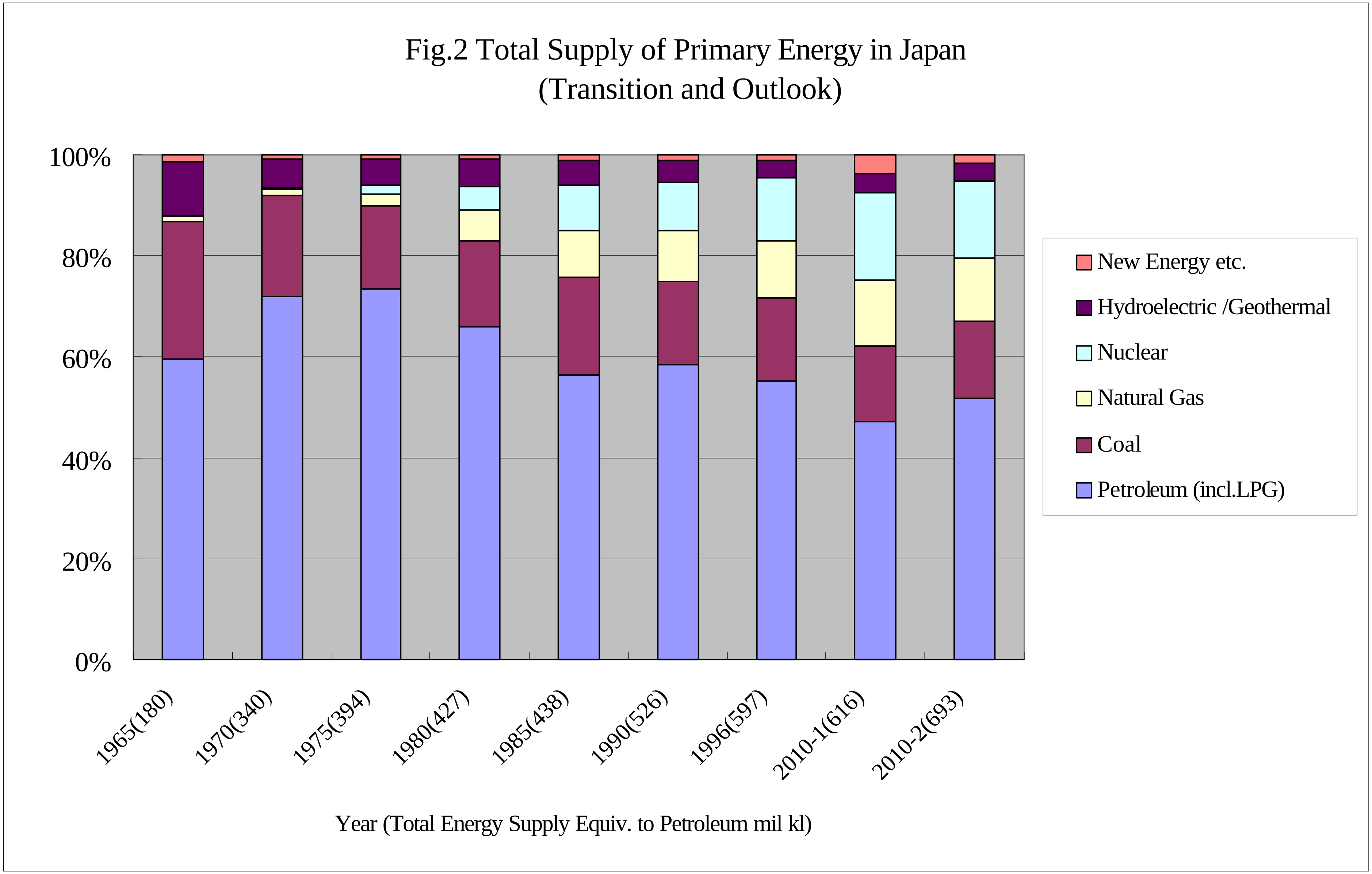
Fig.2 Total Supply of Primary Energy in Japan
(Transition and Outlook)
100%
80%
60%
40%
20%
0%
1965(180)
1970(340)
1975(394)
1980(427)
1985(438)
1990(526)
1996(597)
2010-1(616)
2010-2(693)
Year (Total Energy Supply Equiv. to Petroleum mil kl)
New Energy etc.
Hydroelectric /Geothermal
Nuclear
Natural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

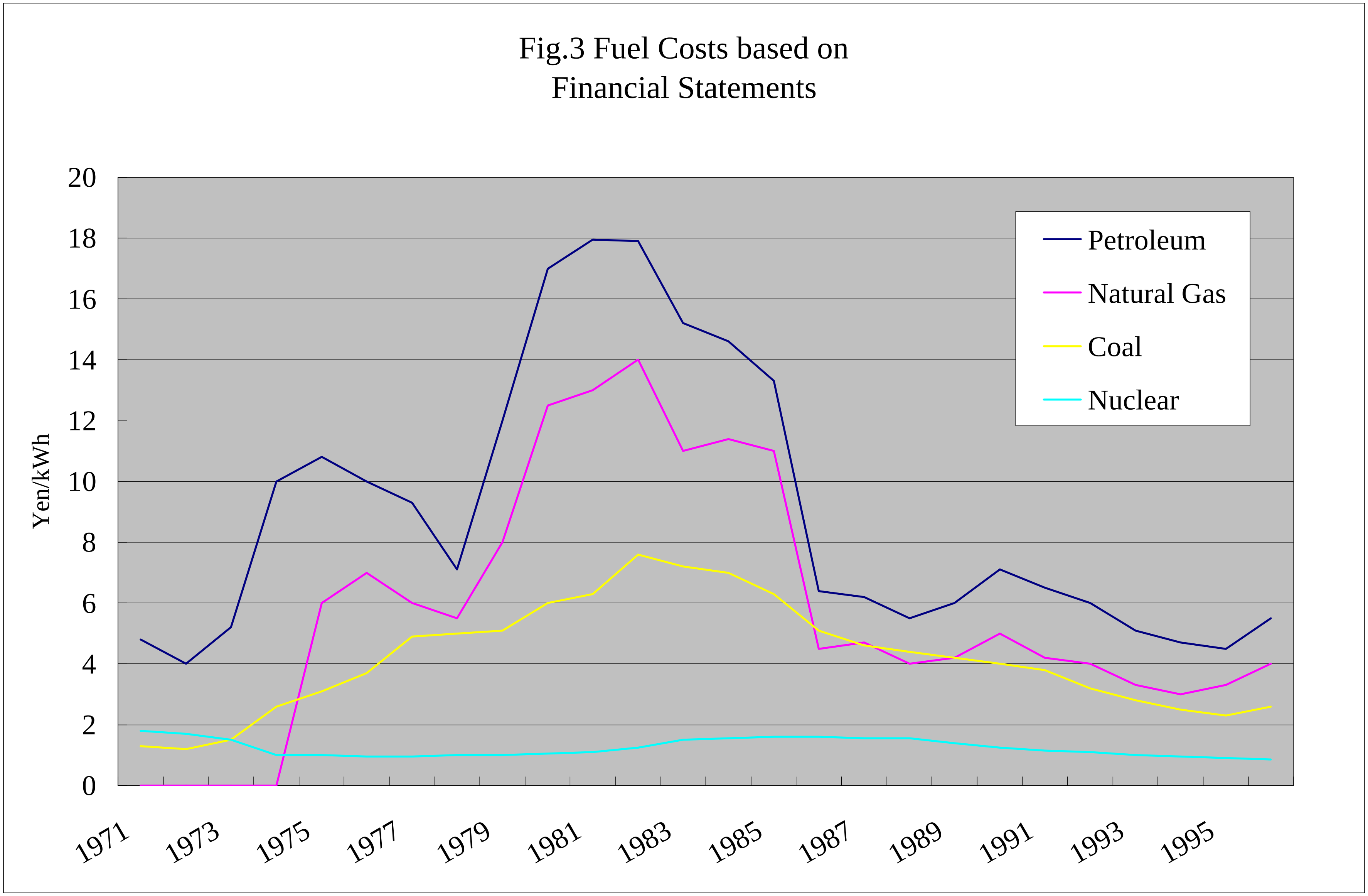
Fig.3 Fuel Costs based on
Financial Statements
Yen/kWh
20
18
16
14
12
10
8
6
4
2
0
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
Petroleum
Natural Gas
Coal
Nuclear

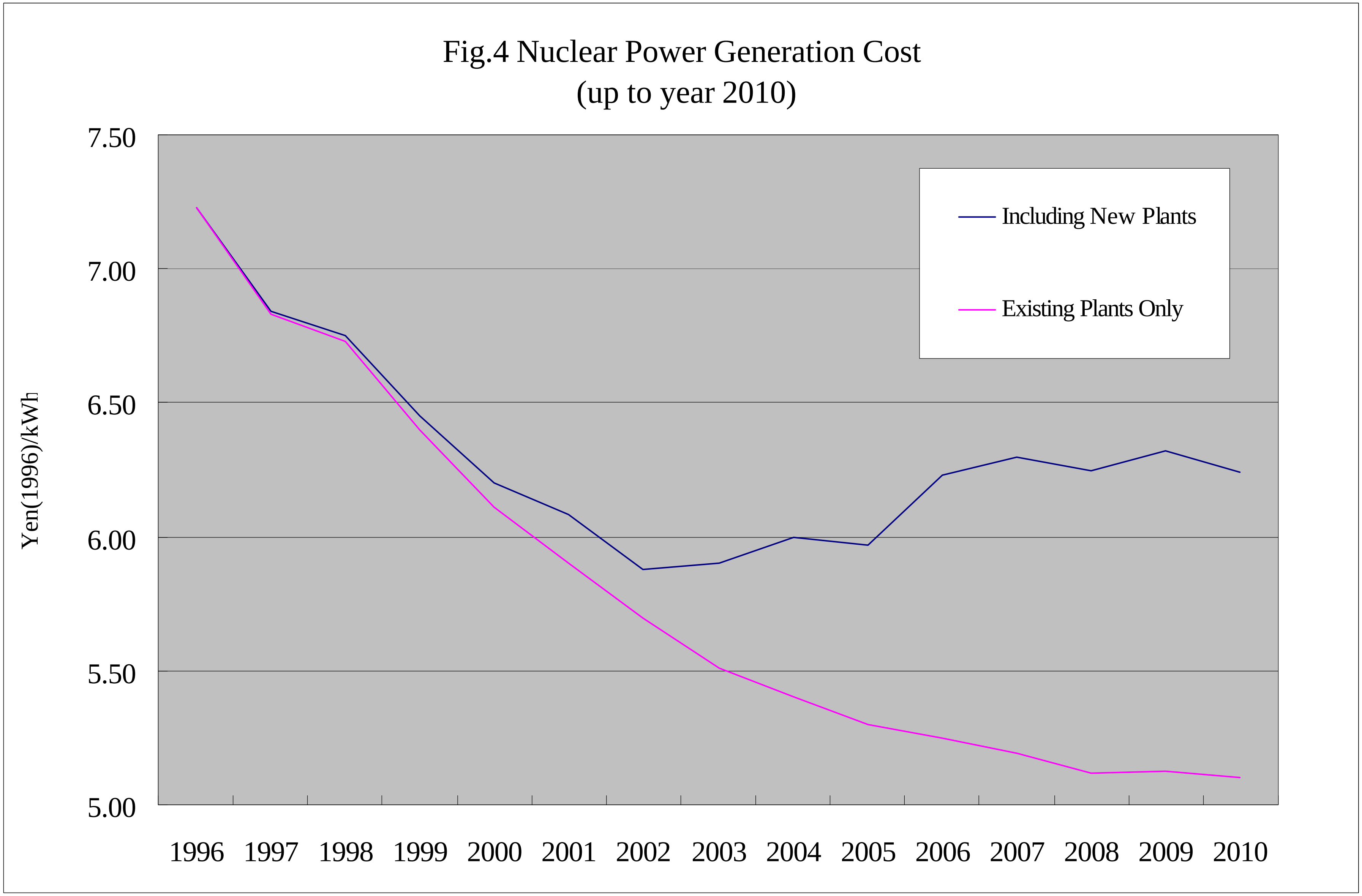
Fig.4 Nuclear Power Generation Cost
(up to year 2010)
Yen(1996)/kWh
7.50
7.00
6.50
6.00
5.50
5.00
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
Including New Plants
Existing Plants Only

Fig.5 Cost Structure of Nuclear Power Generation
(Outlook for year 2010)