Nuclear Power in Japan

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Introduction

Worldwide energy demand in the past 20 years has changed as follows: it increased annually at a high rate by 5 to 6% from 1970 to 1973. But right after the first and second oil crisis, it remained at the same level and decreased respectively. However, it has been increasing since 1983. A rapid increase was seen on a petroleum cost slump in 1986. Especially in 1988, it increased by about 4%, reflecting the global economic expansion. In 1989, energy demand increase rate remained around 2% owing to the slow down of global economic growth. Though this rate was still low in 1990 as the economic growth was slowing down at that time, energy demand total has been increasing since 1983. According to the International Energy Agency (IEA), further increases are expected in future, and 15 years later or in the year 2005, energy demand is expected to grow about 1.5 times larger than the present demand. A faster growth is expected compared with that of 1.3 times in the last 15 years.

In a regional respect, energy demand in developing countries has increased remarkably. Energy demand in those countries has recently increased by around 5%. Considering the future growth in population and economy, demand in the year 2005 is expected to be 1.9 times larger in average than the present demand, although the increase rate depends on the country. In other words, energy demand in developing countries is expected to be more than 30% of the worldwide demand. Besides, in developing countries, although oil demand increases, dependency on oil is expected to reduce relatively because energy demand itself increases and shift of energy source to coal and natural gas is promoted. However, dependency on fossil fuel in developing countries is expected to remain at the same level. About 50% of the estimated increase in global fossil fuel demand from now to the year 2005 is expected in these countries.

On the other hand, energy demand in advanced countries has been growing vastly in recent years by around 3%, but the increase rate was only about 1% in 1990 because of the slow down of economic growth and promotion of energy saving measures. Furthermore, dependency on oil reduced steadily after a lesson learned from the oil crisis. As an alternative energy source to oil, nuclear power has become about 10% of the whole energy demand. Energy demand in advanced countries is expected to be 1.3 times larger than the present demand. Coal and natural gas are expected to be about 40 and 30% of the estimated demand increase respectively. So 'Shift from oil' might be accelerated.

Circumstances of nuclear power generation in Japan

Energy demand (Final energy consumption) in Japan had increased in a slow pace for years after the second oil crisis, reflecting the progress on saving energy and changes in industrial structure and so on. But it increased annually by around 5% since 1987 and increased by 3.8% in 1990. This resulted from the fact that business encouraged by domestic demand is basically expanding as a whole. We can say energy demand is still increased at a high level. In respect of supply, primary energy supply in 1990 totaled 526 million kiloliter in crude oil, achieving the 500 million kiloliter level for the first time and this was up by 5.3% from the previous year. Oil share in primary energy supply sources has become 58.3%, another rise for five consecutive years since 1986.

During the Gulf War which broke out under energy demand growing vastly as such, Japan banned the entire crude oil import from Kuwait and Iraq as a sanction against Iraq. Japan at that time imported 3.8 million barrel of crude oil each day from the two countries. Although that import decrease was 12% of the whole crude oil import, the Gulf War crisis did not cause a critical economic problem in Japan because: Japan had stocked enough oil; dependency on oil had reduced owing to development and introduction of the alternative energy sources to oil; crude

oil was rather oversupplied because oil producing countries such as Saudi Arabia had increased its oil production; last of all the government's call for saving energy and effort to provide oil were effective. However, Japan came to recognize again a weakness of its energy supply structure since the Gulf War crisis.

Therefor, in establishing an optimum combination of energy resources in Japan and in achieving Japan's global responsibility by adopting measures for the worldwide energy stability and contributing to the solution of environmental problems, nuclear power, which has excellent supply stability, high economic performance and environmental friendliness, should play the central role as a main source of energy in Japan. And for these purposes nuclear development and utilization are being promoted with every effort for safety.

In addition, Japan has continued promoting its nuclear fuel reprocessing system consistently from the first stage of the program, aiming to reuse the spent fuel as nuclear fuel by recycling plutonium and uranium recovered from the reprocessed spent fuel. Nuclear power has such a characteristic that it can generate a great deal of energy using a small amount of original sources and at the same time generating a small amount of wastes. Nuclear power can be positioned as a quasiindigenous source of energy because its supply stability can be enhanced through the establishment of nuclear fuel cycle.

Nuclear power can be regarded as technological energy as high technology enables nuclear power to generate a great deal of energy from a small amount of resources as mentioned above. So its fuel supply stability and economic performance are determined mainly by technology itself rather than external factors such as resources. Thus higher technology can even strengthen the status of nuclear energy as a reliable energy source. From these view points, the significance of promoting the development and

utilization of nuclear power is considerable for Japan which is seeking to create a state established on science and technology.

On the other hand, it has been pointed out that there should be reasonable measures for ensuring nuclear power safety and reprocessing and disposing of radioactive wastes. But the development and utilization of nuclear energy is being carried out on the basis that all possible measures for ensuring safety are taken. Actually major advanced countries including Japan have been developing technology to reprocess and dispose of high-level radioactive wastes generated in nuclear power plants. The practical use of the technology is almost at hand. Besides, the amount of the wastes is quite small, so establishment of the most adequate technology for procession and disposal depending on various characters of radioactive wastes is expected to enable controlling radioactive materials.

As stated above, nuclear power is and indispensable energy source in Japan. Recently, however, it tends to take several years to find a new site for a nuclear power plant. To promote the steady development and utilization of nuclear energy in the future, then, it is important to make every effort to guarantee safety, while at the same time facilitating siting through gaining public understanding and cooperation.

As mentioned before, there is a worldwide concern over nuclear power development from the viewpoint of nuclear non-proliferation. Japan's development and utilization of nuclear power are for peaceful purposes only, as settled in the Atomic Energy Basic Law. Japan has joined Non-Proliferation Treaty (NPT) and Nuclear Material Protection Treaty. Japan also adapted the International Atomic Energy Agency (IAEA) safeguards to all the nuclear materials related to Japan's nuclear activities. The policy of peaceful use of nuclear power has thus been made clear in and out of Japan. So Japan will continue to maintain a clear stance on this policy so as not to induce

international concern over nuclear non-proliferation issues. It is important for Japan to contribute to the trustworthy development of IAEA safeguards and to strengthening the world's nuclear non-proliferation regime as its international responsibility in promoting the peaceful utilization of nuclear power.

Present status of nuclear power generation

Reactors for commercial utilities operating in Japan totals 42 units and nuclear power generation capacity is 33,404 MW. Adding to those in operation, plants under construction or being planned, there are 53 units for commercial utilities and the capacity is 45,908 MW. Including those for R&D, the grand total comes to 55 units or 46,353 MW.

Nuclear power generation capacity as of the end of FY 1990 was 18% of the total power generation capacity (for electric utilities) and 26.6% of the total power generated (ibid) as the actual figure in FY 1990. As such, nuclear power has become firmly rooted as a major source of electricity. Also, the capacity factor in FY 1990 was 72.7% and has continuously stood at levels exceeding 70% for the past eight years. The main reason why the capacity factor became larger than FY 1989 level can be considered that regular inspections cause a less suspension of operation.

Economic performance of nuclear power generation

According to an estimate by the Ministry of International Trade and Industry, the cost of electricity is about 9yen/kWh for nuclear power, 10yen/kWh for coal-fired and liquefied natural gas (LNG)-fired plants, and 11yen/kWh for oil-fired plants.

The cost of electricity for nuclear power has become closer to those for the other power sources. The estimated cost includes about 0.2yen/kWh which will be spent in case of decommissioning

of a nuclear power plant. Including the cost for disposal of radioactive wastes, which is not included in that estimated cost, nuclear power is still more economical than the other power-generating methods.

Promotion of facility siting

The government and electric utilities are making efforts to gain public understanding and cooperation, in order to promote the siting of nuclear power plants. These efforts target community residents by way of various media and an opinion monitoring system on nuclear power.

Since the Chernobyl nuclear power plant accident in 1986, a great public concern has been spreading throughout Japan over safety of nuclear power plant and radioactive contamination. In order to deal with that and to explain the safety and necessity of nuclear power, meetings are held and pamphlets are distributed.

Research and development of light-water reactor (LWR) technology

In Japan, the government, electric utilities and nuclear power machine manufacturers have cooperated in pursuit of improving LWR reliability and its operation rate, and reducing worker's radiation exposure by utilizing Japan's own indigenous technology. Their programs for improvement and standardization of LWR have been carried out.

The result was reflected on further improvement of conventional LWR in operation or under construction. Especially, in the last phase, an advanced light-water reactor (ALWR) was developed. Moreover, in the future development of LWR technology, it is important to utilize the past experiences positively, make sure of the principle of safety and apply new ideas and technology. Advanced countermeasures for defects and problems as well as for

satisfying human factors, safer designs, pursuit of possibilities for passive safety and more effective treatment of decommissioned reactors are required to enhance safety in the future development of LWR technology.

Decommissioning of reactors

As for development of reactor decommissioning technology, the technology will be improved toward the latter half of the 1990's in consideration of actual time schedule set to decommission reactors for commercial use.

The Japan Atomic Energy Research Institute (JAERI) has been working on actual dismantling of the Japan Power Demonstration Reactor (JPDR) since FY 1981. Also, the Nuclear Power Engineering Corporation is carrying out such verification tests on especially important technologies required in reactor decommissioning from the viewpoints of its safety and reliability: technologies to cut inside parts and to dispose wastes from decommissioning reactor. In cooperation with the private sector in FY 1988, the government set up the Research Association for Nuclear Facility Decommissioning. This association is accumulating and spreading out the results of decommissioning nuclear power facilities for R&D.

Progress in commercial nuclear fuel cycle

Research and development on the nuclear fuel cycle in Japan has mainly been carried out by the Power Reactor and Nuclear Fuel Development Corporation (PNC) and JAERI. At the same time, a number of achievements have been obtained by the private sector in reconversion and fabrication of nuclear fuel. In addition, uranium enrichment, reprocessing of LWR spent fuel and low-level radioactive waste disposal are now in the commercialization stage. The Japan Nuclear Fuel Limited (JNFL) is proceeding nuclear fuel cycle facilities program in Rokkasho-mura, Aomori Prefecture.

Low-level radioactive waste

Among the low-level radioactive waste generated in nuclear power plants and other facilities, those in gaseous state and part of those in liquid state and being discharged into the atmosphere or sea water by filtering or vaporizing after verifying that release level are sufficiently lower than the permitted level. Other liquid and solid wastes, after being reduced to a minimum level, are properly treated by proper methods such as solidification and incineration, and then stored within each power plant site under safe conditions. As of the end of March 1991, the cumulative volume came to about 780,000 in 200-liter drum equivalent. About 470,000 of those are stored in nuclear power plant.

High-level radioactive waste

As for high-level radioactive waste which should be separated from the spent fuel in reprocessing plants, those generated up to now by the Tokai Spent Fuel Reprocessing Plant of the PNC has been stored in tanks at the plant under strict control. As of the end of March 1992, the cumulative amount in solution form was about 471 m .

The basic process for high-level radioactive waste is vitrification in stainless steel canisters under stable conditions, followed by 30 to 50 years storage for cooling, and ultimate disposal in underground formation deeper than several hundred meters below ground level.

Plutonium utilization

For the purposes of realizing more efficient utilization of uranium resources and securing a stable supply of energy in Japan, it is important to establish a utilization system of plutonium which will be obtained from spent fuel reprocessing.

The practical use of fast breeder reactors (FBR) with high efficiency utilization of uranium is the basic measure, while plutonium utilization on a given scale in LWR and advanced thermal reactor (ATR) will be promoted for the time being.

Plutonium utilization in light-water reactors and advanced thermal reactors

Plutonium utilization in light-water reactors (Pu-thermal) in Japan is mainly being carried out by electric utility industry, and a small-scale demonstration program on MOX fuel use is being promoted today. Besides, in the first utilization program in the middle of 1990's, such ways were adopted to charge MOX fuel equivalent to one quarter of a reactor core, in each one of BWR and PWR with capacity above 800 MW level. In addition, preparations will be made for gradual and intentional expansion of recycled plutonium utilization, using at the end of 1990's about 4 units and in early the 2000's about 12 units in an equivalent 1000 MW level light-water reactor, which charges MOX fuel equivalent to one third of a reactor core.

The ATR development has been promoted by the PNC and the prototype reactor "Fugen" (165 MW of electricity output) is currently operating smoothly.

Besides to that, the Electric Power Development Co., Inc. is making preparations for construction of an ATR with 606 MW of electricity in Ohma-cho, Aomori Prefecture for a scheduled start-up in the year 2000.

Fast breeder reactor

The fast breeder reactor (FBR) is an epoch making reactor which generates power and a greater deal of nuclear fuel than the sources spent for generation. FBR development is being promoted in order that FBR should play a major role in the future nuclear

power generation. FBR development has been promoted mainly by the PNC. The experimental reactor "Joyo" (100 MW of thermal output) has already been operating smoothly, with a steady accumulation of technology data of prototype reactor and operation experiences required for the development. With cooperation by the public sector, the PNC is also constructing the prototype reactor "Monju" (280 MW of electricity output) in Tsuruga City, Fukui Prefecture. The installation of equipments was completed in April 1991 and functional tests are being carried out in hot sodium and criticality is planned in 1993.

Aiming to start the construction of a FBR demonstration reactor in the latter half of the 1990's, the Japan Atomic Power Co., Ltd., will mainly study and develop the demonstration reactor and select a conceptual design.

Reprocessing of FBR spent fuel

The PNC is accumulating the basic data gained at a mock-up test and a high level radioactive material research institute, with respect to spent fuel reprocessing technology essential for FBR's. In future research and development, tests in radioactive engineering test facilities will be conducted while maintaining compatibility between the relevant R&D activity and development of the FBR itself, after which a pilot plant could be constructed with start up scheduled after the year 2000.

MOX fuel fabrication

To establish plutonium utilization system, it is necessary to proceed the necessary R&D including the technology for safe handling of a great deal of plutonium, and to seek establishment of MOX fuel fabrication.

The PNC has been caring out technical development of MOX fuel fabrication. As of the end of March 1991, the cumulative amount

of MOX fuel production reached 107 tons. At present, construction of a fuel production facility for the ATR demonstration reactor (40 tons MOX/year) is planned.

Also, in order to promote domestic commercial operation of MOX fuel fabrication for LWR's, it is necessary to seek demonstration of technology in Japan and also to transfer MOX fuel fabrication technologies from the PNC to the private sector smoothly.

Plutonium transport

As for international transportation of plutonium recovered from reprocessing abroad, the PNC, as the executing body, is mainly preparing a concrete transport plan at present to ensure the smooth and safe execution of shipping transport.

Remarks

Japanese policy for nuclear power generation comes from the fact that fossil fuel resources are very limited in the world and these resources are important as raw materials which produce many useful new materials. Moreover, burning fossil fuel causes to generate gaseous poisons, such as nitrogen- and sulfur-oxides and carbon-dioxide which will destroy all of the lives in the world. This is the reason why we must utilize the divine nuclear energy.

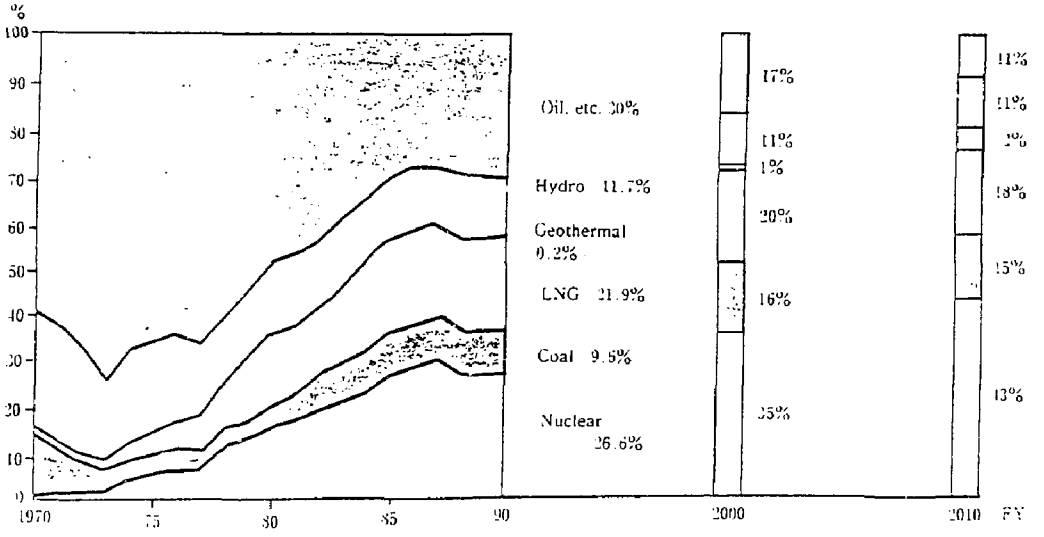
Even the nuclear power density is so large, uranium resource is also limited, but other power sources are now under development. Effective use of uranium resource is therefore very important. This means that plutonium must be utilized, as a new energy resources. Nuclear reprocessing activities are attendant on this matter.

Another important policy in Japan is the fact that nuclear activities must be concentrated only to the peaceful use and never to the military use, as the first and only country

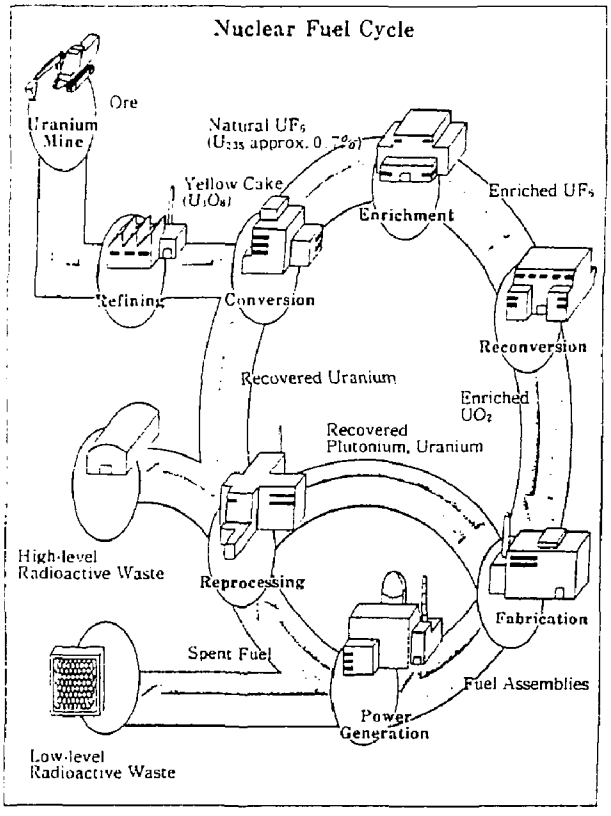
destructed by nuclear explosive bombs. Therefore, Japanese nuclear supports to and cooperations with other countries are only for the peaceful purposes.

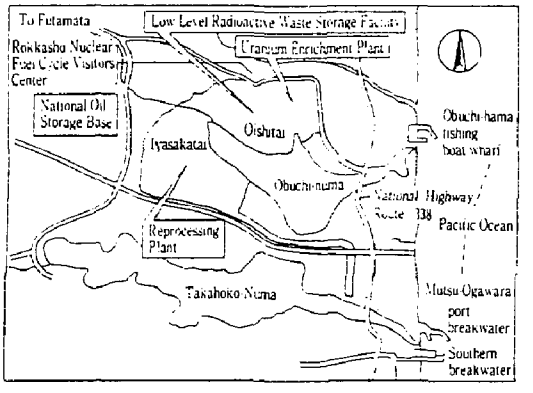
Nuclear technologies and informations developed in Japan are expected to be useful for peace in the future world.

Reference: Nuclear Power white paper in FY 1991

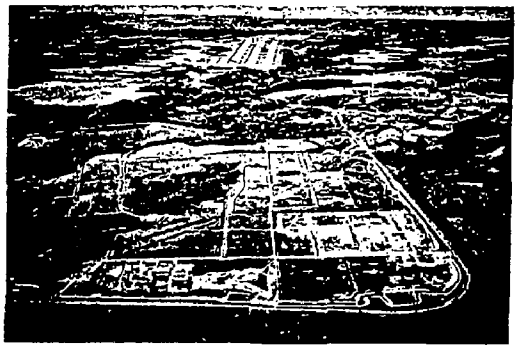


Total Power Generated of Japan Source: Statistics of MITI

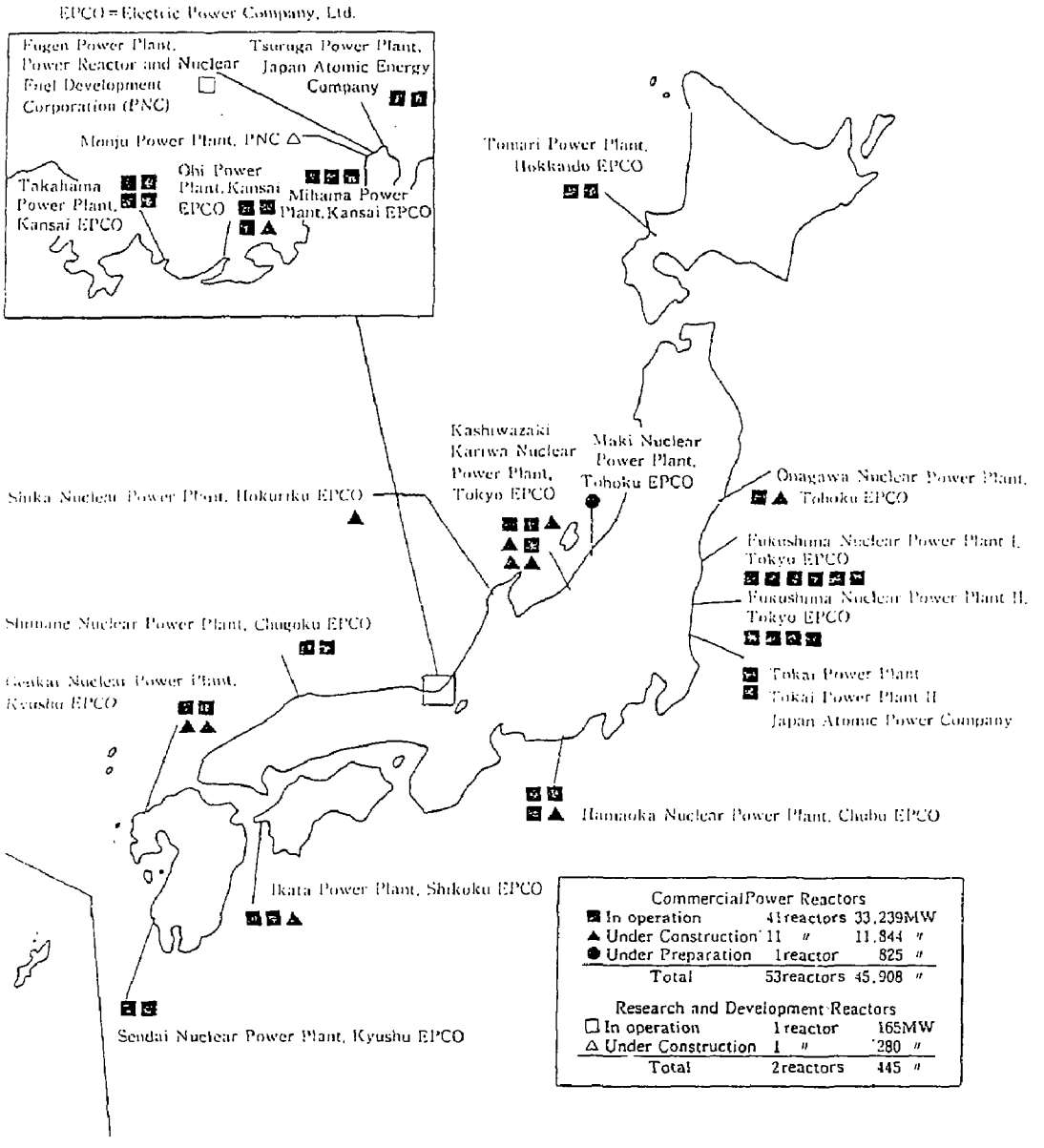




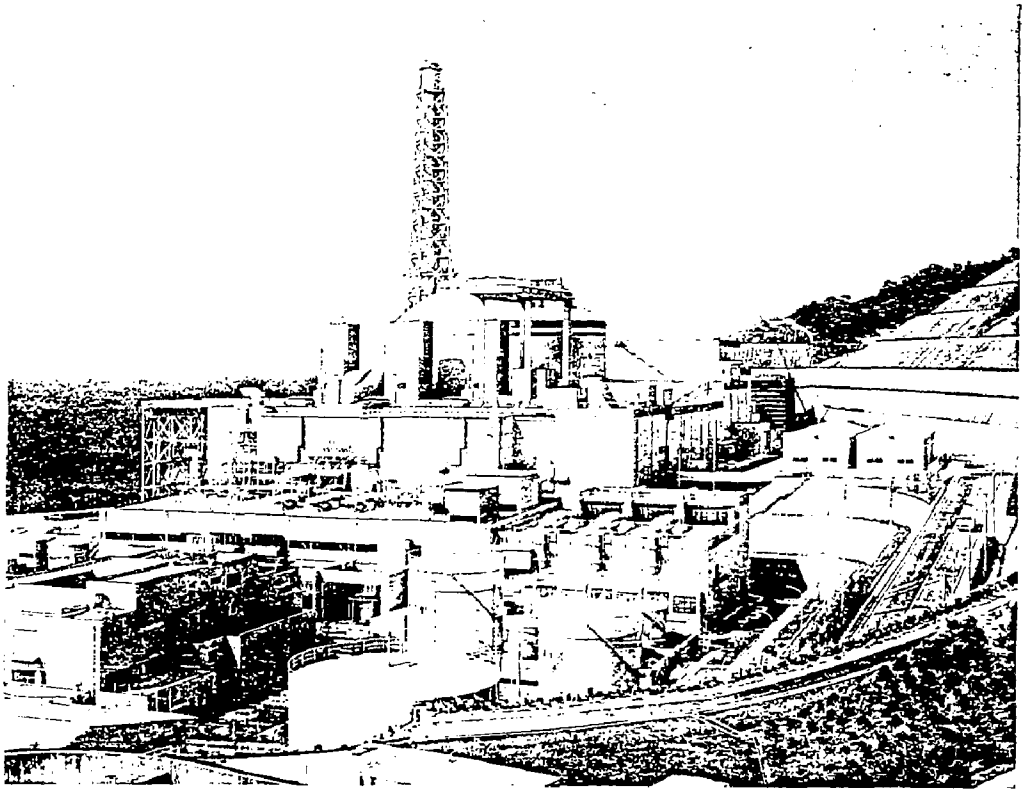
Map around Nuclear Fuel Cycle Facilities



Air Photograph of Nuclear Fuel Cycle Facilities



Location of Nuclear Power Plants (As of August 1992)



Prototype Fast Breader Reactor "MONJU"