The Development of Atomic Energy in Japan

THE DEVELOPMENT OF NUCLEAR POWER GENERATION AND POWER REACTORS

Energy demand in Japan has increased in line with the development of the economy. The demand for electric power is expected to increase at a constant level as the living standard of the people rises and the industrial structure becomes more complex. Faced with this growing demand, the provision of a stable supply of inexpensive and clean energy is an essential task.

Fossil fuels will continue to be used for some time as the main source of electric power generation, but as the consumption of petroleum increases exponencially, it is certain that serious problems relating to transportation, storage and incidental environmental pollution will increase. To ensure stable supplies of electricity for the future, it is essential that alternative energy sources be introduced speedily. Nuclear power generation, now being used commercially in Japan, has advantages in the transportation and storage of fuel, and under proper control the environmental effects from nuclear power stations can be substantially reduced. For that reason there is high expectation that nuclear power generation will be a stable and clean source of energy. This means that Japan will face an insistent demand for nuclear energy as its major source of power, which in turn means that is must be promoted as a major part of government energy policy.

With respect to the economical aspect of nuclear power generation, it must be admitted that the unit power cost of LWR is still high compared with petroleum-fed thermal power plants. But in the long run, the LWR is a type of reactor which, economy-wise, can be greatly improved by technological development. The cost gap between LWR and thermal power plants will be narrowed by 1975-80 and by 1980-85 nuclear power will become competitive. Considering these social and economic facts, the development of nuclear power generation will move fast, and the newly-commissioned nuclear power generating facilities will carry greater weight than thermal plants. This should begin around 1975. After that, nuclear power growth will accelerate even more.

The power demand, expanding with the population's rising living standards, must be met largely with nuclear power generation. Nuclear power generation will be 32,000 MWe by 1980, 60,000 MWe by 1985 and 100,000 MWe by 1990 in installation capacity.

The development of nuclear power generation to meet this demand requires a harmonious and well-balanced programme, not only ensuring safety and protection of the environment, but also demanding the choice of proper sites for plants, stable supplies of nuclear fuel, the effective use of fuel materials and the proper disposal of radioactive waste. Every effort must also be made to develop the advanced thermal power reactor (ATR) and the fast breeder reactor (FBR).

The construction of conventional types of reactors must continue for the time being, but in order to solve the problem of stabilized fuel supplies and efficient utilization of fuel resources, appropriate new types of power reactors must be developed to make use of the full merits of nuclear

The "Mutsu", Japan's first nuclear ship, with a gross tonnage of 8,350 ton.

power generation. Japan must proceed with its own experimental programme on new types of power reactors, as this will make a major contribution to elevating the industrial structure and raising the level of the scientific and technological power of the nation. This will be the main pillar in establishing a national nucler power development and utilization programme. From these points of view the ATR and the FBR now being developed in Japan should come into commercial use between 1975 and 1984 (ATR) and 1985 and 1994 (FBR).

The Advanced Thermal Reactor being developed in Japan is a heavy water-moderated and light water-cooled boiling type reactor. Since this type has a high neutron economy factor, its uranium consumption, especially consumption of enriched uranium, can be reduced compared with the LWR. It is expected that cost per unit power from this new type will be about the same as, or even below that of the LWR.

As the completion of a 200 MWe prototype reactor of this type is expected to reach criticality around 1975, and an R&D for scale-up was laid down in the "Report from the ATR Evaluation Committee" (Nov. 13, 1969), there is reason to believe that the ATR will attain stable operation and become competitive with other types of reactors.

Studies are to be done on steps necessary to ensure smooth and timely construction of commercial reactors of this type.

By 1990, ATRs are expected to assume a large share in the power supply programme. When the FBR reaches the stage of commercial application, the ATR will supply

The Fukushima Nuclear Power Plant, showing No. 1, 2, 3 and 4 BWR, belonging to the Tokyo Electric Power Co.

the plutonium for the fast breeders. When that time comes, ATRs and FBRs will operate side by side for a long time.

The special feature of the FBR is that it produces more nuclear fuel than it consumes, and therefore can make maximum use of potential energy in uranium. This will reduce the volume of enriched uranium needed by Japan. It will also supply clean energy, and therefore it ought to be the main type of power reactor used in Japan in the future. Commercial utilization of the FBR is expected in the decade 1985-1994. Concentration is on the sodium-cooled reactor, using mixed plutonium-uranium oxides, which is generally regarded as the most promising type. Japan's experimental fast reactor with a thermal output of 100 MW is expected to reach criticality in 1974. Efforts are being made to have a prototype fast reactor with an electric output of about 300 MW attain criticality about 1978.

Further studies are needed on the commercial utilization of fast breeders, based on experience gained in the construction and operation of the prototype. Judging from development efforts made overseas, it may be necessary to gain experience with a proven reactor, and to test other measures before moving to the stage of commercial use.

In long range planning parallel to the current sodium-cooled fast breeder development programme, basic studies must be done on gas-cooled fast breeders, the feasibility of carbon oxide fuel and the reprocessing technology of FBR spent fuel. These efforts are necessary in order to increase further the efficiency of the FBR.

NUCLEAR FUEL

Essential for the attainment of the foregoing is the provision of a stabilized large volume supply of nuclear fuel and its effective use. Japan must secure uranium resources and enriched uranium; to meet the needs of the future, the fabrication of fuel and reprocessing of spent fuel must be done. This calls for the establishment of a complete nuclear fuel cycle to ensure economic feasibility and independence. In reaching the stage of a proper fuel cycle, private corporations, on principle, are expected to take the responsibility, but as nuclear energy is an important future energy source for Japan, the Government has a big role to play in working towards this end.

The uranium needed under the revised programme will be 8,000 S/T annually by 1980 rising to 15,000 S/T by 1990. Japan has only poor uranium resources, and will have to depend almost entirely on foreign sources. The electric utilities are expected to secure the uranium they need on short and long term purchase contracts. In long range plans, the ratio of imports from sources developed by Japan should be increased to about one third of the annual need. Prospecting and the development of uranium mines overseas must be vigorously undertaken. The investigations being carried out by Power Reactor and Nuclear Fuel Development Corporation (PNC) need to be expanded, and financial provisions should be made for private corporations engaged in prospecting, making loans available for repayment when the projects are successful.

Required enriched uranium will be increased to 5,000 tons S.W.U./year by 1980 and 11,000 tons S.W.U./year by 1990. The supply capacity of the United States, now supplying enriched uranium on a commercial basis, will reach its limit around 1980.

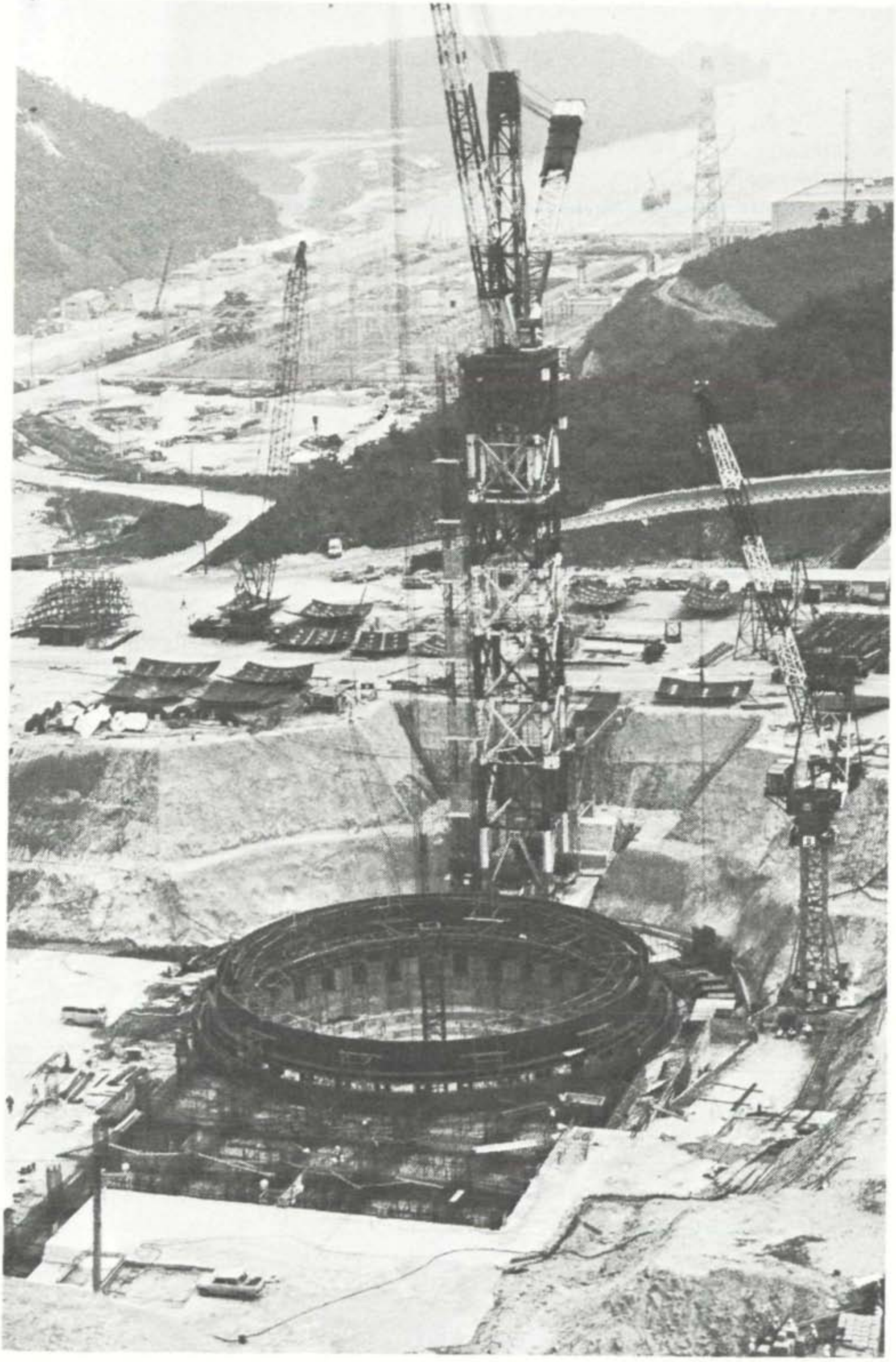
Japan must therefore see that supplies of enriched uranium are available from the United States for power plants that will be commissioned up till 1980. For further needs beyond 1980, the necessary R&D must be done by Japan itself on domestic enrichment; participation in international enrichment projects should be studied.

In nuclear fuel fabrications, domestic makers are consolidating their basis for local fabrication, but the foundation is not yet firm anough. Technological development must be further promoted.

For the reprocessing of spent fuel, PNC is building the first reprocessing plant, to be ready by 1974. A second, and subsequent plants are expected to be built and operated by private corporations, on the principle that reprocessing of spent fuel is to be done in Japan. But as a spent fuel reprocessing plant involves many as yet unsolved problems, the Government must adopt a proper siting policy and provide low-interest, long-term loans. It must also energetically promote R&D to reduce radioactive wastes from the plants to the lowest practicable level.

Plutonium can be most effectively used in the FBR, but pending its commercial use, there are plans for Pu use as fuel in the LWR, as a means of reducing the consumption of uranium and enriched uranium. This is considered feasible in view of the cost of storing plutonium. The Government must help private corporations engaged in the technological development of plutonium to use the facilities of PNC and of the Japan Atomic Energy Research Institute (JAERI).

Prototype of the Advanced Thermal Reactor (ATR) built by the Japan Power Reactor and Nuclear Fuel Development Company, which should be ready for operation in 1975. ▶



SAFETY AND ENVIRONMENT

Proper development and utilization of nuclear energy are possible only when radiation is safely controlled. Japan is so far exercising strict control and regulation of radiation, giving much greater consideration to such safety than to other branches of industry.

But large quantities of radioactive wastes will certainly be produced when more nuclear energy is generated for power and other large-scale utilization. The amount of radioactive wastes emitted into the environment is expected to increase accordingly. Multilateral application of radiation, expected to expand greatly, will further increase the possibility of greater numbers of the population, and of the staff engaged in nuclear industries, being exposed to radiation.

To meet this situation, and to maintain the present high level of safety and safeguard factors, even greater efforts are needed and more consideration is to be given to questions of safety and preservation of the environment. This requires proper steps on the siting of plants, safety measures covering all facilities and equipment, and radiation control. More R&D on the safety of nuclear installations and radiation control is necessary; studies are needed on environmental radioactivity and its effects, as well as on the disposal of radioactive wastes. Results of such studies must be promptly implemented by regulation.

On these questions of safety and preservation of the environment, private corporations engaged in development and utilization of nuclear energy are naturally called on to meet their full responsibilities. For its part, the Government must exercise strict control to ensure the safety of the people. Only by so doing, can the Government expect to develop and utilize nuclear energy properly and improve people's welfare.

NUCLEAR SHIPS

The volume of world trade is rising sharply as the world economy expands. This increases the social and economic demand for low cost and large volume high-speed transport. To meet the need, international shipping is building faster merchant ships and increasing the tonnage of merchant fleets. The enlargement of tankers and raising the speed of container ships are the dominant tendencies in the world shipping picture.

To provide the high power needed to meet these requirements, much is expected of nuclear propulsion. Some people in Japan predict that nuclear-powered ships will come into commercial use in 1975-1984.

But for nuclear ships to be full merchant ships, they must be competitive economically with conventional ships, and their safety and reliability have to be assured. So far only three nuclear ships have been built in the world. All three, however, are rather more for experimental purposes than the Mutsu, the first nuclear ship under construction in Japan. None can compete yet with conventional ships.

The safety and reliability of the nuclear ship have been fully proved by those already built; the outlook for commercial use of nuclear powered ships depends almost entirely on the development of an advanced marine reactor of high economic competence. Along these lines extensive research and investigation of marine reactors is needed for the promotion of commercial nuclear ships. Japan is actively and effectively doing

R&D on a consolidated pressurized water type reactor, noting the trends of the shipping business and seeking international co-operation. It is necessary now to establish a proper technical and economic outlook towards nuclear ships, taking into account improvements in the safety and reliability of marine reactors.

It is expected that private corporations will undertake the construction of a second and subsequent nuclear ship when the performance of the Mutsu is clear.
Attention is being paid to progress in marine reactor development,
the speed-up of container ships and other trends in Japan and abroad.
The results of the private Japan-German joint evaluation study on
nuclear ships is being carefully watched.

The Government should examine the necessary steps to be taken to facilitate the smooth commercial utilization of nuclear ships.

Before commercial nuclear ships are developed, it is important that steps be taken to assure economic feasibility. It is necessary that complete experience be gained concerning ports and navigation during the experimental sailing of the Mutsu, so that data can be accumulated for the operation of future nuclear ships. At the same time, bilateral agreements and other international steps are necessary in line with international trends involving nuclear ships.

The Mutsu is expected to be ready by the middle of this year. The main purpose of the ship is to gain building and operational experience. Experimental navigation will provide data on the desirable form of ownership of the ship after 1976, and the policy of operation and management of ports used by the ship. In the meantime, the outlook for commercial use of nuclear ships is expected to become clearer. When all the facts have been collected, the target date for the development of commercial nuclear ships should be set as soon as possible.

MULTI-PURPOSE UTILIZATION OF NUCLEAR REACTORS

Multi-purpose utilization of nuclear reactors, which means the use of nuclear energy not only for electric power generation but also for the iron and steel industry, the chemical industry, the desalination of sea water and regional heating, is expected to make a great contribution to stable energy supplies in Japan, making possible the effective application of nuclear energy in a wide range of operations. This utilization will also reduce pollution of the environment, a major and growing problem, especially in the vast-energy-consuming industries.
In promoting the multi-purpose utilization of nuclear energy, conventional reactors should first be used, and high temperature gas reactors as well as techniques enabling reactor heat to be applied to wider industrial uses should be developed. This calls for a comprehensive and well deliberated plan, with co-operation between the Government and private business.
Multi-purpose reactors of comparatively low temperature conventional types are to be developed by private corporations or by local communities with government co-operation. But the Government is responsible for the initiative in establishing safety and siting standards for these reactors.

HTGR must be further examined. While it is clear that this type of reactor makes it possible for reactor energy to be applied to broader areas of industry, a series of problems which involve technological progress overseas, the industrial structure in Japan, and the development of multi-purpose utilization still remain to be solved.

But from an energy policy point of view, HTGR, generating a temperature of 1000°C or more at the outlet of the primary coolant, is considered necessary in future. This calls for research on fuel and materials with a long-term R&D programme.

An experimental HTGR should be built, taking into full account the technological achievements and the economic requirements to coincide with the industrial structure of Japan.

NUCLEAR FUSION

Nuclear fusion is the possible answer to the world energy supply difficulties, providing clean power on a semi-permanent basis. Nuclear fusion is therefore expected to be the ultimate source of energy for the future of mankind.

It is said that by 1975-1979 critical core plasma will be successfully created somewhere in the world. The present international scope of R&D is being expanded with the clear aim of building a nuclear fusion reactor, looking toward the comprehensive application of nuclear fusion reactors. In Japan, too, R&D has progressed so rapidly that our research is now regarded as an important part of the world-wide R&D programme. We are looking for good results from JFT-2 located in JAERI.

In view of this, Japan places immediate emphasis on R&D on Tokamak-type torus system facilities, with a goal of building an experimental reactor during the years 1985-1994. Plasma physics studies must move to more overall engineering. Therefore, development of nuclear fusion reactor core engineering techniques and plant engineering techniques should receive more emphasis.

By using the JFT-2 facilities, necessary data for the development of critical reactor core plasma will be gained around 1974. Based on this, critical reactor core plasma testing equipment is expected to be built between 1975 and 1984. In the immediate future, it will be necessary to heavily promote R&D on plasma heating, high magnetic field generation, kinetic control and vacuum techniques. Co-operating closely in efforts to develop critical reactor core plasma testing facilities, the development of an experimental power reactor core should be planned systematically, with the final aim of developing generation and control techniques of commercial scale core plasma.

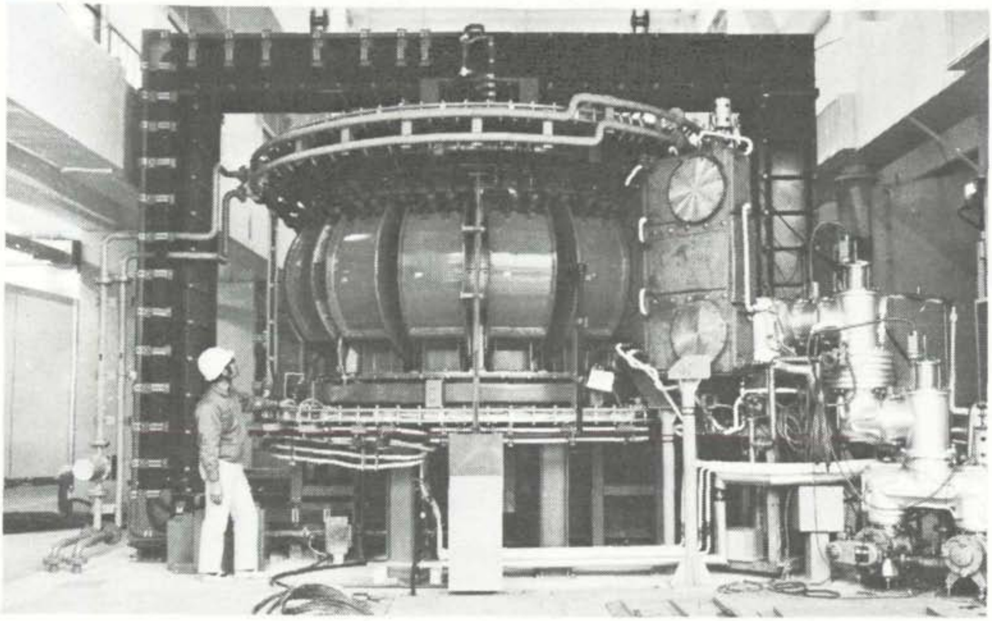
As regards the development of reactor plant engineering techniques, the experience gained from fission reactors of conventional type will be effectively turned to account. This development effort has to be done quickly, parallel to the development of core engineering techniques. Technological development related to reactor engineering, heat transfer and materials should be studied to develop component parts.

UTILIZATION OF RADIATION

Radiation has long been in use for medical purposes as well as for physical, chemical and biological studies. In recent years, radiation has found other areas of application, such as radiation chemistry, process control, cancer diagnosis and improvements in plant breeding. Radiation is expected to play an even more important role in yet wider areas of people's life and industry.

In promoting radiation utilization further, it is necessary to secure radioisotope sources, develop and standardize radiation equipment and facilities, and to pay attention to safety management and safe handling.

JAERI and other national bodies will produce short-life radioisotopes and special



"JFT-2" Nuclear Fusion Research Facility of the Japan Atomic Research Institute, in operation since April 1972.

radioisotopes, but the supply of other widely-used radioisotopes should be secured on a commercial basis. Private corporations are expected to establish their own production and supply systems on a commercial basis. R&D on the securing of radiation sources should be undertaken, using nuclear reactors, and at the same time, R&D on the production of short-life RIs using accelerators should be conducted. The technique of separating and utilizing fission products and transuranium elements from radioactive wastes from spent fuel reprocessing should be carried out mainly by JAERI and PNC.

Radiation equipment and facilities have to be small in size, light, inexpensive and have high capacity and high credibility. Large dose measuring equipment and monitoring equipment have to be developed, and all facilities and equipment must be standardized and subjected to inspection.

The utilization of radiation in various ways has reached the stage of commercial feasibility in many areas. From now on it is necessary that both the Government and private bodies co-operate. As regards radiation chemistry and food irradiation in particular, the commercial uses of radiation for these purposes should spread wide and fast, based on the results of past studies. The uses of radiation should be widened and made more intensive. It is necessary for all groups concerned to continue R&D on radiation utilization, with emphasis, for instance, on the establishment of methods of diagnosis of various diseases, application to environmental problems and food irradiation.

In promoting R&D on these subjects, national research institutes must take the lead, with the co-operation of universities and private companies. On such subjects as environmental problems, the treatment of cancer etc. which cover widely related areas, comprehensive studies should go on, with the different organizations involved each making use of their specialized functions.