Nuclear Energy in Japan — Current Status and Future

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Abstract. Based on the principle of peaceful use only, Japan has pursued development of nuclear power for the last fifty years and now 52 reactors are in commercial operation with a total installed capacity of 46 GW. Nuclear has established itself as one of the major sources of energy production, supplying one-thirds of electricity generation. In order to better utilize uranium resources and to enhance independence of energy supply, Japan has also embarked on development of nuclear-fuel- cycle program as a national policy. Progresses have already been achieved in some fields of fuel cycle activities including uranium enrichment and nuclear waste management. A large-scale reprocessing plant is now ready for test operation. However, in the last ten years, various troubles and disgraces have happened at power plants and nuclear fuel facilities which have led to a heavy loss of trust by public in the nuclear power. Facing such difficulties, the government and industry are making every effort to recover public trust and understanding in nuclear by maximizing nuclear safety and enhancing transparency and accountability. Nuclear power will play an important role in securing sustainable energy supply and in preserving global environment. Japan is determined to pursue safe and peaceful utilization of this precious source of energy in the 21 st century.

1. History of Nuclear Power in Japan

The Atoms for Peace address by the United States President Eisenhower in 1953 opened the door to peaceful uses of the tremendous potential of nuclear energy, and simultaneously provided the impetus for energy-poor Japan to launch a peaceful nuclear development program of her own.

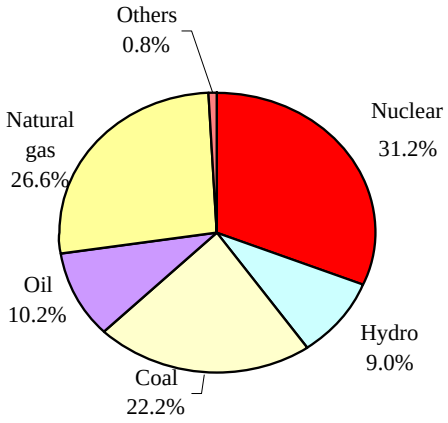
The 1955 Atomic Energy Basic Law sets out the basic principles of the nuclear energy program in Japan. The Act specifically stipulates that nuclear research, development, and utilization are to be conducted for peaceful purposes only, and calls for an autonomous,

democratically managed program on the basis of safety first principle, with all results and outcomes to be released into the public domain. These are called the three basic principles of peaceful utilization of nuclear energy. To this end, the Atomic Energy Commission (AEC) was established in 1956 with responsibility to plan, decide and oversee the basic policy of nuclear development program in Japan. Every five years, the Atomic Energy Commission reviews the progress of the development program and revises the long-term program as necessary. Also in 1956, the Japan Atomic Energy Research Institute (JAERI) was established as the central body of the nuclear research activities and the full scale research and development program started. In 1963, JAERI put the Japan Power Demonstration Reactor (JPDR) into operation which marked the first successful nuclear power generation in Japan. The private utilities also embarked on development of nuclear power generation, and the first commercial nuclear power plant at Tokaimura went into operation in 1966 (this was a gas cooled reactor(GCR) and after 32 years of operation, it was shut down in 1998). Since then, the domestic nuclear power industry has grown steadily over the ensuing years. As Table1 shows, Japan now has 52 nuclear units in operation (as of the end of FY2003) which are owned and operated by ten different private utilities. All of these units are of the light water reactor type. The total installed capacity amounts to 46 GW, and they supply about one-third of total power generation in Japan. The Japanese nuclear power industry is the third largest in the world, after the United States and France. In addition, four nuclear units are currently under construction, with another eight at the planning stage. I can proudly say that the Japanese nuclear program is moving forward steadily.

Table1. Nuclear Power Plants in Japan (as of Dec., 2003)

	Number of Plants	**Total Output(MW)**
Operational	52	45742
Under construction	4	4118
Under planning	8	10315
Total	64	60175

FIG.1. Electric Power Generation in Japan (2002)



2. Nuclear Development Policy in Japan

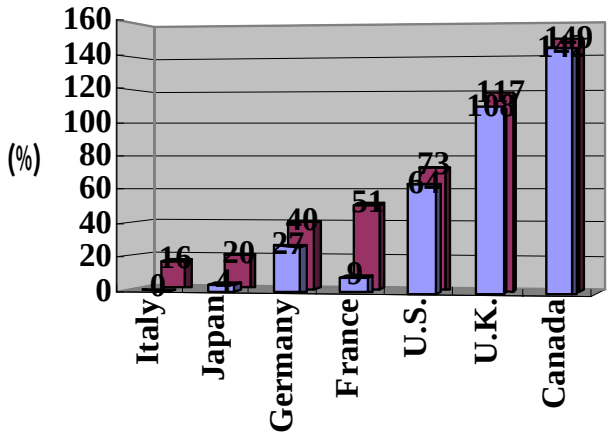
Japan has very little domestic energy resources, as evidenced by an alarmingly low energy self-sufficiency ratio of barely 4% (or just 20% if nuclear energy supplies are counted as domestic resources). As FIG. 2 shows, this is the lowest among industrialized countries. Considering that Japan's self-sufficiency ratio for food of around 40% is often regarded as a high degree of reliance on imports, her energy supplies can be considered very vulnerable indeed. Therefore, security of energy supply is one of the most important agenda in the national policy. Nuclear can play a vital role here because it consumes much less amount of fuel and provides a constant power supply over a much longer period of time than fossil fuels. Uranium fuel is also easy to stockpile, which helps to enhance the ongoing reliability of energy supplies. Furthermore, if spent fuels from reactors are reprocessed, and recovered plutonium and uranium are recycled into reactors again, nuclear power can become domestic energy and will boost energy self-sufficiency significantly. I will come back to this point later.

Another important considerations in the energy policy is global warming issue. Nuclear energy, which produces no carbon dioxide in the power generation process, provides a solution to the worsening problem of global warming and the need for drastic strategies to cut greenhouse gas emissions, while at the same time enabling Japan to meet her commitments under the Kyoto Protocol. In 2001, the reduction in CO_2 emissions attributable to nuclear power generation was approximately 230 million t-CO_2. This

figure represents approximately 17% of total CO_2 emissions of 1,300 million t-CO_2 in Japan.

Thus, nuclear power now features as a key power source from both energy security and environmental protection points of view.

FIG.2. Self-sufficiency of Energy in Industrialized Countries



Energy self-sufficiency(Including nuclear power)

Energy self-sufficiency(not including nuclear power)

Source: ENERGY BALANCES OF OECD COUNTRIES (1999-2000)

3. Present Situations

Unfortunately, a string of incidents at nuclear power plants and fuel processing facilities over the last decade has exacerbated public anxieties and concerns over nuclear power. I will briefly talk about these incidents.

• Attempts to suppress information at the time of sodium leak incident in 1995 at the Monju fast breeder reactor significantly increased public distrust of both the government and the industry. The Monju facility remains shut down to this day because repair work has been unable to proceed under such severe circumstances.

• A criticality accident at the JCO nuclear fuel processing plant in 1999 claimed the lives of two workers, the first casualties of the domestic nuclear industry. The accident exposed flaws in the quality assurance procedures at the plant and prompted the enactment of the Special Law of Emergency Preparedness for Nuclear Disaster.

• In 2002, it was revealed that internal inspection records at nuclear power plants operated by Tokyo Electric Power Co. (TEPCO) had been handled improperly, falsified in some cases, for a number of years. The discovery led to a state of emergency in which all 17 reactors of TEPCO were shut down, casting grave doubts over the safety culture of the company. Despite the company's best efforts to win back public trust, it was to be some considerable time before the reactors were finally restarted .

Compounding the heightened concerns about nuclear power as a result of these incidents is prolonged economic stagnation which has led to almost zero growth in demand for power. Under these circumstances, the nuclear development program is somewhat slowing down with some construction projects being postponed and others cancelled outright. However, in the government energy policy released last year, nuclear power retains its importance as the nation's primary source of electricity generation. As mentioned at the outset, the nuclear development program overall is still very much on track.

Now let me come back to the subject of nuclear fuel cycle in Japan.

At present, light water reactors are only capable of utilizing about 0.5% of the energy potential in uranium fuel, and the spent fuel still contains a considerable quantity of usable uranium and plutonium. Spent fuel from light water reactors can be reprocessed and the recovered uranium and plutonium can be recycled in order to make more efficient use of these resources. To this end, Japan has been exerting tremendous efforts to complete a nuclear fuel cycle in accordance with the national policy objective of developing nuclear power into a genuine domestic energy resource. The fuel cycle approach also brings environmental benefits, since recycling of uranium and plutonium produces less radioactive waste than direct disposal of spent fuel.

Technical development of the nuclear fuel cycle, originally the preserve of government agency, JNC, was gradually transferred to the private sector (in the form of development outcomes) from the mid 1980s onwards. The power companies has jointly set up Japan Nuclear Fuel Limited, which is in the process of constructing a central facilities for nuclear fuel recycling at the town of Rokkashomura in the northeastern tip of mainland Japan (see FIG. 3). A 1,050-tSWU enrichment plant is in operation, as is a low-level radioactive waste disposal facility which has already seen some 165,000 drums buried

underground. Meanwhile, about 900 vitrified high-level radioactive waste canisters which were returned from France are currently stored in a specially designed storage facility. The core facility in the fuel cycle, a fuel reprocessing plant with annual throughput of 800 t-HM, has been completed and is currently in the trial operation phase. If all goes according to plan, the commercial operation will begin in 2006(see FIG. 4). Plutonium, the final link in the fuel cycle, will for the time being be recycled into light water reactors in the form of MOX fuel. Several power companies have already initiated preparations for this, and it is expected that between 16 and 18 reactors will have introduced recycling by 2010.

FIG.3. Nuclear Fuel Cycle Planned in Japan

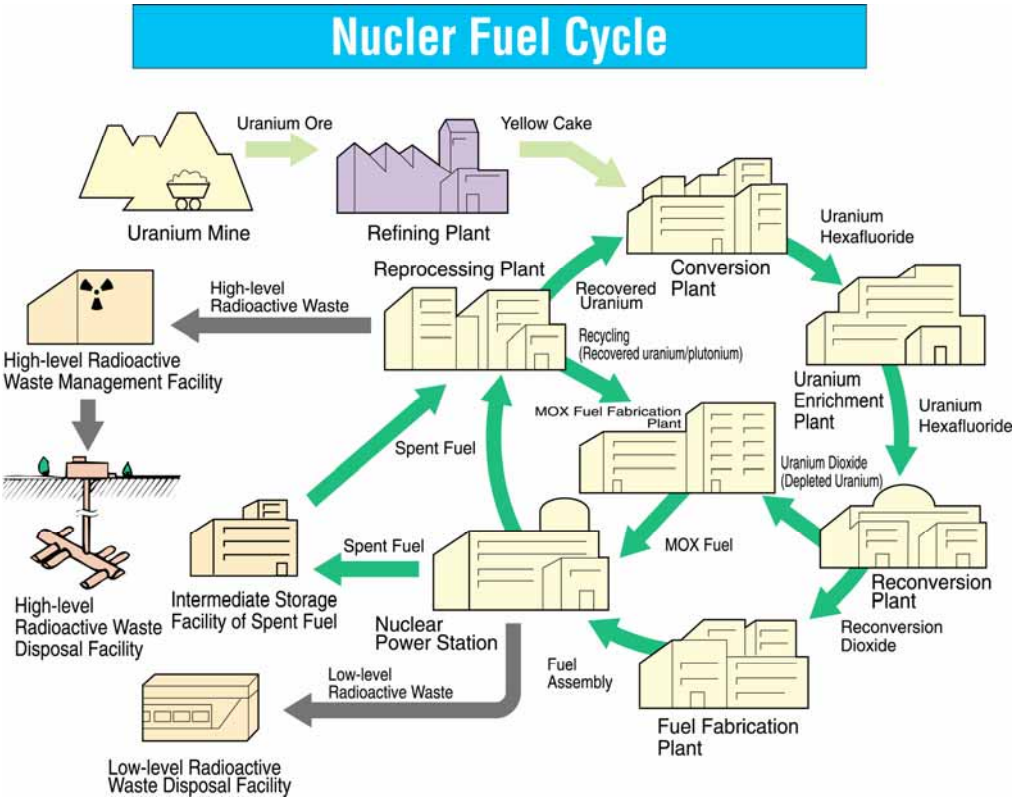
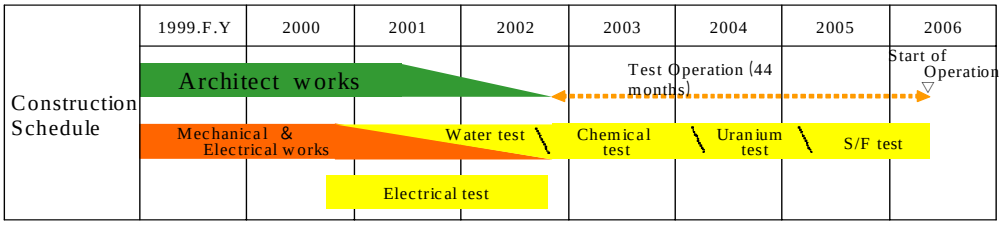


FIG.4. Reprocessing Plant(under construction)

○ Reprocessing Capacity : Max.800t-HM/y
○ Work Progress : 95% (as of Mar.,2004)
○ The Number of Workers : 1,400/day
○ Start of Commercial Operation : July.,2006



4. Future issues

We have seen that the nuclear industry in Japan has developed in line with the two basic principles of energy policy, namely, to provide stable energy supplies while alleviating the environmental impact of power generation. Notwithstanding the setbacks described above, the nuclear industry has been making steady progress. In order for us to continue to move forward, there are several issues we must strive to solve.

(1)The first is safety. As we are entering into a crucial stage of completing the nuclear fuel cycle, it is more important than ever to provide safety guarantees in every activity of nuclear power and win the support of the general public. Safety performance of nuclear power generation in Japan has shown satisfactory records. For instance, figures for 2003 show that the average number of unplanned shutdowns was approximately 0.1 per reactor, while the number of incident of INES Level 1 or higher was zero. These figures represent a perfectly acceptable level of safety. Yet history shows us that extended periods of good safety performance can often cause complacency to creep into the safety culture, with the inevitable consequence of a major incident occurring. For this reason, we must continuously strive to enhance safety levels.

(2) Second is the public understanding and trust. It must be recognized that even a high level of technical safety may not be sufficient to win public support for nuclear power. The majority of respondents to an opinion survey on nuclear power conducted by the Institute of Nuclear Safety System conceded that nuclear power was necessary but expressed concerns about safety issues and felt that the government and the power companies were unwilling to release information.

Question	Answer Yes
• Is Nuclear power Necessary?	>70%
• Is Nuclear not Safe Enough?	>80%
• Is Openness of Nuclear not Enough?	approx.70%

Thus, while safety remains the top priority, it is also important for the government and the industry to mitigate public concerns by striving to ensure transparency, actively promoting the release of information and demonstrating a willingness to keep the public properly informed.

(3) Third is cost competitiveness. In the context of the ongoing deregulation of the power industry in Japan, the cost competitiveness of nuclear power is of critical importance. While nuclear power is already considered superior to other power sources in cost terms, the industry is always looking to pursue cost reduction at all stages — construction, operation, maintenance and the fuel cycle. However, we should not forget that cost advantage of nuclear can be realized only if stable and trouble-free operation is maintained. If safety is compromised as a result of cost reduction or excessive production pressure, then the cost superiority of nuclear will be wasted.

(4) Next is aging reactors. Nuclear power has been used in Japan for over 30 years now, and the number of aging reactors is steadily increasing. When a reactor approaches 30 years of life, a comprehensive review and assessment of its safety aspects is carried out to ensure that the plant is well conditioned for safe operation for the next ten years. Periodical Safety Review as such will be conducted every ten years so that the plant life can be extended further. Ensuring the safety of older reactors and extending their usable life spans represent important issues for the industry.

(5) Fifth is nuclear fuel cycle. As I have already mentioned several times, completion of the entire nuclear fuel cycle is most important for Japan. When brought on stream, the

Rokkashomura fuel reprocessing plant will become the key facility of the Japanese nuclear fuel cycle, as will plutonium recycling for light water reactors. An intermediate storage facility for spent fuel will also need to be built by 2010 to provide long-term storage for spent fuel in excess of the processing capacity of the Rokkashomura facility.
(6) Next is fast breeder reactor. FBR technology represents one of the most obvious options for ensuring the long-term stability of nuclear energy supplies. The development of FBR technology for practical usage will necessitate restarting the Monju reactor, where operations have been suspended for a number of years after the sodium leak incident. Operation of Monju will give us an opportunity to work on breeding performance and sodium handling technology and conduct minor actinoid experiments. At the same time, we will conduct a feasibility study on advanced FBR systems by evaluating a wide range of technical options for reactor and fuel cycles with a view to coming up with basic design of candidate systems in 2015.
(7) Finally, but not the least is disposal of high level waste. The construction and management of a final disposal facility for high-level radioactive waste represents the single largest remaining issue in the nuclear industry. The legal framework for the final disposal facility was promulgated in Japan in 2000, including the establishment of an implementing body specifically for this purpose. Potential sites are now being surveyed, to be followed by geological investigations and the facility construction and the operations are planned to commence by the late 2030s. However, the site selection for the disposal facility is expected to be even more difficult than for other nuclear facilities. We remain determined and resolute in our effort to obtain residents' understanding and trust for the safety and necessity of final disposal of high level waste. (see FIG.5)

FIG.5. Projected Schedule of High-level Radioactive Waste Disposal

5. Conclusions

As we walk into the 21st century, we face serious energy-divide between the rich and the poor. Two billion people in the world still do not have access to commercial energy supply. Energy is one of the most essential commodities for economy and human life, and the quest for energy will continue to rise. Nuclear power, a form of high-technology energy developed in the 20th century, has tremendous potential as a viable energy source for the 21st century which has less environmental impact and promises a high degree of supply stability. In order to bring the benefits of this precious energy source to all mankind, it is an absolute prerequisite that all nations with peaceful nuclear development program must strictly adhere to the non-proliferation framework of IAEA including the full-scope safeguards and Additional Protocol. Also essential is international collaboration in research and development of advanced nuclear technology which is safer in use, more environmentally friendly and more proliferation resistant. As we succeed in achieving these objectives, we will be closer to sustainable development of the global society.