

# Plutonium Utilization in Japan

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Japan Atomic Energy Commission

## 1. Nuclear Power Generation in Japan

### (1) Energy Situation in Japan: Stable Supply of Energy

A stable supply of energy is indispensable for wholesome and cultured living of the Japanese people. Japan is poor in energy resources, and relies almost entirely on foreign imports for all fossil fuels such as coal, crude oil, and natural gas.

The “Long-term Energy Supply and Demand Outlook” (July 2015, Ministry of Economy, Trade and Industry) presented an outlook of Japan’s electric power supply-demand structure in FY2030, where renewable energy accounts for 22-24%, nuclear energy 20-22%. Nonetheless, the primary energy self-sufficiency ratio (including nuclear power generation) is roughly 25%, which is lower than that of other advanced industrialized countries.

### (2) Nuclear Power Generation in Japan

Japan began addressing the peaceful use of nuclear energy prompted by the President Eisenhower’s “Atoms for Peace” speech before the United Nations General Assembly in 1953. A small test power reactor (JPDR: Japan Power Demonstration Reactor, boiling water reactor) imported from the US started operation in 1959. Commercial nuclear power reactors began with a Calder Hall type reactor (GCR, graphite-moderated, carbon dioxide gas-cooled reactor) imported from the U.K. in 1965. Since 1970, light water reactors (LWRs) have been used for power generation.

At the peak there used to be 60 commercial nuclear power reactors in Japan. Three of them were designated to be decommissioned before TEPCO’s Fukushima Daiichi Nuclear Power Station Accident (hereinafter called the Fukushima NPS Accident). After the accident, six small and medium LWRs constructed in the early days, and six of TEPCO Fukushima Daiichi Power Station were designated to be decommissioned. A total of 12 were designated to be decommissioned after the Fukushima NPS Accident. There are 45 LWRs remaining at present. Conformity review on the New Regulatory Requirements introduced after the Fukushima NPS Accident is underway. Some LWRs

have already received permission and are put back online.

## 2. History of the Use of Plutonium in Japan

Plutonium is produced and accumulated in spent nuclear fuel as a result of the use of nuclear power. Since Japan is poor in energy resources and reserves of uranium were considered to be finite, Japan has adopted, from the beginning of nuclear energy use, a nuclear fuel cycle policy that uses plutonium separated from spent nuclear fuel.

The Atomic Fuel Corporation--established in 1956--started the technology development of uranium exploration and nuclear fuel manufacturing. Technology development such as spent nuclear fuel reprocessing, uranium enrichment, radioactive waste disposal also started. The project was taken over by the Power Reactor and Nuclear Fuel Development Corporation founded in 1967, and the Tokai Reprocessing Plant started its operation in 1977. The development of such technologies as uranium and plutonium mixed oxide (MOX) fuel fabrication, uranium enrichment, and radioactive waste disposal also continued. The Power Reactor and Nuclear Fuel Development Corporation became the Japan Nuclear Cycle Development Institute in 1998, when the research and development was handed over to the Japan Atomic Energy Agency (JAEA) established in 2005.

In the field of nuclear reactor development, an advanced thermal reactor “Fugen,” an experimental fast reactor “Joyo,” and a prototype fast breeder reactor “Monju” were built. “Fugen”--which began operation in 1979--was a nuclear power reactor (heavy water moderated, boiling light water cooled, pressure tube type) capable of increasing the conversion rate of uranium to plutonium, and operating with a large number of MOX fuel assemblies loaded. It stopped its operation in 2003, and is now undergoing decommissioning process. “Monju,” which began operation (first criticality) in 1994, provided various experimental results and knowledge as a prototype reactor, but stopped operation for a long period of time due to the sodium leak accidents, and other factors. In December 2016, it was decided not to resume its operation as a nuclear reactor and to be decommissioned in due course. The advanced boiling water reactor (ABWR) which was jointly developed with the US can theoretically operate exclusively with MOX fuel assemblies. A demonstration reactor of the advanced thermal reactor (ATR) has not been built.

Commercial nuclear power generation in Japan is carried out by privately owned electric power companies (nine electric power companies including TEPCO, KEPCO as

well as JAPC and EPDC<sup>1</sup>); a pluthermal<sup>2</sup> plan was formulated by the Federation of Electric Power Company (FEPC) based on the agreement among those electric power companies. Commercial nuclear fuel cycle business i.e. low-level radioactive waste disposal project, uranium enrichment project, reprocessing project, and a high-level radioactive waste management project, is also run by Japan Nuclear Fuel Ltd (JNFL) in Rokkasho Village, Aomori Prefecture, a private enterprise owned by electric power companies. While the Rokkasho Reprocessing Plant (RRP) has had once an active test run (using actual spent nuclear fuel), it is now undergoing a Nuclear Regulation Authority (NRA) review process to ascertain it meets the new safety requirements including seismic performance evaluation based on the new regulatory requirements established after the Fukushima NPS accident. The JNFL currently expects to start operating the RRP after completing necessary works to fulfill the new safety requirements and construction plan approval. An adjoining plant for the manufacturing of MOX fuel is expected to become operational following the start of the reprocessing project.

Prior to the commencement of the commercial reprocessing operation in Japan, electric power companies reprocessed their spent nuclear fuel and manufactured MOX fuel assemblies using the separated plutonium by contracting out to the U.K. and France, transported them to Japan, and used them in LWRs, and thus accumulated the experience of MOX fuel utilization.

The use of MOX fuel in LWRs started at Tsuruga Unit 1 of JAPC in 1986 using a few MOX fuel assemblies, and now each electric power company plans to use MOX fuel in about 1/4 to 1/3 of the reactor core. Before the Fukushima NPS Accident, there had been a track record of commercial pluthermal usage in four LWRs.

### 3. Japan's Policy of Plutonium Utilization

The Atomic Energy Basic Act of Japan stipulates that the research, development and utilization of nuclear energy shall be limited to peaceful purposes. As a nation that suffered from the atomic bombings in Hiroshima and Nagasaki, Japan has neither developed any nuclear weapons nor intended to do so. This led to the Three Non-Nuclear Principles<sup>3</sup>. Japan aims to realize a world without nuclear weapons.

Japan has been assuring the peaceful use of nuclear energy under stringent safeguards of the IAEA and firmly maintains the principle of not possessing plutonium

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<sup>1</sup> EPDC owns one reactor which is under construction in the Ohma NPS.

<sup>2</sup> The term "pluthermal" refers to the use of plutonium in thermal reactors (i.e. LWRs).

<sup>3</sup> the Three Non-Nuclear Principles; not possessing, not producing and not permitting the introduction of nuclear weapons

without specified purposes. Under this principle, Japan continues its efforts to gain understanding of the Japanese people and the international community and enhances transparency of its use of plutonium. At the Hague Nuclear Security Summit held in 2014, Prime Minister Shinzo Abe stated that he would fully mind the balance between separation and utilization of plutonium. The communiqué adopted at the summit encouraged States to keep their stockpile of separated plutonium to the minimum level.

#### (1) Stringent Implementation of the IAEA Safeguards for Peaceful Use

Japan concluded the NPT, and its entire materials and activities are subject to the IAEA Comprehensive Safeguards Agreement (CSA) and its Additional Protocol (AP) that were agreed to by the Japanese government.

As a reprocessing plant that reprocesses large quantities of nuclear material under the CSA, the Rokkasho Reprocessing Plant (RRP) was subject to a close examination in cooperation with the IAEA and U.S., through its design and construction phases to determine how best to carry out the safeguards procedure. Consequently, it will receive an unprecedented safeguard verification that will continually monitor the amount and the movements of nuclear material throughout the reprocessing process.

Japan has a track record of accepting the IAEA safeguards inspection for years and has been granted “Broader Conclusion” (that there is no indication of diversion of declared nuclear material from peaceful nuclear activities and no indication of undeclared nuclear material and nuclear activities in the state.) by the IAEA from 2003 to 2016; therefore, it is safe to say that the peaceful use of the Japanese plutonium is secured at a high level. Japan also promotes the strengthening of nuclear security measures.

#### (2) Publication of Plutonium Management Status

With a view to enhancing transparency and gaining understanding of the public and the international community, Japan has been annually publishing since 1994 a status report on the management of separated plutonium that is used or held within and outside of Japan, and reporting it to the IAEA in conformity with the “Guidelines for the Management of Plutonium” since 1997.

The amount of plutonium is reported in two categories; a) the amount of un-irradiated separated plutonium and b) estimated amount of the plutonium contained in spent nuclear fuel.

As of the end of 2016, the amount of Japanese un-irradiated separated plutonium was approximately 47 tons, approximately one ton less than the previous year as a result of the irradiation of MOX fuel at Units 3 and 4 of Takahama Nuclear Power Plant, and

the removal of plutonium fuel from the Fast Critical Assembly (FCA). Approximately 10 tons are held in Japan while the remaining major portion (approximately 37 tons), is held in the U.K. and France. The amount of plutonium contained in spent nuclear fuel, as reported to the IAEA, is estimated to be approximately 164 tons.

All of this plutonium is, as mentioned above, kept under the stringent IAEA safeguards.

### (3) Proliferation resistance of the plutonium held by Japan

Besides the stringent safeguards procedure, Japan has adopted a reprocessing process called co-conversion, in which both uranium and plutonium are recovered in mixture and then converted to a mixed oxide (MOX). Therefore, Japan does not keep separated plutonium oxide as a singular substance (except for trace amounts for the purpose of research and analysis). MOX itself cannot be used for nuclear weapons, and considered to be nuclear proliferation resistant.

As the Japanese plutonium separated in the U.K. and France is shipped to Japan after being fabricated into MOX fuel assemblies, there is less apprehension about nuclear proliferation either. The amount of plutonium contained in MOX fuel returned to Japan is added to that of domestic plutonium holdings.

When MOX fuel assemblies are loaded into the reactors and irradiated, the amount of plutonium contained in them is deducted from the plutonium holdings because the radiation levels after irradiation are so high making themselves inaccessible.

Estimated amount of the plutonium contained in spent nuclear fuel is also reported to the IAEA and the plutonium will not be separated before reprocessing. Because spent nuclear fuels have high levels of radiation, there is little concern over nuclear proliferation.

### (4) Japan's Basic Policy on the Utilization of Plutonium

In August 2003, the Japan Atomic Energy Commission (JAEC) adopted "the Basic Policy on the Utilization of Plutonium in Japan". It stated that Japan would not possess plutonium without specific purposes. Since then the JAEC has asked electric power companies and the Japan Nuclear Cycle Development Institute (now the Japan Atomic Energy Agency) to submit plans for the use of plutonium and has ascertained the policy is maintained in practice. This basic policy remains unchanged and consistent to date.

Furthermore, the JAEC has decided on "the Basic Policy for Nuclear Energy" on 20 July 2017. It stated that "In pursuing the effective use of plutonium, peaceful use is a major precondition. Japan, therefore, should continue to adhere strictly to the principle of not possessing plutonium without a specific purpose so as to secure international

understanding and to contribute to nuclear non-proliferation. In doing so a good attention should be paid to the balance between the production and the consumption of plutonium.”, “Japan needs to ensure the steady consumption of plutonium in the form of MOX fuel for LWRs, which is the only practical way of using plutonium as of today. At the same time, Japan needs to continue its unceasing efforts toward gaining the understanding and confidence of the international community on these plutonium related policies.” and “To utilize LWRs over long periods, nuclear energy-related organizations need to strengthen their efforts to upgrade facilities and capabilities for intermediate storage of spent nuclear fuel.”

The Cabinet decided, in its meeting on July 21, 2017, that this “Policy” should be respected by the entire government.

#### 4. Future Prospect

##### (1) Use of Plutonium in Light-water Reactors (LWRs)

In the Plutonium Utilization Plan presented by the FEPC in September 2010, 5.5-6.5 tons per year of fissile plutonium was to be used as MOX fuel in 16-18 LWRs by FY 2015. However, after the Fukushima NPS Accident of March 2011, all the LWRs in Japan stopped their operation and are undergoing a Nuclear Regulation Authority (NRA) review process to ascertain they meet the new regulatory requirements.

Six years after the accident, the NRA so far has cleared 12 LWRs. Out of them, five LWRs are back online. Of these reactors, pluthermal operation is conducted at three reactors (KEPCO’s Takahama Units 3 and 4, and Shikoku Electric Power Company’s Ikata Unit 3). The remaining LWRs will be put back online after they receive NRA clearance and finish required works. By the time the RRP starts its operation, electric power companies are to announce officially a revised plutonium utilization plan on the basis of the state of their LWRs operation resumption and the progress of pluthermal, and the Japanese government (JAEC) is to assess the appropriateness of the plans.

##### (2) The Rokkasho Reprocessing Plant (RRP) and MOX Fuel Fabrication Plant of JNFL

At present, JNFL’s RRP and MOX Fuel Fabrication Plant are undergoing a NRA review process to ascertain they meet the new regulatory requirements.

The JNFL plan is to complete the construction of the RRP in the first half of FY 2018 and the MOX Fuel Fabrication Plant in the first half of FY 2019.

As the review process is taking more time than expected, the completion of the plants’ construction may be delayed; however, the time lag between the completion of the works on the two plants would not be significantly extended.

The RRP does not plan to operate up to its maximum reprocessing capacity immediately after it completes the construction works; it plans to gradually increase its workload.

When the MOX Fuel Fabrication Plant starts operation, a certain amount of mixed oxide powder will need to be stocked as its feedstock. In case the completion and operation of the RRP goes ahead of the MOX Fuel Fabrication Plant, the amount of mixed oxide powder stock will temporarily increase. Yet it should be done that way because a certain amount of mixed oxide powder will need to be stocked for the fabrication of MOX fuel.

In addition, the “Supplementary Resolution to accompany the Bill to amend the Spent Nuclear Fuel Reprocessing Fund Act” (Committee on Economy, Trade and Industry - House of Representatives on April 20, 2016, Committee on Economy, Trade and Industry - House of Councilors on May 10, 2016) stipulates that the Minister of Economy, Trade and Industry, in the process of approving the mid-term implementation plan for spent nuclear fuel reprocessing (MRP) of the Nuclear Reprocessing Organization of Japan (NuRO), should ask for the view of the JAEC from the viewpoint of peaceful use of nuclear energy and securing the supply-demand balance of plutonium. In October, 2016, the JAEC accordingly requested the Minister of Economy, Trade and Industry to submit, before the reprocessing is carried out, the MRP showing the timing and the amount of reprocessing and fabrication related to reprocessing. The Minister of Economy, Trade and Industry has also announced that he will never approve the MRP if it is devised not in line with the government policy.

### (3) Ensuring Plutonium Supply-Demand Balance

Japan firmly maintains the principle of not possessing plutonium without specific purposes, including separated plutonium held abroad which was derived from past reprocessing overseas which was derived from past reprocessing overseas.

Japan can also secure the appropriate supply-demand balance of plutonium by consuming it through pluthermal operation.

Regarding plutonium used in Commercial reactors a) electric power companies utilize it through pluthermal operation; b) the RRP will not operate immediately at full reprocessing capacity but do only in a step-by-step manner; c) while the operation of the RRP will proceed that of the MOX Fuel Fabrication Plant due to the reprocessing of a certain amount of feedstock for the MOX Fuel Fabrication Plant's operation, the startup of the MOX Fuel Fabrication Plant will not significantly lag behind that of the RRP; d) the Japanese government assesses the plutonium utilization plans held by nuclear operations

and the MRP.

As to the plutonium used for research and development activities, the government (JAEC) will ascertain appropriateness of the plutonium utilization plan held by national research institutes such as the Japan Atomic Energy Agency and enhance the transparency by publishing it while paying due consideration to nature of the activities that require flexibly to respond to changes in the situation of research and development.

In this way, the plutonium in Japan will not keep accumulating, be managed in a steady balance although there may be some ups and downs due to the operation and processing works of the RRP and other facilities. It is the recognition of the JAEC that the goal of reducing the amount of plutonium stock held by Japan will be achieved in the long term.

It is the intention of the Japanese government (JAEC) to remain engaged to secure appropriate supply-demand balance of plutonium under the current framework of assessing future plutonium consumption by fully grasping the nuclear operators' demand for plutonium and their consumption and verifying its appropriateness.

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