

Research on Back-end Nuclear Fuel Cycle in Japan

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1. Introduction

The policy of Japanese nuclear fuel cycle is reprocessing and recycle of spent nuclear fuel. Rokkasho reprocessing plant will be the first commercial reprocessing plant in Japan planned to operate on 2018. Reprocessed Plutonium and Uranium from this facility will be recycled as mixed oxide fuel (MOX) for fast breeder reactors or commercial power plants. However, on last December Japanese government officially announced to shut down Monju fast breeder reactor which is key facility of Japanese back end fuel cycle.

The policy for nuclear fuel cycle in South Korea is still under discussion and not decided yet. In other words the policy of our government is wait and see. When we decide the direction of our nuclear fuel cycle policy, Japanese case will be a good reference for our nuclear policy.

2. Japanese nuclear fuel cycle policy

2.1. Basic principles of radioactive waste management

Radioactive wastes are managed with 4 basic principles in Japan. Those are described as follow. First, “principle of generators’ liability”. Radioactive wastes should be safely managed and disposed by who generated that and is responsible for management. Therefore, 9 nuclear power plant utilities take responsible for management of spent nuclear fuel. Second, “principle of minimization of radioactive wastes”. The amount of radioactive waste should be reduced by recycling and reduction. Therefore, Japanese government try to do reprocessing for spent nuclear fuel to decrease the volume of radioactive waste and toxicity of high level radioactive waste. Third, “principle of reasonable treatment and disposal”. The radioactive waste should be reasonably treated and disposed depending on type and level of how much contaminated or depending on characteristics of radioactive wastes. The last “principle of implementation based on mutual understanding with the public”. The radioactive waste management and disposal process should be based on transparency and all process and information are opened to public.

2.2. Spent fuel management policy

Spent nuclear fuel management policy is affected by perspective of spent nuclear fuel. There are two views of spent nuclear fuel. First, some countries like France, Russia, United Kingdom nuclear power states treated spent nuclear fuel as recyclable resources. Their policy for the management of spent fuel is reprocessing and they only dispose high radioactive waste generated from reprocessing process. On the other hands some countries treats spent fuel as radioactive waste. Their policy for management of spent fuel is generally direct disposal.

In Japan, the basic policy for the spent nuclear fuel is reprocessing and recycle. The spent nuclear fuel generated from nuclear power plants were reprocessed in abroad (France and UK) until 2011. Consignment reprocessed spent nuclear fuel were made as mix oxide fuel and send back to Japan with vitrified high level radioactive wastes. However, establishment of Japanese policy as reprocessing in their country, they started to construct a reprocessing plant in Aomori Prefecture at Rokkasho village. It is first commercial reprocessing plant in Japan built by JNFL. It is planned to operate 2018 after several times postponement of operating time.

Plutonium and Uranium separated from spent nuclear fuel is made as MOX fuel for fast breeder reactor to use for generating more fuel materials than used as fuel. MOX fuel is also used for Plu-thermal project using MOX fuel for commercial nuclear power plants.

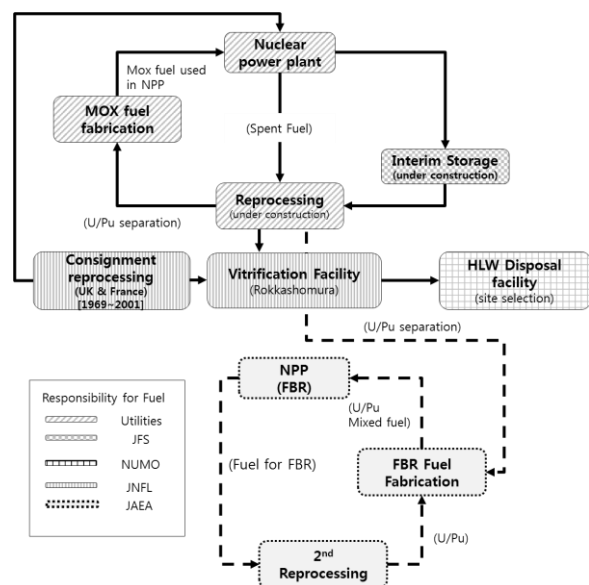


Figure 1 Back-end fuel cycle in Japan

3. Legislative and regulatory System

2.1. Legislation in Japan

In Japan, nuclear energy usage and nuclear regulation are based on the Atomic Energy Basic Act enacted on 1955. Operating, research and development for nuclear facilities are based on 3 basic principles with the Atomic Energy Basic Act. The basic principles of the act are peaceful use, safe use and independence of regulation. Acts for the spent nuclear fuel managements are prescribed in chapter 5 reprocessing service, chapter 5 verse 2 disposal service, chapter 5 verse 3 utilization of spent fuel and chapter 6 utilities for nuclear fuel cycle.

The management for the spent fuel and HLW is based on the Act for Deposit and Administration of Reserve Funds for Reprocessing of Spent Fuel from Nuclear Power Generation management. The Final disposal act prescribes to establish independent fund management institute for geological disposal of vitrified HLW generated from reprocessing of spent fuel. Governments regulate nuclear fuel cycle facilities under the Act on the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors. This act and the Act of Establishment of the Nuclear Regulation Authority prescribe the role of regulatory authorities.

2.2. Regulatory System in Japan

In Japan, regulatory authorities for back end fuel cycle are divided into 3, government for establish policy and safety regulatory body, utilities using nuclear facilities and specialized authority for management of HLW.

Governments establish policy for nuclear energy and regulates the safe use of nuclear facility and materials. The Atomic Energy Commission under the Diet makes scheme for research, development and usage of nuclear energy. Agency of Natural Resources and Energy under the Ministry of Education, Culture, Sports, Science and Technology (MEXT) establishes policy for spent fuel management including basic policy for spent fuel management and disposal of HLW with processes for practice. In Japan, the Nuclear Regulation Authority (NRA) that is extraordinary session of Ministry of Environment (MOE) establishes the safety standards and regulates spent fuel management. The Nuclear Regulation Authority was established for independent regulation as extraordinary session of the Ministry of Environment unrelated with nuclear fields after Fukushima accident.

It is Nuclear Waste Management Organization of Japan (NUMO) specialized authority for disposal of vitrified HLW after reprocessing. NUMO promotes site selection with stepwise process, construction and operation for final disposal facility. The deposited fund for spent fuel management and final disposal of HLW

from each utilities is managed by independent fund management organization which is established on Final Disposal Act is Radioactive Waste Management Funding and Research Center (RWMC). Storage of spent fuel for reprocessing is managed by Japanese Fuel Storage Company (JFS) which is established from joining investment of Tokyo Electric Power Company Inc. and Japan Atomic Energy Company Inc. on 2005.

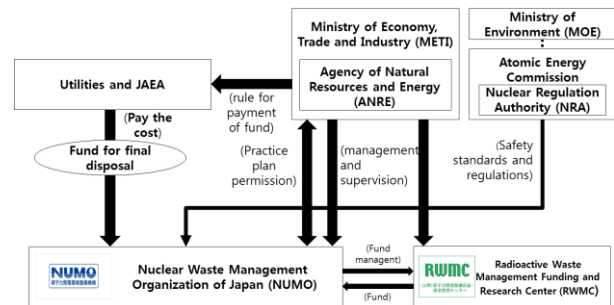


Figure 2 Nuclear Spent Fuel Management Structure in Japan

Japan has an experimental reprocessing plant in Tokaimura and now they are on construction of commercial reprocessing plant in Rokkashomura prefecture plan to operate on 2018. Japan had sent their spent fuel to France and UK for consignment reprocessing until 2011. The company established for back end fuel cycle, Japan Nuclear Fuel Limited (JNFL) consisted of utilities take charge of reprocessing abroad. They also operate the vitrified waste storage center and low level radioactive waste disposal facility in Rokkasho.

3. Spent nuclear fuel treatment facility

It was scheduled to operate the spent fuel reprocessing plant on 2014. However, after several times delay of operation, spent nuclear fuels are stored in on-site temporary storage. The major facilities for spent nuclear fuel management in Japan are as follow. There are total 48 nuclear power plants operating and shut down for satisfy the new safety regulation after Fukushima accidents (24 BWR and 24 PWR). They operate 2 reprocessing plants (1 on construction) and 2 fuel fabrication and enrichment facilities, 1 interim storage (on construction) and 2 radioactive waste disposal facilities and 2 radioactive waste storage facilities in Japan. The detail of the each facility is described as below. Reprocessing plant managed by JNFL for reprocessing of spent fuel at Rokkasho village in Aomori Prefecture did test operation from 2006 to 2014 and treated 430 tons of spent fuels. It is preparing for commercial operation on 2018. In previous Japan Atomic Energy Agency (JAEA) operated reprocessing plant in Tokaimura from 1977 to 2006 and treated more than 1,100 tons of spent fuel which is not operating now. The process for management of spent fuel in Japan is similar to other countries. Spent fuel

came out from NPP are stored in on-site temporary storage for a while, and move to interim storage for reprocessing. The HLW from reprocessing process are vitrified and disposed in geological final disposal facility. Interim storage for off-site centralized spent fuel facility is on construction at Mutsu by JFS. The total capacity of interim storage is 5,000 tons, the facility for 1st step will be 3,000 tons capacity. It will be expanded to 5,000 tons capacity adding 2,000 tons capacity facility. 1st facility is finished to construct on 2013, however, new safety regulation checks are ongoing and on 2016 impacts of tsunami and seismic was reviewed. Final disposal facility for HLW from reprocessing process is on siting. Japanese government tried to find proper site for final disposal by local government's application. However, they couldn't find site in 18 years. They changed their strategy from 2015 as selection of proper site from JAEC first, after that solving the public acceptance problem.

4. Fast breeder reactor in Japan

On last December Japanese government officially announced to shut down Monju fast breeder reactor which is key facility of Japanese back end fuel cycle. First, accident leakage of coolant sodium happened on 1995. It was re-operated on 2010 and second accident dropped of fuel loading machinery was happened. After those series of accident, Monju plant had been shut down until last year and because of economic and safety problems, government decided to shut down the Monju FBR.

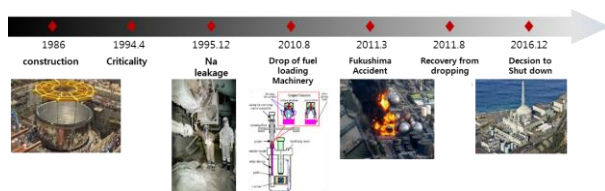


Figure 3 Events of operating Monju FBR

JAEA will submit application for re-operating Joyo experimental fast breeder reactor in this year. Japan is planning to join France fast breeder reactor ASTRID project which is 600MWe FBR using MOX fuel studied from 2010 by France CEA. Japan has collaborated with CEA for developing emergency cooling system from 2014. It is expected to join full involvement on 2016 as France proposed to Japan.

6. Political implication

Legislative and regulation acts for nuclear energy in Japan is different from South Korea. Japan regulates the each fuel cycle by regulations and acts prescribed about each steps of fuel cycle. For instance, Japan has a regulations and acts about each fuel cycle and business like enrichment, fuel fabrication and decommissioning

etc and construction, operation etc. In South Korea, they prescribe their acts and regulations about only construction and operation of nuclear facility. It is same in acts of radiation protection and physical protection.

Japanese policy is reprocessing and recycle by fast breeder reactor and Plu-thermal project. However fast breeder reactor and Plu-thermal projects have a problem and could not operate as scheduled. Reprocessed plutonium stacked in Japan is about 47.9 (2015). If Rokkasho reprocessing plants is operated on 2018 without practical way to use spent nuclear fuel, it will be keep increasing. It can be a risk for non-proliferation in the view point of having nuclear material for weaponization. Some specialists doubt about desire to having nuclear weapon in Japan. One of the solution of this can be transfer the authority of reprocessed Plutonium and Uranium to consignment reprocessing countries.

Japanese reprocessing and recycle policy for spent nuclear fuel is unsuccessful policy in the view point of economics. However it can be maintained considering recycling of natural resources and decrease of toxicity and volume of radioactive wastes. Nonetheless, it will be not easy to decide uneconomical closed nuclear fuel cycle as our nuclear policy because of the public acceptance of reprocessing is not amicable. In this year (2017), KAERI will start long term operation test of the Pyroprocessing and has a plan to operate fast breeder reactor on middle of 2040. To decide our nuclear policy as closed fuel cycle, we should thoroughly consider the safety and economics of this policy without doing hasty action.

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