

Chapter 24

Issues of HLW Disposal in Japan

Kenji Yamaji

Abstract Concerning the disposal of high-level radioactive waste (HLW) in Japan, the Nuclear Waste Management Organization of Japan (NUMO) has been making efforts toward beginning a literature survey, a first step of HLW disposal according to fundamental policies and final disposal plan based on the “Designated Radioactive Waste Final Disposal Act.” However, a difficult situation continues in which responses from municipalities, which are necessary for beginning a literature survey, are not being made.

In September 2010 the Science Council of Japan (SCJ) received a deliberation request from the Chairman of the Japan Atomic Energy Commission, and SCJ formed a Review Committee for Disposal of High-Level Radioactive Waste. The Review Committee made a Reply on Disposal of High-Level Radioactive Waste in September 2012, in which six proposals are made including safe temporal storage and management of the total amount of HLW. In this chapter, an outline of the current HLW disposal policy in Japan and the contents of the Reply are introduced.

Keywords Geological disposal • High-level radioactive waste (HLW) • Risk • Temporal safe storage

24.1 Concerns on HLW

HLW stands for high-level radioactive waste. Concern about the safety of HLW disposal is another important element for the public in deciding their choice of nuclear power along with the safety issues related to nuclear power plant operation. Former Prime Minister Koizumi changed his political stance clearly after the Fukushima nuclear accident in March 2011, from pro-nuclear to anti-nuclear, mainly on the basis of his concern about the safety of HLW disposal.

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24.2 Current Status of HLW

HLW contains very toxic fission products. Fission products in the spent nuclear fuels are highly radioactive. Some countries such as Finland, Sweden, and USA directly dispose spent nuclear fuels as HLW after cooling at spent fuel storage. According to the conventional nuclear fuel cycle policy, spent nuclear fuels in Japan are reprocessed for separating fission products from uranium and plutonium, and the separated fission products are vitrified and then contained in canisters made of stainless steel. The option of direct disposal of spent nuclear fuels was seriously discussed in the first time in Japan at the process for formulating the 2005 Framework for Nuclear Energy Policy, and after the Fukushima accident, direct disposal of the spent fuel is becoming a more realistic option.

Right now, 1,984 HLW canisters (vitrified wastes) are stored in Japan. Among the 1,984, 1,442 HLW canisters were sent back from France and UK according to the contracts for the reprocessing commissioned to these countries; the rest are the HLW canisters produced by domestic reprocessing (295 from the test operation of the Rokkasho reprocessing plant and 247 from the Tokai pilot reprocessing plant). An additional 770 HLW canisters will be sent back from the UK, and high-level liquid waste, which is equivalent to 630 HLW canisters, is stored at the Tokai pilot plant.

In addition to the HLW canisters produced by reprocessing, about 17,000 t of spent nuclear fuels is stored at nuclear power plants (about 14,000 t in total) and the Rokkasho reprocessing plant (around 3,000 t). If all these spent fuels are reprocessed at the Rokkasho reprocessing plant, about 21,250 HLW canisters would be added. Thus, even if Japan decided to no longer operate nuclear reactors, we still must dispose HLW equivalent to 24,634 HLW canisters. We cannot run away from HLW issues.

24.3 HLW Disposal Program in Japan

Japan's research and development program for HLW disposal started in 1976 (Fig. 24.1). The first progress report was released in 1992 by PNC (Power Reactor and Nuclear Fuel Development Corporation). PNC was reorganized as JNC (Japan Nuclear Fuel Cycle Development Institute) in 1998, then merged with JAERI (Japan Atomic Energy Research Institute) to be JAEA (Japan Atomic Energy Agency) in 2005).

In 1999, JNC released the second progress report, and more importantly, in 2000 the Specified Radioactive Waste Final Disposal Act (Final Disposal Act, hereinafter) was legislated.

The process for the legislation of the Final Disposal Act is shown in Fig. 24.2. As shown here, the Special Panel on Disposal of High-Level Radioactive Waste formed under the Japan Atomic Energy Commission (AEC) played an important

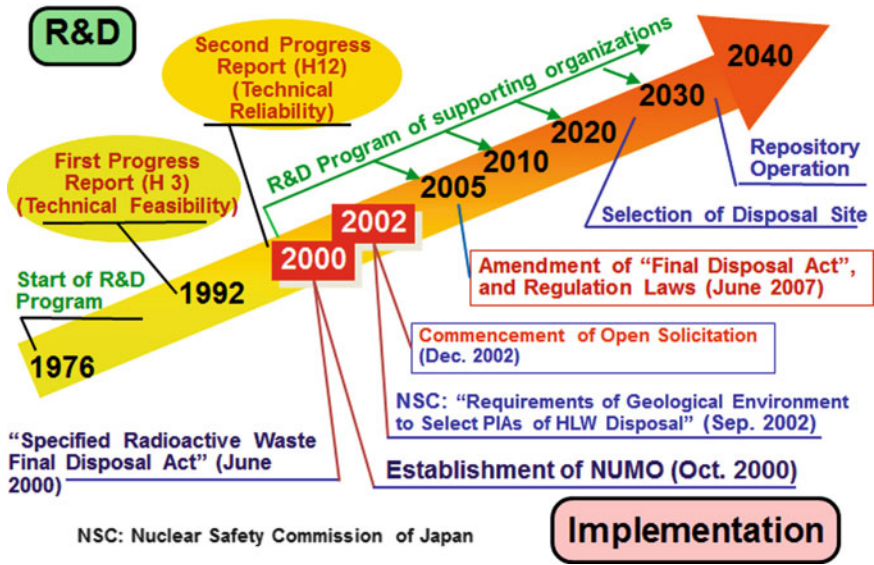


Fig. 24.1 Evolution of high-level radioactive waste (HLW) disposal in Japan (Modified from ANRE/METI and JAEA [1])

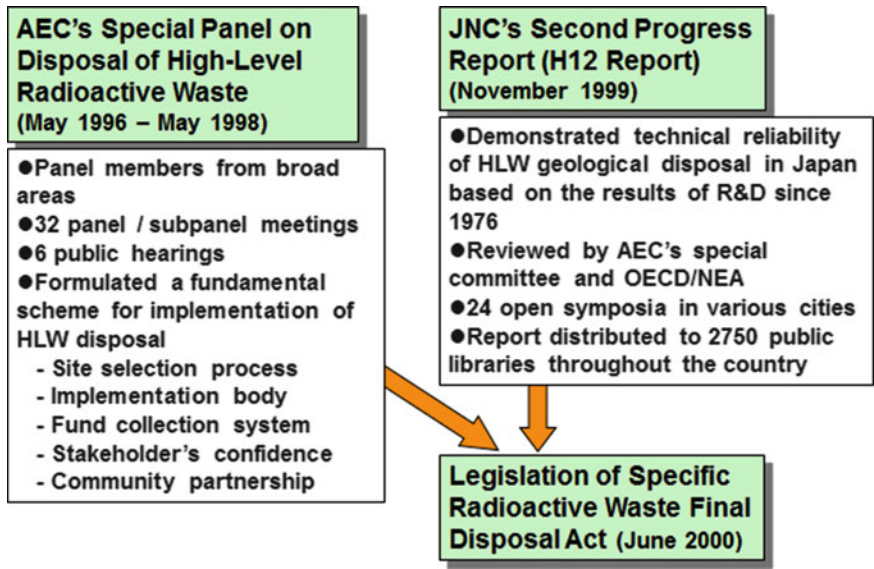


Fig. 24.2 Legislation of specific radioactive waste final disposal act (June 2000) (Private communication from NUMO on November 13, 2013)

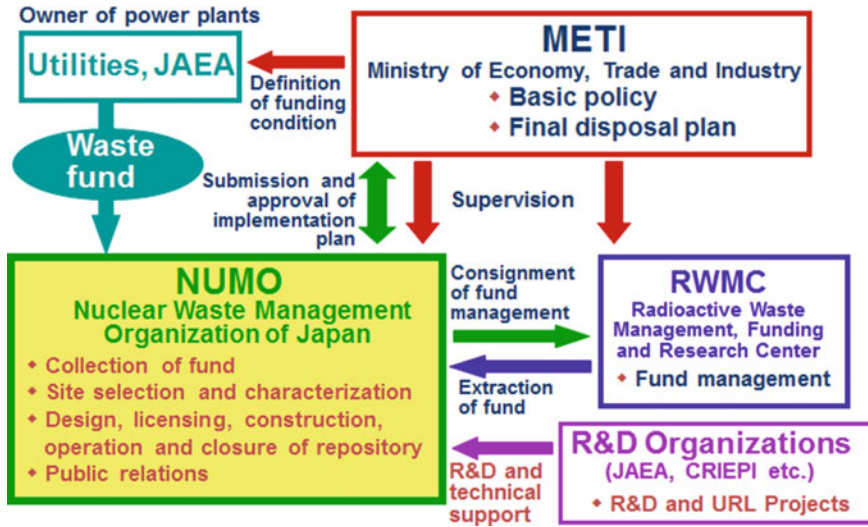


Fig. 24.3 Organizations and roles in the HLW disposal program in Japan (CRIEPI Central Research Institute of Electric Power Industry, URL Underground Research Laboratory) (From NUMO [2])

role along with the second progress report of JNC to set the contents of the Final Disposal Act.

Under the act, geological disposal is chosen for HLW disposal, and NUMO (Nuclear Waste Management Organization of Japan) was established for implementing the final disposal of HLW.

Organizational structure and the roles of related organizations set by the Final Disposal Act are shown in Fig. 24.3. As shown here, METI (Ministry of Economy, Trade and Industry) decides a basic policy and supervises all related activities. Owners of nuclear power plants provide a waste fund, which is collected from the electricity tariff, and the fund management is done by RWMC (Radioactive Waste Management, Funding and Research Center), while implementation of HLW disposal including site selection is borne by NUMO.

According to the current final disposal plan (Fig. 24.1), site of the final HLW disposal is to be selected in the 2020s and the final disposal will start in the middle of 2030s.

The Final Disposal Act was amended in 2007 to include TRU (trans-uranium) waste as a second type of specified waste (first type is HLW canisters, vitrified waste) because TRU waste is also to be disposed by geological disposal technology.

Although open solicitation for volunteer municipalities was employed for site selection, there has been no case except for a failed attempt by Toyo Town in Kochi Prefecture in 2007. Taking into account the failed attempt, METI added another scheme by the government to invite municipalities. The difficult situation, however, has continued, and after the Fukushima accident, the difficulties are increasing greatly.

24.4 Concept of Geological Disposal and Risk

Geological disposal is a globally common technology of HLW disposal for either vitrified HLW canisters or the spent nuclear fuel itself. Figure 24.4 shows the HLW disposal scheme employed in Japan, which incorporates the multi-barrier concept in the scheme. The first barrier is the vitrified HLW canister itself; the solubility of vitrified waste is very low and it is contained in a canister made of stainless steel. The second barrier is a thick package made of carbon steel, the third is a buffer made of bentonite and sand, and last, the multiply packaged waste is placed in stable host rock located deep underground.

Difficulty in securing the safety of HLW disposal comes from the requirement that risks associated with HLW disposal must be maintained below an acceptable level for a very long period, beyond 10,000 years. Whatever technical measures are taken, risks would remain. This is basically the same problem as the case of safety measures for severe accidents of nuclear power plants. The safety issue of HLW disposal, however, is more difficult because of the very long time period in which human intervention for maintaining safety cannot be expected.

24.5 Difficulty in Site Selection

According to the current basic policy for HLW disposal in Japan, the siting process is to be carried out with three stages (Fig. 24.5). The first stage is “literature survey,” the second is “preliminary investigation,” and the third is “detailed investigation.” Then, construction of the repository will start. At each stage,

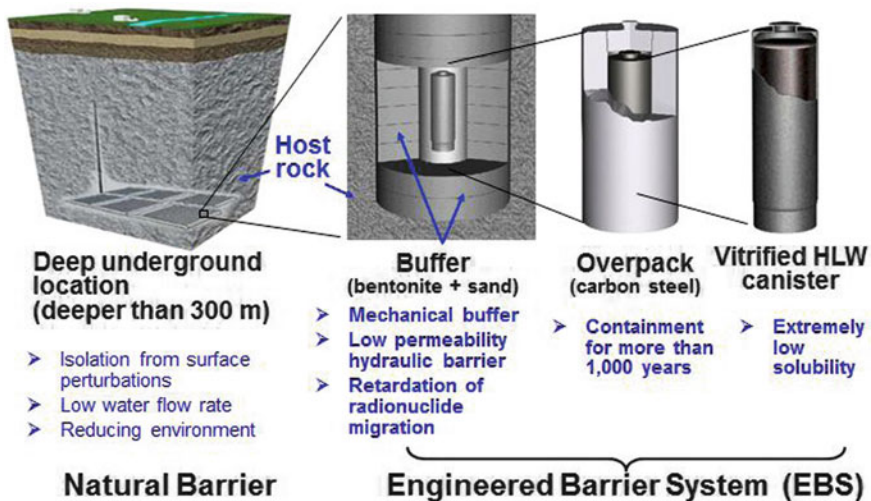


Fig. 24.4 HLW disposal scheme in Japan (multi-barrier concept) (Modified from NUMO [2])

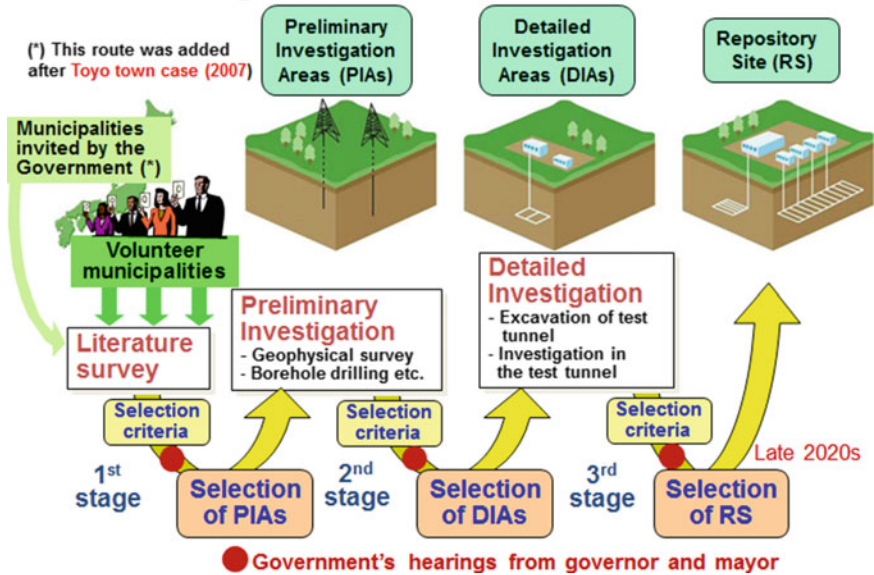


Fig. 24.5 Three stages of site selection process for HLW disposal in Japan (Modified from NUMO [2])

decisions will be made by selection criteria, taking into account the opinions of the local mayor (municipality) and local governor (prefecture).

In reality, there has been no occurrence of the first literature survey, although more than 10 years have passed since the siting process started. As mentioned before, a scheme of open solicitation was adopted for volunteers to apply for the literature survey, but after the failed attempt of Toyo Town in 2007, another scheme was added in which the government invited municipalities for the literature survey. However, the situation did not improve; rather, after the Fukushima accident the situation is becoming worse.

Facing these difficult situations, the government of Japan decided to take a more positive role in site selection. It is expected that a promising area could be more narrowly defined by screening sites on the basis of existing geological and geographical information.

24.6 Six Proposals by the Science Council of Japan

In September 2010 the Science Council of Japan (SCJ) received a deliberation request from the Chairman of the Japan Atomic Energy Commission, and SCJ formed a Review Committee for Disposal of High-Level Radioactive Waste. The author participated in the Review Committee as a member of SCJ. The Review

Committee made a Reply on Disposal of High-Level Radioactive Waste [3] in September 2012.

The Review Committee of SCJ pointed out the following six proposals to search for a path toward consensus formation: (1) fundamental reconsideration of policies related to disposal of HLW with extended definition, which includes spent nuclear fuels as well as vitrified HLW canisters; (2) awareness of the limits of scientific and technical abilities and securing scientific autonomy; (3) rebuilding a policy framework centered on temporal safe storage and management of the total amount of HLW; (4) necessity of persuasive policy decision procedures for fairness of burdens; (5) necessity of multiple-stage consensus formation by establishing opportunities for debate; and (6) awareness that long-term persistent undertakings are necessary for problem resolution.

Considering the SCJ report, the Japan Atomic Energy Commission, however, expressed its intention to maintain a policy of implementing the geological disposal on December 2012 with extension of the scope to include the direct disposal of spent nuclear fuel [4].

24.7 Setting a Moratorium Period by “Temporal Safe Storage”

Proposals of the SCJ report, particularly, the concepts of temporal safe storage and management of total amount, triggered many discussions widely concerning the issue of HLW disposal.

The temporal safe storage is characterized by securing a moratorium period of several dozen or several hundred years to establish appropriate handling measures for the problem. It provides the advantages of using this period to refine technological developments and scientific knowledge, guaranteeing the possibility of creating handling measures that target a longer period; for example, improvement of the durability of containers, development of nuclear transmutation technology to reduce volume and toxicity of HLW, and research related to the stability of geological layers.

In addition, the temporal safe storage makes it possible to keep various options for future generations to choose for final disposal of HLW.

The concept of safe storage, however, still has a wide range of uncertainties in technical specifications; for example, duration of storage, location characteristics such as on ground or underground, and number of storage facilities. The concept ranges from currently available interim storage of spent fuel to retrievable geological disposal. In fact, the response of Japan Atomic Energy Commission mentioned retrievable geological disposal in the context of temporal safe storage.

SCJ had set up a Follow-up Committee as an extension of the Review Committee in August 2013 to clarify the concept of the temporal safe storage.

24.8 “Management of the Total Amount” of HLW

As clearly stated in the SCJ report, “management of the total amount” has two connotations: “setting an upper limit for the total amount” and “controlling increases of the total amount.” “Setting an upper limit for the total amount” corresponds to the withdrawal from nuclear power, and the level of upper limit depends on the tempo of that withdrawal. On the other hand, “controlling increases of the total amount” corresponds to keeping nuclear power in the future with strictly controlling increases of the total amount, and the amount of disposed waste per unit of generated power must be controlled to the smallest amount possible. There are many technical options to control the increase of the total amount of HLW, for example, increasing burn-up of fuels, transmutation of radioactive nuclides, and longer temporal storage of HLW, which secure time for radioactivity to decay.

However, in fact, many readers of the SCJ report mistakenly recognized that management of the total amount means setting an upper limit for the total amount, and thus believed that SCJ proposed withdrawal from nuclear power: this is a complete misunderstanding. At the background of the proposal of management of the total amount, there is recognition that we should respond to the concerns on the limitless increase of HLW.

24.9 Awareness of the Limits of Scientific and Technical Abilities

The Review Committee of SCJ consists of various experts from wide-ranging academic fields from physical science, engineering, life science, social science, and humanities. The proposal concerning awareness of the limits of scientific and technical abilities was formed through interdisciplinary discussions among the experts. Some readers of the SCJ report seem to have felt uneasiness with this proposal because this proposal apparently cast a scientific doubt on the feasibility of the geological disposal of HLW. To the author’s understanding, this proposal is a rather general statement that there is no perfect scientific evidence to support the safety of HLW disposal for more than 10,000 years.

Having heard the discussions related to this proposal, the author recognized there are many different academic approaches depending on the field of science. For example, natural scientists seek truths in natural phenomena, whereas engineers try to make things and/or systems that are valuable and acceptable for human society. HLW issues are related not only to various fields of science, but also to value systems shared by society. Here again, the author was convinced that we need to reflect more deeply on the relationship between science and society.

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