

Site Selection for the Disposal of LLW in Taiwan

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ABSTRACT

This paper presents the implementation status of the low-level radioactive waste (LLW) disposal program in Taiwan, including the disposal facility regulations, status of waste management, final disposal program, licensing procedures, waste acceptance criteria, site selection criteria and processes and preliminary disposal concepts.

The first phase of site selection for low-level radioactive waste final disposal in Taiwan was implemented between 1992 and 2002. The site selection process adopted a Geographic Information System (GIS), Hierarchical Analysis System, Expert Evaluation System, and site reconnaissance. An incentive program for voluntary sites was also initiated. After a series of evaluations and discussion of 30 potential candidate sites, including 8 recommended sites, 5 qualified voluntary townships, and several remote uninhabited small islets, Hsiao-chiou islet was selected as the first priority candidate site in February 1998. The geological investigation work in Hsiao-chiou was conducted from March 1999 through October 2000. An Environmental Impact Statement Report (EIS) and the Investment Feasibility Study Report (IFS) were submitted to the Environmental Protection Agency (EPA) in November 2000 and to the Ministry of Economic Affairs (MOEA) in June 2001, respectively. Unfortunately, the site investigation was discontinued in 2002 due to political and public acceptance consideration.

After years of planning, the second phase of the site selection process was launched in August 2004 and will be conducted through 2008. It is planned that a repository will be constructed in early 2009 and start to operate in 2014. The site selection process for the second phase is based on the earlier work and four potential candidate sites were selected for evaluation until 2005. A near surface disposal concept is proposed for a site located in the Taiwan strait, and cavern disposal concepts are proposed for three other sites located on the main island.

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procedures, waste acceptance criteria, site selection criteria and processes, and preliminary disposal concepts

“NIMBY” (Not in my backyard) is a critical problem for implementation of the final disposal project. Resistance from local communities has been continuously received during site characterization. To overcome this, an incentive program to encourage community acceptance has been approved by the Government. Programs for community promotion are being proposed and negotiations are also underway.

INTRODUCTION

At present, there are three nuclear power plants (NPPs) in Taiwan, with six units in operation and one plant with two units under construction. The total installed capacity is 7,844 MW(e), which provides about 15% of Taiwan's total power generation. Assuming 40 years of operation for all four NPPs and accumulation of LLW from small waste producers to 2045, the total quantity of LLW will be nearly 973,000 drums, including 293,000 drums of operations waste and 680,000 drums of decommissioning waste. Total estimated radioactivity will be nearly 25,400 Ci [3]

For the organizations responsible for radioactive waste management in Taiwan,. both the Atomic Energy Council (AEC) and the Ministry of Economic Affairs (MOEA) are under the Executive Yuan (the Cabinet). The Fuel Cycle and Materials Administration (FCMA), a subordinate organization to the AEC, assumes regulatory control over radioactive waste management matters. The Institute of Nuclear Energy Research (INER) was empowered by the AEC to take responsibility for managing radioactive waste generated by medical, industrial and research applications. In the Taiwan Power Company (TPC), the Nuclear Backend Management Department (NBMD) is responsible for managing radioactive waste produced by Nuclear Power Plants (NPPs), the operations of the Lan-yu Storage Facility and the Volume Reduction Center (VRC), and LLW disposal and spent nuclear fuel interim storage and disposal programs.

REGULATIONS

The “Regulations on Final Disposal of Low Level Waste and Safety Management of the Facilities” [1] document defines the waste classification, waste-form quality, and siting criteria. The regulations include the following features:

- Based on the concentrations of the radionuclides, LLW is classified as Class A, B, C, and Greater Than Class C (GTCC). GTCC waste may not be disposed in the LLW disposal facility unless it is approved by the competent authority.
- Siting of LLW disposal facilities must be avoided in areas of active faulting, ecological protection areas, known important natural resources areas, and high population density and development potential areas.

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- The design of LLW disposal facilities shall ensure the annual effective equivalent dose to a member of the general public outside the facility is not more than 0.25 mSv per year, and conform to the as low as reasonably achievable principle.
- After the LLW disposal facility is closed, the disposal control area shall be monitored for not less than five years.

LICENSING PROCEDURES

For the LLW repository, there is a three-step licensing process:

- Environmental impact assessment (EIA) process: The Environment Protection Agency (EPA) approves the EIS/EIA report.
- Investment feasibility study (IFS) process: The Ministry of Economic Affairs (MOEA) makes the site confirmation and investment decision, but an approval by the Executive Yuan is required.
- Construction and operating license application approval process: The Atomic Energy Council (AEC) approves the Safety Analysis Report (SAR) and associated documents.

SITE SELECTION CRITERIA

The candidate site for the LLW final repository should satisfy the following criteria, using information developed from earlier studies and first phase work. These criteria are defined in an Institutional Rule of the Legislative level in Taiwan. LLW disposal facility sites shall meet the following provisions:

1. Areas must be avoided in areas of active faulting or other areas likely to influence the safety of the disposal facilities.
2. Areas must be avoided where geochemical conditions are unfavorable for effectively suppressing the diffusion of radioactive nuclides and are likely to endanger the disposal facilities.
3. Areas must be avoided where the surface and underground hydrographic conditions and geology are likely to endanger the disposal facilities.
4. Areas must be avoided in ecological protection areas that are already known or announced by the government.
5. Areas must be avoided in the vicinity of known important natural resources or announced by the government as national resources.
6. Areas must be avoided in historical protection areas that are known or announced by the government.

7. Areas must be avoided in the vicinity of high population density and development potential.

FIRST PHASE SITE SELECTION

As the principal producer of LLW, TPC is charged by the government to assume the responsibility of establishing a repository. The first phase of the LLW disposal project was launched in October 1992. TPC entrusted the work to Pacific Engineers & Constructors, Ltd. (PECL) and its subcontractors, including Bechtel National, Inc. and the Energy & Resources Laboratory (ERL) of the Industrial Technology Research Institute (ITRI). The site selection process adopted a geographic information system (GIS), hierarchical analysis system, expert evaluation system, and site reconnaissance. Eventually, eight potential candidate sites were proposed for further consideration. However, public resistance was continuously received during the site selection process. Therefore, an initiative program for voluntary sites was developed. Subsequently, five voluntary townships were being qualified, but they withdrew their application after some information was made public and local resistance developed. Regardless of the public resistance, TPC conducted the evaluation of 30 potential candidate sites, including the 8 recommended potential candidate sites, 5 qualified voluntary townships, and several remote



Fig. 1. Locations of nuclear facilities in Taiwan

uninhabited small islets. After a series of discussions, the Hsiao-chiou islet was selected as the first priority candidate site for detailed investigation.

The Hsiao-chiou islet has an area of 32 hectares and a maximum elevation 33 m above mean sea level. It lies about 70 nautical miles to the west of Taiwan and 20 nautical miles from the eastern coast of Mainland China, as shown in Figure 1. The rock type of Hsiao-chiou islet consists mainly of granite and includes some intermediate to basic dikes such as diorite and dolerite. A geologic survey of Hsiao-chiou islet was conducted from June 1998 to March 2000. Survey activities included geologic boring, rock properties and mechanics, borehole logging, geohydrologic study and geochemical investigation.

For the Hsiao-chiou site, a sub-seabed cavern disposal concept was proposed [5]. The repository would be located 100 m below sea level with at least 50 m rock overburden. A circular access tunnel 4,164 m long, 8 m wide, and 7 m high was designed to connect the surface and underground facilities. A total of 28 disposal tunnels would be needed for disposal of 980,000 drums. Each disposal tunnel is 192 m long, 12 m wide and 12 m high, and is divided into ten disposal cells. The 55-gallon waste drums would be stacked vertically with 9 layers and the voids between the drums grouted. The spacing between disposal tunnels is 24 m.

TPC submitted the Environmental Impact Statement Report (EIS) to the EPA and the Investment Feasibility Study Report (IFS) to the MOEA in November 2000 and June 2001, respectively, for review. The review comments asked TPC to take the political and public acceptance problems into account. Finally, MOEA announced the abrogation of the Hsiao-chiou site in August 2002.

SECOND PHASE SITE SELECTION

After years of planning, a second phase site selection project started on August 2004 and will end in December 2008. The working team is composed of Sinotech Engineering Consultants (SEC), Swedish Nuclear Fuel and Waste Management Co. (SKB), and INER. The second phase of the site selection process is based on the first phase work and the management plan is divided into the four stages shown in Figure 2 [2].

In the first stage, four possible sites will be selected from 30 candidate regions by reviewing and updating the earlier first phase studies. In the second stage, site investigation work will be conducted for the four possible sites to narrow the selection down to three candidate sites based on an evaluation of socioeconomic, political, environmental, and technical factors. In the third stage, the site characteristics, preliminary repository design, performance assessment, cost estimate and schedule plans of the three candidate sites will be evaluated, the preliminary feasibility study

report will be submitted, and the first priority candidate site will be recommended to MOEA. In the fourth stage, the detailed site investigation, repository design, performance assessment, cost estimate and schedule plans of the first priority candidate site will be conducted. Finally, the investment feasibility study report will be submitted to MOEA for approval by the Government, and the final disposal site for LLW decided.

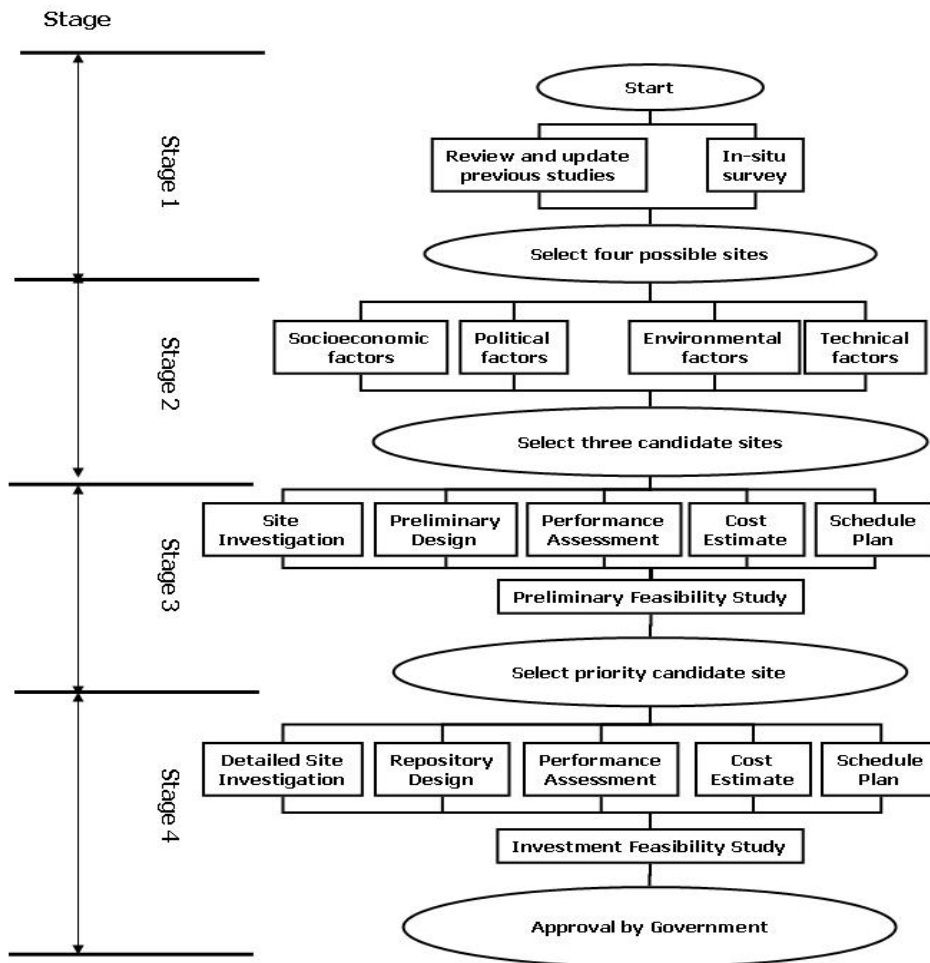


Fig. 2. The Stages of Second Phase Site Selection

Following the selection process described above, four possible sites were selected in September 2004. The location of these four sites is shown in Figure 3, three located on the main island and

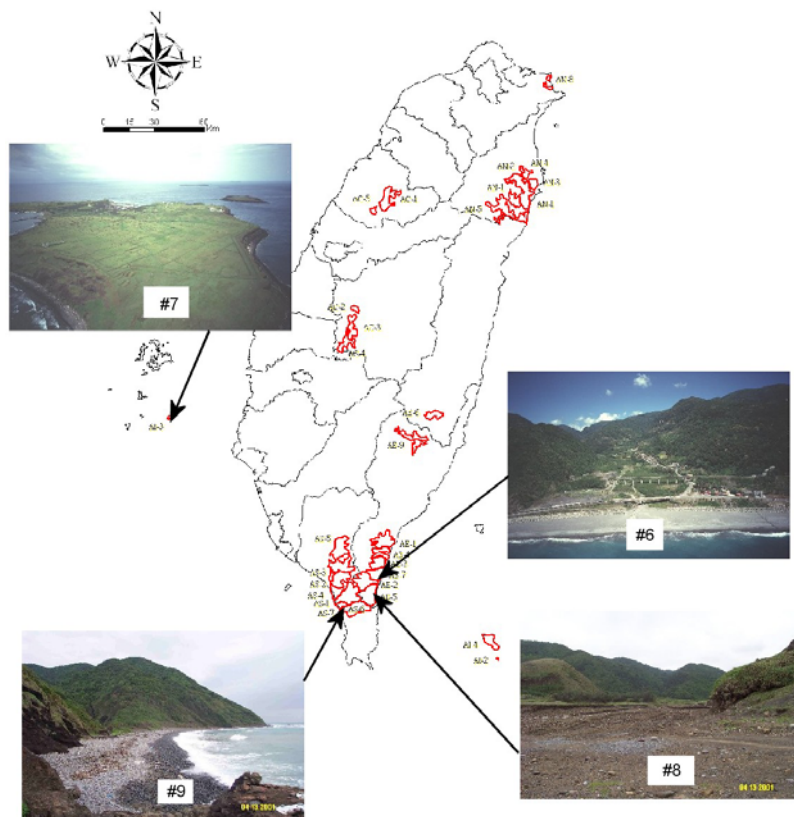


Fig. 3. Potential candidate sites

one located in the Taiwan archipelago [4]. Two different disposal concepts were proposed, depending upon the geographical and geological conditions of the individual sites.

For site No. 6, the highest peak in this area is 1,929m with an average gradient of 70 m/km. The rock types are mainly slate/argillite with subordinate meta-sandstone. Slaty and pencil cleavages are well developed in this area. A mined cavern disposal concept is proposed for this site, as well as for the similar sites No. 8 and No. 9. Two portals are designed for the repository at an elevation of 85m. The repository is composed of two access tunnels and twenty-one disposal tunnels. The disposal area is at an elevation of 125m. The overburden decreases from 640 m at the northwestern side to 220 m at the southeast side. The spacing between parallel access tunnels is about 400 m. The western access tunnel is used for entry, and is 2,120m long with a +2% slope. The eastern access tunnel is used for exit, and is 2,490m long with a slope of +1.5% to +2%. Disposal tunnels are constructed with concrete linings and have an inside height of 11.6 m. Each disposal tunnel is 400 m long, and the spacing between tunnels is 63 m. The disposal tunnel can be divided into 10 cells, each of which is nominally 7.6 m wide by 8.3 m high by 35.1 m long. Waste drums will be emplaced vertically in each section 12 drums wide

and 7 drums high. Each disposal cell has approximately 56 sections for a total of 4,704 drums. Each disposal tunnel can therefore dispose of about 47,040 drums.

Site No.7 is an island with total area of about 1.8 km² located at the southern part of the Taiwan Strait. The middle part of the site is lowland with elevation less than 10 m; which divides the island into northern and southern terraces. The major rock type of the island is basalt. A near surface disposal concept with earth mounded concrete bunkers is proposed for this site. The repository has three disposal units, two on the northern terrace and one on the southern terrace. The disposal units are built as concrete structures, with 360, 294, and 360 disposal cells, respectively. Each disposal cell is nominally 7.6 m wide by 7.6 m long by 7.5 m high. Each disposal cell can accommodate 1,008 drums, using a geometry 12 drums wide by 12 drums long and 7 layers high.

CONCLUSIONS

Through 2005, the current status of the second phase site selection process for a LLW final repository in Taiwan has been the selection of four sites based on a thorough evaluation of possible candidate sites. The most difficult problem encountered is the NIMBY effect (Not in My Back Yard) during the site selection process. Due to this problem, borehole drilling has been postponed until December 2005. To overcome this problem, an incentive program to encourage community acceptance has been approved by the MOEA, which will give certain policy compensation and bring local economic and social welfare programs when the people of the affected county accept the borehole drilling study intended to enhance understanding of the geological characterization of the sites.

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