

# Spent Nuclear Fuel Final Disposal Management in Taiwan

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**Key words;** Spent Nuclear Fuel, Final Disposal, Radioactive Waste Management

## Abstract

According to “Nuclear Materials and Radioactive Waste Management Act”, Taiwan Power Company (TPC) has responsibility to well manage the spent nuclear fuel (SNF) that generated from its nuclear power plants. In 2004, TPC submitted a “Spent Nuclear Fuel Final Disposal Plan in Taiwan (hereinafter referred to as the “Disposal Plan”)” to the regulatory authority (Atomic Energy Council, AEC). According to the Disposal Plan (revised in 2014), the period from 2005 to 2017 is considered as the “Potential Host Rock Characterization and Evaluation Stage”. There are two missions: (1) to complete two milestone reports including “Preliminary Feasibility Assessment Report for the Spent Nuclear Fuel Final Disposal Technology in Taiwan (abbreviated as the SNFD2009 report)” and “Technical Feasibility Assessment Report on Spent Nuclear Fuel Final Disposal (abbreviated as the SNFD2017 report)” to demonstrate the technical capabilities in Taiwan, and (2) to propose recommended survey areas to continue more detailed investigation in next stage.

In this study, the achievements of SNFD2017 report are described and then propose a siting procedure for survey areas of candidate sites. In order to respond the new government’s policy “no nuclear power plants operate in Taiwan after 2025”, a “Nuclear-free Homeland Task Force” has been established in Taiwan to discuss national nuclear strategies. Thus, the relevant current status and strategies are also presented (e.g., the status of a dedicated agency of radioactive waste management in Taiwan, the future siting procedure of candidate sites, and public engagement).

## 1. Introduction

Taiwan has been using nuclear power for electricity generation since 1978. To this day, there are a total of six nuclear power units in operation in three nuclear power plants. Among them, four nuclear power units are boiling water reactors (BWR), and the other two units are pressurized water reactors (PWR). Furthermore, two advanced boiling water reactors have been under construction but were being mothballed since 2015.

As to financing the cost of nuclear back-end management, starting in 1987, TPC has been depositing annual fees at a rate of NT\$ 0.17 per kilowatt-hour of generated nuclear electricity in Nuclear Back-end Fund (NBEF). To September, 2017, the cumulative fund has reached NT\$ 327 billion.

In order to ensure the SNF could be well managed in Taiwan, TPC submitted the Disposal Plan in 2004 which was reviewed and approved by AEC in 2006, and revised in 2010 and 2014. The Disposal Plan is divided into five successive stages (see Fig. 1).

According to the schedule proposed in the Disposal Plan, candidate sites for the SNF final

disposal in Taiwan should be decided by the end of 2028, and the final disposal site should be decided by the end of 2038, as well as the repository should start to operate by 2055.



Fig. 1

## 2. Current status

According to the Disposal Plan, we are in the end of the first stage “Potential Host Rock Characterization and Evaluation Stage”, which sets two goals needed to reach by this year (2017). One is to submit SNFD2017 report to demonstrate our capabilities, the other is to recommend appropriate survey areas as candidate sites in next stage for the investigation.

Two institutes, Industrial Technology Research Institute (ITRI) and Institute of Nuclear Energy Research (INER), now are mainly involved in the Disposal Plan with TPC to implement geological survey, disposal technologies and safety assessment related R&D projects.

In addition, in the January of this year our new government had amended the Electricity Act, clearly state that the target of nuclear-free homeland will be achieved by 2025 in Article 95. In order to respond the amendment, a “task force of nuclear-free homeland” had been grouped under national development council of Executive Yuan to consult the corresponding national nuclear strategies. According to the amendment, the mothballed nuclear power units will be abolished and the operating periods of existing units will not be extended beyond their design life (40 years). So, it is estimated that around 5,000 tons uranium of SNF (see Fig. 2) will be generated by these six nuclear power units for 40 years of operation.

Nuclear Power Plant	Fuel element weight	Unit 1	Unit 2	Six units total
	kgU/bundle	fuel assemblies	fuel assemblies	
Chinshan(BWR)	178.5	3,694	3,652	4,913,220
Kuosheng(BWR)	178.5	5,580	5,676	
Maanshan(PWR)	417.5	1,894	1,921	

Note: forty years of operation

Fig. 2

## 3. SNFD2017 report

Taiwan started to conduct the final disposal related projects for SNF since 1986. The general concept is based on the deep geological disposal method which is widely adopted by the international community. According to the research results from Taiwan’s SNF disposal program over the past 20 years suggested that there are three kinds of potential rock (granite, mudstone, and Mesozoic basement rock) in Taiwan. At present, granite is considered as the preferred host rock for the geologic repository in Taiwan and has been chosen as reference case.

The SNFD2017 report mainly focus on the scientific feasibility and demonstrate related R&D efforts of SNF final disposal in Taiwan’s granite rock. There are three major objectives were set by AEC including (1) to confirm whether a scientifically suitable granitic rock body for geological final disposal could be identified in Taiwan or not, (2) to confirm whether adequate engineering capabilities

for constructing a geological repository have been established in Taiwan or not, and (3) to confirm whether adequate capabilities for assessing the long term safety for a repository site have been established in Taiwan or not.

Furthermore, in order to take advantage of international R&D results and experiences as well as in view of the similarity of geological environments in Japan and in Taiwan, the AEC also requested that the structure of the SNFD2017 report should be based on the Japanese H12 report (H12: Project to establish the scientific and technical basis for HLW disposal in Japan). So, refer to the H12 report, the SNFD2017 report contains one main report and three technical supporting reports including (1) Geological Environment of Taiwan, (2) Repository Design and Engineering Technology, and (3) Safety Assessment.

There are total seven chapters in the SNFD2017 main report (see Fig. 3). Chapter 1 describes present Taiwan’s current status consisting of overview of SNF characteristic, Disposal Plan, and related regulations. Chapter 2 introduces the geological disposal concept we applied and several safety cases constructed by other countries. Chapter 3, 4, and 5 are the main chapters in accordance with AEC’s three major objectives respectively.

Chapter 3 is to briefly introduce Taiwan’s overall geological environment and compiled to highlight the geological characteristics regarding to the scientific requirement of a suitable candidate site. The feasibility of siting a repository in Taiwan was evaluated considering the volcanism, seismic event, diapirism, denudation, etc.. Long-term stability of potential host rocks, granite, mudstone, and Mesozoic basement rock, have been compared. We also integrated all the geological characterization results of a western offshore granitic islands, K area, as reference case to demonstrate the capabilities of field investigation as well as to establish a conceptual geosynthesis model for following safety assessment.

At present, the KBS-3 disposal concept developed by Swedish SKB is adopted in the SNFD2017 report. The feasibility of KBS-3 disposal concept in Taiwan and related engineering technology capability are discussed in chapter 4.

Based on the geological conceptual model of reference case and repository design described in chapter 3 and 4, we also followed the safety assessment methodology applied in the SR-Site report developed by SKB to proceed safety assessment. The technical feasibility and research achievements of safety assessment are demonstrated in chapter 5.

Since the regulation for siting and related procedure are not well prepared in Taiwan now, chapter 6 reviews the domestic studies and then proposes a procedure starting from screening, survey and confirmation with three concept principles

including disposal safety, public acceptance, and stepwise siting with feedback improvement mechanism for site selection in next stage.

Finally, chapter 7 summarizes all the results of the research and development presented in the previous chapters. For the upcoming next stage, Potential Site Selection and Approval, a preliminary plan is also described in this chapter.

SNFD2017 report had been reviewed by an international peer review team (IRT) supported by OECD/NEA during March to September, 2017. We will integrate and response all the comments and then deliver to our regulatory authority at the end of 2017.

The framework of the SNFD2017 main report	
Chap 1.	The Spent Nuclear Fuel Management Strategy and the Geological Disposal Program in Taiwan
Chap 2.	The Geological Disposal System and the Safety Concept
Chap 3.	The Geological Environment of Taiwan
Chap 4.	Repository Design and Engineering Technology
Chap 5.	Safety Assessment
Chap 6.	Technical Basis for Site Selection and Development of Safety Standards
Chap 7.	Conclusions and Future R&D Requirements

Fig. 3

#### 4. Proposed siting procedure

To date, there are no regulation on siting for high level radioactive waste disposal in Taiwan. Preparing for the goal to recommend appropriate survey areas as candidate sites for next stage, we tried to propose a concept of two-step siting procedure refer to the domestic studies and related restrictions written by law.

The first Area Exclusion Stage is to apply exclusion factors to screen the area with apparent fatal weakness in geological or social aspects from whole territory. The exclusion factors are planned to be composed of two categories including based on policy or regulation (e.g. Soil and Water Conservation Act, National Park Law) and based on geological characteristics (e.g. active fault, volcanism, diapirism). The inappropriate areas will be excluded from beginning through this procedure.

The next Assessment Stage is to assess the remaining areas after screening. The assessment factors (e.g. host rock size, groundwater flow,

geochemical condition) will be applied to conduct complete evaluation and comparison. All the results and information will finally be submitted to regulatory authority as reference and basis for site selection.

Although we are lacking support of specific act for siting high level radioactive waste final disposal facility at this stage, a study for the act on sites for establishment of high level radioactive waste final disposal facility has been in progress. Refer to the siting experience of low level radioactive waste in Taiwan, local agreement rather than referendum will be considered. That means the whole siting procedure will be consent based and a public communication platform would be needed.

#### 5. Nuclear-free Homeland Task Force

A “Nuclear-free Homeland Task Force” had been established in early this year following new government’s policy and is chaired by Minister without Portfolio under Executive Yuan. The two Vice Chairperson are undertaken by Administrative Deputy Minister of Ministry of Economic Affairs and the representative of non-governmental organization (NGO) respectively.

Its first meeting was held on May 3<sup>rd</sup>, 2017, several conclusion regarding SNF disposal were made. We need to keep transparency to general public for all information. The legislation for siting procedure is needed and based on the public consensus. Domestic direct disposal is our first priority and should be actively implemented, but extraterritorial disposal option isn’t excluded.

#### 6. Dedicated agency

Referring to international experiences, the establishment of dedicated agency for radioactive waste management was proposed by Ministry of Economic Affairs in 2014. The domestic NGOs, scholars, and experts were then grouped to arrange seven workshops to discuss the feasibility and tried to reach a consensus. After two years’ internal coordination and discussion between government departments, a draft proposal of dedicated agency was finally approved by Executive Yuan in the end of 2016. This draft is under discussion by several committees of Legislative Yuan now. According to the draft proposal, there shall be no less than one-third of the representatives from NGOs, unbiased members of the society, and local residents around the candidate sites of repository to establish the board of directors.

#### 7. Summary

In the end of this year, TPC will complete SNFD2017 report to demonstrate the technical capabilities of spent fuel final disposal in Taiwan, and proposed siting procedure for survey areas of

candidate sites as a sound basis for progressing to the next stage. Before the promulgation of siting regulation, the R&D plan for the next stage “Candidate site selection and approval” will continue to follow our Disposal Plan and mainly focus on the preparation of site investigation.