

---

# **Radioactive Waste Management in Taiwan**

---

Wen-Chung Liu  
Fuel Cycle & Materials Administration  
Atomic Energy Council  
Taiwan (R.O.C.)  
Jan. 29, 2013

---

---

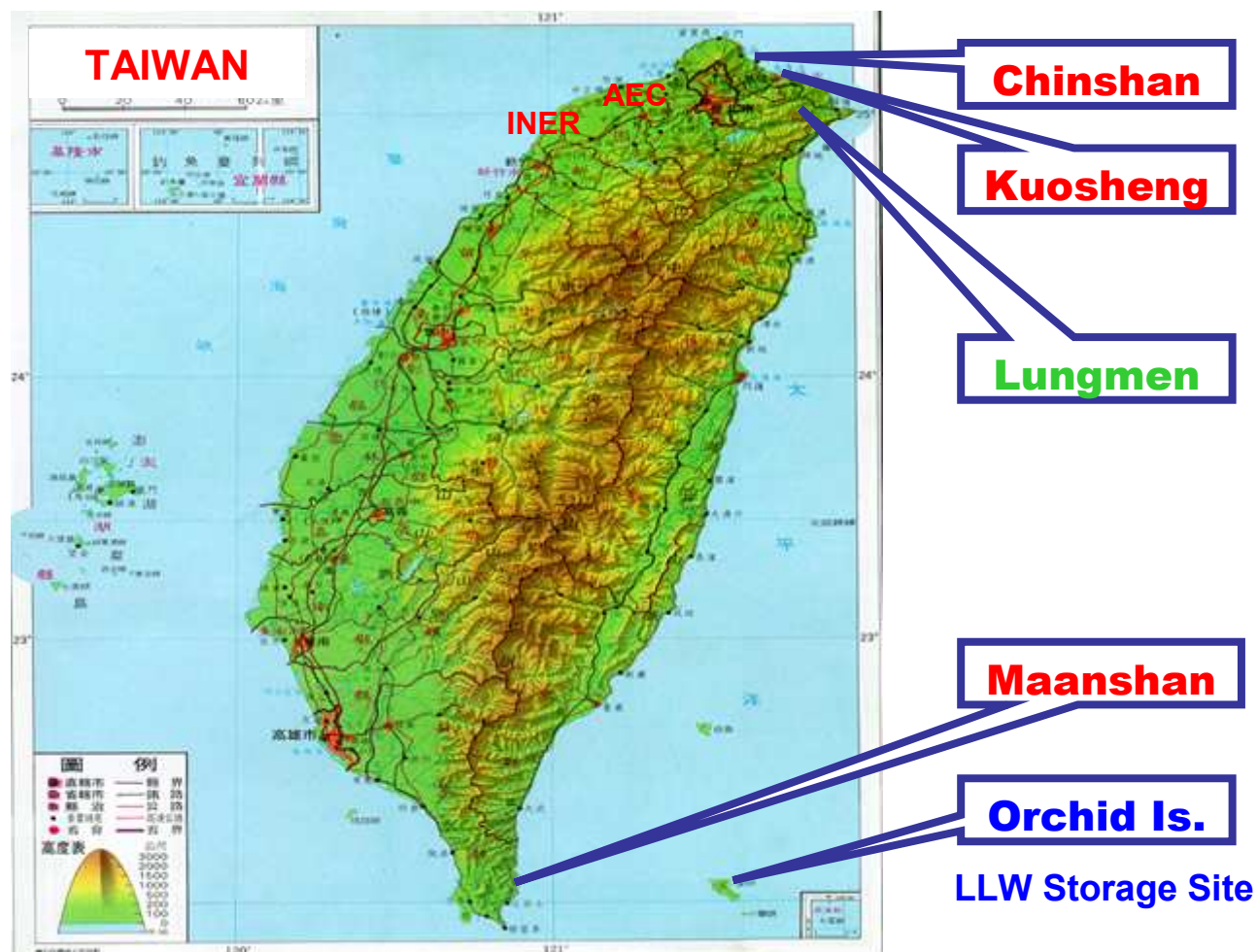


## Outline

- ❖ Introduction
- ❖ Low Level Waste Management
  - Treatment and Storage
  - Final Disposal
- ❖ Spent Fuel Management
  - Dry Storage
  - Final Disposal
- ❖ Public Acceptance
- ❖ Summary Remarks



SNF: 7,350 MTU  
LLW: 200,000 M<sup>3</sup>



## Locations of Nuclear Power Plants in Taiwan



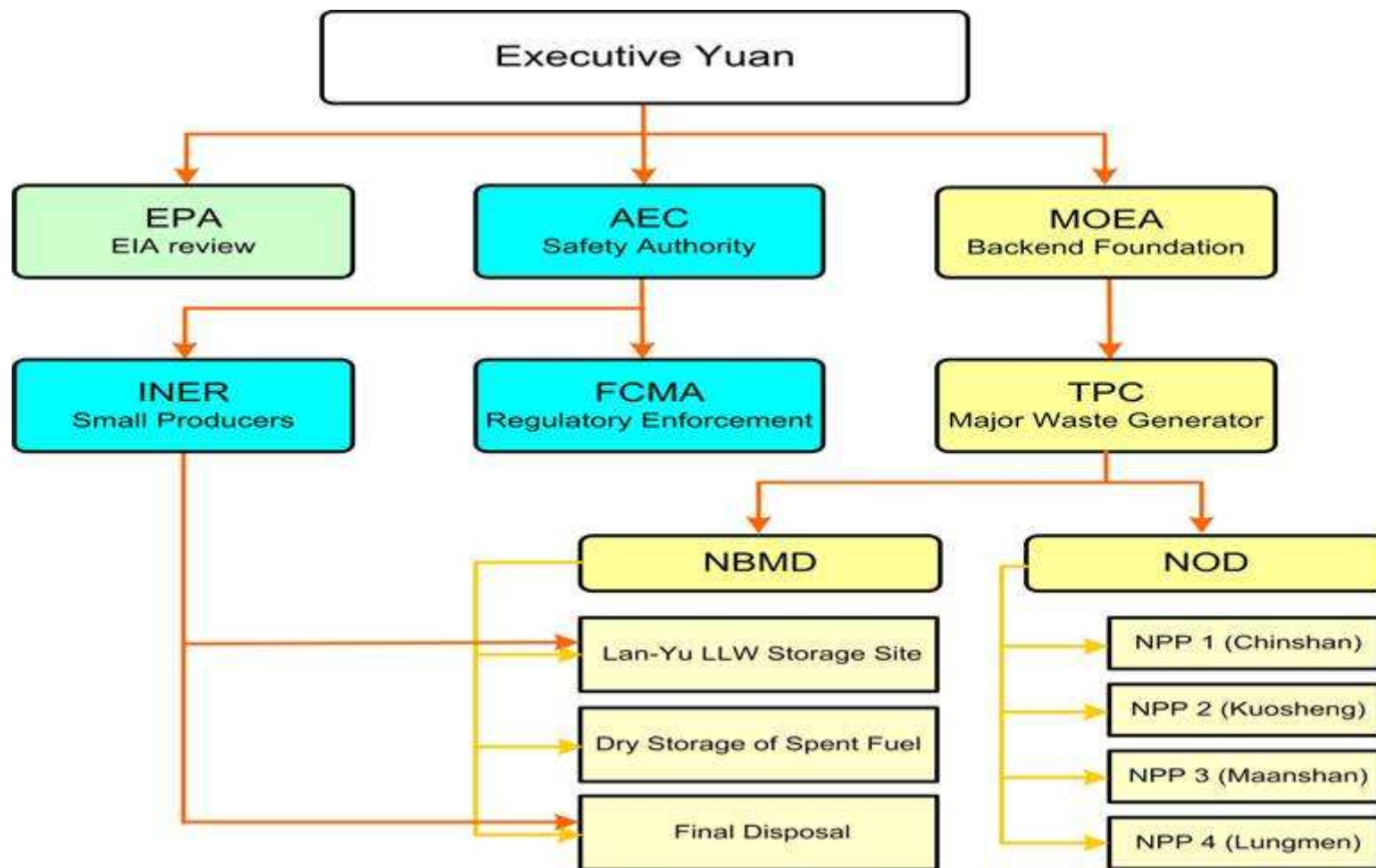
## Introduction

- ❖ Radwaste management policy
  - Promulgated in 1988 and amended in 1997
  - Consistent with “The Principles of Radioactive Waste Management”, IAEA 111F, 1995
- ❖ LLW management strategies
  - Minimization, Solidification, Safe storage and disposal
- ❖ Spent fuel management strategies
  - Short-term: pool storage, Medium-term: on-site dry storage, Long-term: direct disposal
  - Watching the feasibility of reprocessing



## Introduction

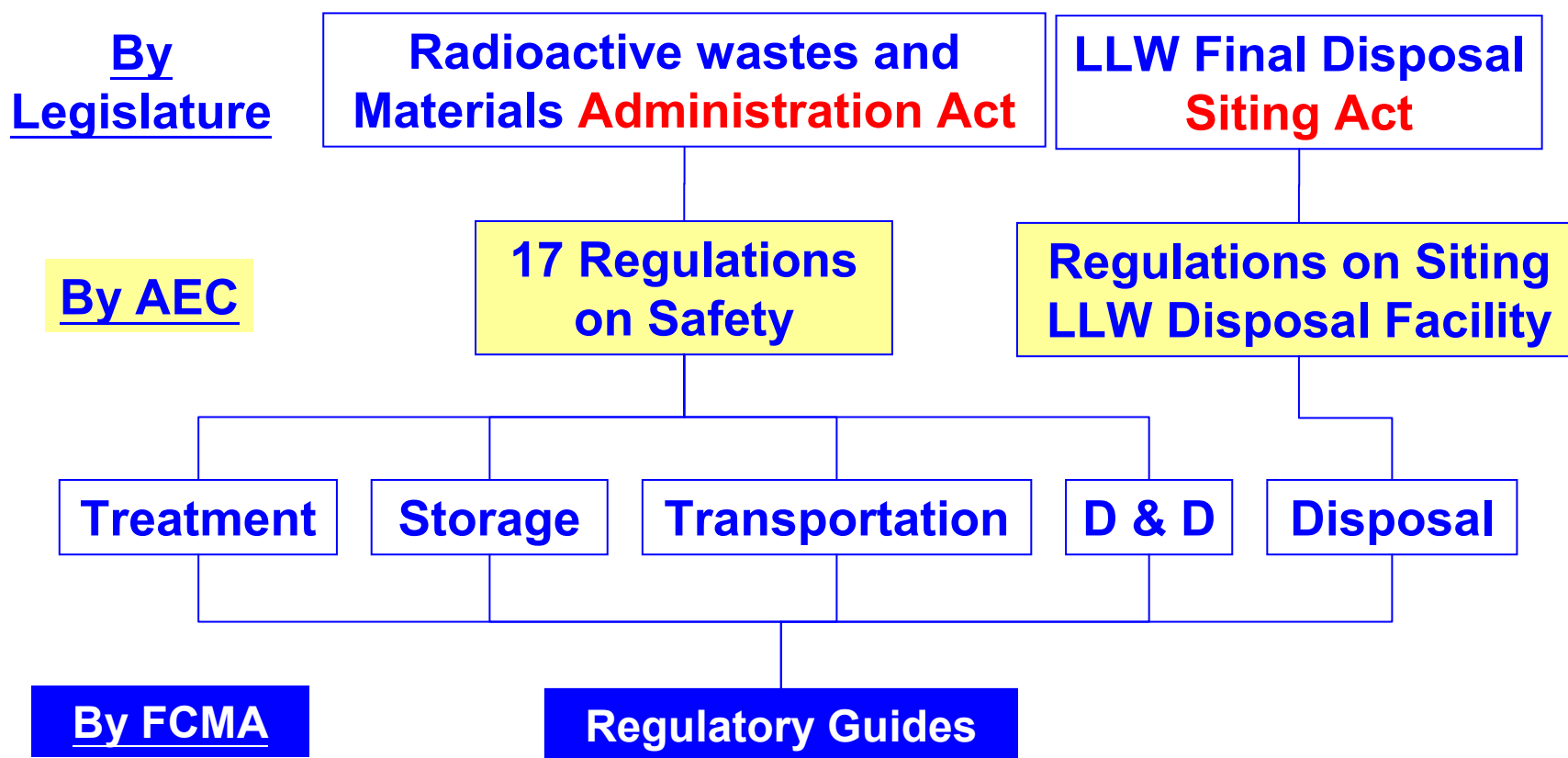
### ❖ Organizational Structure for Radwaste Management





## Introduction

### ❖ Legal and Regulatory System



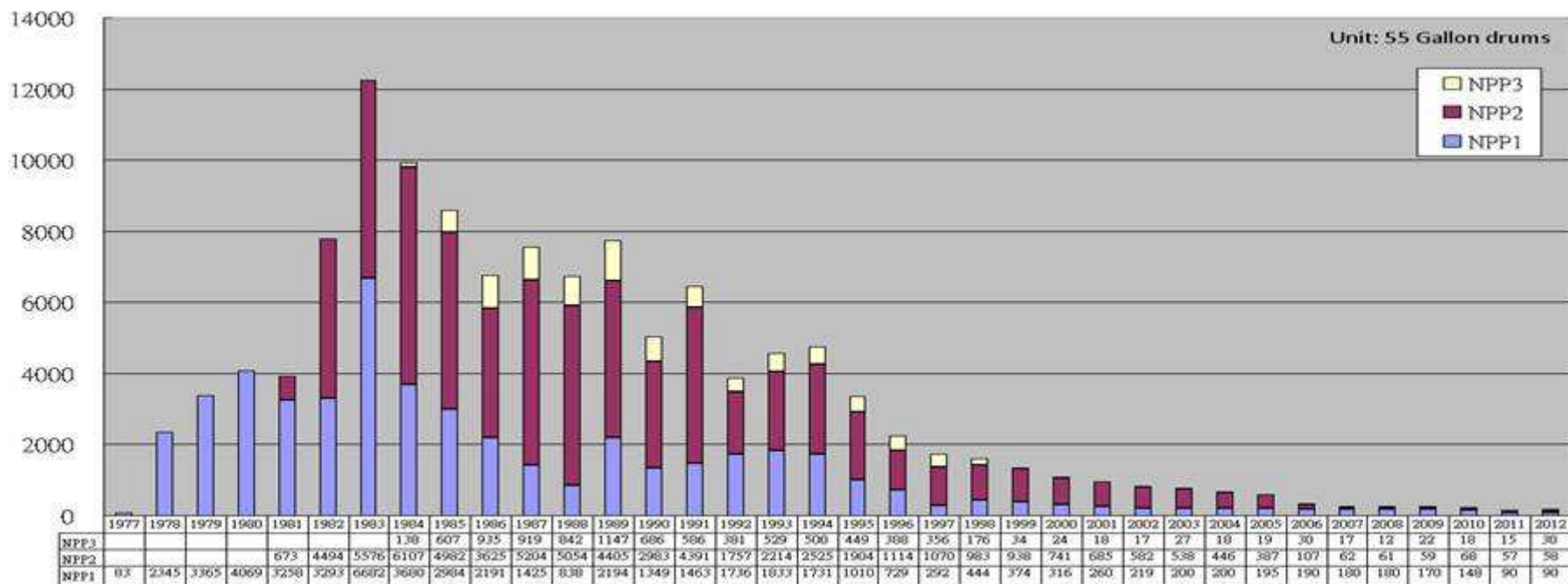




## LLW Treatment and Storage

### ❖ Radwaste Minimization

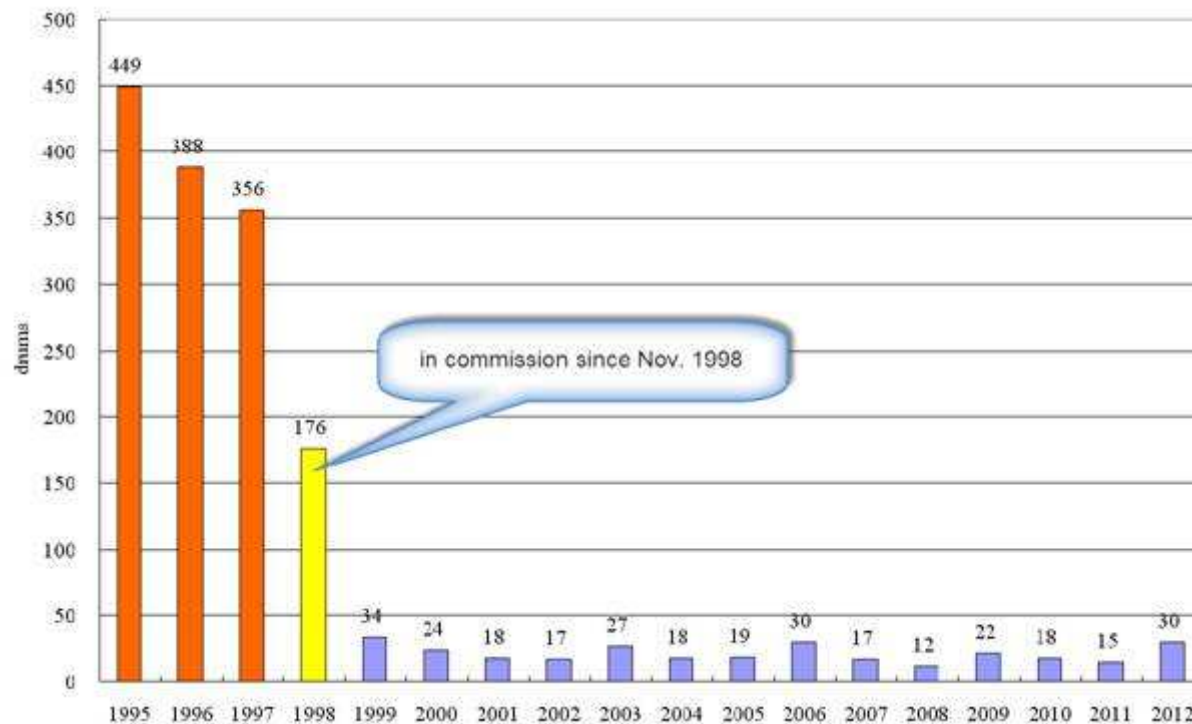
- The amount of solidified LLW has been reduced to the minimum practicable.
  - ◆ The maximum volume was 12,258 drums(55 gal) by 2 BWR NPP in 1983
  - ◆ 3 NPPs generated only 178 drums in 2012





## LLW Treatment and Storage

- ❖ PWRHEST (High-Efficiency Solidification Technologies, HEST) was implemented at Maanshan NPS in 1998
- ❖ Solidified waste has been reduced from 400~500 drums to 20~30 drums annually







## LLW Treatment and Storage

- ❖ BWRHEST was implemented at Kuosheng NPS in 2006
- ❖ Solidified waste has been reduced from 300~500 drums to ~60 drums annually





## LLW Treatment and Storage

### ❖ Safe Storage of LLW

- Total amount of LLW was 203,189 drums, as of Dec. 2012
- Storage facilities at NPPs: Air-conditioned, automated and well-shielded
  - ◆ Chinshan : 101,000 drums
  - ◆ Kuosheng : 91,000 drums
  - ◆ Maanshan : 30,000 drums
  - ◆ Lungman : 20,000 drums
- Total storage capacity is 340,000 drums, including Lanyu storage site(98,000)



行政院原子能委員會  
Atomic Energy Council

## LLW Treatment and Storage



Air-conditioned, automated and well-shielded  
storage facility at Kousheng NPP





## LLW Treatment and Storage



Lanyu LLW storage site



## LLW Disposal

### ❖ LLW Final Disposal Siting Act

- Openness and transparency
  - ◆ MOEA publicizes a siting plan and selection report of recommended site to invite public's comments.
  - ◆ Public comments on selection report of recommended site shall be addressed one by one
  - ◆ Public hearing before referendum.
- Democratic self-determination
  - ◆ Only if the recommended site has been approved by a local referendum, can the site be listed as a candidate site.



## LLW Disposal

- ❖ Processes and Progress of Siting (2nd run)
  - MOEA (Ministry of Economic Affairs) publicized, Daren and Hsiao-chiou as potential sites (Sep, 2010)
  - MOEA announced Daren township and Hsiao-chiou islet as Recommended Candidate Sites (July, 2012), only after inviting the public comments by publicizing a “Selection Report” and addressing them
  - County level referenda for candidate site selection are scheduled for the 2nd half of 2013



## Recommended Candidate Sites





## LLW Disposal



Conceptual design of LLW disposal facility at Daren site





## LLW Disposal



Conceptual design of LLW disposal facility at Hsiaoichiou islet



## Spent Fuel Management

### ❖ Capacity and inventory of spent fuel pool at NPPs

| NPP      | Pool Capacity (Assembly) | Quantity after 40-yr Operation (Assembly) | Current Inventory (As of 12/2012) | Time Reaches Full Pool Capacity |
|----------|--------------------------|-------------------------------------------|-----------------------------------|---------------------------------|
| Chinshan | 3,083                    | 3,766                                     | 2,870                             | 2014                            |
|          | 3,083                    | 3,766                                     | 2,856                             | 2016                            |
| Kousheng | 5,026                    | 5,766                                     | 4,042                             | 2016                            |
|          | 5,026                    | 5,766                                     | 3,872                             | 2016                            |
| Maamshan | 2,151                    | 1,921                                     | 1,251                             | 2025                            |
|          | 2,159                    | 1,921                                     | 1,214                             | 2026                            |



## Spent Fuel Management

### ❖ Progress of the Chinshan Dry Storage Project

- Taipower submitted the construction license application in Mar., 2007.
- AEC issued the Construction License in Dec, 2008.
- After its water and soil reservation plan approved by the county government ,TPC started the construction in Nov. 2010.
- Dry run of pre-operational tests was completed in Jan., 2013
- Hot test, loading 2 cask spent fuel, of pre-operational tests is scheduled for Aug., 2013.
- Dry storage is scheduled to be operational by June 2014.





## Spent Fuel Management

- ❖ TPC commissioned INER to implement Chinshan on-site dry storage project in July 2005
- ❖ The INER-HPS dry storage system was developed
  - Technology transfer from NAC International
  - Design change made by INER and fabrication in Taiwan
  - 56 assemblies each cask.
  - 30 casks loading 1,680 spent fuel assemblies in total





# Spent Fuel Management

## Components of INER-HPS



Canister (**TSC**)

*OD 1.70 m  
Ht. 4.84 m  
Wt. 16.65 t*



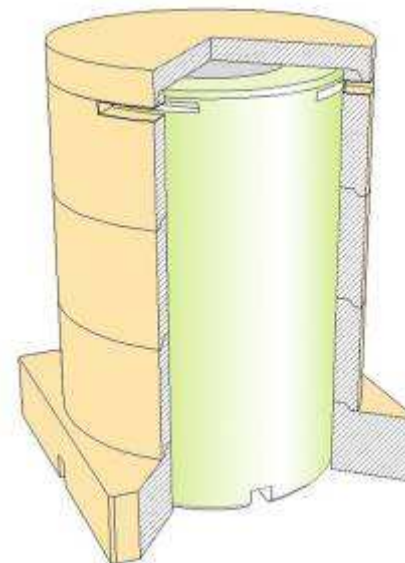
Transfer Cask (**TFR**)

*OD 2.12 m  
ID 1.72 m  
Ht. 5.13 m  
Wt. 46.18 t*



Concrete Cask (**VCC**)

*OD 3.45 m  
ID 1.89 m  
Ht. 5.70 m  
Wt. 112.73 t*



Add-on Shield (**AOS**)

*Sq. foot 4.5 x 4.5 m  
OD 4.20 m  
Wall thk. 0.35 m  
Ht. 6.03 m  
Wt. 81.20 t*



## Spent Fuel Management



Weld NDE



Basket Assembling



Canister Fabricating & Concrete Cask Constructing





## Spent Fuel Management



Dry run tests of Chinshan dry storage facility





## Spent Fuel Management

- ❖ Progress of the Kuosheng Dry Storage Project
  - Licensing application was submitted in March, 2012
  - As requested, TPC carried out 2 verification studies
    - ◆ Structural seismic behavior
    - ◆ Criticality analysis
  - AEC organized a review team with 10 technical subgroups for detailed technical review
  - Meanwhile, AEC performed 2 independent evaluations
    - ◆ Heat removal function
    - ◆ Radiation shielding
- ❖ Kuosheng dry storage is scheduled to be operational by 2016



## Spent Fuel Management

### ❖ Kuosheng Dry Storage

- TPC entrusted the **CTCI Machinery Corporation (Taiwan)** and **NAC International (USA)** to construct the facility in Nov. 2010
- 27 MAGNASTOR concrete casks will be used, capable of storing 87 BWR assemblies each (Total 2,349)





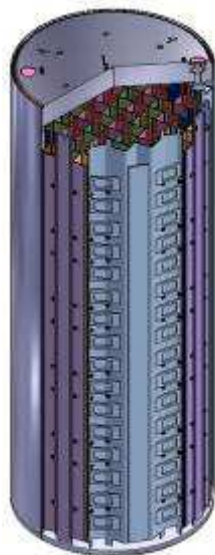
# Spent Fuel Management

## Components of MAGNASTOR



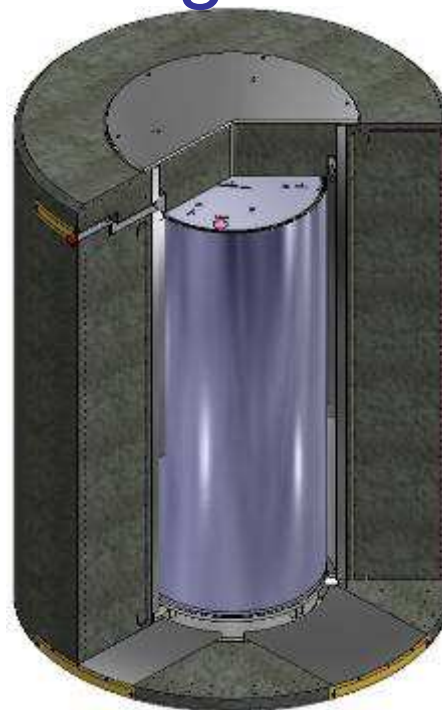
Spent Fuel

87 Assemblies/  
Canister



Sealed Canister

OD:1.828 m  
Height:4.87 m  
Empty Weight: 19.1mt



Concrete Cask

ID:1.87 m  
OD:4.25 m  
Height:5.99 m  
Empty Weight: 183mt



Transfer Cask

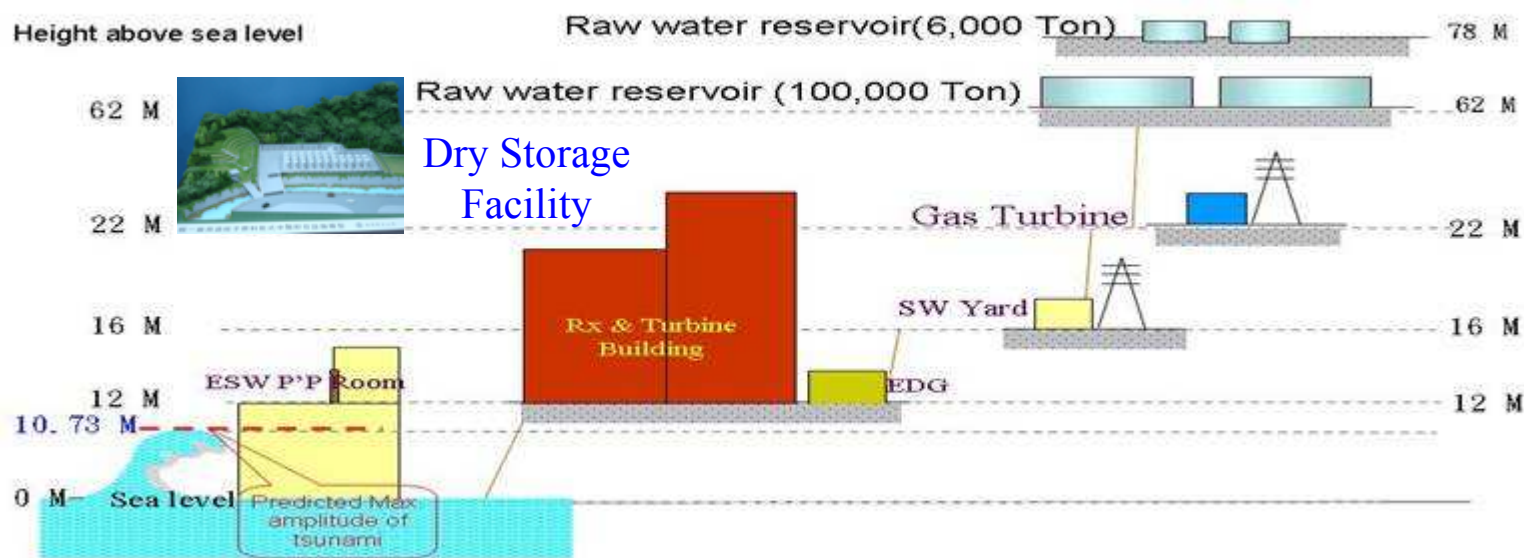
ID: 1.85 m  
OD: 2.23 m  
Height: 5.05 m  
Empty Weight: 49.0mt



## Spent Fuel Management

- ❖ After Fukushima nuclear accident, the seismic and tsunami design of Chinshan dry storage were reevaluated and **no significant impact was found**
- ❖ Lessons learned will be taken into consideration for the safety review of Kousheng dry storage

### *Elevation Description of Chinshan*

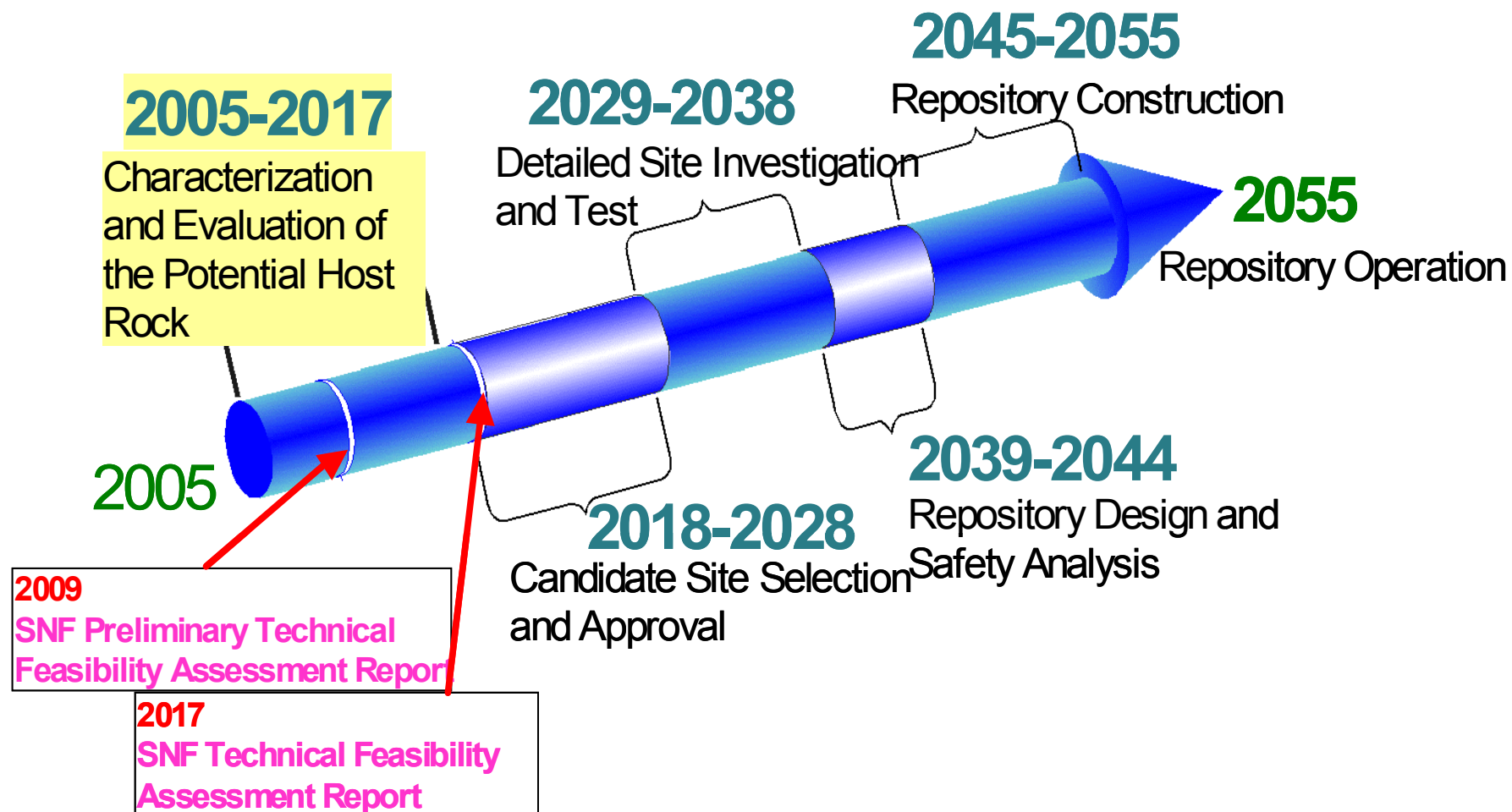






# Spent Fuel Management

## Schedule for SNF Disposal (Five Phases)





## Spent Fuel Management

- ❖ “Preliminary Technical Feasibility Report for Final Disposal of Spent Nuclear Fuel”, SNFD 2009 was completed and reviewed by domestic experts
- ❖ “Technical Feasibility Report for Final Disposal of Spent Nuclear Fuel”, SNFD 2017 will be completed through international peer review
- ❖ The main goals of SNFD 2017
  - To identify the candidate rock formations for site characterization
  - To establish the capabilities of site characterization, engineered technology and safety assessment



## Public Acceptance

### ❖ Public Hearing and Consultation



Public hearing on Kousheng  
dry storage in July 2012



Public consultation meeting on  
Chinshan dry storage in Oct.  
2012



## Public Acceptance

### ❖ Public Participation in Dry Storage Project

- Participants: 20 representatives from local government officials, and village chiefs, experts, and environmental groups.
- Activities: Observing the construction quality of the facility and monitoring the environmental radiation around the facility quarterly







## Public Acceptance

- ❖ Public Participation in Lanyu LLW Storage Site
  - Participants: 17 representatives from Council of indigenous peoples, Local governments, indigenous chiefs, environmental groups, school teachers etc.
  - Activities: Environmental radiation monitoring and agricultural products, drinking water and soil sampled at villages biannually
  - Each sample is separated and cross checked by TPC, AEC and a third party, Tsing-Hwa university





## Public Acceptance

### ❖ Information transparency and understanding

- Topic window of spent fuel dry storage on AEC website has been built for public information.
- All information of the topic webpage such as SAR, review and inspection reports, records and minutes, FAQ and publications are available and easily accessible.
- Animated movies on spent fuel dry storage and LLW disposal are available for public understanding



## Summary Remarks

- ❖ Radwaste is an existing reality which must be well managed to establish a sustainable environment, even if the future becomes nuclear free in Taiwan.
- ❖ Radwaste issues are not only technical but also social issues that need patience and time to resolve.
- ❖ Public acceptance is the decisive factor in the success of radwaste management in Taiwan.
- ❖ Radwaste people in the world are a family sharing good experiences and setbacks together



Thank you for Your  
Attention!