Nuclear Waste Status Report - Taiwan

Mom Loves Taiwan Association National Taiwan University 徐光蓉 (Gloria Kuang-Jung HSU) 2017年4月9日 TAIWAN

Outline

- Background information: existing dangers
- Nuclear waste: LLW, HLW
- Experience of LLW management little trust
- Interim storages for HLW
- Questions better be addressed early
- Challenges: 2025 nuclear free

Nuclear status - Taiwan

Existing problems:

- I. Aging reactors: next to active faults, close to capital
- II. (NPP4 controversy -- almost end)
- III. But operator seeks all possibilities to keep NPPs running
- IV. Poor waste management: (radioactive apartments), LLW in LanYu, HLW projects
- V. Lenient Regulator: stress test
- VI. Uncertain Future: nuke free by 2025 law passed without preparation, lack of adequate nuclear waste managementVI. Challenges: spent fuels, nuclear power plants retirement

Aging Reactors

	NPP1	NPP2	NPP3	NPP4
Capacity (MW)	636 *2	985*2	951*2	1350*2
Start	1978/1979	1981/1984	1984/1985	
Reactor/ Containment	BWR-4/ Mark I	BWR-6/ Mark III	PWR	ABWR
Supplier	GE	GE	Westinghouse	GE(Toshiba/ Hitachi)
Generator	Westinghouse	Westinghouse	GE	Mitsubishi



繪圖/陳幸萱 資料來源/

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Distances if on active seisnic faults, 7km (111)	L
5km (NPP2), and inside NPP3	

	(km) between	NTU	TPE 101	總統府	
	NPP1	30.5	27.4	28.5	
Taiv	NPP2	24.8	28.2	24.0	
	vanNuclearWasteSta	tus 2017HSU 39.6	36.7	43.0	

Current Administration

- Tsai, Ing-Wen of DPP won presidential election in 2016.
- Article 95 of the revised Electricity Bill states "all nuclear power generation facilities shall stop operating by 2025". (Jan 2017)
- Vague on nuclear waste issue
- Known to be "afraid of electricity shortage".



LLW in Orchid Island (LanYu)

- 1978 construction began, as fish cannery. Operating started in May 1982. Stopped by aboriginal Taos, April 1996.
- Early 1995, $\sim 1/3$ barrels showed clear signs of rusting.
- Taipower promised all LLW will be removed <u>by 2002</u> contingent promise to win NPP4 EIA permit
- July 2001, Taipower submitted revised EIA, remove the condition.
- 2002 President Chen promised Taos removing all LLW during his terms. Failed.
- Search for LLW permanent sites: Hsiao Chiu; Orchid Island (?), DaZen, and PenHu; North Korea, Solomon Islands, Marshall Island, China – nothing materialize
- 2006 "The LLW Permanent Site Act" requires a permanent LLW site being identified <u>by 2011</u> nothing in sight

LLW rusting

Re-packaging started in 2008, was poorly handled.



LLW not all 'low'

Readings in Unit: mSv/h A half-day exposure exceeds nuke worker annual allowance.



Trust, lack of

- Promises and law to removal of LLW from Orchid Island were repeatedly failed.
- A supposedly easier job (LLW vs. HLW) was done poorly. Can HLW be managed better?
- Who would trust government to locate 'temporary' waste storage site nearby?

Spent Fuels

		Capacity	Inside pool		Refuel	Fukushi	事故時
		(bundle)	(bundle)	U (tons)	(bundle)	ma	U (tons)
	NPP1-1	3083	3074	528	110	1號機	50
	NPP1-2	3083	3076	529	110	2號機	81
	NPP2-1	4398	4365	734	180	3號機	88
	NPP2-2	4398	4388	738	180	4號機	135
	NPP3-1	2160	1452	580	70	5號機	142
	NPP3-2	2160	1407	563	70	6號機	151
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AEC Plan for HLW

- Interim dry cask storage, (reprocessing), and final geological disposal
- Dry cask contract won by INER, a division under AEC conflict of interest?

2006 Final Disposal Plan:

- (1) 2005-2017, 「Ground Characteristic Survey and Assessment of Potential Final Disposal Sites」; (13 Yrs)
- (2) 2018-2028, $\[\]$ Evaluation & Identification of Candidate Sites $\]$; (11 Yrs)
- (3) 2029-2038, [¬] Detailed Sites Surveys and Tests 」 ; (10 Yrs) select Final Site by 2039
- (4) 2039-2044, $\[\]$ Design and Safety Evaluation of Final Disposal Site $\]$; (6 Yrs)
- (5) 2045-2055, ^C Construction of Final Disposal Site ; (11 Yrs)
- Accepting HLW disposal begins 2055.
- -- Will everything proceed as planned?

<u>Draft law</u> proposing "A Designated Facility" takes over all HLW issues from Taipower -- site selection, HLW waste management, ..., by a handful experts, fund by official budget without answering to Legislators

- Rationales and Acceptance of such law asteStatus 2017HSU

Interim dry casks

- Taipower: 2 thermometers /cask and 2 radiation monitors for the whole field, are enough to monitor cask safety over 40 years
- Cask' performances entirely depend on computer simulations
- No backup plan!



Cement seepage

hold by New Taipei City Government

Power Plant Operating Experience with SCC of Stainless Steels



Plant	Distance to water, m	Body of water	Material/ Component	Thickness, or crack depth, mm	Time in Service, years	Est. Crack growth rate, m/s	Est. Crack growth rate, mm/yr
Koeberg	100	South Atlantic	304L/RWST	5.0 to 15.5	17	9.3 × 10 ⁻¹² to 2.9 × 10 ⁻¹¹	0.29 to 0.91
Ohi	200	Wakasa Bay, Sea of Japan	304L/RWST	1.5 to 7.5	30	5.5 × 10 ⁻¹² to 7.9 × 10 ⁻¹²	0.17 to 0.25
St Lucie	800	Atlantic	304/RWST pipe	6.2	16	1.2 × 10 ⁻¹¹	0.39
Turkey Point	400	Biscayne Bay, Atlantic	304/pipe	3.7	33	3.6 × 10 ⁻¹²	0.11
San Onofre	150	Pacific Ocean	304/pipe	3.4 to 6.2	25	4.3 × 10 ⁻¹² to 7.8 × 10 ⁻¹²	0.14 to 0.25

• CISCC growth rates of 0.11 to 0.91 mm/yr for components in service

- Median rate of 9.6 x 10⁻¹² m/s (0.30 mm/yr) reported by Kosaki (2008)

Activation energy for CISCC propagation needs to be considered

Thin canisters not/maintainablenol) reported by Hayashibara et al. (2008)

- May crack and leak in 20+ years
- Some may already have cracks
- Cannot inspect or repair
- Not transportable with cracks
- No solution for cracked canisters
- No warning until AFTER radiation leaks^{tatus}

Change to thick cask!

Hardly discussed Questions

- Who are responsible for managing (& handling) nuclear waste? --Taipower, AEC, or tax payers? -- Or a third party?
- What type <u>safety</u> we wish to have for nuclear waste? Permanent and interim storage.
- Do those (permanent) nuclear waste storage to <u>be retrievable</u>?
- How much we are willing to <u>pay</u> for managing nuclear waste?
- What are the adequate geology for safely storing all nuclear waste forever? Geologists explain!
- Does Taiwan have that type of geology? Or, alternatives?
- How much nuclear waste we can handle? We are still adding more!
- -- Most of us keep a blind eye just wish nuclear wastes disappear!

Nuclear Free 2025?

- Nuclear contributes 15-17% of total electricity.
- President Tsai aims at 20% renewable electricity by 2025. (to fill the gap of closing all NPPs)
- Renewable Energy Act began 2010. % electricity generated by wind + solar PV are: 0.43 (2010), 0.62 (2011), 0.63(2012), 0.78(2013), 0.79(2014), 0.93 (2015) and 1.02 (2016). In ~7 years!
- Small hydro + waste contributes $\sim 3\%$ electricity.
- 9 years remain to boost REN to 20%! Possible?
- Then, burning more coal (and gas), increase CO2 emission? Or revive nuclear?
- Last May, Premier Lin attempted restarting the problematic unit 1 of NPP1, in response to Taipower 'electricity shortage' warning, two weeks after President Tsai's inauguration.