The Impact and Lessons Learned from the Fukushima Accident in Taiwan

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1. Introduction

The Fukushima Daiichi Nuclear Power Plant accident was initiated primarily by the tsunami following the Tōhoku earthquake on 11 March 2011. The accident led to meltdowns of three units and the release of radioactive material, caused serious concerns on nuclear safety in the global community.

The impact of this accident is worldwide. Not only in Japan, it also has profound influences on Taiwan. This severe accident forced both Taiwan and Japan to re-evaluate their energy policies, especially on nuclear energy. On September 14, 2012, the ruling Democratic Party of Japan made a decision with a policy statement which would phase out nuclear energy by 2030. However, after lengthy discussions and debates, nuclear energy is now included in Japan's energy mix as the base load for electricity, after the cabinet made the decision on April 11, 2014. It is also included in Japan's long term energy program, and the government has decided to restart nuclear power units since then. The goal set in July of 2015 was that nuclear power would provide 20~22% of the energy mix to the country in 2030, and solar energy combined with other renewable energy would provide 22~24% of electricity in Japan.

Nuclear power in Taiwan was moving in a different way compared to Japan. The government of Taiwan had decided to build more nuclear power units and push for license renewal on operating units to reduce its dependence on fossil fuels as well as reducing greenhouse gas emissions in 2010. Protesters against nuclear power supported by local media and non-governmental organizations started anti-nuclear rallies in Taiwan after the Fukushima accident. These activities forced the government of Taiwan to change its energy policy with a new version released in November of 2011. The new energy policy stopped the license renewal applications for the 6 operating power units, and it also cancelled the plan of constructing new power units in the following years. The Lungmen plant (the fourth nuclear power plant) with 2 ABWR units will continue its construction and pre-operational tests, and Taiwan's energy policy will be re-evaluated every 4 years.

The new energy policy issued in 2011 could not stop the anti-nuclear rallies in Taiwan. The government was forced to make a decision searching for a national referendum to decide the future of Lungmen nuclear power plant on February 25, 2013, but the time for the referendum was not decided. The government made a more strict decision to "mothball" the nearly completed Lungmen unit 1 together with stopping all construction work at unit 2 after persistent protests and conflicts between ruling and opposition parties in congress on April 27, 2014. The future of Lungmen power plant will be decided via referendum.

The protests against nuclear power continues, and the Democratic Progressive Party (DPP) won the presidential election then took office on May 20, 2016. The new government made a decision to stop license renewal on the operating nuclear power units. All nuclear power units will start

decommissioning after their operation license expires, and Taiwan will become "nuclear free" by 2025. The amendment of electricity act, which was implemented on January 11, 2017, set the rule for a "nuclear- free Taiwan" by 2025. Becoming nuclear free by 2025 is not just a government statement, but it is now part of the regulations in Taiwan.

2. Current status of nuclear power in Taiwan

Nuclear power in Taiwan accounts for 5,028 MWe of capacity by means of 3 active plants and 6 reactors, which makes up around 8.1% of its national energy consumption, and 19% of its electricity generation as of 2015.[1][2] The technology chosen for the reactors has been General Electric BWR technology for 2 plants and Westinghouse PWR technology for the Maanshan Nuclear Power Plant. Construction of the Lungmen Nuclear Power Plant using the ABWR design has encountered public opposition and a host of delays, and in April 2014 the government decided to suspend construction.[3]

Commercial nuclear power plant in Taiwan was first started in 1978.Nuclear power in Taiwan made a great contribution to the economic development of Taiwan during the years of 1980s.Table 1 shows the current status of NPPs in Taiwan.

The construction of the fourth nuclear power plant at Lungmen on the north coast started in 1999, but it has been halted for several times because of the escalating public debate over safety issues.

The government originally scheduled to increase the use of nuclear power in order to reduce the emission of carbon dioxide, but the new policy was unveiled in 2011 due to the Fukushima accident. All the operating nuclear power plants (Chinshan, Kuosheng, and Maanshan) will not operate beyond their planned 40-year lives, and Lungmen will not begin operations until all safety requirements have been met. Furthermore, there will be no more new nuclear power plants and the share of nuclear in the country's energy mix is set to be 15% in 2020 and 5% in 2030 respectively.

In January 2017, the Amendment of the Electricity Act was passed. Article 95 of the Amendment states "all nuclear power generation facilities shall cease operation by 2025." President Tsai's campaign promise became law officially. The first nuclear-free country in Asia was born.

Table 1. Current Status of Nuclear Power Plants in Taiwan

Name of NPP		Reactor Type	Capacity (MW)	A/E	Reactor	Turbine	Operation Since	Plant Area (hectares)	No. of units may be added
Chinshan	No. 1	BWR-4	636	Ebasco	GE	WH	1978.12.10	239	2
	No. 2	BWR-4	636	Ebasco	GE	WH	1979.07.15		
Kuosheng	No. 1	BWR-6	985	Bechtel	GE	WH	1981.12.27	216	2

	No. 2	BWR-6	985	Bechtel	GE	WH	1983.03.16		
Maanshan	No. 1	PWR	951	Bechtel /PECL	WH	GE	1984.07	338	4
	No. 2	PWR	951	Bechtel /PECL	WH	GE	1984.05		
Lungmen (Gongliao)	No. 1	ABWR	1,350	S&W	GE	MHI		480	6
	No. 2	ABWR	1,350	S&W	GE	MHI			

3. The relationship between the 4th NPP and Japan

Although General Electric was the main contractor of the Lungmen NPP project, the rest of the main components were supplied by different Japanese companies. During the second half of the construction (stage of detail design, equipment installation, and device system tests), the project received a lot of assistance from experts with practical experience related to ABWR from different Japanese companies or institutions like TEPCO, Chubu Electric Power, Toshiba, and JNES.

As for safety regulations, Nuclear Science & Technology Association (NuSTA) from Taiwan has signed a co-operation agreement with Japan Nuclear Energy Safety Organization (JNES) in 2004 to take turns in holding the annual meeting of nuclear safety every year in both countries.

Furthermore, the Japan-Taiwan Nuclear Safety Seminar, which is held every year for both countries to exchange the technology and experience related to nuclear safety. There were several experts coming to Taiwan from Japan to deliver speeches on what really happened during the Fukushima accident and the corresponding safety regulations to carry out after that.

Due to the active support by Japan, we would be able to upgrade the construction management, QC/QA and safety regulations of the Lungmen NPP. It was seriously a great contribution to the completion of the NPP.

Table 2. Outline of the 4th NPP (Lungmen Project) in Taiwan

Plant Site	Gongliao, New Taipei City (40km to Taipei City)
Site Area	480 hectares (1,186 acres)
Capacity	1,350 MW, 2 units
Reactor Type	ABWR (same type as No.6 and No.7 NPP of Kashiwazaki-Kariwa)
Fuel Consumption (year average)	81 tonnes
Total Budget*	NTD 169.7 billion (US $6.2 billion)
T/G	MHI
A&E	Stone&Webster
Process of Rad-waste	Hitachi
Civil Construction	GE (清水建設)
Discharge Tunnel	RSEA Engineering Corp (鹿島、大豐)
Cooling Water Circulating Pump	Ebara (荏原)

Security	Japan Nuclear Security System (日本原子力防護システム)
Current Status	Unit #1: Sealed Unit #2: Construction halted

*reimposed budget NTD 52.3 billion, total budget 283.8 billion.

4. The Impact of 311 Fukushima Disaster

It is extremely hard for Taiwanese people to believe a serious disaster would happen in Japan, a country that is very proud of its own advanced technologies. The impact of Fukushima disaster is tremendous.

(1) Anti-nuclear movements have become more and more intense:

Green Citizens' Action Alliance has been in close contact with No Nukes Asia Forum(NNAF), an anti-nuclear organization in Japan. NNAF has held several anti-nuclear gatherings in Taiwan. NNAF has visited Taiwan more frequently after the Fukushima accident, which accelerated Taiwan's anti-nuclear movement. Then, the Japanese anti-nuclear politicians (ex. former prime minister and senators), scholars, experts also visited Taiwan for the appeal of "zero nuclear society. "On March 9, 2013, several unprecedented anti-nuke demonstrations took place throughout Taiwan to echo the second anniversary of the Fukushima disaster.

Harms are caused by groundless rumors and plausible information. False information about the accident was over-exaggerated by the media which also caused the public misunderstanding. For example, a scholar from a Japanese university came to Orchid Island, where Taiwanese radioactive waste is stored, to measure the radiation, in the name of investigating environmental radiation. The scholar found out radiation hotspots up to 60 and 103μSv/h near an elementary school and then held a press conference to announce this finding. The pro anti-nuclear mass media did not verify the finding before reporting it, and this finding became a serious issue in the Legislative Yuan (the parliament) in Taiwan. Taiwanese and Japanese experts started investigations immediately and found out that the instrument that the Japanese scholar brought, the SamRAE940, was interfered with by an 99.4998MHz electromagnetic wave emitted by a wireless relay station on the island. Although the results have been published on the Issue 53 of the report of *The Thinking on Nuclear Coverage* (原子力報道を考える会) in Japan, several associations and magazines still report some similar content like this, leading to misunderstanding. Although the mass media's attitude in relation to this issue is problematic, we still have to ask what the purpose of this academic researcher is.

(2) Significant changes in energy policies:

In response to the sharp rise in crude oil prices and countermeasures for global warming, Taiwan Power Company was planning to build another nuclear power plant and extend the life of the existing nuclear power plants in 2010. However, energy policies have changed significantly after the Fukushima disaster. Former President Ma announced several new energy policies, including: (1) the operation of Nuclear Power Plants 1, 2, and 3 (6 units in total)

will not be extended; (2) the fourth one will maintain a stable operation for commercial purpose after completion; (3) no new nuclear power plant will be built; (4) renewable energy ratio of the country's energy mix will account for 30% by 2030; (5) nuclear will then reduce to 15% by 2020 and 5% by 2030; and (6) These policies will be reviewed every four years.

However, the ruling party (KMT) and opposition parties (DPP mostly) in the Legislative Yuan still held different opinions about the operation or abolishment of nuclear power and the debate did not stop. In March 2014, Mr. Lin Yi-hsiung, the former chairman of the opposition party and a moralist, began an 8-day hunger strike to demand that the government to halt the construction of the 4th nuclear power plant. On the other hand, several anti-nuclear protests were also expanding very quickly. Former President Ma declared the following guidelines for the 4th nuclear power plant on April 27: Unit 1 will be sealed after the completion of safety inspections. Construction of unit 2 will be fully suspended. A final decision will depend on the result of the national referendum.

The current energy policy has aimed the country will reach nuclear-free in 2025. The share of renewable energy, natural gas, and coal is set to be 20%, 50%, and 30% respectively. Renewable energy in 2025 will be mainly composed of solar and wind (Table 3).

Table 3. Renewable Energy Targets in Taiwan (Unit: MW)

	2015	**2016**	**2020**	**2025**
Solar	842	1,342	8,776	20,000
Onshore Wind	647	747	1,200	1,200
Offshore Wind	0	8	520	3,000
Geothermal	0	1	150	200
Biomass	741	742	768	813
Water	2,089	2,089	2,100	2,150
Total				27,363 MW

Source: Bureau of Energy, Ministry of Economic Affairs, R.O.C

5. Issues we are facing now

Regardless of whether Taiwan should insist on the path of "nuclear-free", nuclear waste is the biggest issue today and it is inescapable. At present, the final disposal site of low radioactive waste has not yet been decided, and the waste on the Orchid Island still cannot be moved out. The local Yami people are strongly opposed to the waste disposal. Other final disposal candidate sites, such as Daren Township in Taitung County, and Penghu, they have also launched campaigns against the disposal for years. The government has been standing at a disadvantageous position since the beginning.

Although medium-range interim dry storage facilities have been built for NPP 1 for the storage of used nuclear waste fuel (Taiwan adopts "once-through" method, and thus the waste is considered as high radioactive), it is not yet permitted by the local government, leaving Taiwan Power Company at a difficult and also awkward situation. Most of the spent nuclear fuel pools in the plants are almost full. It will be dangerous to continue operating under this condition. In addition, the disposal of NPP 1, 2, and 3 after decommissioning is also imminent. The operation of unit 1 of

NPP 1 will be terminated in 2018, and a decommissioning plan had already been proposed in 2015. NPP 2 and 3 will also be decommissioned one after another. Decommission of nuclear power plants in Taiwan has been highly supported by Central Research Institute of Electric Power Industry (CRIEPI) and the Association for Nuclear Decommissioning Study (ANDES) for years.

6. Conclusions

The danger of nuclear power plants to Taiwan is actually from Fujian Province, China, which is located at the other side of Taiwan Strait. Fuqing and Ningde nuclear power plant, Fujian Province, has 6 units under construction in each plant. Construction of commercial high-temperature reactors (HTRs) and fast breeder reactors (FBRs) is being planned in Zhangzhou and Sanming. In the event of an accident, both Taiwan and Japan will suffer the disaster.

Japan's restart of nuclear power plants also has a significant influence on Taiwan. The confusion and nuisance of the two countries' energy policies is caused by populism. Honestly, the nuclear energy dispute in Taiwan is beyond the scope of energy discussions, especially its connection with the political ideology, which made it become more complex.

Whether to support nuclear energy is a matter of choice, and there is no right or wrong answer. However, the problem has been raised to the level of good and evil, justice and morality, which obscured the true matter. It is meaningless but makes nuclear power a tool for political struggle. I think, to solve this problem, it requires the elevated national literacy and knowledge of energy, as well as wisdom. I hope everyone can make his/her own best choice and judgment and I look forward to the political parties' self-awareness.

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