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TAIWAN'S SPENT NUCLEAR FUEL: A BURDEN IN A POTENTIAL TAIWAN STRAIT CONFLICT

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The war in Ukraine has drawn concerns that a potential conflict may happen across the Taiwan Strait. In Ukraine, the attack and occupation of nuclear facilities, including the Zaporizhzhia nuclear power plant (NPP) by the Russian military, initiated a dangerous situation for the safe and secure operation of civilian NPPs, including the spent fuel facilities. It also hindered the International Atomic Energy Agency's effort to assure the proper accounting and control of nuclear materials in these facilities. If a military conflict were to happen across the Taiwan Strait, there would be similar concerns.

There are six operating or shutdown nuclear reactors (two pressurized water reactors, PWRs and four boiling water reactors, BWRs) in Taiwan. Of the six, the four BWRs located in the northern tip of Taiwan pose the biggest safety, security, and safeguards concerns. Taiwan's first NPP, Chinshan 1 & 2, were BWRs similar to Fukushima Daiichi 1 NPP that was involved in the 2011 accident in Japan, with spent fuel pools that are located high up above ground. Taiwan's second NPP, Kuosheng 1 & 2, were of a later BWR design, with spent fuel pools located at a lower elevation. The two PWR reactors have spent fuel pools located at ground level.

When Chinshan 1 & 2 went offline in 2018-2019, more than 6,000 spent fuel assemblies were stored in the two elevated spent fuel pools. At Kuosheng 1 & 2, the capacities of both ground-level spent fuel pools have become insufficient to support reactor operation. To free up space in the pools for newly discharge spent fuel, TAIPOWER, the utility company, moved those 15-year-old spent fuel assemblies to the upper (refueling) pools for storage, which are located well above the ground level.

According to the US National Academies of Sciences, the vulnerability of a spent fuel pool depends in part on its location with respect to ground level as well as its construction. In a potential military conflict across the Taiwan Strait, the spent fuel pools located above ground in Chinshan and Kuosheng may thus be susceptible to accidental attacks from misfired or stray missiles. Significantly, to protest the Pelosi visit to Taiwan in August 2022, two missiles fired by the Chinese military landed in water about 50 km north of the Chinshan NPP.

The Fukushima accident highlighted the vulnerability of elevated spent fuel storage. The explosion that occurred in the reactor building of Fukushima Daiichi 4 destroyed the roof and most of the walls on the fourth and fifth (refueling) floors. The Japanese utility company, TEPCO, had to reinforce the region underneath the pool with steel beams and concrete to prevent pool leakage and a potential collapse of the pool. To reduce the vulnerability, Unit 4 pool's inventory of 1,535 spent fuel assemblies (half of that in Chinshan 1 pool) was moved between November 2013 and December 2014 into a common pool on the ground level built after the accident.

If an attack caused an explosion similar to what happened in Fukushima Daiichi 4, damaging the roof and walls on the fourth and fifth floors in Chinshan or Kuosheng NPP, a loss-of-cooling (due to damage to the pool spray system), and/or loss-of-coolant (due to leaky pools) accident could occur. To prevent a loss-of-cooling-and-coolant accident in any one of the Chinshan or Kuosheng high-elevation pools, spent fuel must be removed and placed in water pools or dry storage casks located at or below ground level.

A sense of urgency

Spent fuel has accumulated in Chinshan and Kuosheng NPPs over the 40 years of their operating lives. Due to objections from the local public over

moving the spent fuel to dry cask storage and the lack of suitable storage or disposal sites in the geographically limited island, spent fuel discharged from Chinshan 1&2 reactors has remained in the refueling-turned-into-storing pools adjacent to the reactor wells, which is high above ground. To support continued reactor operation of Kuosheng NPP and to free up space in its lower-level spent fuel pools, spent fuel assemblies were moved into the upper (refueling) pools, situated well above ground.

The Fukushima accident and the subsequent action by TEPCO to move the spent fuel into a ground-level common pool built after the accident should have led TAIPOWER to conclude that spent fuel stored at Chinshan and Kuosheng high-elevation pools creates a significant risk. The war in Ukraine and rockets/missiles landing in or around Zaporizhzhia NPP (with all six PWRs' spent fuel pools located at ground level) should have given TAIPOWER another warning that spent fuel in high-elevation pools should be moved to ground-level pools or dry cask storage. TAIPOWER should have a sense of urgency for this "clear and present" danger in Taiwan, especially given that it has the technology and resources to accomplish the task. Taiwan's internal politics and objection of the local public are the primary causes for the procrastination.

The longer-term problem with moving the spent fuel off the island centers around something called "consent rights," which is complicated given US involvement in the installation of the NPPs in Taiwan.

Consent-rights and possible solution to remove Taiwan's spent fuel

The United States holds the prior consent rights for Taiwan's spent fuel (over the "alteration" of nuclear material by Taiwan) based on the terms of Taipei's 123-Agreement with Washington in conjunction with the original construction of Taiwan's NPPs. The United States also has a bilateral safeguards agreement with Taiwan, as well as a trilateral safeguards agreement with both Taiwan and the IAEA (INFCIRC/158). The US rights over Taiwan's nuclear activities are so extensive that Washington instructed the German government in the 1980s that any nuclear items supplied to Taiwan by a German exporter would be subject to US "control rights," which included US "fallback safeguards rights" if deemed necessary. Nowhere else does the United States have as much leverage over a foreign nuclear program. Yet whenever Taiwan has requested the United States to take-back the spent fuel, Washington has declined.

The alternative to resolve the spent fuel issue in Taiwan may be a cooperative multi-site/multi-national arrangement (MSMNA). Such an arrangement could help manage the spent fuel in existing/emerging nuclear-power programs. Emulating the URENCO model for a uranium-enrichment enterprise, an MSMNA can be led by nuclear-weapon states (NWS) and major uranium producers (MUP)—the two groups of countries having the most at stake for a sustainable global nuclear enterprise—to provide a safe and secure supply of energy and assure nonproliferation in the backend of the nuclear fuel cycle. It involves an NWS for the assurance of nonproliferation, just as United Kingdom is an essential partner in the URENCO enrichment enterprise.

An MSMNA could be formed by a consortium consisting of any one of the NWS (China, France, Russia, the United Kingdom, or the United States) and an MUP (Australia, Canada, Kazakhstan, etc.), and providing spent fuel interim storage and/or final disposal at multiple sites within MSMNA countries.

Broadly, an MSMNA can help a country decouple their power generation from the back-end nuclear fuel cycle. Such decoupling is essential for solving the intractable spent fuel dilemma, providing a better way to manage nuclear weapon-usable materials, and facilitating a resilient nuclear fuel cycle to support a sustainable use of nuclear energy. Examples for using MSMNA services in conjunction with the Taiwan dilemma include the removal of Taiwan's spent fuel by MSMNA and their assignment to any one of the MSMNA countries for 40-year interim storage and/or final disposal.

Removing the spent fuel from Taiwan would eliminate its "clear and present" spent fuel danger,

while fulfilling its goal of ensuring a "nuclear-free" Taiwan. This should be a priority.

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