Key Findings Nuclear Energy Experts Group Singapore, Aug. 2-4, 2023

The Pacific Forum, with support from Sandia National Laboratories and in collaboration with Singapore's S. Rajaratnam School of International Studies, held the 12th Nuclear Energy Experts Group (NEEG) Meeting in Singapore on August 2-4, 2023. About 40 senior researchers and officials attended, as well as five Pacific Forum Young Leaders, all in their private capacity. The off-the-record discussions focused primarily on nuclear power development as part of the global clean energy transition, emerging technologies, and nuclear governance in the Indo-Pacific. Key findings include:

Nuclear energy is back in vogue. Countries with established programs like India, Japan, and the Republic of Korea are leaning into further commercial nuclear power development with support from the respective Modi, Kishida, and Yoon administrations. There is also notable interest in developing new nuclear technologies in these countries. While public perceptions toward nuclear energy have improved broadly since the Fukushima Daiichi disaster, hurdles remain. The Republic of Korea's nuclear power sector enjoys high but declining levels of public support, due to concerns surrounding radioactivity and spent fuel management, while India's primary obstacle toward further development remains NIMBYism. Japan, for its part, is grappling with international concerns over its IAEA-sanctioned release of treated wastewater at Fukushima Daiichi, even as it reverses course from its nuclear power phaseout policy adopted after the accident.

In Southeast Asia, several states are considering an entry into nuclear power – most notably Indonesia, Thailand, and the Philippines. During past instances, the region failed to follow through on momentum toward this end, but current interest appears robust. States are seeking to decarbonize their power sectors, as well as diversify from the heavy import dependencies tied to fuels like coal and natural gas. Nuclear power is also appealing to Southeast Asia nations because it is seen as helpful to strengthen energy security. In that spirit, small-modular reactors (SMRs) and floating nuclear power plants (FNPPs) have captured the attention of high-level officials such as Philippine President Marcos Ferdinand Jr., who see the emerging wave of advanced designs as a way to leapfrog current nuclear power technologies while solving their energy problems. Of note, however, there was considerable skepticism among participants regarding the somewhat ambitious timelines for implementation of nuclear energy programs by some countries.

While the region may not strictly require nuclear power to meet its energy demand, its addition is assessed to be necessary if states are going to be able to achieve their 'net zero' goals and clean energy targets. The 'firm' baseload power from nuclear complements the variable power

generation of renewables. During trough demand periods, excess power may be redirected to generating hydrogen, ammonia, or desalinated water through a process known as load following. This concept could be applied further in combination with FNPP designs to create a 'floating multi-utility complex' concept, which would be capable of supplying power or industrial outputs across a maritime-linked region.

Coal-to-nuclear conversion (C2N) offers a potential pathway to facilitate the retirement of coal power plants through cost savings. Recent research from Poland and China, as well as the US Department of Energy and IAEA, suggests that retrofitting current and retired coal power plants with SMRs scaled to meet existing "balance of plant" requirements could provide up to 35% in cost savings against greenfield development, from the reuse of land, structures, and various components. In addition, studies suggest that there are other associated benefits like local pollution reduction and economic stimulus. While the techno-economic feasibility appears sound from a hardware perspective, challenges in workforce upskilling, sociopolitical impacts, and regulatory aspects all require further study. The C2N conversion concept also sparked numerous concerns surrounding nuclear safety, security, and safeguards, which highlights the need for more investigation.

The SMR space is flourishing, with 80-90 commercial designs worldwide now at various stages of development and licensing. Enthusiasm abounds over SMRs ability to facilitate access to nuclear energy within new economic sectors or geographical regions, though it remains to be seen if they can deliver on their promises of safety, reliability, and low-cost unit economics from factory-based modular production. US-based upstart, NuScale, is making headway in the Philippines and Indonesia, but the larger conglomerate entities like Samsung, Mitsubishi, GE-Hitachi, and Rolls-Royce possess the industrial scale to distribute nuclear technology more easily to the region over the long-term. While there is a wide variety of new technologies associated with the emergence of SMRs, several experts suggested that the safest approach for early adoption would be to go with the proven technology associated with pressurized water reactors.

Development of microreactors also continues; this is the class of specialized, portable reactors even smaller than SMRs. Financing is complicated since per unit cost is very high, so these products will likely fill niche markets with critical power needs such as remote military bases or research outposts. As the commercial space industry continues to mature, emerging designs for thermoelectric or thermoionic space reactors are also gaining attention. Recent technical breakthroughs in nuclear fusion have also captured popular imagination. The prospect of clean, abundant, broadly available fusion energy could be realized in the late 21st century, but not without its own set of issues worth studying, like 3S risks and tritium supply constraints.

Emerging nuclear technologies and progress toward commercial implementation of SMRs are outpacing regulators' ability to develop adequate governance frameworks. While the existing

regimes supporting nuclear safety, security, and safeguards continue to be applicable, communication between national regulatory agencies and the IAEA requires sharp improvement. There is a particular urgency with understanding the potential impact FNPPs could have on maritime safety and security.

With the introduction of commercial nuclear power to the region on the horizon, ASEANTOM will become increasingly important as a regional regulatory body. However, for now it remains occupied with developing a regional radiological monitoring network, emergency preparedness, strengthening adherence to the requirements outlined in the Southeast Asia Nuclear Weapon-Free Zone (SEANWFZ) Treaty, and collaboration with the IAEA. It is vital that all states in the Asia-Pacific accede to the applicable global safety, security and safeguards treaties and protocols to ensure comprehensive nuclear governance in the region.

Given that the place and role of nuclear power will grow in the Indo-Pacific, nuclear fuel procurement and spent fuel management are topics that should receive greater attention. Also, and significantly, they are avenues for greater regional collaboration, potentially through the expansion of ASEANTOM's portfolio. As nuclear power is integrated into the energy planning process in the region, both practical and governance issues regarding the entire fuel cycle will become an increasingly important issue for the policymakers and energy planners.

While there is great potential for regionalizing nuclear governance in Southeast Asia through ASEANTOM, it will be a slow process rife with potential barriers, but potentially worthwhile as it would avoid duplication of efforts. Regardless of approach, conversations involving all national interests and stakeholders in the region will be key to forming a strong foundation for the regional outlook for nuclear safety, security, and safeguards as countries continue to think about adopting nuclear energy as a source of power.

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