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Pakistan's civil nuclear programme

Ambitious expansion plans to face multiple challenges

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Foreshadowed by the strategic weapons programme, Pakistan's civil nuclear energy sector has expanded slowly yet steadily over the last two decades. However, despite China's support, ambitious expansion plans are not likely to materialise due to Pakistan's faltering proliferation credentials, NSG opposition, financial constraints and other domestic factors.

Image Source: Dawn

On 21 May 2021, Pakistan's Prime Minister Imran Khan inaugurated a 1100 MW Karachi nuclear power plant (KANUPP-2). A similar plant (KANUPP-3) is under construction. Both plants, like other major power assets in the country, are financed, supplied, and built with China's assistance. With the inclusion of both these units into the power grid, the share of nuclear energy in Pakistan's electricity mix will go up to about 3500 MW. As of April 2020, the contribution of the nuclear sector to the electricity mix was 8.2 per cent, while thermal,

hydro and renewables stood at 58.4, 30.9 and 2.4 per cent respectively.[1] Despite a significant share and ambitious expansion plans for future, the civil nuclear energy sector in Pakistan rarely gets the limelight or attention that is devoted to its strategic weapons programme in regional as well as global discourse.

What is the size and scope of Pakistan's civil nuclear sector? How did it evolve over the decades? What is China's role? What are the expansion plans? What are the kinds of challenges it faces? What is its future?

I

'Slow, yet steady': Evolution of nuclear energy in Pakistan

While Pakistan had research reactors in the 1960's thanks to the Atoms for Peace programme of the US, the first commercial reactor to commence operation in the country was the 137 MW Karachi Nuclear Power Plant (KANUPP-1) constructed by the Canadian General Electric (CGE). It was built with assistance from Canada; and since Canada had mastered the heavy-water based reactor design, it supplied the same to Pakistan. It is a Pressurised Heavy Water Reactor (PHWR) and it runs on natural uranium. It operated from 1972 to 1976 with Canadian support. In the aftermath of the Indian nuclear tests, the Canadian withdrew not just from India, but also Pakistan. Giving primacy to proliferation concerns over commercial interests, Canada terminated nuclear partnership with Pakistan, and disassociated themselves from the KANUPP-1 in 1976. Subsequently, like the Indian counterparts, the Pakistan Atomic Energy Commission (PAEC) developed indigenous human resource and fuel fabrication capabilities and took full responsibility for the plant, including supplying fuel.[2]

Then, almost for three decades, there was a lull as proliferation concerns took centre-stage and Pakistan's efforts were more dedicated to weapons development. While PAEC wanted to build more nuclear power plants, there were no easily available suppliers due to the Western embargo. This lull lasted until 1990, when China, which was already collaborating with Pakistan on the strategic weapons programme, decided to sell it a civil power reactor. Thus, in early 1990's, Pakistan and China signed an agreement to build a power plant at Chashma.[3] In 2000, Chashma nuclear power plant CHASNUPP-1 commenced commercial operations. Supplied by the China National Nuclear Corporation (CNNC), it is a 325 MW Pressurised Water Reactor (PWR) and runs on slightly enriched uranium, within the 3-5 per cent range. In 2011, CHASNUPP-2, with similar power capacity, commenced operations. It was followed by 340 MW CHASNUPP-3 in 2016 and CHASNUPP-4 in 2017. There was also

[1] "Thermal has largest share in Pakistan's energy mix", *The Express Tribune*, 12 June 2021, available at: https://tribune.com.pk/story/2240789/thermal-largest-share-pakistans-energy-mix (last accessed on 22 August 2021)
[2] Zia H. Siddiqui and I.H. Qureshi, "Nuclear Power in Pakistan", *The Nucleus*, Vol. 42, No. 1-2, 2005, p. 64
[3] Ibid., p. 65

news in 2017 that Pakistan and China had signed an *a*greement for 5th unit at Chashma. But its status remains unknown.[4]

This year, 2021, served to be a milestone for Pakistan's nuclear journey as KANUPP-2, country's first reactor to cross the 1000 MW mark, commenced operations. KANUPP-3, with similar power capacity, is expected to commence operations in 2022.

II

'The only friend': China's role in Pakistan's civil nuclear expansion

China's support has been instrumental in Pakistan's nuclear energy journey. Except the first reactor supplied by Canada, all other reactors have been supplied by China. Not just that, China has also provided financial support in terms of long-term loans and enriched uranium supply guarantees for the entire lifecycle of the plants.

China's collaboration with Pakistan on nuclear technology and materials is decades old; it started in 1980s when there was a mutual sharing of expertise and resources relating to the strategic weapons programme. Collaboration on civil nuclear energy was only but a natural outgrowth of this exchange. Moreover, supplying reactors to Pakistan should not be seen in isolation; it is part of the larger investments China has been making into the former's energy sector including coal and renewables, especially after the launch of China Pakistan Economic Corridor and the Belt and Road Initiative. While much of the global nuclear trade is still dominated by the Western countries, in Pakistan China finds a lucrative market for its own domestic nuclear industry.

China is also expected to play a key role in helping Pakistan realise its ambitious expansion targets. What are these targets? In 2015, while speaking at the 59th International Atomic Energy Agency General Conference in Vienna, PAEC Chairman Muhammad Naeem outlined the country's vision of scaling up nuclear energy to whopping 40,000 MW by the year 2050.[5] Pakistan has also declared its intention of generating 8800 MW of electricity from nuclear source by the year 2030, which would be about 20 per cent of its generation capacity.[6]

[4] "China signs deal to build new nuclear reactor in Pakistan: WNN", *Reuters,* 24 November 2017, available at: https://www.reuters.com/article/us-pakistan-nuclear-china-idUSKBN1DO1W6 (last accessed on 22 August 2021)
[5] "Pakistan envisions 40,000MW of nuclear power generation capacity: PAEC", *Dawn,* 17 September 2015, available at: https://www.dawn.com/news/1207543 (last accessed on 22 August 2021)
[6] Stanley Carvalho, "Pakistan plans to build several new nuclear reactors – official", *Reuters*, 31 October 2017, available at: https://www.reuters.com/article/pakistan-nuclearpower-idUSL8N1N668Q (last accessed on 22 August 2021)

KANUPP-1: Pakistan's first commercial nuclear power plant, KANUPP-1 is situated in close proximity to the Arabian port city of Karachi. Construction began in 1966 with Canadian assistance and the reactor was supplied by Canadian General Electric (CGE) on turnkey basis. A Pressurised Heavy Water Reactor (PHWR) of CANDU design running on natural uranium as fuel and heavy water as moderator, it started commercial operations in 1972 with a gross capacity of 137 MW. After Canada withdrew from the plant in 1976 owing to proliferation concerns, the PAEC assumed full responsibility, including supplying fuel.

CHASNUPP-1: After a lull of two decades, the process for building Pakistan's next reactor was set in motion in the early 1990s. Construction of CHASNUPP-1 began at Chashma in Punjab province in 1993 with assistance from China. Situated on the bank of Chashma-Jhelum Canal, it is based on the CNP-300 reactor design developed by the China National Nuclear Corporation (CNNC). CNP-300, a generation II Pressured Water Reactor (PWR) running on slightly enriched uranium (2-3 per cent), it was the first commercial reactor design developed by China, with Pakistan being the first foreign buyer. With 325 MW of installed capacity, it started commercial operations in 2000.

CHASNUPP-2: Construction of CHASNUPP-2, with similar design and power capacity as that of CHASNUPP-1, began in 2005. It was also supplied by the CNNC. It started commercial operations in 2011.

CHASNUPP-3: Based on the same CNP-300 design but with slightly increased installed capacity of 340 MW, CHASNUPP-3 was the third reactor to come up at the Chashma site. Construction began in 2011 and it started commercial operations in 2016.

CHASNUPP-4: Being built in parallel with CHASNUPP-3, it had similar design and capacity. Construction began in 2011 and the reactor started commercial operations in 2017. With this reactor, the total installed capacity of the Chashma nuclear complex increased to 1330 MW.

KANUPP-2: After four decades, Karachi got its second reactor KANUPP-2 based on the HPR1000 (Hualong One) reactor design developed by CNNC and China General Nuclear Power Group (CGN). It is a generation III PWR with better safety features as compared to the previous ones. Construction began in 2015 and the 1100 MW reactor commenced commercial operations in 2021. Like other PWRs at Chashma, it also runs on slightly enriched uranium.

KANUPP-3: Work on KANUPP-3 began in 2016. It is similar to KANUPP-2 in terms of reactor design and installed capacity. It is expected to start commercial operations in 2022. Once complete, the cumulative installed capacity of the Karachi complex will go over 2000 MW.

III

The future of Pakistan's civil nuclear programme: Six major challenges

Despite China's support, Pakistan would find it difficult to realise its ambitious expansion plans due to six major challenges discussed below.

AQ Khan Network, proliferation credentials and NSG opposition

Pakistan has a poor track record when it comes to proliferation. The infamous AQ Khan network, which supplied nuclear materials and technology to Iran, Libya and North Korea[7], significantly damaged Pakistan's proliferation credentials. While Pakistan, like India, has not signed the Nuclear Non-Proliferation Treaty (NPT of 1968), the Nuclear Suppliers Group (NSG), which is a cartel of nuclear supplier countries, has refused to give the Pakistan a waiver similar to that given to India in 2008. This means that Pakistan cannot do business with nuclear supplier countries for reactors or for uranium because it is the recipient of a de facto embargo. This is despite the fact that Pakistan has been a member of the International Atomic Energy Agency (IAEA) for decades now and all its commercial nuclear power plants are under IAEA safeguards.

China, which is the only country doing nuclear trade with Pakistan, has also faced NSG's ire. China joined the NSG in 2004. It argues that since the agreements with Pakistan pre-date its joining NSG, it can keep supplying the reactors. But it is unclear how long China would be able to defy the NSG norms. Also, eventually Pakistan would have to establish nuclear plants at sites other than Chashma and Karachi and it is unclear what justification China will give for supplying to those new sites.

Lack of experience in building reactors

While Pakistan has been operating nuclear power plants of both civilian and strategic nature for many decades now, they do not have the requisite experience of building a large commercial nuclear power plant indigenously. And even though they have built small scale PHWRs for plutonium production (weapons purposes), all their commercial reactors have been built by foreign suppliers on turnkey basis. It is highly unlikely that they will be able to realise the nuclear dream without first mastering the art of building commercial reactors. They also lack an advanced manufacturing base, something that is a critical requirement for building reactors as they require high-quality components. Therefore, even if they intended to build indigenously, they would have to rely on foreign suppliers for critical equipment and components.

[7] Catherine Collins and Douglas Frantz, "The Long Shadow of A.Q. Khan", *Foreign Affairs*, 31 January 2018, available at: https://www.foreignaffairs.com/articles/north-korea/2018-01-31/long-shadow-aq-khan (last accessed on 22 August 2021)

Low quality uranium ore

Pakistan's primary uranium mines are in the Dera Ghazi Khan district in the Punjab province. Domestic uranium is largely used for the weapons programme while imported fuel from China runs the civil reactors. While data about Pakistan's total uranium deposits is not readily available, it has been producing 45 tonnes of uranium annually from 20011-19 according to the *World Nuclear Association*. This is miniscule in comparison to Kazakhstan, which produced 22,808 tonnes of uranium in 2019.[8] Not only are Pakistan's uranium production capabilities grossly inadequate for an ambitious expansion, uranium ore also happens to be of low grade, thus increasing the cost and complexity of mining. Unless Pakistan discovers and mines a high-quality, large-quantity uranium deposit, it would be difficult to achieve indigenization in fuel supply. Adding to their woes, going to the international uranium market would be unhelpful because of the NSG embargo.

Financial constraints

Although precise estimates of the cost incurred on building different power plants in Pakistan are difficult to muster, a single 1000 MW nuclear reactor generally requires billions of dollars to construct. As Pakistan does not have the kind of financial wherewithal to realise its ambitious expansion goals, reliance on China for finance has will only increase, not unlike other energy and infrastructure projects, putting the country in ever-increasing debt.

Domestic consensus

Lastly, while there has been a domestic consensus about nuclear power and energy in the political as well as social spheres, there have been opposing voices in civil society, especially relating to KANUPP, owing to its proximity to Karachi city.[9] If Pakistan embarks on a rapid expansion of nuclear power plants in future, the possibility of civil society opposition emerging as a major challenge cannot be discounted at this stage.

Conclusion

Foreshadowed by the strategic weapons programme, Pakistan's civil nuclear energy sector has expanded slowly yet steadily over the decades, barring the lull between 1970s to 1990s. However, given the challenges highlighted above, what does the future hold? Given the state-of-affairs, Pakistan is not likely to meet its targets, which are ambitious enough to be brushed aside as mere rhetoric that have been typical of nuclear establishments throughout the world. Further, its nuclear landscape is going to be China's dominated, like most of its energy sector.

[8] "World Uranium Mining Production", *World Nuclear Association*, available at: https://www.world-nuclear.org/information-library/nuclear-fuel-cycle/mining-of-uranium/world-uranium-mining-production.aspx (last accessed on 22 August 2021)
[9] Tim Craig, "Outcry and fear as Pakistan builds new nuclear reactors in dangerous Karachi", *The Washington Post*, 5 March 2015, available at: https://www.washingtonpost.com/world/asia_pacific/outcry-and-fear-as-pakistan-builds-new-nuclear-reactors-in-dangerous-karachi/2015/03/05/425e8e70-bc59-11e4-9dfb-03366e719af8_story.html (last accessed on 22 August 2021)

Only if Pakistan does a course-correction and takes the following three steps would it be able to expand nuclear energy satisfactorily: first, make a clear separation between the civilian and strategic nuclear sector; second, gradually establish non-proliferation credentials; third, in the long-term, contingent on getting a NSG waiver, diversify beyond China for nuclear trade.

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