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Centre for Air Power Studies (CAPS)
Forum for National Security Studies (FNSS)

By Manpreet Sethi

Nuclear Energy in India's Energy Mix

Distinguished Fellow, Centre for Air Power Studies

No. 15 31 March 2024

Two contrasting developments in the nuclear energy domain caught public attention last year. In Europe, Germany shut down the last of its 17 nuclear reactors and bid goodbye to nuclear energy in April 2023. Meanwhile, in Asia, India's 23rd nuclear reactor, Kakrapar 3, began commercial operation in July 2023. Earlier this year, India announced an ambitious nuclear expansion, planning to add 18 new nuclear power reactors with a capacity of 13,800 MWe by 2031-32. The Nuclear Power Corporation of India Limited (NPCIL) has announced that with these additional units, the total share of nuclear power in India's energy mix will rise to 22,480 MWe by 2031-32 from the current capacity of 8,180 MWe.

Why is India steadfast on its nuclear power programme, though it is currently contributing only about 2 per cent to the electricity share, while Germany, which was once getting 22 per cent of its electricity from nuclear, decided to dispense with it? The answer to this question lies in the unique circumstances of each country which make it choose the sources of electricity generation in its national energy mix.

Understanding Germany's Decision to Phase Out Nuclear Energy

Germany took the decision to phase out nuclear energy two months after the March 2011 nuclear accident in Fukushima, Japan, which severely shook public confidence in nuclear safety. Succumbing to the pressure from Green parties, the government announced that all of the

17 operational nuclear reactors in Germany, which were then producing about 22 per cent of the country's electricity, would be phased out by 2022. By 2020, 11 of the 17 plants had been shut down, and Germany was down to producing only 13 per cent of its electricity from nuclear energy. Thirty per cent was being generated from coal-fired plants and 47 per cent from renewables. To its credit, the country had, in a decade, become a front-runner in the use of renewables for electricity generation. However, several German business and industry leaders argued in favour of nuclear energy for the sake of having a reliable baseload source of electricity. Many expressed concern that the loss of nuclear electricity could end up pushing the country towards greater use of coal, thereby increasing its environmental emissions.

One challenge, though, that Berlin had not accounted for while taking the decision to shut out nuclear energy was the disruption in its energy relations with Russia, a major supplier of natural gas to Germany. The Russia–Ukraine conflict cast an ominous shadow on Germany's energy scenario, and the country had to push back its planned date of shut down of the last reactor from 2022 to one year later so as to make time for securing electricity from other sources.

The German decision of a nuclear phase-out in 2011 was only in part triggered by the anti-nuclear inclinations of the political firmament of the time. It was also facilitated by several national socio-economic realities. These included a stable population with high per capita energy consumption of above 7000 kWh; a surplus national electricity market that had been exporting electricity to the tune of about 15 billion kWh; a forecast of as low as 1.1 per cent per annum growth of electricity; the option of making up for the loss of electricity caused by the shutdown of nuclear plants by importing more coal from Poland, more gas from Russia, and even electricity from France and Czechoslovakia. Germany, therefore, had the luxury of removing the option of nuclear electricity from its energy basket. Not many others enjoy this situation. India certainly does not.

Understanding India's Need for Nuclear Energy

India faces a different reality. Some facts peculiar to India need to be understood to answer questions that are often raised about why India should continue to invest in a nuclear power programme when, even after 60 years of having been in the fray, it contributes only a small slice to national electricity generation. Should the focus not be on modern, renewable sources like hydro (including small hydel plants), solar and wind energy? Afer all, in just the past decade new installed

capacities in solar and wind have taken the share of renewables from about 14 per cent to close to 40 per cent? Today, India ranks fourth globally in Renewable Energy Installed Capacity (including large hydro), fourth in wind power capacity and fourth in solar power capacity.[1] Solar energy has emerged as the star performer in this period, with more than thirty times increase in installed capacity from 2.5 GW in 2014 to 75 GW in 2024. What, then, is the rationale for retaining nuclear power in India's energy mix?

This question cannot be answered without adequately understanding India's unique socio-economic realities and energy compulsions. India is a developing nation with a population close to a billion and a half that is mostly young and aspirational. The country's economy is dominated by the manufacturing and service sectors, which are energy-intensive. The first thing to note, therefore, is a continuous upward demand for electricity in the coming years. India's power generation capacity has increased phenomenally from the total installed power generation capacity of a mere 1362 MW at the time of Independence to 400,000 MW today.[2] Today, India is the third largest producer of electricity in the world. These are all creditable developments, but India's per capita electricity consumption is still at a mere 1255 kWh in 2021-22. This compares dismally with Canada's 17179 kWh, 13338 kWh in the US, and about 5000 kWh even in China.[3]

According to the '*Economic Survey'* tabled in Parliament in July 2019, India needs to quadruple electricity production to assure a reasonable quality of life to its citizens. To give one example, the World Energy Outlook 2023 predicts skyrocketing consumption of electricity in India based on a surge in air conditioner ownership. As temperatures soar to new highs, electricity demand for cooling registers a surge, with nearly 10 per cent of total electricity consumption attributed to space cooling. With household air conditioner ownership projected to increase nine-fold by 2050, this trend will further exacerbate energy demands and peak electricity requirements.[4] Besides growing ownership of such personal appliances, the Indian economy in general is expected to grow at over six per cent , concurrently increasing the demand for electricity too.

Unlike the situation a few decades ago when the government could have nonchalantly met this demand with the cheapest and easiest available fuels, mostly by quickly setting up coal-fired plants, an increased sensitivity to human and environmental health has changed the focus on kinds of fuel sources now found acceptable. Currently, India draws nearly 63 per cent of its total energy generation from thermal sources. Of this, nearly 55 per cent is met from coal and the rest from gas,

with a miniscule amount from oil-fired plants. Such a configuration causes two types of worries. The first of course relates to the greenhouse gases emitted from such use of coal. India's per capita carbon emissions stand at 1-1.2 tons, compared to the US' 20 tons per capita. If a growing Indian economy continues to rely on coal, carbon emissions are bound to rise. This will have implications for national expenditure on domestic environmental and health measures and India's global climate commitments. The second cause for concern comes from the fact that India imports a significant part of its fossil fuels. For a large and rapidly developing country, bulk fuel imports raise economic and strategic vulnerabilities.

Both these concerns explain the current inclination towards increased use of low-carbon sources. Amongst such sources that India has in its energy mix, the most important are renewables such as hydro, solar and wind. Of these, hydroelectricity from large hydel projects was the first to be exploited going back to the decade of the 1890s well before independence. Interestingly, in 1947, of the total installed capacity of 1362 MW, 508 MW came from small and medium hydropower projects. Soon after independence, the focus shifted to building large hydroelectric power stations. Work on the Bhakra Nangal dam and hydroelectricity project, for instance was initiated in 1948 itself. Over the decades, however, interest in such plants has plateaued and they have become less popular owing to the related large-scale displacement and rehabilitation issues. Micro or small hydel projects are more common today, but these are only expected to meet the needs of a local community or industry.

Evidently, the contemporary focus is on solar and wind energy, and installed capacities of both have grown exponentially in the last decade, as stated earlier. However, their limitations should also be understood. Firstly, solar and wind energy generation is land-intensive. To give a comparison on this front, one can look at Asia's largest solar park, which was commissioned in 2018 in Rewa, Madhya Pradesh. It is spread over 1590 hectares and produces 750 MWe. In comparison, the Kakrapar Atomic Power Station (KAPS), which houses two operational 220 MWe units and two 700 MWe reactors, occupies only 959 hectares. Of this area, nearly 500 hectares are covered by the green belt and 200 hectares by a township, with the actual plant site being a minor fraction of the total. In fact, nuclear plants offer the best land utilization factor. As explained by the Nuclear Energy Institute, wind farms require up to 360 times as much land area, while solar photovoltaic (PV) facilities require up to 75 times as much land area, to produce the same amount of electricity as a nuclear energy facility.[5]

Another handicap of solar plants is a high dependence on imported materials such as photovoltaic cells and battery and storage equipment, as compared to the Indian Pressurised Heavy Water Reactors (PHWRs) that have become completely indigenous. KAPS 3 and 4, for instance, which are the largest indigenously designed PHWRs and the first to have advanced safety features, "have been designed, constructed, commissioned, and operated by NPCIL, with the supply of equipment and execution of contracts by Indian industries and companies, reflecting the true spirit of *Atmanirbhar Bharat*," NPCIL has said. In contrast, India's domestic solar photovoltaic (PV) module manufacturing has yet to come to the level of meeting the pace of solar capacity growth. While hopes are tied to the Production Linked Incentives programme offered by the government, the nation, for now, remains a net importer of solar PV modules.

Despite these challenges, renewables still merit a place in India's energy basket. Given the country's demographic growth, the aspirations of a young population, lack of indigenous fuel resources, and mounting climate change, India needs a long-term vision and commitment to safe generation of electricity that must include all sources. However, it must be recognised that the exploitation of renewables alone cannot take India to meet its net zero commitments because both solar and wind energy would need backup options for the time they are unable to generate electricity for want of sun and wind. Therefore, the advantage of nuclear energy as a baseload source of electricity remains indisputable.

Moving Ahead

It is not surprising, therefore, that India has indicated its plans to move ahead with nuclear energy expansion. At the recently concluded first Nuclear Energy Summit, Dr KK Mohanty, Chairman, Atomic Energy Commission and Secretary Department of Atomic Energy, said that "as a medium-term target, we aim to achieve tripling nuclear power generation capacity by 2030 from around 7.5 GW at present."[6] In order to meet this objective, the government had approved the construction of ten indigenous new nuclear reactors. As these become operational, built in the fleet mode, there will be a steady increase in the country's nuclear power capacity. Apart from this indigenous fleet, hopes are also pinned on reactors that are to be built with international cooperation and are at various stages of negotiations. Of course, Kudankulam (KK) 1 and 2 built with Russian help are already operational, and KK 3 and 4, will be the next among the foreign ones to become operational. Negotiations with France and the US continue but these have not yet reached the stage

of construction commencement. However, it needs to be noted that in every new civilian nuclear cooperation agreement that India has recently signed with nuclear supplier countries such as the USA, France and South Korea, the possibility of cooperation on small modular reactors (SMRs) has been mentioned. One of the future issues of *NuClealry Put* will explore the concept, advantages and disadvantages of SMRs.

For now, a question that is often raised is whether India needs foreign reactors at all, given that the Indian nuclear reactors have now graduated to 700 MW. The answer to this should be yes because imported nuclear power plants of a capacity higher than 700 MW would help India rapidly meet its electricity requirements. It must be remembered that India's electricity demand remains on the ascendant. The rehabilitation of India into international nuclear commerce with the conclusion of the Indo-US nuclear deal has opened possibilities of newer technology induction for accelerated capacity expansion, and this should not be allowed to go to waste.

Nuclear energy, certainly, will have to remain a part of the country's electricity mix owing to the vulnerabilities faced with other fuel sources. Fortunately for India, its nuclear programme is mature, and the industry is geared to perform its role, especially with the announcement on construction of a fleet of reactors.Another recent development of significance is the commencement of core loading of the prototype fast breeder reactor that has raised hopes that India's move into the second stage of its nuclear power programme may be on the anvil.

For the future, a three-pronged approach is recommended to move India's nuclear power programme up the ladder: firstly, the government must continue to offer its steadfast commitment and support to the nuclear sector including by providing predictability into the policy environment; secondly, the NPCIL must continue to provide safe operations and use of good management practices to ensure rapid induction of reactors to undercut the cynicism that is often expressed at the slow pace of growth of the nuclear sector vis a vis other sources of electricity generation. In fact, it would be a further shot in the arm if the joint ventures already formed by NPCIL with NTPC and Indian Oil Corporation, as well as the recent reports on possibility of investments by private firms, such as Reliance Industries, Tata Power, Adani Power, and Vedanta, could come to fruition; and thirdly, there is need for a continuous and proactive public outreach by the Department of Atomic Energy (DAE) to help the public better understand the need for nuclear power as part of the country's humongous electricity requirement, its environmental advantages and the focus on safety aspects.

India needs every watt it can get from all safe, secure, and sustainable sources, and nuclear energy ticks all the three boxes.

(Disclaimer: The views and opinions expressed in this article are those of the author and do not necessarily reflect the position of the Centre for Air Power Studies [CAPS])

Notes:

[1] "Creating a Sustainable World", Invest India, https://www.investindia.gov.in/sector/renewable-energy. Accessed on March 21, 2024.

[2] Ganesh Srinivasan, "OPINION: A narrative of the Indian power sector since independence", *The Economic Times*, August 16, 2022, https://energy.economictimes.indiatimes.com/news/power/opinion-a-narrative-of-the-indian-power-sector-since-independence/93580873. Accessed on March 22, 2024.

[3] Daniel Slotta, "Annual per capita electricity consumption in China from 2009 to 2020", Statista, January 03, 2024, https://www.statista.com/statistics/867590/china-per-capita-electricity-consumption/. Accessed on March 10, 2024.

[4] Trishant Dev, "IEA World Energy Outlook 2023: Fossil fuel demand to peak by 2030, urgent investment shift needed", *Down to Earth*, October 30, 2023, https://www.downtoearth.org.in/blog/climate-change/iea-world-energy-outlook-2023-fossil-fuel-demand-to-peak-by-2030-urgent-investment-shift-needed-92538.

[5] "Land needs for Wind, Solar Dwarf Nuclear Plant's Footprint", Nuclear Energy Institute, July 09, 2015, https://www.nei.org/news/2015/land-needs-for-wind-solar-dwarf-nuclear-plants. Accessed March 13, 2024.

[6] Department of Atomic Energy, "India's Statement at Nuclear Energy Summit Brussels 2024", March 21, 2024, https://dae.gov.in/indias-statement-at-nuclear-energy-summit-brussels-2024/. Accessed on March 29, 2024.