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Does Nuclear Energy Really Hold Promise for India's Clean Energy Transition?

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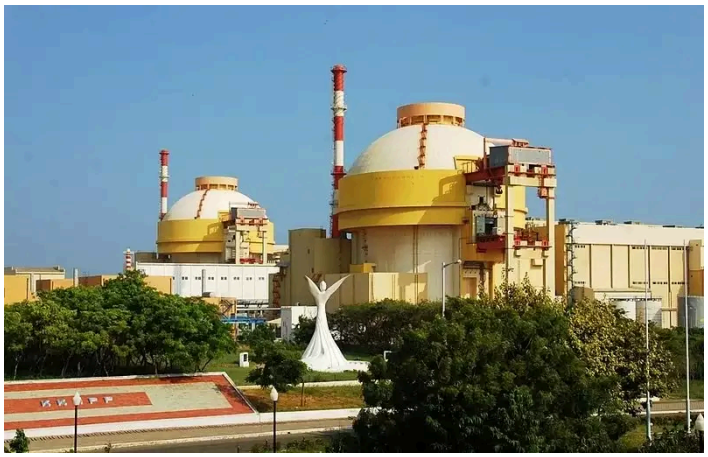
At the recently concluded 29th Conference of the Parties or COP29, several critical issues were discussed. Nuclear energy was also a key topic, following the COP28 commitment by 22 countries to triple



nuclear capacity by 2050. This year saw more countries entering the above commitment, taking the total count to 31, while the discussions mostly delved into the details of advancing nuclear energy, emphasising strategies for attracting investments, strengthening cross-border partnerships and identifying ways to deploy small modular reactors (SMRs) for energy-intensive sectors.

India has been signalling its commitment to nuclear energy for some time now. Earlier this month, the Ministry of Power urged states to identify sites for new nuclear plants, and had , in the Union Budget 2024-25, announced its intention to partner with the private sector for nuclear energy deployment.

The buzz around nuclear energy—a near zero-carbon energy source offering reliable, round-the-clock power supply that sets it apart from intermittent sources like solar and wind—is understandable. With technological innovations like SMRs, nuclear energy is becoming more adaptable and affordable for developing countries. But despite its long-recognised benefits, nuclear energy development has been slow in India. Commissioning delays, cost overruns, and public opposition have been the key obstacles, which must be addressed head-on to realise the potential of nuclear energy.

The promise of nuclear energy

According to World Energy Outlook 2024, by 2030, India will likely need an additional 60 gigawatts of new coal-fired power capacity to meet its growing demand. Though solar and wind energy have witnessed decent expansion, they alone would not suffice as a cleaner alternative to coal for meeting India's energy demand. In this context, nuclear energy can both supplement and complement other energy sources, with two key advantages (over other non-fossil sources).

One of the advantages is nuclear energy's small land footprint. According to a 2022 World Economic Forum study, it requires 27 times less land per unit than that required for coal plants and 34 times less than what solar plants need. With the significant expansion of its built environment, India faces stiff competition for land use, making nuclear energy's small land footprint an asset. Further, the capacity utilisation factor or CUF (viz., the ratio of actual energy output to a power plant's maximum energy generation) of a nuclear plant is also significantly higher, ranging from 80% to 90%. In contrast, solar plants operate at a CUF of 18% to 25% and wind plants at 25% to 45%.

Second, as the energy demand in India typically peaks in the evening—when solar power generation is unavailable—nuclear energy can provide reliable and continuous supply of electricity during this crucial period. Though battery storage technology has been advancing, it is not yet capable of making RE a round-the-clock solution for power generation.

The challenge posed by the variability and intermittency of solar and wind sources can be overcome by deploying nuclear energy for power generation, enabling a stable base-load power supply that can lead to a more balanced grid.

Barriers to nuclear power plant development

India's first commercial nuclear power plant (Tarapur Atomic Power Station) began operations in 1969 with an initial capacity of 160 megawatts. Despite the first nuclear plant being established before the country's first solar plant, nuclear energy now accounts for only about 1.8% of India's total installed generation capacity. In contrast, solar energy, which gained traction in the early 2000s, now contributes nearly 20%.

The lag in nuclear energy's growth has many facets. To begin with, India's nuclear sector has historically faced delays and budget overruns, impacting project costs and affordability. For instance, the Kudankulam nuclear plant in Tamil Nadu, which was commissioned in 2017 after an 8-year delay, cost the Nuclear Power Corporation of India (NPCIL) over INR 10,000 crore in losses.

Then, land acquisition for nuclear energy has also proven to be contentious. Although less land-intensive, the criteria for a suitable location to set up a nuclear power plant are stringent: plants must be situated at a safe distance from residential areas, away from disaster- or flood-prone zones, at lower altitudes, and near a water source for cooling purposes. These criteria significantly limit the availability of potential locations. For instance, recently the Kerala State Electricity Board (KSEB) chairperson called nuclear energy a viable long-term solution for

the state's energy needs (considering its current heavy reliance on external energy sources), but the plans to conduct feasibility studies in Thrissur and Kasaragod were opposed by experts, given their vulnerability to landslides. Instead, increasing the capacity of the nearby Kudankulam plant was recommended.

What can make for an effective nuclear energy strategy?

To develop an effective nuclear energy strategy, it is crucial to begin with robust pre-feasibility studies. These studies, in addition to ensuring geographical feasibility, should aim to avoid potential issues related to land acquisition and public opposition by thoroughly assessing locations. Proactively engaging communities in understanding the risks and benefits of nuclear energy is also essential to ensure that they are informed and can stand to benefit from such projects. Further, with potential private sector involvement, strong monitoring and regulatory mechanisms should be established to prioritise public safety, maintain affordability, and support local community engagement.

Additionally, India should focus on identifying specific sectors and use cases for deploying SMRs. Due to its smaller size and flexibility, SMR offers significant advantages in nuclear energy deployment. Key industries with high energy demands, such as steel, cement, and chemical production, can benefit from its ability to provide a stable and substantial power supply. SMRs could also serve data centres, and remote rural areas that need reliable energy access. Moreover, since SMRs do not necessarily require large tracts of public or forest land, they can be deployed with minimal impact on local communities.

While nuclear energy holds potential to further India's clean energy

goals by providing a stable, low-carbon power source that complements the intermittent energy sources, realising this potential will require careful planning, investment in regulatory and safety infrastructure, and strong community engagement. Without such efforts, effective nuclear energy deployment will remain a pipe dream. However, targeted reforms may allow India to create a nuclear energy pathway that firmly supports the country's transition to a low-carbon economy.

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