The nuclear option

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Ahead of the Prime Minister's landmark net-zero announcement at the G20 summit at Rome, Union Minister and India's Sherpa to the G20, Piyush Goyal said, "For our baseload to be replaced from coal to maybe nuclear, we will need large amounts of capital to set up nuclear plants both to replace our current demand and for the future demand that our development imperative requires."

As he pointed out, nuclear reactors are immensely capital-intensive, while nuclear fuel is energy-dense and cheap, making them economically feasible when operated at full capacity. This makes it a dependable substitute for coal as a baseload provider.

At the climate summit, Prime Minister Modi also committed to a target of sourcing 50% electricity capacity from renewable sources and ramping up fossil-free capacity to 500 GW by 2030.

Currently, with over 100 GW of installed renewable energy capacity, coal and natural gas-based power plants are operated in a flexible mode to manage intermittency caused by renewable energy in the grid. The draft National Electricity Plan 2021, while stating its primary objective as promoting clean energy, suggests continued reliance on coal and natural gas for flexible power requirements to ensure grid stability.

With the escalating integration of intermittent renewables to the grid along with the net-zero 2070 target, nuclear energy must play a complementary role. However, nuclear energy in India seems to be on the backburner, with the installed capacity at just 6.8 GW even though we are expected to reach 22 GW by 2030. From this perspective, let us take a fresh look at nuclear energy in the Indian context.

Nuclear designs

One of the most promising nuclear designs is the Molten Salt Breeder Reactor (MSBR), an advanced design pursued by India for long-term sustainable energy using thorium. Thorium-fuelled MSBR meets many of the future goals of nuclear energy—improved sustainability, higher efficiency, inherent safety, low-pressure operations that do not require expensive containment, and waste reduction.

Furthermore, MSBR is designed to be operated in the load following mode, which is a power plant that can adjust its power output as the demand for electricity fluctuates throughout the day. It is possible to expedite the thorium stage if we are able to strengthen our thorium-based fuel value chain.

Another option we could explore is the coupling of the nuclear reactor with a heat energy storage system. One such example is natrium technology, which is touted to be one of the key elements of the United States' net-zero plan. It is a sodium-cooled fast reactor coupled with a heat energy storage system.

A portion of the heat generated by the fast reactor will be stored in the molten salt energy storage system. The stored heat energy can then be converted to electricity, and flexibly dispatched as per the grid requirement. The prototype design, expected to be commercialised by the late 2020s, is a 345 MWe reactor, which can provide up to 500 MWe (+ 45%) with the storage system for more than 5.5 hours as per requirements. Such a design potentially offers a win-win solution, where the nuclear power plant can provide grid stability and operate economically in full capacity.

Our current fleet of light and heavy water nuclear reactors are not typically operated in a flexible manner, which can be realised by operating at a capacity lower than what they are designed for and ramping up as per requirement. While the imported Kudankulam light water reactors have this capability by design, it might not be financially viable to operate them in this manner.

It is indeed possible for us to leapfrog to advanced nuclear technology that can balance a high renewable energy grid, given that India has been pursuing both sodium-cooled fast reactor as well as molten salt technology as part of its three-stage nuclear energy programme.

The prototype fast breeder reactor, an indigenously designed and manufactured sodium-cooled reactor, is in the advanced stages of commissioning. The atomic energy establishment has also been carrying out extensive research in molten salt technology and materials as part of India's long-term thorium plans.

Continued dependence on cheaper coal and other fossil-based power for base and flexible energy will prove to be a significant financial burden given the net-zero target. Nuclear energy has the potential to be a flexible and clean power for India, provided a level-playing field in terms of decarbonisation policy. It has the potential to be a cost-effective energy option too. India's net-zero action plan and demand for climate finance support must definitely consider the nuclear energy option.

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