Flexible operation of nuclear power plants: international experience and perspectives for India

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While India is taking ambitious steps in nuclear power deployment, rising variable renewable penetration prompts discussions on characteristics of nuclear power reactors related to operational flexibility. The present article reviews international experience of flexible operation across reactor technologies, emphasising those relevant to India. The review shows that feasible flexibility is fundamentally technology-specific and remains limited for the pressurised heavy water reactors and fast reactors underpinning India's indigenous nuclear programme. Long-term energy modelling hints that planned baseload deployment does not hamper renewable integration, suggesting that policymakers prioritise rapid nuclear capacity expansion while periodically assessing future flexibility requirements to guide reactor development and deployment.

in some of the countries. the experience is mainly derived from reactor technologies and power-system conditions that differ substantially from those envisaged in India's nuclear programme. Consequently, the applicability of limited international experience to India needs assessment. The present article attempts this by reviewing the global experience in flexible operation of NPPs. It analyses the historical conditions forcing the adoption of flexibility, the extent of operational agility demonstrated across various reactor technologies, and the strategic relevance of these findings for India's future nuclear roadmap.

Operational flexibility

Flexibility of a power plant is broadly classified into load following and frequency control, distinguished by depth and speed of response, with the latter demanding rapid response in a narrow power range. Plant flexibility is