

Transforming India's Power Landscape: Managing Large-Scale Renewable Energy Integration Through Flexibility

India has adopted a low-carbon path to meet its growing power demand. The Government of India is actively promoting renewable energy (RE) to bolster energy efficiency and security for the country, reduce oil imports, and improve air quality. The focus on expanding India's RE capacity — targeted to reach 175 GW by 2022 — represents an immense economic and environmental opportunity but also a huge challenge to grid stability.

TRANSITIONING TO A FLEXIBLE POWER SYSTEM

Generation of energy from sources like wind and solar is variable and unpredictable due to changing weather conditions. Large-scale integration of this variable RE into the electricity grid necessitates changes in the functioning of existing power generating capacity, which in India is largely coal-based, so that grid reliability and stability are not compromised. India's RE integration plans, thus, critically hinge on its coal-based power plants having the flexibility to tune their generation responsively to variable RE generation. An evidence-based approach to this critical imperative has been demonstrated by the Greening the Grid-Renewable Integration and Sustainable Energy (GTG-RISE) program, a partnership between the United States Agency for International Development (USAID) and the Ministry of Power (MoP), Government of India. GTG-RISE conducted a series of prioritized innovation pilots and demonstrations to validate technologies and solutions to support large-scale RE integration into the Indian power grid.



One third of India's coal based power generation capacity should be made ready for flexible generation and dynamic simulation models could play a key role. The study reports supported by USAID & IGEF are pre-cursor to ascertain flexible operations for many of these units.

Vivek Kumar Dewangan

Joint Secretary (Thermal & International Co-operation),
Ministry of Power, GOI

The GTG-RISE pilot on coal-based flexible generation supports the Ministry of Power's efforts to build a resilient and self-reliant power sector and meet India's ambitious RE goals.

EVIDENCE-BASED APPROACH TO MITIGATING OPERATIONAL CHALLENGES

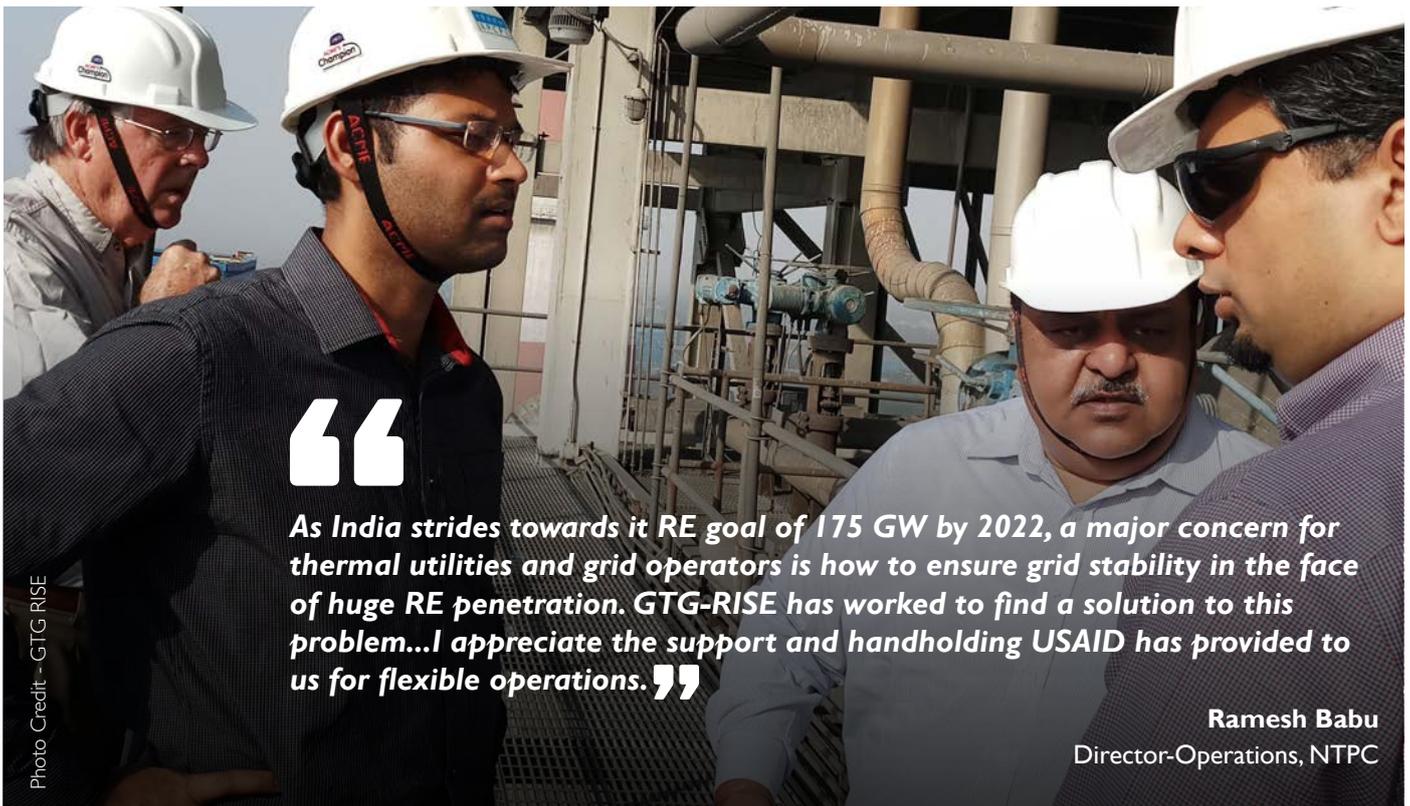
GTG-RISE conducted a four-year (2017–2020) pilot to identify the technical interventions and operational changes needed to implement flexibility in coal-based plants. The pilot was undertaken at a total of four coal-fired units in partnership with power utilities at national and state levels: at the national level with National Thermal Power Corporation Limited (NTPC), which produces almost 74% of India's coal-based power generation, and at the state level with Gujarat State Electricity Corporation Limited (GSECL).

The pilot leveraged best practices and international experience as it studied flexibility needs of coal-fired plants and the techno-economic impact on plant equipment's life. GTG-RISE carried out detailed technical feasibility studies at the four pilot sites/units (a total of 1,400 MW) to assess the units' preparedness, including the technical interventions needed for flexibility and their cost implications. The studies were followed by low-load test runs, conducted based on the procedure developed by GTG-RISE in collaboration with Bharat Heavy Electricals Limited (BHEL). Low-load test runs were conducted at NTPC's Mouda unit in Maharashtra and GSECL's Ukai unit, with gradual reduction of technical minimum up to 40% while maintaining all other operating parameters under stable conditions and without any supplementary oil firing support. The test runs gauged the responsiveness of plant equipment when subjected to low loads on a sustained basis. Data from test runs was analyzed to arrive

at comprehensive recommendations about the specific changes needed in operational practices and procedures and the retrofits/upgrades required. The pilot also built the capacity of key plant personnel for flexibility operations; more than 500 plant engineers and officials were trained through trainings, knowledge dissemination workshops, and executive exchanges.

Over its past four years, the coal flexibility pilot made a notable impact, providing a comprehensive set of recommendations that can prove the building blocks for nationwide rollout of flexible operations at coal power plants. In addition to NTPC and GSECL, the pilot's results also lent inputs and support to the Central Electricity Authority (CEA), Central Electricity Regulatory Commission (CERC), and Power System Operation Corporation Limited (POSOCO). It provided robust data and evidence on flexible operations to these lead power sector entities in India, supporting them to identify, address, and bring out changes to existing policies, guidelines, and regulations in the near future. The key recommendations emanating from the pilot have been captured in a summary report, titled 'Transition towards flexible operations in India' (available at <https://www.gtg-india.com/>). Some key outcomes of the regulatory consultation paper, including increased operations and maintenance (O&M) cost due to life consumption on account of cyclic operation and higher cost from increased oil consumption due to frequent start/stops, etc., got featured in the CEA report on coal flexibility, titled 'Flexible operations of thermal plants for integration of renewable generation' (2019).

Evidence from the pilot's studies and test runs will guide the development and implementation of a long-term flexibilization roadmap for the country and boost integration of renewables.



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As India strides towards its RE goal of 175 GW by 2022, a major concern for thermal utilities and grid operators is how to ensure grid stability in the face of huge RE penetration. GTG-RISE has worked to find a solution to this problem...I appreciate the support and handholding USAID has provided to us for flexible operations.”

Ramesh Babu
Director-Operations, NTPC

PAVING THE WAY FOR SUCCESSFUL RE INTEGRATION

The pilot's studies and test runs have generated evidence to inform the development and implementation of a long-term flexibilization roadmap for the country and boost integration of renewables. Importantly, the pilot has built a business case for policy and regulatory changes to implement coal flexing on a larger scale in India.

Some of the pilot's recommendations are already being adopted: NTPC is retrofitting Nitrogen sparging and blanketing system across its country-wide thermal power plants to prevent long-term corrosion damage during flexible operations. Further, based on the experience and learning from the flexibility study of Ukai TPS Unit # 6 (500 MW), GSECL has finalized the scope for major renovation and modernization (R&M) at Ukai TPS Unit # 3 and # 5, covering the majority of requirements for flexible operation. The scope covers the minimum technical load of 40% without oil

support as well as control and instrumentation (C&I) upgrade to facilitate flexible operation.

In what is a crucial testimony to the pilot's success and part of its scalability efforts, GTG-RISE has also supported Karnataka Power Corporation Limited (KPCL) to scale up its interventions and make its coal plants more flexible. Based on the project's inputs, KPCL is conducting similar studies at two of its units (BTPS Unit #2 500 MW and RTPS Unit #5 200 MW).

The flexibility pilots with NTPC and GSECL have also contributed to the broader objective of reducing greenhouse gas emissions, with an estimated 24.25 MMtCO₂e reduction at the pilot level and potential 714.83 MMtCO₂e reduction by 2030. The pilot has set standards for flexing coal-based plants in the country to balance the grid in the face of increasing variable RE penetration. Its results have served to improve the capacity of participating Indian states to finance and manage growing levels of grid-tied RE and establish new mechanisms to balance variable RE in the country.

Insights from the pilot will go a long way to support the country in addressing variability in RE generation effectively, a critical achievement that will spur progress on India's decarbonization journey.



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Our partnership with USAID's GTG-RISE on flexible operation has given us the confidence to balance our operations. Going forward, policy and compensation will play a critical role in scaling up flexible operations”

H N Baxi

Executive Director cum MD (A), GSECL



Photo Credit - GTG RISE



With RE contribution of 31% in 2019-20, presently at 40%, it's high time for Karnataka to think about flexibilization. We need to take conservation, technical possibilities of balancing the grid and associated cost into consideration and our pilot with USAID's is guiding us in the right direction

V Ponnuraj
 Managing Director, Karnataka Power Corporation Ltd (KPCL)

SUCCESS AT A GLANCE



2,120^{MW}
 capacity of India's energy utilities supported for improved financial and operations performance



Low-load (flexible)
 test runs (up to 40%) supported and procedures developed for nationwide scale-up



500+
 power plant officials and engineers trained on flexible generation



44^{GW}

capacity of NTPC, India's largest public sector power generation utility, adopted improved operational performance recommendations (Nitrogen blanketing and condenser throttling)



~ USD
10 million
 mobilized for improved operational performance by energy utilities



375^{MW}
 of RE curtailment avoided due to coal flexibility pilot interventions

The GTG-RISE pilot built a business case for policy and regulatory changes to implement coal flexing at a larger scale in India. Insights from the pilot are helping India build a strategy to address variability in RE generation and set a benchmark for the entire South Asia region.

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This document is made possible by the support of the American People through the United States Agency for International Development (USAID). The contents of this document are the sole responsibility of Deloitte Consulting LLP and do not necessarily reflect the views of USAID or the United States Government. This document was prepared under Contract Number AID-OAA-I-13-00018/AID-386-TO-17-00001.