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Unlocking the Potential of Distributed Energy Resources in Advancing India's Green Energy Transition

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2030 and net-zero target by 2070, showing a remarkable growth of 135 per cent from F
15 to FY2023–24.

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India is rapidly expanding its renewable energy (RE) capacity to meet the 500 GW target by 2030 and net-zero target by 2070, showing a remarkable growth of 135 per cent from FY2014–15 to FY2023–24.

While grid-scale RE sources are crucial for this green energy transition, distributed energy resources (DERs), which are small-capacity RE plants, play a significant role in accelerating the progress towards national RE targets. DERs are connected to a lower-voltage distribution network near load centres.

Unlike large power plants, which are often located far from demand centres and rely on extensive transmission networks, DERs generate and supply power locally. This reduces the need for additional transmission infrastructure, minimises network losses, and ultimately lowers energy costs for consumers.

To boost the uptake of DERs, the Government of India (GoI) has introduced several schemes. The Pradhan Mantri Kisan Urja Suraksha evam Utthan Mahabhiyan (PM-KUSUM) scheme aims to add 10 GW of decentralised ground/stilt-mounted grid-connected solar, 14 lakh standalone solar agricultural pumps, and 35 lakh grid-connected agricultural pumps including feeder-level solarisation, summing up to 34.8 GW of solar capacity by March 2026. Further, the Pradhan Mantri Surya Ghar: Muft Bijli Yojana seeks to light up one crore households by installing rooftop photovoltaic (RTPV) panels that can provide up to 300 units of electricity every month.

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Following GoI's lead, the Government of Maharashtra has announced the addition of 7 GW of distributed solar plants under the Mukhyamantri Saur Krushi Vahini Yojana 2.0 (MSKVY 2.0) scheme by December 2025.

This initiation seeks to achieve solarisation of 30 per cent of agricultural feeders in each district in the state.

This quantum of distributed solar plants is expected to rise further in the future, with other states such as Rajasthan, Karnataka, Andhra Pradesh, and Uttar Pradesh also introducing similar schemes to promote DER installation.

The primary purpose of DERs is to generate power and supply the local loads, especially for the agriculture sector at distribution voltage levels. However, during low load conditions, the power generated from DERs flows towards the higher voltage transmission network. This is contrary to the conventional method of transferring power from the transmission network to the distribution network.

As the power system is designed for one-way power transfer, reverse power flows may overload certain network elements. Therefore, the associated network infrastructure must be enhanced to integrate higher levels of DERs.

The interface mechanism between RE plants (both utility scale and DERs) and the grid involves power electronic-based equipment (inverters and converters). Unlike conventional thermal power plants, these devices have no rotating mass and do not contribute to system inertia. As more RE plants are connected to the grid, the system inertia will be reduced.

Power system inertia, a shock absorber for the electricity grid, comes from the big, heavy spinning parts in traditional power plants, which should not be suddenly sped up or slowed down. When there's a problem in the grid, like an outage of any power system equipment, causing an imbalance between load and generation, this inertia helps keep the electricity flowing smoothly and prevents big swings in frequency (similar to the heartbeat of the power system).

With the optimal usage of DERs, the power imbalances in the network can be avoided. DERs like solar and battery energy storage systems (BESS), equipped with advanced power electronic devices, can respond quickly to grid frequency changes either by absorbing the surplus from the grid or injecting the deficit power into the grid to maintain the grid frequency within the permissible limits. DERs can form microgrids, ensuring local power supply during widespread outages and aiding in faster grid restoration.

This can be achieved by forming an entity called a distribution system operator (DSO) to manage and co-ordinate the distribution electric system at a more granular level. The DSO manages the generation from DERs being injected into the grid and also the system demand. It is responsible for scheduling the generation from the DERs present in the local area.

It is also responsible for selling and purchasing power from power utilities in the area. DSOs operate the DERs and supply power throughout the state based on the instructions from the state load dispatch centres (SLDCs). For example, if the state requires 50 MW of additional power, the SLDC requests the DSOs to inject the power generated from the DERs in their respective areas.

The hierarchical structure, wherein DSOs respond to SLDCs, aligns with the existing practices in transmission and distribution systems, facilitating easier integration into the current grid framework. Further, a white paper released by the Department of Science and Technology, GoI, underscores the requirement of DSOs for ensuring reliable distribution network operations.

Implementing a DSO model enables the seamless integration of DERs, strengthening the grid and enhancing network robustness. It also encourages more consumers to install DERs like solar (RTPV and utility-scale solar) and BESS in their local premises because of less effort and more monetary benefit from the energy produced by them. With the implementation of smart grid technologies, communication between operators and SLDCs can even be automated, which could further accelerate the power exchange between them.

Moreover, with AI-optimisation techniques, DER operations can be controlled through automation. Thus, implementing the DSO model could accelerate India's transition to a decentralised, sustainable energy future.

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