Ensuring Efficiency

Role of AI in distributed solar segment

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Renewable energy is gaining traction in India as a viable alternative to fossil fuels. It is cleaner and safer than traditional energy sources. The renewable energy sector in India has achieved substantial progress because of technological improvements in the recent decade. The most used renewable energy sources in India are solar (45 GW) and wind (39 GW), totalling 85 GW out of the total renewable energy capacity of 100 GW. India plans to go beyond the current 175 GW target for 2022, aiming for 450 GW of renewable energy by 2030.

Wind turbines, unlike solar panels, cannot be used in highly inhabited regions, which is why they are most prevalent in rural locations. Solar panels can be installed on nearly any roof or the ground, making them a more practical option for distributed energy sources. However, unpredictable weather is a major challenge in producing solar energy, impacting the energy output significantly. Despite having weather forecasting technologies, it is difficult to predict the weather as changes occur rapidly, disrupting energy flow.

Under microclimatic conditions, unexpected generation drops might occur because of cloud cover over large solar plants. We do not have balancing or scheduling mechanisms that can quickly ramp up conventional sources to satisfy demand in real-time. Large solar plants also necessitate a dedicated power evacuation system. Solar generation occurs for around nine hours a day, and the infrastructure is inactive for over 15 hours.

Another key challenge is load estimation. Accurate load predictions are needed to maintain a successful distributed renewable energy operation. Large-scale battery storage systems can be combined with renewable sources to provide a continuous and steady supply of electricity in off-grid scenarios. If future demand is unclear, the operating and maintenance costs of such systems could become expensive.

Distributed solar reduces investments in transmission and distribution infrastructure, and electricity lost during evacuation over the grid because of local consumption. Agriculture and rooftop sectors are the key nodes where distributed solar generation could create an impact. The agriculture sector in India consumes 20 per cent of the electricity produced. A majority of states offer farmers dedicated hours of free power or highly subsidised rates. Farmers typically leave their pumps running for lengthy periods without monitoring as turning the pumps on at odd hours of the day would be difficult. Solar power can meet the amount of electricity that any agricultural feeder requires during the day in a single stretch at a lower cost than the average power purchase cost.

Artificial intelligence (AI) could play a major role in improving the efficiency of distributed solar generation. AI systems drive crop-type recognition (image processing), automatic irrigation, soil moisture content detection, crop monitoring, and weather data. These systems can reliably predict a field's future electricity consumption. Decentralised solar can meet a portion of this need, with the rest imported from the grid. Distribution companies could reduce revenue loss caused by free supply while simultaneously reaching their annual targets using distributed solar. Farmers could also make more precise decisions—such as when to plant, water, apply fertiliser, and harvest.

In the urban environment, rooftop solar is the viable choice for distributed energy generation. AI models can be used to address issues in rooftop solar plants. They can identify panels with defects, learn system behaviour, anticipate system performance, and prescribe measures to increase solar production and revenue. Advanced AI models forecast a plant's behaviour utilising dynamic

pollution modelling and climate change factors by estimating actual energy production, recommending cleaning schedules, precisely preventing shading losses, and monitoring the electrical characteristics of the plant.

AI models can also help detect early signs of untimely module degradation caused by high temperatures, corrosion, cell contamination, hot spots, and other concerns, allowing them to make decisions such as replacing or removing bad panels from a system without compromising performance. Some solar facilities—for example, the Digital Twin Solar initiative in the Kassel region of Germany are employing AI and big data to boost the efficiency of their photovoltaic systems.

Given that grid management is on the path of modernisation, AI has become a critical cog in distributed solar technology. Access to a large amount of data is one of AI's primary requirements. Machine learning algorithms can analyse data generated from distributed solar systems and help identify a plant's health, provide better forecasts than before, and control loads or services. Deep learning has so far proved to be highly efficient in projecting loads, prices, and solar energy generation. Cutting-edge research on the topic is ongoing globally, and the technology is improving day by day. Not to be left behind, various Indian software giants are also developing AI to provide distributed solar energy that is stable, economical, and accessible to all.