

3. Distributed Renewable Energy- Environment

Artificial intelligence (AI) can be a game changer for India's rapidly expanding distributed renewable energy, said the Ministry of New and Renewable Energy (MNRE) at India AI Impact Summit

Distributed Renewable Energy (DRE)

Distributed Renewable Energy (DRE) refers to small-scale, decentralised electricity generation systems that produce power from renewable sources at or near the point of consumption. These systems typically range from a few kilowatts (kW) to a few megawatts (MW) and can function independently (off-grid) or be connected to the local distribution network.

Unlike conventional centralized thermal or hydro power plants that require extensive transmission and distribution infrastructure, DRE systems reduce dependency on long-distance power transmission and enhance localized energy resilience.

Sources of DRE

Distributed Renewable Energy systems primarily utilise-

1. Rooftop solar photovoltaic (PV) systems.
2. Small wind turbines.
3. Biomass gasification plants.
4. Small hydro projects (up to 25 MW).
5. Solar agricultural pumps.
6. Hybrid solar-plus-storage systems.

India currently has around 140 GW of total solar capacity, of which approximately 35 GW is attributed to DRE. In the past 15 months alone, India has added nearly 18 GW to DRE capacity, largely under flagship schemes such as PM Surya Ghar Yojana and PM-KUSUM.

Importance of DRE in India's Energy Transition

Addressing Energy Access Gaps- DRE enables rapid electrification in remote and geographically challenging regions such as hilly areas, islands, and tribal belts without waiting for costly grid expansion. It is particularly relevant in states with dispersed settlements.

Reducing Transmission and Distribution (T&D) Losses- Since electricity is generated close to the point of use, DRE significantly reduces transmission losses, which remain a structural concern in India's power sector.

Enhancing Energy Security- By diversifying energy sources and decentralising production, DRE reduces dependence on fossil fuels and centralized generation. It strengthens resilience against grid failures and natural disasters.

Environmental Sustainability- DRE systems produce low or zero greenhouse gas emissions during operation. They reduce air pollution and limit land degradation compared to large centralized power plants.

Economic and Social Benefits

DRE promotes-

1. Local job creation in installation, maintenance, and manufacturing.
2. Entrepreneurial opportunities in rural energy services.
3. Income enhancement for farmers through solar pump integration.
4. Community ownership models such as cooperatives and mini-grids.

Thus, DRE contributes to inclusive and sustainable development.

Role of Artificial Intelligence (AI) in DRE- AI is increasingly integrated into DRE systems to improve efficiency, forecasting, and grid management.

Optimising Renewable Integration

AI-based forecasting models predict solar irradiation and wind speeds more accurately, reducing curtailment and improving grid balancing.

Smart energy management systems use AI to-

1. Optimise battery storage cycles.
2. Manage demand-response mechanisms.
3. Reduce peak load stress.

Industrial and Urban Efficiency

AI-driven optimisation reduces emissions across sectors-

1. Transport- AI-based route optimisation and logistics management reduce fuel consumption.
2. Buildings- Smart HVAC systems and predictive maintenance improve energy efficiency.
3. Manufacturing- Process automation lowers energy wastage.

The Energy Conservation Building Code and the National Energy Efficiency Roadmap integrate AI-enabled sustainable design principles.

Smart Real Estate Applications- AI-powered smart lighting, predictive HVAC systems, and automated building management systems can achieve energy savings of up to 25 percent in commercial and residential buildings.

Challenges in AI-Enabled DRE Deployment

Data Scarcity and Quality Issues

AI systems require high-resolution, real-time data from rooftop installations, microgrids, and rural networks. However-

1. Many small systems lack digital monitoring.
2. Data collection is fragmented.
3. Forecasting accuracy suffers due to limited datasets.

High Initial Costs- Deployment of smart sensors, AI software platforms, and skilled technical manpower increases upfront capital expenditure. This reduces financial viability for small-scale DRE projects.

Skill and Capacity Constraints- There is a shortage of professionals trained in AI-energy integration, particularly within DISCOMs and rural utilities. Limited institutional capacity hampers large-scale adoption.

Cybersecurity and Interoperability Risks

AI-enabled DRE systems are vulnerable to-

1. Cyberattacks targeting smart grids.
2. Data breaches.
3. Compatibility issues due to diverse hardware vendors and legacy grid systems.

A secure and interoperable digital energy architecture is essential.

Key DRE Solutions Transforming India's Energy Landscape

Rooftop Solar Systems- Residential installations typically range from 1-10 kW, while commercial and industrial systems operate at higher capacities. These systems reduce electricity bills and promote prosumer participation.

Solar + Storage Solutions

Integrated solar and battery storage systems address intermittency by-

1. Storing excess daytime generation.
2. Providing power during night or peak demand.
3. Enhancing grid stability.

Solar Agricultural Pumps- Solar pumps reduce farmers' dependence on diesel and unreliable grid electricity. They also lower irrigation costs and carbon emissions.

Biomass and Small Hydro- Biomass gasification plants convert agricultural residue into electricity, offering reliable baseload power complementary to solar.

Small hydro projects harness flowing water in hilly regions and provide decentralized clean energy.

Government Policies Driving DRE Adoption

PM-KUSUM Scheme

The PM-KUSUM scheme aims to add 30.8 GW of solar capacity through-

1. Component A- 10 GW decentralized ground-mounted solar plants.
2. Component B- 20 lakh standalone solar pumps.
3. Component C- Solarization of 15 lakh grid-connected agricultural pumps.

The scheme provides subsidies ranging from 30% to 90% depending on the beneficiary category.

Pradhan Mantri Surya Ghar Yojana

This scheme targets one crore households for rooftop solar adoption by providing-

1. 40% subsidy for systems up to 3 kW.
2. 20% subsidy for systems between 3–10 kW.
3. Simplified application process through a national portal.
4. Access to low-interest loans.

The initiative aims to reduce household electricity bills by up to ₹15,000 annually.

State-Level Initiatives

Several states complement central schemes through-

1. Additional subsidies.
2. Net-metering policies.
3. State-specific rooftop targets.
4. Local financing mechanisms.

Strategic Significance of DRE for India

DRE aligns with-

1. India's Net Zero 2070 commitment.
2. Energy access and SDG 7 (Affordable and Clean Energy).
3. Atmanirbhar Bharat through local manufacturing.
4. Climate-resilient infrastructure development.

It supports a shift from centralized, fossil-fuel-dependent systems toward decentralized, low-carbon energy ecosystems.

Conclusion

Distributed Renewable Energy represents a transformative paradigm in India's energy transition. By generating clean electricity close to the point of consumption, DRE enhances energy access, reduces transmission losses, improves reliability, and fosters local economic development.

The declining cost of renewable technologies, combined with supportive government policies and emerging AI integration, is accelerating DRE adoption. However, sustained success will require improvements in digital infrastructure, data governance, cybersecurity, financing mechanisms, and institutional capacity.

DRE is not merely an energy solution; it is a structural reform in India's power architecture that supports sustainable, inclusive, and resilient growth.

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