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Session : Name of the Session

Application of digital twins for the low-voltage electricity grid– Challenges and opportunities of Distribution Grid Analytics in India

Presented By

Dr Ajeet Kumar Singh

Associate Fellow, The Energy & Resources Institute (TERI), New Delhi

INTRODUCTION

- **Focus**
  - Explores challenges and opportunities in India's distribution grid analytics.
  - Highlights the role of digital twin technology in studying renewable energy integration.
  - Key lessons learned and future recommendations for smart grid solutions.

- **Case Study**
  - Uses a real-world example from Delhi to demonstrate digital twin applications.
  - Results from solar PV system integration and EV charging station in Shivalik substation.

Challenges In Indian Distribution Grids

- **Rapid Electrification & Grid Transparency Issues**
  - Organically grown grids make tracking connections difficult.
  - Challenges in balancing phases and distribution transformers.
  - Non-technical losses (energy theft) still prevalent in rural areas.
- **High Seasonality of Electricity Consumption**
  - Peak loads driven by air conditioning demand, especially at night.
  - Rising urbanization and incomes will intensify seasonal peaks.
  - Need for energy-efficient cooling and demand response programs.
- **Limited Expansion Space in Urban Areas**
  - Urban centers face space constraints for grid infrastructure upgrades.
  - Growing electricity demand requires innovative grid solutions.
  - Integration of distributed energy resources is crucial for sustainability.

RELEVANCE

- Global Commitment to Renewable Energy: Many nations, including India, are prioritizing renewable energy (RE) to curb carbon emissions.
- India's Ambitious Targets: Plans to establish 500 GW of non-fossil fuel-based capacity by 2030 and achieve net-zero emissions by 2070.
- Rising Energy Demand: India's electricity consumption is expected to grow by 1.5 times by 2031-32 compared to 2023-24 levels.
- Infrastructure Challenges: The expansion of electrical infrastructure must balance economic constraints and space limitations in urban areas.
- Need for Smart Grid Solutions: Enhancing grid efficiency and management is crucial for accommodating RES and growing demand.
- Unique Challenges in India: Rapid urbanization, a diverse electricity system, and high seasonal energy consumption create distinct grid-related issues.
- Digital Twin Technology: Offers a potential solution by improving grid transparency, operation, and planning through real-time data analytics.

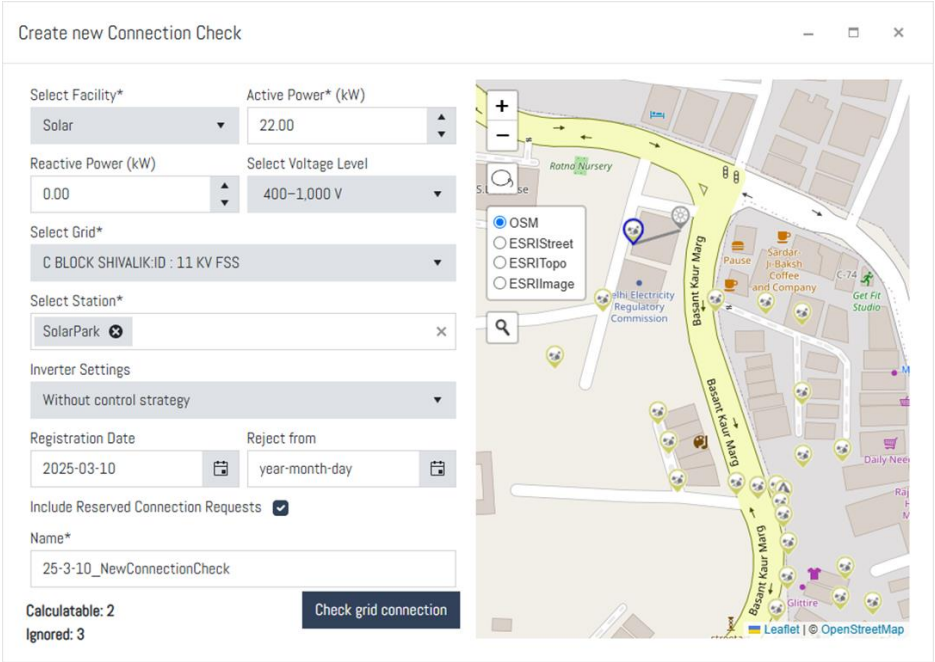
Information Transparency in Distribution Grids

- Different Information Intensities Across Voltage Levels
  - High-voltage transmission grids: Fully transparent with redundant measurement infrastructure.
  - Medium-voltage grids: Partial visibility, but limited measurement coverage.
  - Low-voltage distribution grids: Minimal real-time data, making them underdetermined systems.
- Challenges in Achieving Grid Transparency
  - Rolling out extensive measurement infrastructure is impractical due to cost and complexity.
  - Investment in measurement technology should be based on specific transparency needs.
  - Traditional SCADA systems struggle with incomplete data at low-voltage levels.
- Potential of IoT & Smart Meters
  - IoT devices could enhance low-voltage grid monitoring.
  - Smart meter data can significantly improve state estimation accuracy.
  - Next steps: Digital twins for advanced data-driven grid management.

PRESENTATION ON THE TOPIC (2/2)

Digital Twin as a Solution for Grid Management

- Capabilities of Digital Twins
  - Performs network calculations, grid state estimation, and simulations.
  - Supports load flow analysis, short-circuit calculations, and optimization.
  - Integrates real-time and pseudo-measured data for improved accuracy.
- Integration with Existing Systems
  - ADMS/SCADA: Receives pseudo-measured values and grid notifications.
  - Asset Management: Utilizes generated load data for maintenance and planning.
  - Geographic Information Systems (GIS): Tracks network topology changes.
- Comprehensive Digital Twin Approach
  - Multiple interacting digital twins operate at different abstraction levels.
  - Prosumers and grid components contribute real-time data for better forecasting.
  - Enables a fully integrated, data-driven approach to distribution grid management.



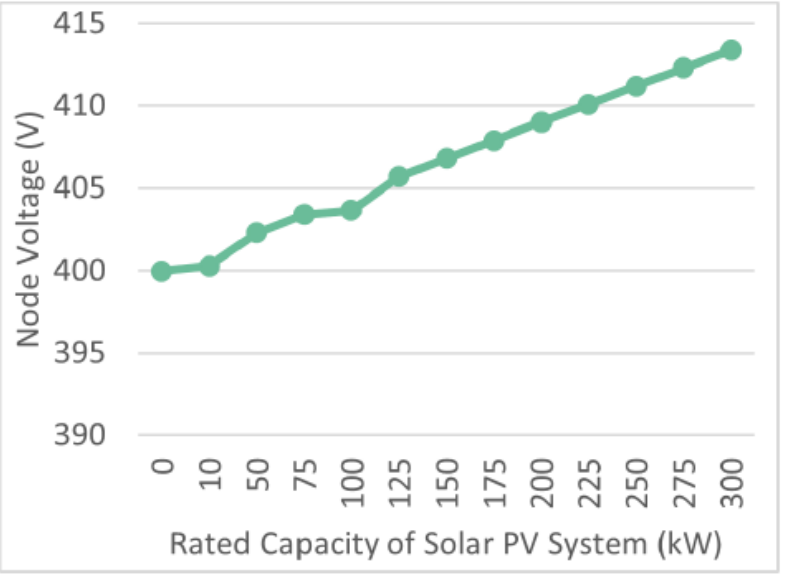
Creating connection check with Venios.NET digital twin

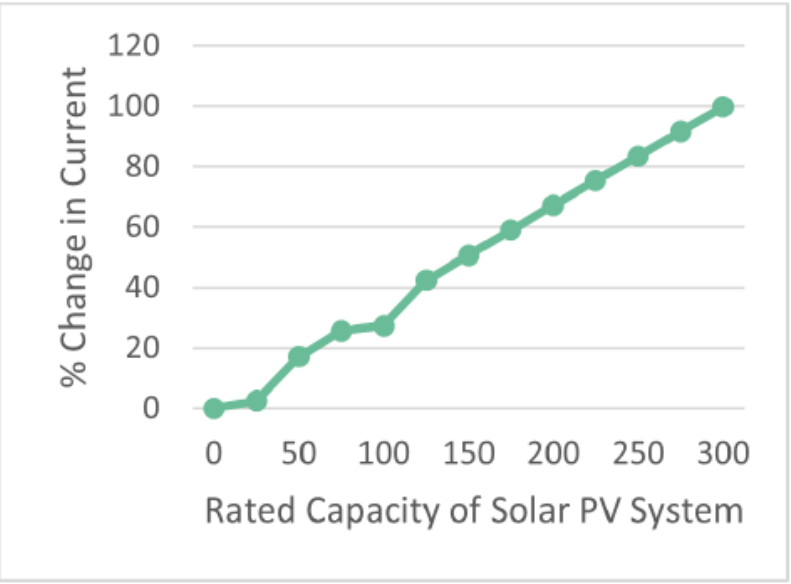
USE CASE / CASE STUDY

Grid Connectivity Check in Venios.NET

- Simulates integration of solar, wind, biomass, and various consumer loads.
- Four locations in Delhi were modeled with network topology, transformer data, cable details, and load values.

- Solar PV Integration Findings
  - Test site: Shivalik C Block, Delhi.
  - Capacity tested: 10 kW – 300 kW at unity power factor.
  - Result: Up to 250 kW PV system can be installed without exceeding feeder capacity.
  - Voltage change: ~3%, minimal impact on grid stability.
- EV Charging Station Integration Findings
  - Charger type: Level 2 (7.4 kW – 22 kW per gun).
  - Load assumption: 176 kW static load.
  - Result: 176 kW EVCS can be safely installed at the site.





KEY TAKEAWAYS / RECOMMENDATIONS

Recommendations for DER Integration

- Adoption of Digital Twin Platform → Simulates grid scenarios and enhances decision-making.
- Improving Data Collection → Real-time SCADA, GIS, and consumer data ensure accuracy.
- Smart Grid Infrastructure → Enhances grid flexibility, efficiency, and consumer empowerment.
- Deployment of Advanced Meters → Enables better monitoring of power quality parameters.
- Updating Protection System Schemes → Adapting to bidirectional power flow and preventing overvoltage issues.

Conclusion

- Digital twins provide critical insights into grid performance and DER integration.
- Simulation findings highlight grid capacity limits for solar PV and EV charging.
- Future focus on digital transformation will enhance grid resilience and efficiency.

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THANK YOU

For discussions/suggestions/queries email: ***isuw@isuw.in***

www.isuw.in

Links/References (If any)