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ISGF
India Smart Grid Forum

DISTRIBUTION UTILITY MEET
DUM 2024

Session 6: RE, EV AND GRID STABILITY AND CHALLENGES OF 10 MILLION ROOFTOP SOLAR PV SYSTEMS

Grid Integration of Distributed Renewable Energy and Grid Codes

Presented By

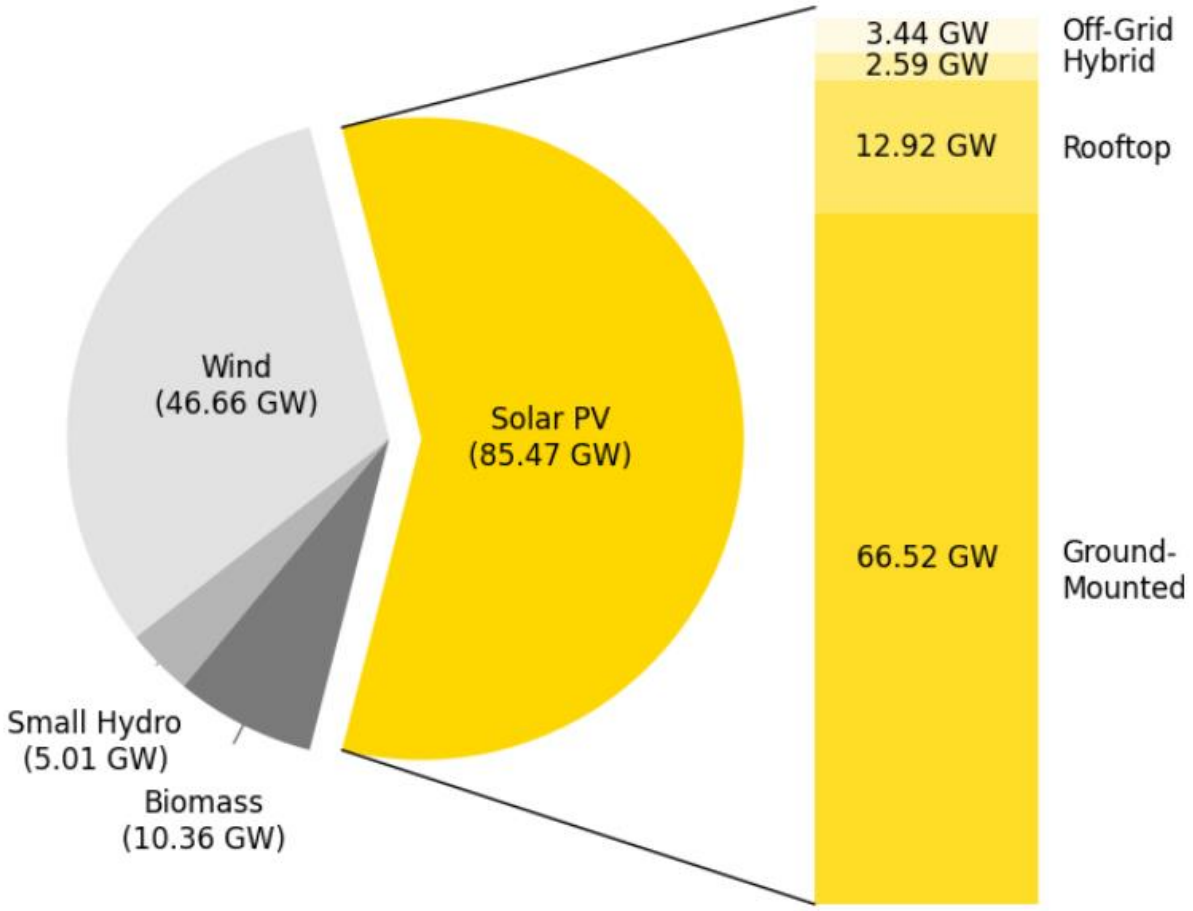
Dr. Murali Baggu, Laboratory Program Director
National Renewable Energy Laboratory
Golden, Colorado, USA





Accelerated Renewable Energy Growth and DERs

- As of October 2024, India had installed over 85.47 GW of Solar PV
- Of that, close to 13 GW of capacity is rooftop solar projects connected to the distribution network
- The means in which distributed solar responds to grid conditions will be paramount to system stability and local power quality



DER Connectivity Standards

- DER connectivity standards must make sure that these devices provide the necessary grid support to provide stability and power quality of both the **transmission** and **distribution system**
- As DER continue to displace bulk generation, the response of these devices is critical to the health of the overall power system
- As of 2024 there close to 13 GW of rooftop PV installed in India

	Evolution of IEEE DER Standards	Evolution of CEA/MNRE Grid Codes
IEEE 1547-2003	• Shall NOT actively regulate voltage • Shall trip on abnormal voltage/frequency	• Shall trip on abnormal voltage/ frequency
IEEE 1547a-2014	• May actively regulate voltage • May ride-through abnormal voltage/frequency • May provide frequency response (frequency droop).	• Future Indian grid codes
IEEE 1547-2018	• Shall be capable of actively regulating voltage • Shall be capable of frequency response • Shall ride-through abnormal voltage/frequency • May provide intertial response	
Future Standards	• Potential greater inclusion of grid-forming capabilities • Potential greater consideration of inertial response • Potential inclusion of fault-current requirements	

Locally Appropriate Grid Codes for DERs in India

- NREL public report on DER grid codes (with a focus on IEEE 1547-2018) adaptation in the India context, examining settings locally appropriate for India DISCOMs, key takeaways:
  - There is great potential to expand support required of DERs in India
  - Consideration of supply voltage characteristics are important for DER grid support
  - Frequency support will be important at high DER levels

Interconnection of Distributed Energy Resources in the Indian Context: IEEE 1547-2018 Adaptation for Locally-Appropriate Grid Code Development

Erik Pohl, Killian McKenna

National Renewable Energy Laboratory

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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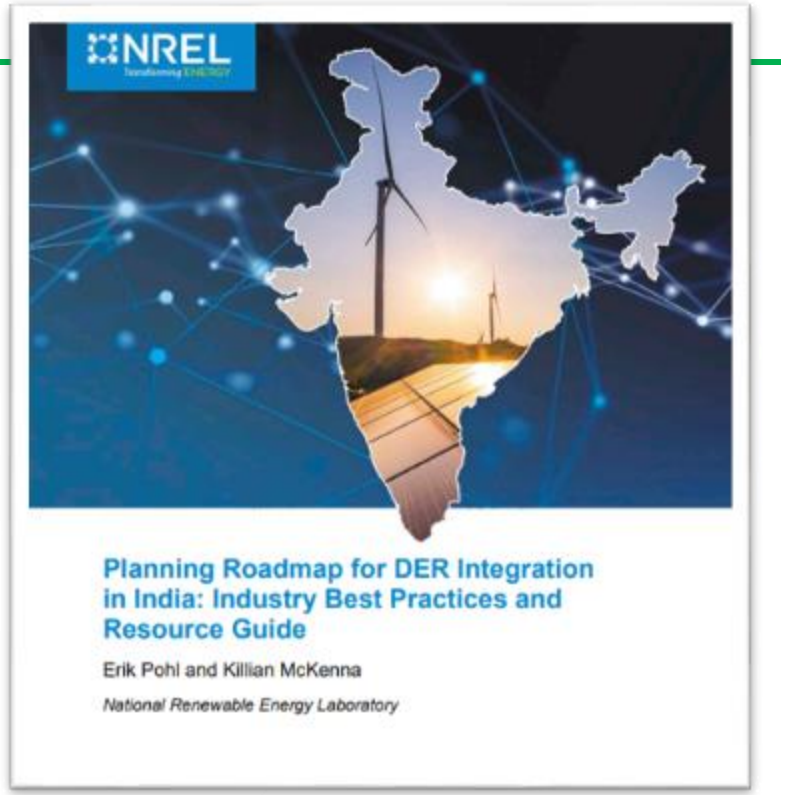
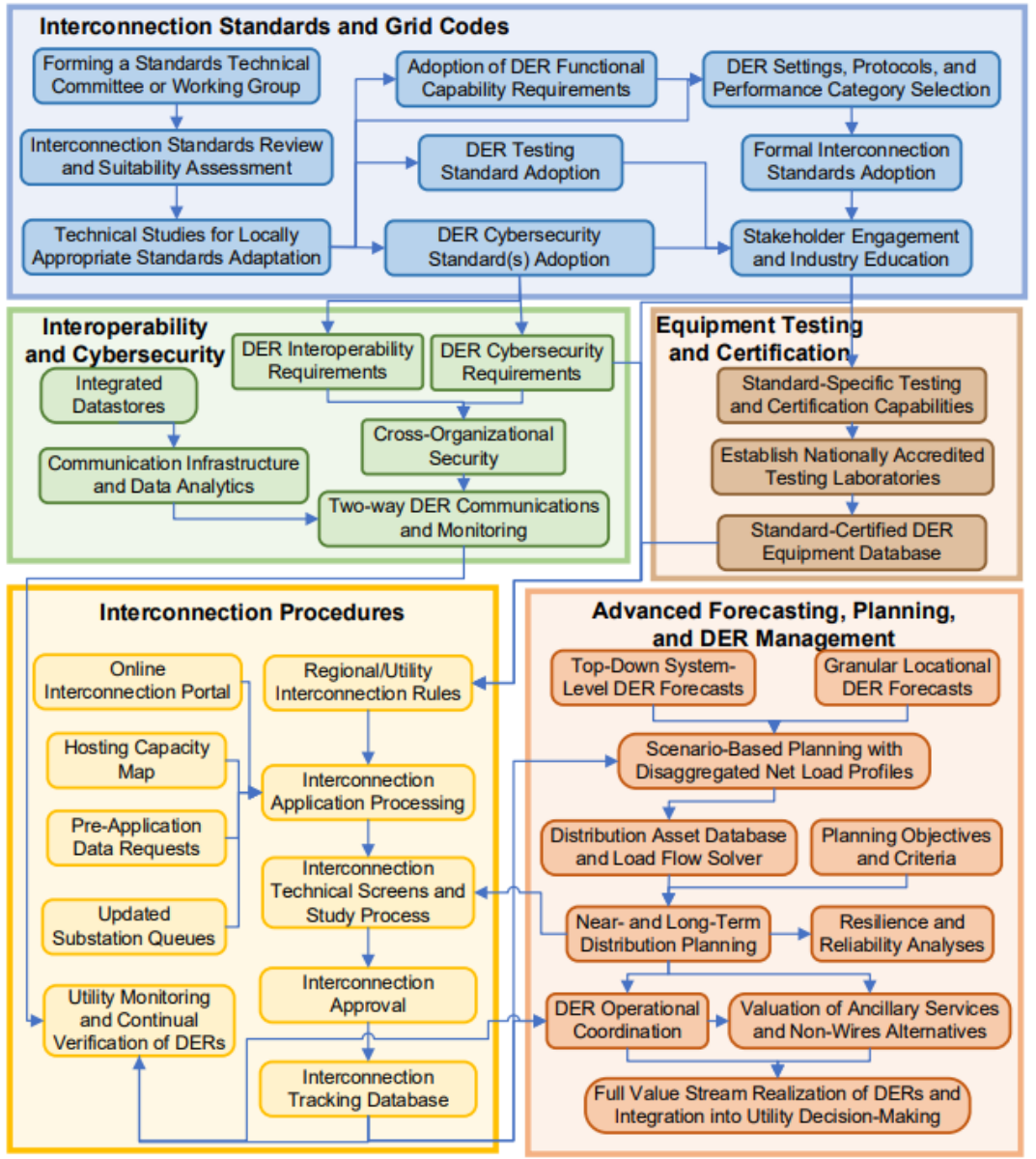
Technical Report
NREL/TP-6A40-87756
March 2024

https://www.nrel.gov/docs/fy24osti/87756.pdf

Planning Roadmap for DER Integration in India

NREL public planning roadmap for DER integration in India >





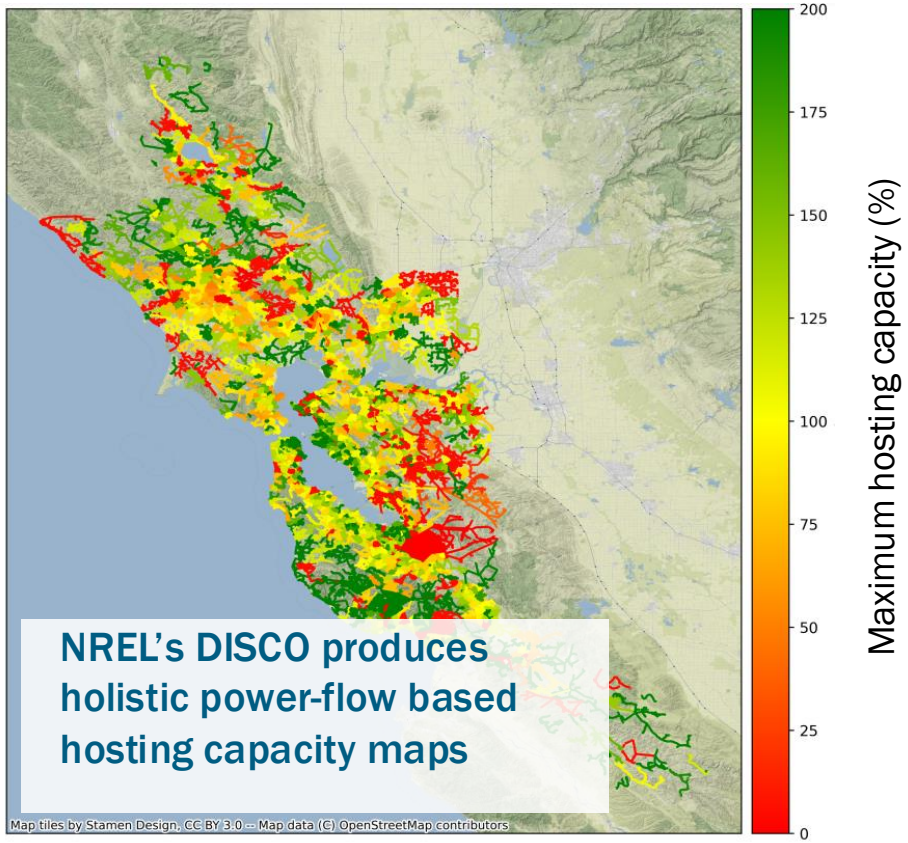
Outlines pathways for interconnection standards and grid code adoption, equipment certification and testing, interoperability and cybersecurity, interconnection procedures, and advanced forecasting, planning, and DER management

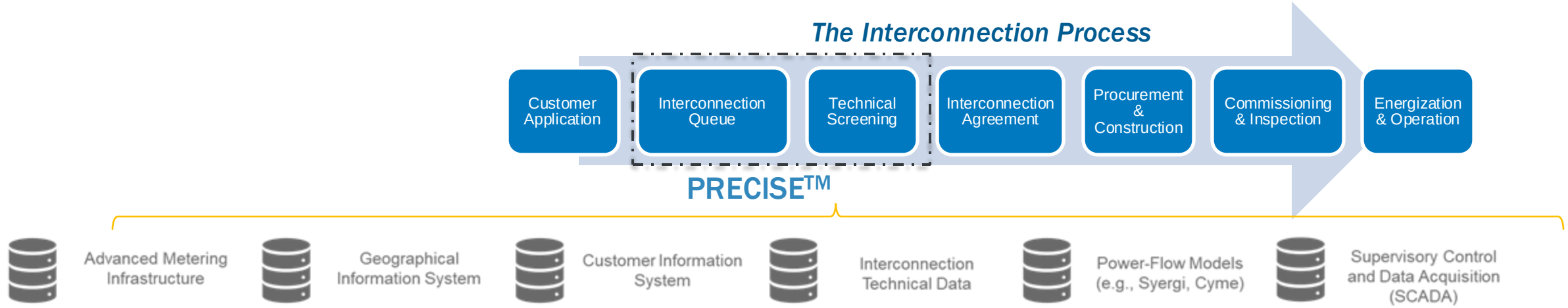
https://www.nrel.gov/docs/fy25osti/89603.pdf

Accelerating DER Interconnection

NREL capabilities to know:

- **Interconnection Study Process:** NREL's PRECISE automates & streamlines detailed DER interconnection studies
- **Hosting Capacity:** NREL's DISCO performs solar and EV hosting capacity and upgrade analysis

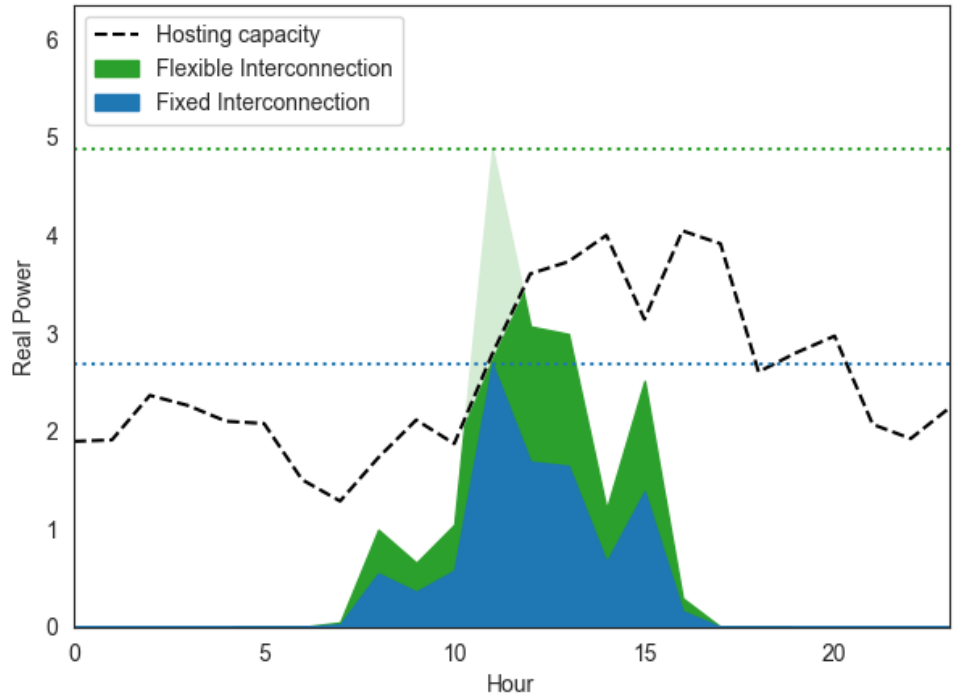




Next-Generation Interconnection

NREL is working on next-generation DER interconnection including:

- Means to *automate and modernize* the interconnection process
- Methodologies to *generate flexible interconnection profiles*



Flexible interconnection enables raising hosting capacity by leverage export-limited interconnection

Interconnection roadmap:

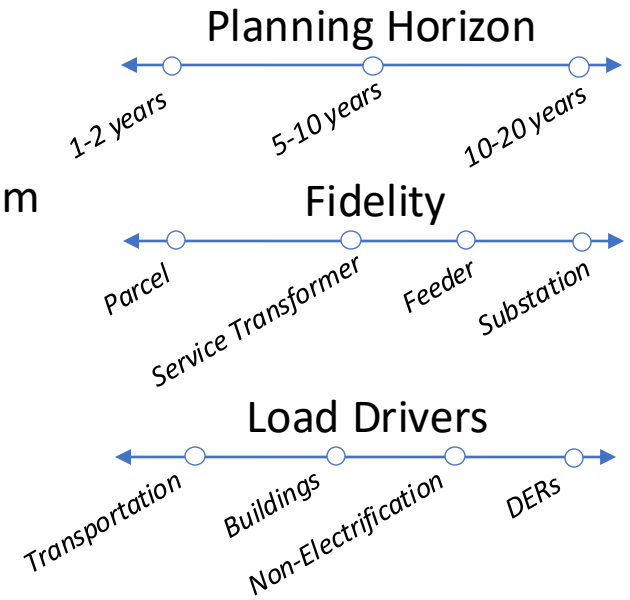
- Data integration and automation
- High visibility of network impacts
- Greater reliance on studies and automation then on screens
- Greater data integration and power-flow analysis
- More optionality in the interconnection process (e.g., NWA, flexible interconnection)

Capacity Expansion Decision Support for Distribution Networks

The Challenge: How should engineers consider uncertain load growth, resilience, voltage class upgrades, bridge-to-wires, load management with DERMS, hosting capacity, and integrated T&D planning?

Design Goals

- Flexible "building block" architecture minimizes effort on tailor made problem formulations
- Decision support tool for developing long-term multi-objective distribution capacity planning strategies.



CADET Development Status

- Released open Source "Grid Data Models (GDM)" using Sienna inspired "infrastructure_systems" python library.
  - https://github.com/NREL-Distribution-Suites/grid-data-models
- Implemented nonlinear and linearized distribution powerflow (single and three-phase) with network reduction options using GDM
- Implemented several Pyomo MILP prototype capacity planning problems.
- Implemented one hybrid heuristic + mathematical optimization problem combining OpenMDAO with Pyomo
- Working on several projects with use cases for resilience, optimal solar+battery sizing, bulk-grid planning, and integrated distribution planning.

Capacity Expansion Decision Support for Distribution Networks

A flexible platform for developing distribution capacity planning strategies.

CADET

Long-term, Multi-objective Capacity Planning

- Affordability
- Reliability
- Resilience
- Energy Justice
- Hosting Capacity
- Equity
- Carbon emissions

Integration with NREL Forecasting and Planning Tools

- dsgrid
- dGen
- EVI-X
- ERAD
- PyDSS
- ReEDS
- DISCO
- REopt
- Distribution Unit Cost Database

Repeatable, defendable solution sets for engaging with stakeholders on decisions about traditional solutions, non-traditional solutions, customer programs and EV Charging.

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THANK YOU

Developed by NREL for limited use only. Contact killian.mckenna@nrel.gov

For discussions/suggestions/queries email: ***murali.baggu@nrel.gov***