



DER Boot Camp at GridTech CONNECT

11:00 a.m. – 3:00 pm February 7, 2023

San Diego, CA

An EERE collaboration between SETO & WETO

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PNNL-SA-181625

Agenda

•	i2X and Boot Camp Overview	PNNL	11:00
•	OpenDSS Intro, Examples (Smart Inverters, Local Air Qual	ity) PNNL	11:05
•	OMF Intro, Examples (DER Interconnection Applications)	NRECA	11:20
•	GridUnity Intro, Examples (Automation with CYMDIST)	GridUnity	11:40
•	Lunch Across the Hall	DistribuTech	12:00
•	Form Small Project Teams	PNNL	12:45
•	Work on Small Problems	all	1:00
•	Discussion and Recap	PNNL facilitates	2:30
•	Adjourn		3:00

- Pre-requisites:
 - Bring a laptop. (OpenDSS may require local installation and Python)
 - Optional pre-readings: https://cigre.ca/papers/2021/paper%20460.pdf, https://ieeexplore.ieee.org/document/5275253, https://ieeexplore.ieee.org/document/985677



i2X Key Elements

Mission: To enable a simpler, faster, and fairer interconnection of clean energy resources all while enhancing the reliability, resiliency, and security of our electric grid.



Stakeholder Engagement

Nation-wide engagement platform and collaborative working groups



Data & Analytics

Collect and analyze interconnection data to inform solutions development



Strategic Roadmap

Create roadmap to inform interconnection process improvements

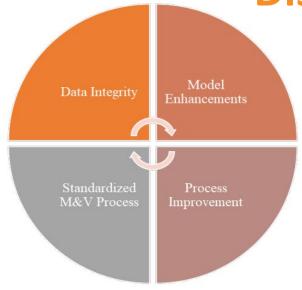


Technical Assistance

Leverage DOE laboratory expertise to support stakeholder roadmap implementation



IEEE P1729, Recommended Practice for Electric Power Distribution System Analysis



- Hosting capacity analysis (HCA) for small, medium, and large utilities
- Distribution system dynamics, using electromagnetic transient (EMT) tool running at $\Delta t \ge 100 \ \mu s$
- To ballot by September 30, 2023
- Collaborating with CanmetENERGY
- See https://standards.ieee.org/ieee/1729/10759/

Commonly Applied Boundary Parameters

- Thermal limits (overloading of feeder equipment or conductors)
- Voltage limits (steady-state)
- Rapid voltage changes (dynamic variations)
- Impact on voltage regulators and tap changers operation
- Reverse power flow

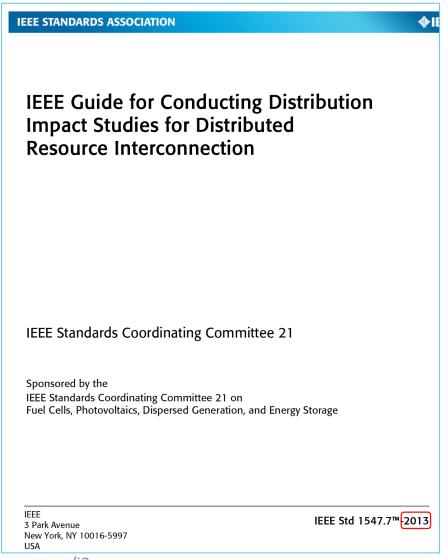
Advanced Boundary Parameters

- Protection
 - > Reach reduction
 - > Sympathetic tripping
- Harmonics
 - ➤ Individual harmonics
 - > THD/TDD

Figures from: https://cigre.ca/papers/2021/paper%20460.pdf



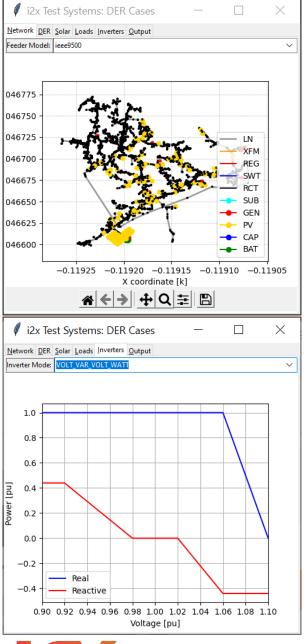
i2x Guide to Interconnection Studies of Renewable DER, replacing the outdated IEEE Guide for DER Impact Studies



- Assumptions and Criteria
- Standards and Guidelines
- Data Collection
- Model Development and Validation
- Analytical Steps and Automation
- DER Interconnection Studies
 - Screening
 - Impact
 - Facility
- Hosting Capacity Studies (consistency)
- Multi-DER (Feeder Cluster) Studies
- Influence of Storage and Chargers
- When to use EMT (or Dynamics)
- Aggregating DER for Bulk System Studies
- Sub-transmission vs. Distribution Connections
- Report Formats

PNNL's OpenDSS Examples

- Choose either a radial system or an urban low-voltage network
- How much more PV can you connect to the chosen system?
 - What evaluation criteria will you consider?
 - What data and tools do you need?
 - Result: a list or pattern of sizes and locations
 - Evaluation: how could the result or process be improved?
- OpenDSS models, with Python front end, to assist users with:
 - Adding PV at existing locations
 - Setting parameters for capacitors, regulators, and smart inverters
 - Choosing from a list of load and PV profiles
 - Executing solutions in daily mode at 1-minute steps
 - Outputs: min and max customer voltages, max voltage fluctuations, overloaded components as measured by "energy exceeding normal"
- Focus on IEEE 1547 Category A vs. B, and the effect of inverter control modes
- See https://github.com/pnnl/i2x for instructions and downloads





OpenDSS Radial System: IEEE 9500-Node Test Case

- 12.47 kV, 3 substations, 3 feeders
- 13,669 kW peak load
- 12 Synchronous Machines
 - Total rating is 7060 kW, 9112 kVA
 - Dispatched to 1210 kW grid-connected
 - Includes 150 kW (225 kVA) permanentmagnet wind turbine generators
 - Displace the fossil-fuel generators with PV to improve local air quality?
 - Discuss possible impact on grid reliability
- 178 PV Inverters, 2955 kW
- 2 Batteries, 500 kW



Reference: https://cmte.ieee.org/pes-testfeeders/wp-content/uploads/sites/167/2022/03/9500-Node-PES-TPWRS-Paper-2022.01.14.pdf

Models: https://github.com/GRIDAPPSD/CIMHub/tree/feature/SETO/ieee9500



OpenDSS Urban System: IEEE Low-Voltage Network

