INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

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

i2x@ee.doe.gov | energy.gov/i2x

PNNL-SA-181625

Agenda

• i2X and Boot Camp Overview	PNNL	11:00
• OpenDSS Intro, Examples (Smart Inverters, Local Air Quality)	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

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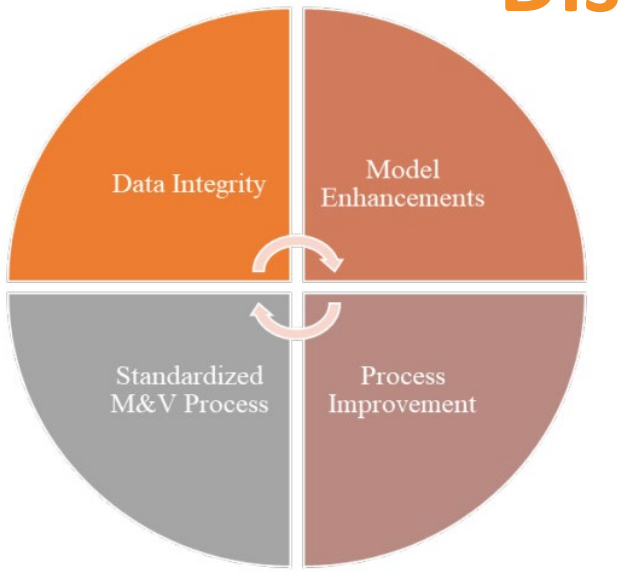
IEEE P1729, Recommended Practice for Electric Power Distribution System Analysis



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

Commonly Applied Boundary Parameters

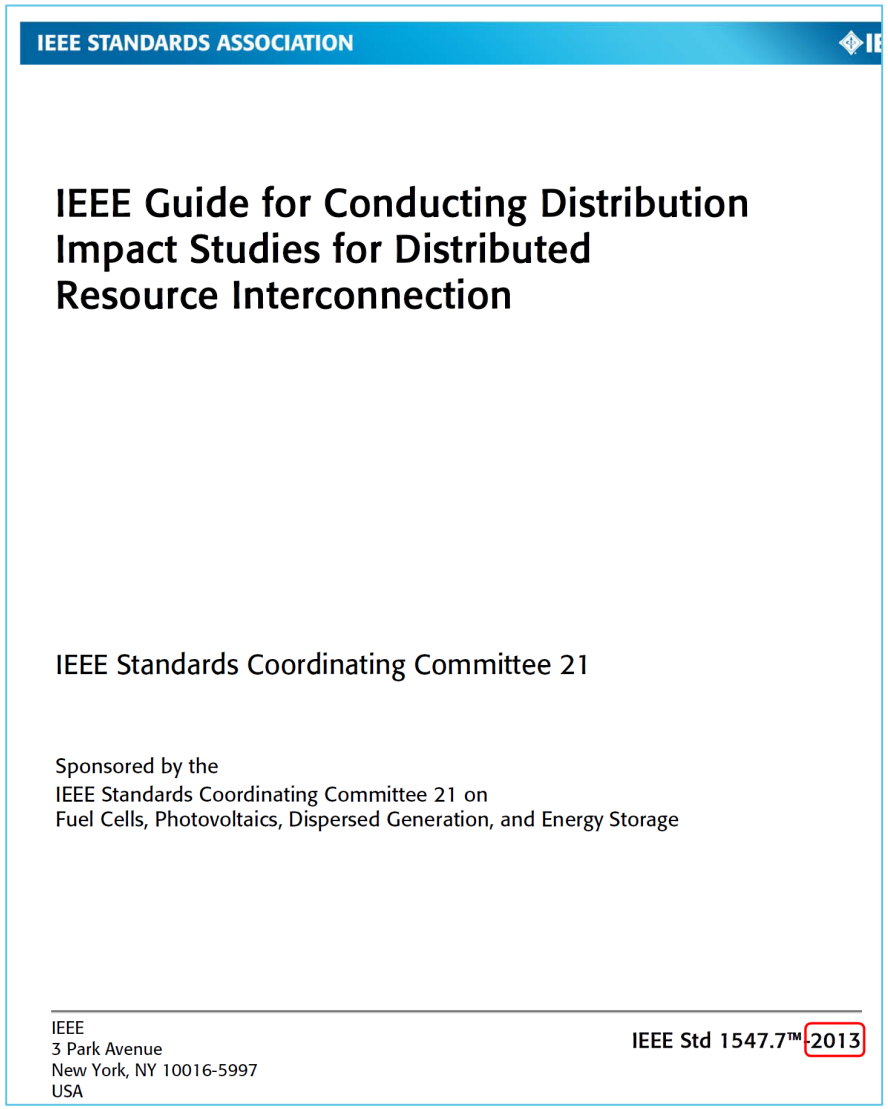
- Thermal limits (overloading of feeder equipment or conductors)
- Voltage limits (steady-state)
- Rapid voltage changes (dynamic variations)
- Impact on voltage regulators and tap changers operation
- Reverse power flow

Advanced Boundary Parameters

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

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

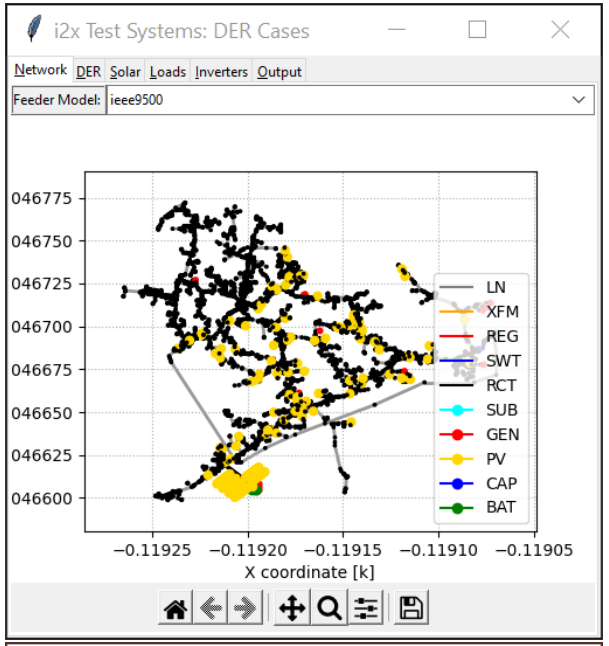
i2x Guide to Interconnection Studies of Renewable DER, replacing the outdated IEEE Guide for DER Impact Studies

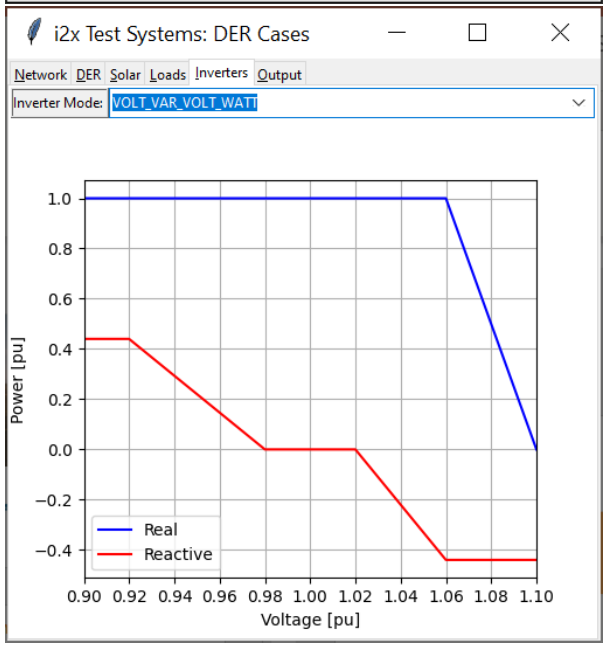


- Assumptions and Criteria
- Standards and Guidelines
- Data Collection
- Model Development and Validation
- Analytical Steps and Automation
- DER Interconnection Studies
  - Screening
  - Impact
  - Facility
- Hosting Capacity Studies (consistency)
- Multi-DER (Feeder Cluster) Studies
- Influence of 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



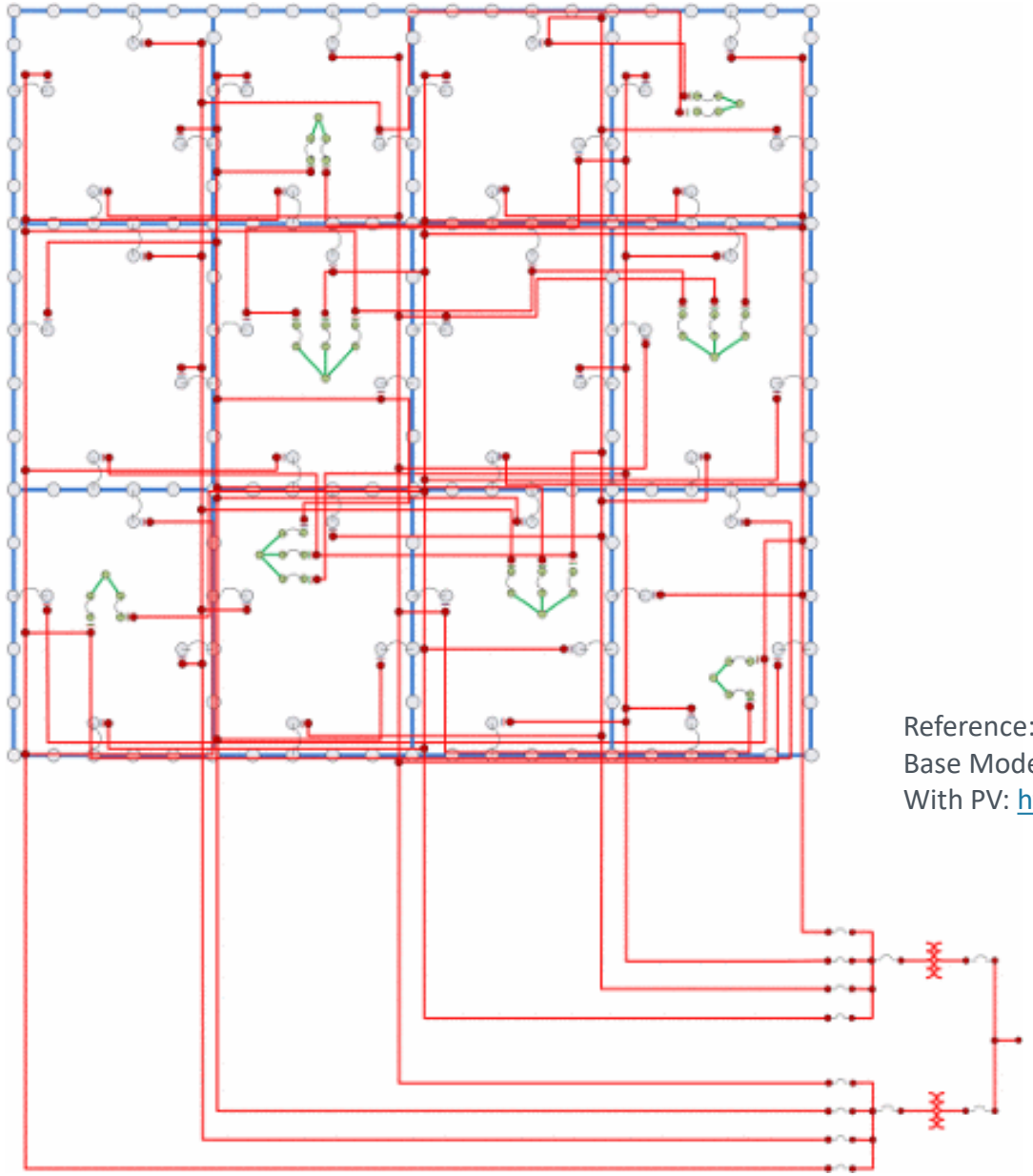


OpenDSS Radial System: IEEE 9500-Node Test Case

- 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) permanent-magnet 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



- 13.2 kV, 8 primary feeders
- 42,210 kW peak load
- 8 PV Inverters, 8000 kW
  - Verify network protectors do not trip on reverse flow
  - How much more PV could be added?

Reference: https://doi.org/10.1109/PESGM.2014.6939794
Base Model: https://github.com/GRIDAPPSD/CIMHub/tree/feature/SETO/lv_network
With PV: https://github.com/GRIDAPPSD/CIMHub/tree/feature/SETO/OEDI/base