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

DER Boot Camp at GridTech CONNECT NE

Monday, October 23rd
Newport, RI

An initiative spearheaded by the Solar Energy Technologies Office and the Wind Energy Technologies Office

PNNL-SA-191626

Agenda

Time	Activity
09:00 - 09:30	Settle in and tech setup
09:30 - 10:00	i2x and Bootcamp Overview
10:00 - 11:00	**Activity 1**: *Rapid Voltage Change* • Run an example that results in a rapid voltage change violation and try to resolve • Observe how the hosting capacity is affected by each choice
11:00 - 12:00	**Activity 2**: *Islanding Considerations* • Compare performance with and without inverter functions • Also address more upgrade options
12:00 - 13:00	Break/Lunch
13:00 - 15:00	**Activity 3**: *Sequential vs. Cluster Study* • Interconnect multiple resources one after the other • Look at cost estimates for upgrades and their allocation • Look at potential methods of sharing these among a cluster
15:00 - 16:00	Wrap up and discussion

Setup instructions available at:
https://github.com/pnnl/i2x/tree/develop/der-bootcamp#der-bootcamp

i2X Mission

To enable the **simpler**, **faster**, and **fairer** interconnection of clean energy resources all while boosting 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

Learning Objectives

- Show how hosting capacity tools can be used to *simulate* interconnection processes and thus inform policy decisions.
- Develop intuition for how metrics impact hosting capacity and, on occasion, conflict.
- Explore examples around queue management and cost allocation.
- Expose participants to open-source tools for distribution system analysis.

Caveat

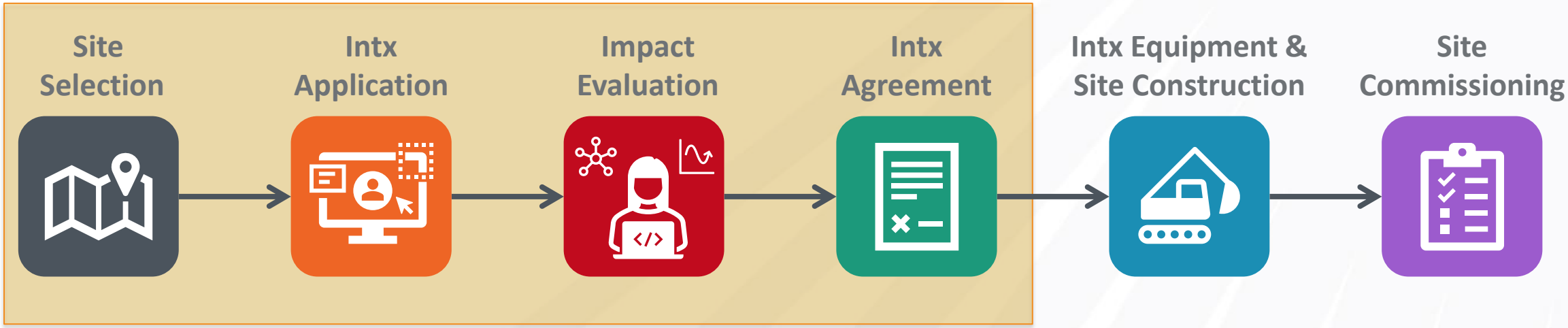
Interconnection is complex, and with increasing resources, complexity will only increase:

- Different systems are different
- Different interconnection processes
- Different equipment/performance limits and requirements
- Different costs
- …

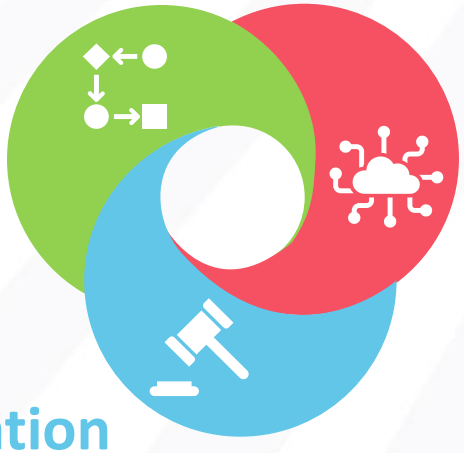
Today's focus is on *methods*:
We'll string together assumptions and techniques to produce insight

All assumptions are negotiable!

A Framework for Examining Interconnection



Administrative Processes

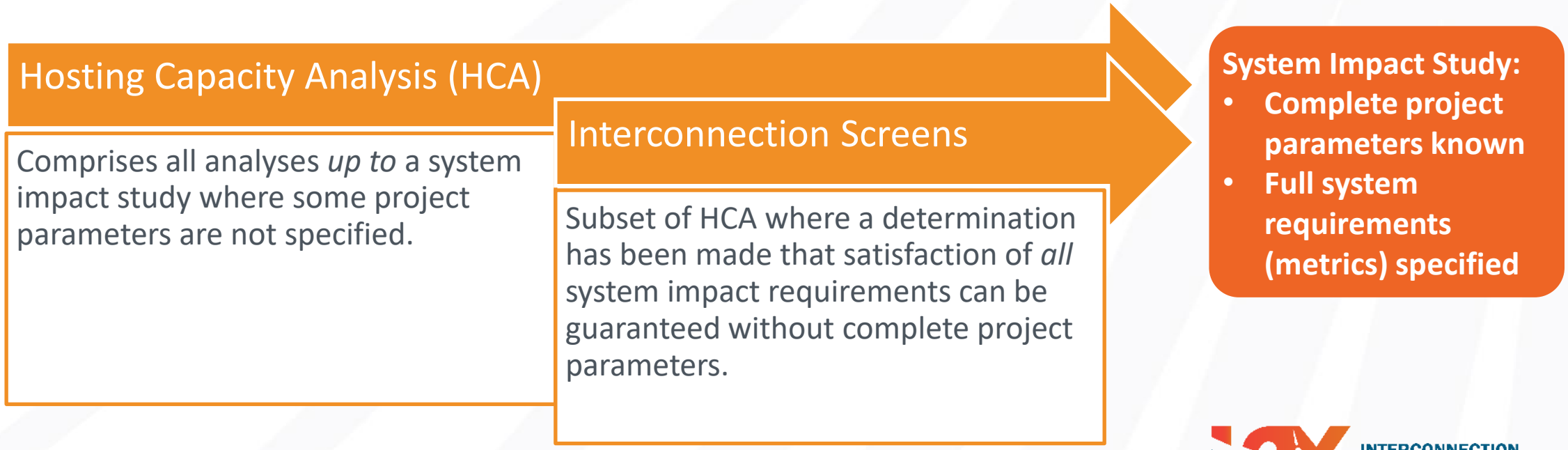


Technology & Engineering

Markets and Regulation

Hosting Capacity Spectrum

- Hosting Capacity means different things, to different folks, in different contexts.
- For today's purposes it is: The estimate of possible capacity that can be integrated without violating a given set of agreed upon metrics.



DER Hosting Capacity - Approach

- Time-Series based quasi-steady state evaluation
  - Allows to better consider the impact/benefit of coincidence or lack-thereof.
- Progresses in a random or prescribed fashion over the nodes of the system
  - Functions as both HCA and also as a model for a growing system (i.e., simulates the queue)
- At each iteration following options are available:
  1. Add capacity *despite* violations OR
  2. Add the *minimum* of chosen capacity and calculated HC
- If the first option is chosen, upgrades can be made to bring the system back to a non-violating state.

DER Hosting Capacity - Metrics

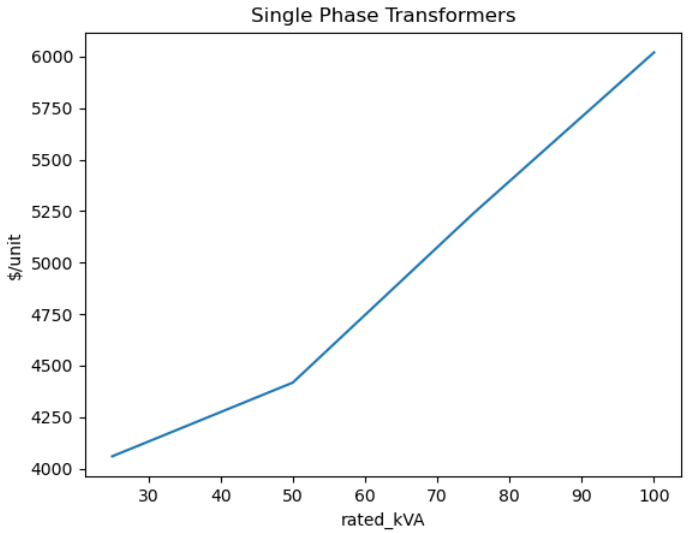
- The following metrics are currently considered:
  - **Note**: these are intended more as an example. Additions/omissions can be made based on use case.

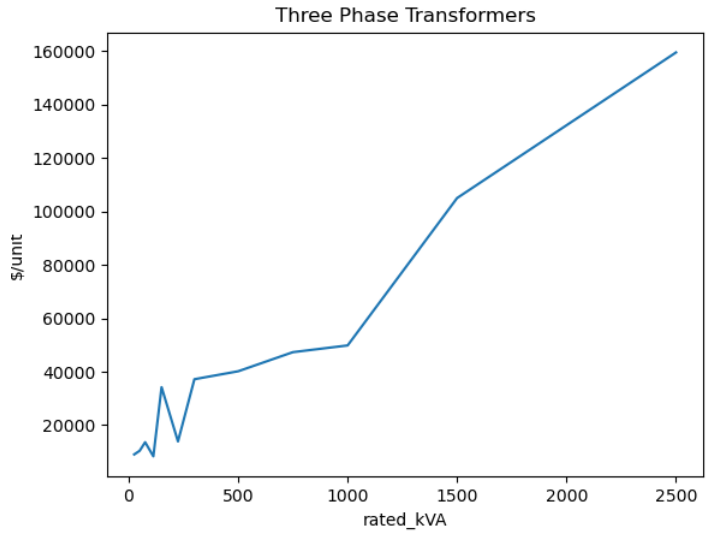
Metric	Criteria*	Possible Upgrade Action
Thermal Emergency Rating	Not exceeded	Upgrade conductor/transformer
Normal Rating	No more than 3 hours of violation	Upgrade conductor/transformer
Rapid Voltage Change	< 3%	• Activate advance inverter functions such as Volt/Var • Upgrade conductors • Alter regulator/transformer setpoints (minimal help)
Maximum Voltage	≤ 1.05	• Activate advance inverter functions such as Volt/Var • Alter regulator/transformer setpoints
Minimum Voltage**	≥ 0.95	• Activate advance inverter functions such as Volt/Var • Alter regulator/transformer setpoints
Potential Islanding	• Net flow out of each "island-able" region is always in same direction • The ratio of the minimum magnitude to maximum magnitude is sufficiently large	• Depending on violation, deactivation of inverter functions. • DTT

*The described criteria are enforced. However, if a starting case shows pre-existing violations, these are allowed and relax the criteria accordingly.
** Shouldn't really arise due to DER integration

Upgrade Cost Estimation

- **Conductors***
  - *Overhead lines*: 196 $/ft (average of urban and rural Overhead line costs
  - *Underground lines*: 268 $/ft
- **Transformers****





- **Regulators**
  - *New:* $175000 (combining input from PG&E and NREL)
  - *Changed settings*: $2575*

    (Also used for transformer tap changes)

*based on data from PG&E Unit Cost Guide 2023: https://www.pge.com/pge_global/common/pdfs/for-our-business-partners/interconnection-renewables/Unit-Cost-Guide.pdf
**Modified from Source: Horowitz, Kelsey. 2019. ""2019 Distribution System Upgrade Unit Cost Database Current Version."" NREL Data Catalog. Golden, CO: National Renewable Energy Laboratory. Last updated: September 16, 2022. DOI: 10.7799/1491263."

Ways to get involved

- i2X website for any and all information regarding the program: https://energy.gov/eere/i2x
- The i2X Solution e-Xchanges have a wealth of useful materials: https://www.energy.gov/eere/i2x/i2x-solution-e-xchanges
- IEEE P1729 Recommended Practice for Electric Power Distribution System Analysis (with new chapters on Hosting Capacity and Dynamics): https://standards.ieee.org/ieee/1729/10759/
- IEEE 1547.7 IEEE Guide for Conducting Distribution Impact Studies for Distributed Resource Interconnection will be starting work on a new version shortly: https://standards.ieee.org/ieee/1547.7/4572/