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

Grid Engineering Practices & Standards Hosting Capacity on the BES | 4/26/23

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

Meeting Notes

Notes synthesizing keys points, insights and questions from the meeting can be found here: Box Link

The first half of this Teams call is being recorded and may be posted on DOE's website or used internally. If you do not wish to have your voice recorded, please do not speak during the call. If you do not wish to have your image recorded, please turn off your camera or participate by phone. If you speak during the call or use a video connection, you are presumed to consent to recording and use of your voice or image.

Recording will stop after the scheduled presentations.

Agenda

- Introduction to i2X Solution e-Xchanges (5 min)
- Summary of HCA Value from April 13 (5 min)
- Technical Presentations (45 min)
  1. MISO (Simon Guo)
  2. Enerzinx (Anupam Gopal)
  3. Pearl Street Technologies (David Bromberg)
- Interactive Group Discussion (45 min)
  1. How much time and cost could hosting capacity maps save during a BES interconnection process?
  2. What are the security concerns with publishing BES hosting capacity maps?
  3. How could utilities and system operators produce BES hosting capacity maps that provide expected benefits?
  4. What can we learn from AEMO's new Connections Simulation Tool?
- Commenting Process for BES Interconnection Study Guide (5 min)

Interconnection Innovation e-Xchange (i2X)

Mission: To enable a **simpler**, **faster**, and **fairer** interconnection of clean energy resources while enhancing the **reliability**, **resiliency**, and **security** of our **distribution and bulk-power electric grids**

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

Key Outcomes from Our e-Xchange Meetings

- Inform and formulate a ***publicly available***, strategic roadmap for interconnection
  - Topical challenges and issues
  - Practical solutions to implement and scale
  - Knowledge and data gaps and new solutions to pilot
  - Success goals and measures of success
- Summary documentation for each meeting regarding ideas discussed and opportunities for targeted stakeholder action
- Provide platform for ongoing engagement before and after meetings
- **Longer term vision** → Solution e-Xchanges to continue building a national forum for all stakeholders as a community of practice, excellence, and innovation

Upcoming Solution e-Xchanges to Consider Joining

BOLDED ITEMS FOCUSED ON GRID ENGINEERING TOPICS

1. April 27th, 2-4 p.m. Eastern: DER Grid Readiness and Network Upgrades
2. **May 3nd, 2-4 p.m. Eastern: Distribution System Protection with High DER Adoption Levels**
3. May 11th, 2-4 p.m. Eastern: Managing the Bulk Power System Interconnection Study Process
4. May 24th, 2-4 p.m. Eastern: DER Interconnection Process Approaches & Flexible Interconnection
5. **August 2nd, 2-4 p.m. Eastern: Synergizing Two Cylinders of Excellence**

Follow the schedule of events on the i2X website.
https://www.energy.gov/eere/i2x/i2x-solution-e-xchanges

Virtual Meetings Code of Conduct

1. *Assume good faith and respect differences*
2. *Listen actively and respectfully*
3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
5. *Seek to learn from others*

Mutual Respect . Collaboration . Openness

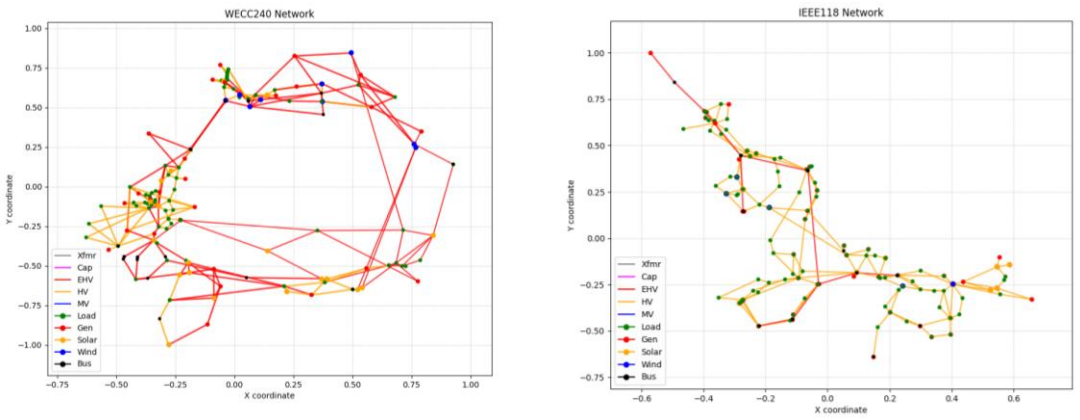
Results from the April 13 Solution e-Xchange (Queue Management and Cost Allocation) on the Value of Pre-application Information

Hosting Capacity value is #2 after Expected Costs

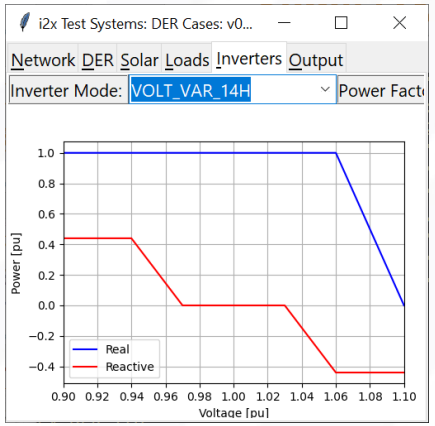
- Based on power flow
- Doesn't estimate IX cost
- Doesn't account for redispatch
- Not useful if stale
- Show Network Resource vs. Energy Resource Interconnection Service, i.e., NRIS vs. ERIS
- Useful to know where fiber communications exist

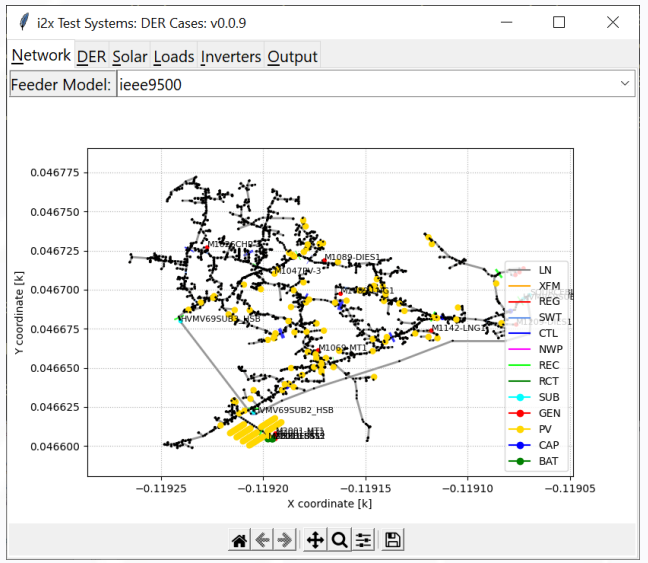
i2X has been producing test systems, documents, software tools, visualizations, and proposed new metrics for interconnections.

Bulk Electric Test Systems for EMT Analysis Boot Camps

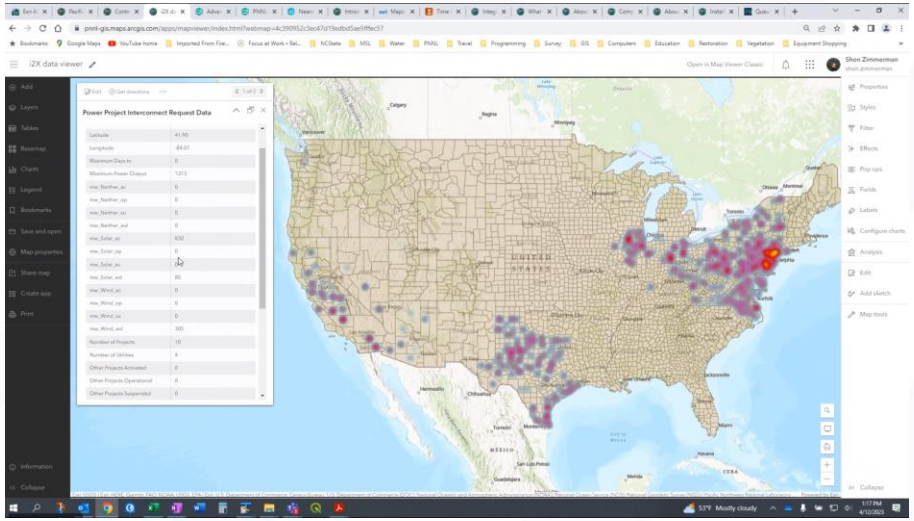


DER Analysis Tool for Boot Camps

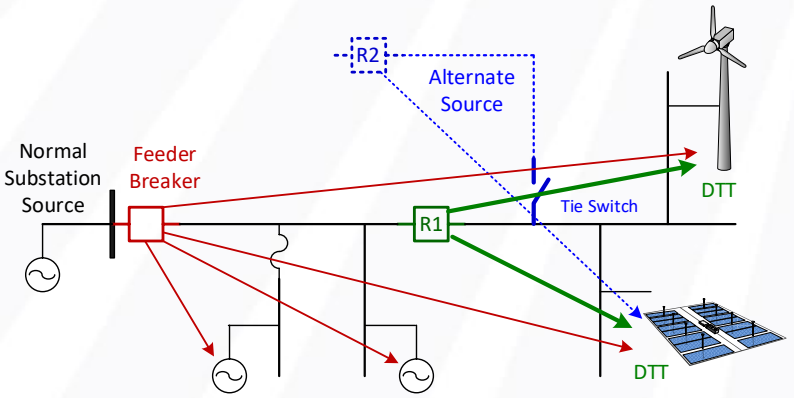




GIS Portal for Queued Up, SolarTRACE, and Interconnection Metrics



Contributions to Study Guides and Recommended Practices



INTERCONNECTION INNOVATION e-XCHANGE
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DER Hosting Capacity Analysis has a lineage of nearly 20 years on the distribution system.

- CIRED Paper, 2005: https://ieeexplore.ieee.org/document/5427947
- Sandia Screening Guide, 2012: https://www.osti.gov/servlets/purl/1039001
- EPRI, 2013: https://ieeexplore.ieee.org/document/6672320
- Natural Resources Canada, by Quanta Technology Canada, 2021:

Table 4. HCA Boundary Parameters

Commonly Applied Boundary Parameters	Advanced Boundary Parameters

□ Thermal limits (overloading feeder equipment or conductors),
□ Voltage limits (steady state),
□ Rapid voltage change (dynamic variations),
• Impact on voltage regulators and tap changers operation
• Reverse power flow
	• Protection
	  • Reach reduction
	  • Sympathetic tripping
	• Harmonics
	  • Individual harmonics
	  • THD / TDD

Introduction of Stakeholder Presentations

1. Simon Guo, Resource Utilization Engineer, MISO,
   https://www.linkedin.com/in/shaotong/

2. Anupam Gopal, Founder and President, Enerzinx,
   https://www.linkedin.com/in/anupam-g-5ab5593/

3. David Bromberg, Co-founder and CEO, Pearl Street Technologies,
   https://www.linkedin.com/in/dmbromberg/

Interactive Group Discussion Topics

Word Cloud Icebreaker:

What is the main obstacle to achieving weekly hosting capacity map or data updates?

[Go to **menti.com** and enter event code **9815 7531**]

Topic #1: How much time and cost could hosting capacity maps or data save during a BES interconnection process?

- For written commentary, please go to **Menti.com** and enter event code **9815 7531**
  - Meeting chat will be disabled
  - The Menti page will remain open throughout discussion of this topic
- For verbal commentary, please use the raise hand feature and we will call on you
- Additional discussion points:
  - Might they encourage **more** applications for sites that have capacity?
  - Might they discourage applications for sites with low capacity?
  - Which components of cost and schedule would be most affected?
  - How might they affect the % of applications approved and built?

Discussion Best-Practices

1. *Assume good faith and respect differences*
2. *Listen actively and respectfully*
3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
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Topic #2: What are the security concerns with publishing BES hosting capacity maps or data?

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- For verbal commentary, please use the raise hand feature and we will call on you
- Additional discussion points:
  - Has the precedent already been set by MISO, PJM, and others publishing injection capacity?
  - Is there a difference between maps and spreadsheet data?
  - What mitigations are available to protect critical energy infrastructure information (CEII)?

Discussion Best-Practices

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3. *Use "Yes and" to build on others' ideas*
4. *Please self-edit and encourage others to speak up*
5. *Seek to learn from others*

Topic #3: How could utilities and system operators produce BES hosting capacity maps or data that provide expected benefits?

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  - Meeting chat will be disabled
  - The Menti page will remain open throughout discussion of this topic
- For verbal commentary, please use the raise hand feature and we will call on you
- Additional discussion points:
  - How can we automate model building and model validation?
  - How can we promote consistent, transparent, and best practices? For example, case selection, mitigations considered, range of parameter variations, etc.
  - What factors would enable cost recovery for new automated analysis capabilities?
  - How can the presumed lack of engineering resources be addressed?
  - Is there enough support for scripting, cloud computing, and parallelization for all the necessary software tools? If not, how can this be achieved?

Discussion Best-Practices

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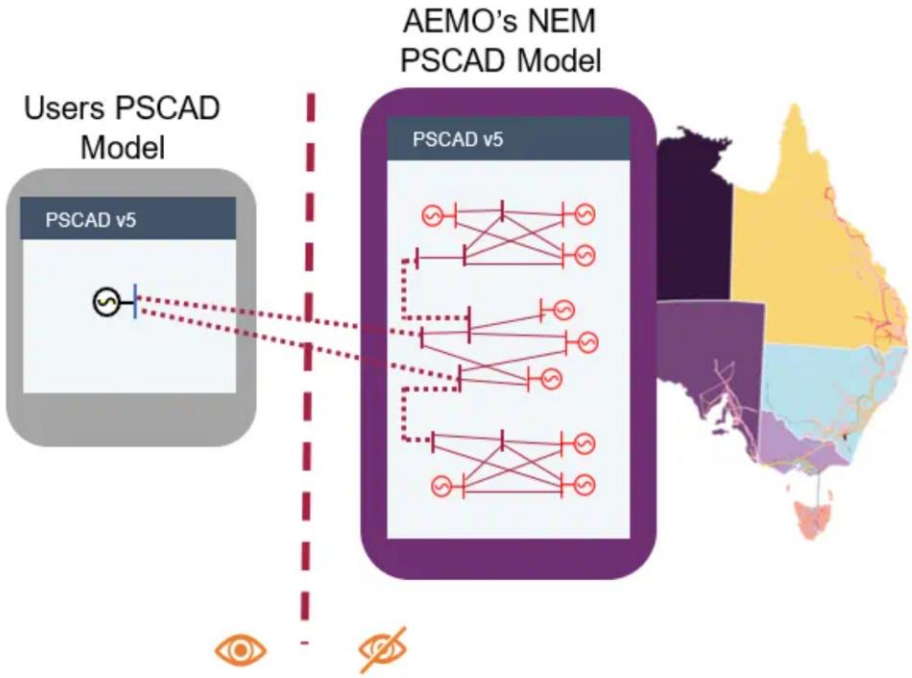
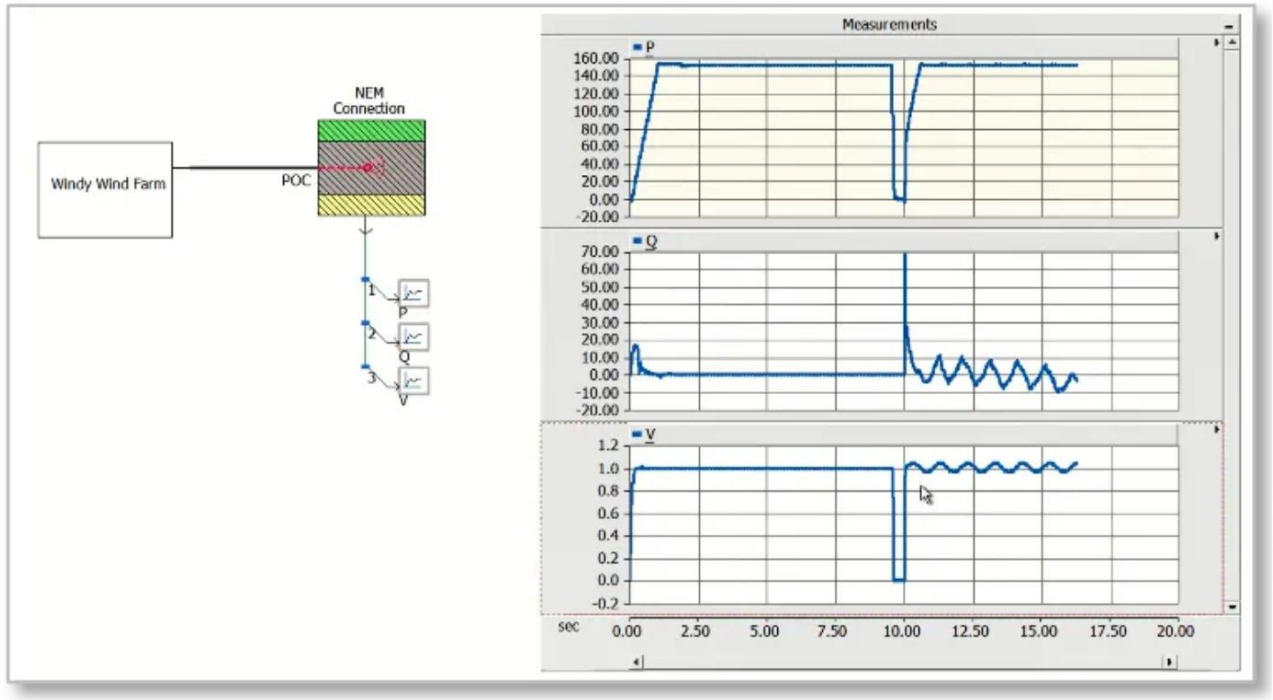
Australian Energy Market Operator (AEMO) Connections Simulation Tool





- https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/participate-in-the-market/network-connections/connections-simulation-tool
- AEMO presented a Webinar on March 20, 2023 via the Energy Systems Integration Group (ESIG)

Topic #4: What can we learn from Australian Energy Market Operator's (AEMO's) new Connections Simulation Tool?

- For written commentary, please go to **Menti.com** and enter event code **9815 7531**
  - Meeting chat will be disabled
  - The Menti page will remain open throughout discussion of this topic
- For verbal commentary, please use the raise hand feature and we will call on you
- Additional discussion points:
  - How much burden does this place on the utility or system operator?
  - How could a trusted third party manage this service?
  - How would the software license, cloud computing, and labor costs be recovered?
  - How important is software tool independence for steady state, dynamics, and electromagnetic transients (EMT)?
  - Do we need a comparable service for power flow or positive sequence dynamics?

Discussion Best-Practices

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3. *Use "Yes and" to build on others' ideas*
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Guide to BES Interconnection Studies of Renewables

1. Introduction
2. Utility Organization Preparation
   a) Tools and Automation
   b) Maintenance of Grid Data
   c) Link to System Planning (QM/CA e-Xchange)
   d) Workforce Training
   e) Adoption of Standards
   f) Report Format and Delivery
3. Developer Organization Preparation
   a) Plant Models and Validation
   b) Applications to Interconnect
   c) Adoption of Standards
   d) Response to Data Requests
   e) Scoping Meetings
   f) Material Modification Studies
4. Phases of the Interconnection (depending on FERC Final Rule)
   a) Interconnection Application Review
   b) Feasibility Study (still used in some places?)
   c) Informational Study
   d) Impact Study
   e) Facility Study
   f) Pre-commissioning Conformity Assessment
   g) Commissioning Tests
   h) Post-commissioning Model Validation
   i) Post-commissioning Monitoring
5. Special Topics
   a) When to use EMT (coordinate with NERC EMT guides)
   b) DER Aggregation
   c) Hosting Capacity on the Bulk System
   d) POI screening and SCR studies.
   e) Affected System Studies (timeliness, disruptiveness, interaction between FERC and DER project queues)
   f) Jurisdiction for Distribution and Sub-transmission
6. EMT Study Boot Camps (with NERC)
   a. Test systems and tools
   b. Sample problems
7. Forward-looking Improvements
8. References

Key:
- Suggestions made during the January 31 meeting
- Items of special importance

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Analytics To Inform And Inspire

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AUTOMATED GRID WIDE FCITC ANALYSIS SOFTWARE

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Enerzinx OVERVIEW

- 102 GW
- 600+ PROJECTS
- 2.00 MILLION MILES OF TRANSMISSION LINES
- 15+ COUNTRIES

TOP RENEWABLE ENERGY SERVICE COMPANIES 2021

RECOGNIZED BY ENERGY Tech Review

ENERZINX®

Analytics To Inform And Inspire

MOTIVATION

FERC is concerned that the lack of transparency to obtain information about potential interconnection costs prior to submitting an interconnection request is problematic.

FERC recommends providing a visual representation of available interconnection capacity, as well as a table of relevant interconnection metrics that allow prospective interconnection customers to see certain estimates of a potential generating facility's effect on the transmission provider's transmission system.

This could provide valuable information to prospective interconnection customers considering efficient interconnection points and could ameliorate the incentive to submit multiple speculative interconnection requests.

Improvements to Generator Interconnection Procedures and Agreements. A Proposed Rule by the Federal Energy Regulatory Commission on 07/05/2022.
https://www.federalregister.gov/documents/2022/07/05/2022-13470/improvements-to-generator-interconnection-procedures-and-agreements#citation-426-p39984

SOLUTION

ViewZ Automated Grid wide FCITC Analysis Software

ViewZ®

AUTOMATED GRID WIDE FCITC ANALYSIS SOFTWARE

- Fully automated end to end solution
- 20,000 Man hours of development and testing
- Employs full AC power flow
- Employs industry standard PSSE, PSLF etc. software engines
- Validated against several Utilities/ ISO studies
- 80,000+ substations analysed
- 40+ Utilities analysed

ViewZ®

NOTABLE FEATURES

Auto Corrects

Auto-corrects Base Case rating errors.

Auto Generates

Auto generates Contingency and monitoring elements' list specific to a chosen POI.

Parallel Processing

Can be efficiently deployed on multi -core processors.

Multi Utility/ ISO Support

Customized to the respective utility feasibility analysis guidelines.

Thermal & Voltage Analysis

Evaluates thermal as well as voltage violations to compute appropriate hosting capacity

SCR Analysis

Performs SCR analysis on all POI's

ViewZ®

NOTABLE FEATURES CONT.

Intelligent Algorithm

Intelligently switches between solution methods to efficiently solve the case with minimal iterations.

Hybrid projects

Computes charging as well as discharging interconnection capacity for hybrid projects

Upgrades

Provides list of upgrades required to achieve target capacity

Import/ Export features

Supports import and export in universal formats. Saves/Restores session in encrypted mode.

Heat maps

Supports seamless Google Earth integration to generate interactive Heat maps and Feature maps.

Third party support

Supports third party SDK's and REST API's to integrate with external geographical maps

ViewZ®

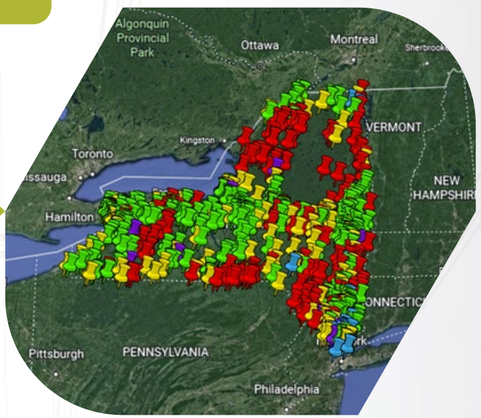
HEAT AND FEATURE MAPS

NYISO

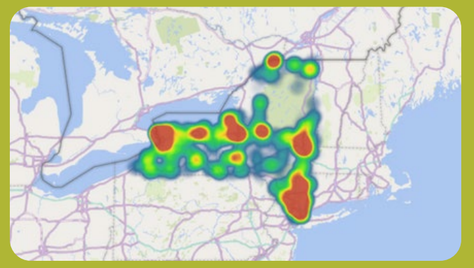
CAISO

ERCOT

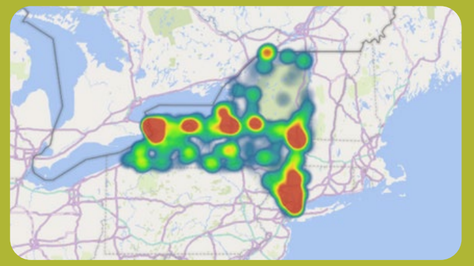
FEATURE MAP



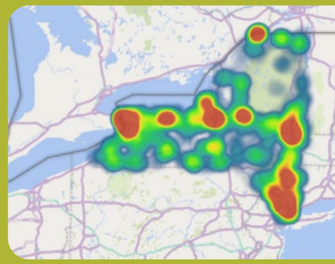
HEAT MAP



2021

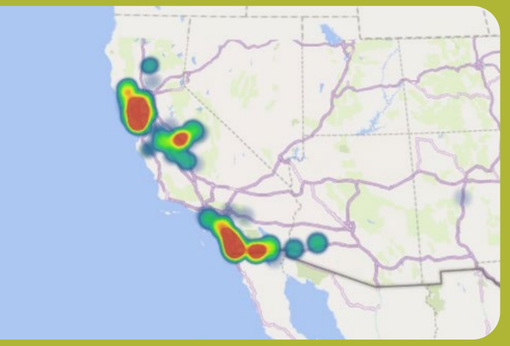


2026

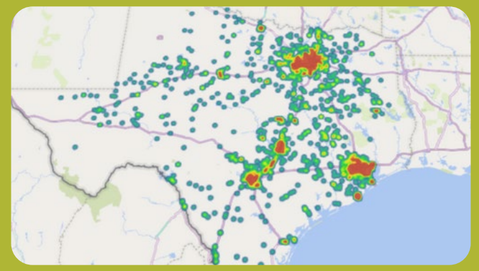


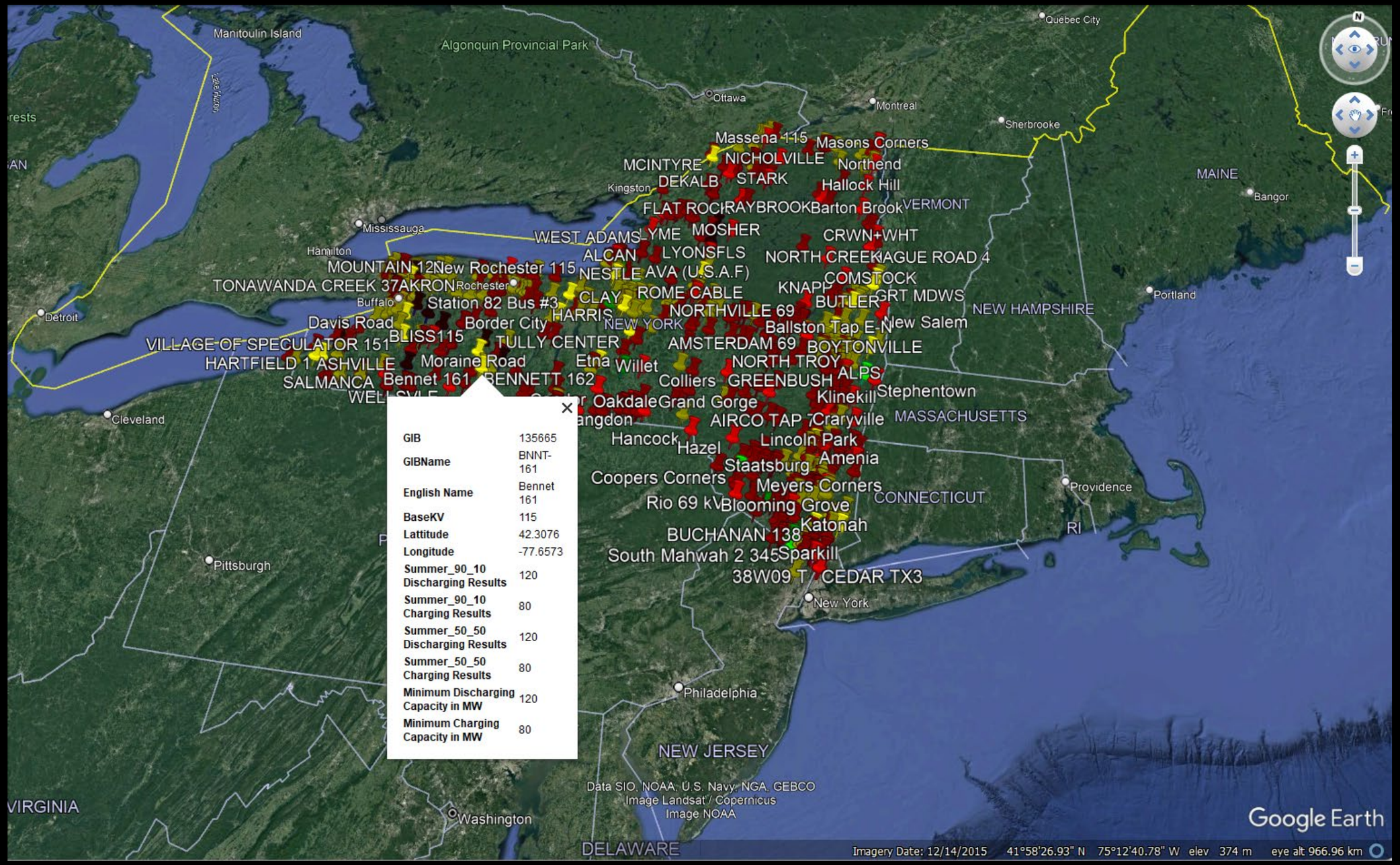
2031

2023



2023

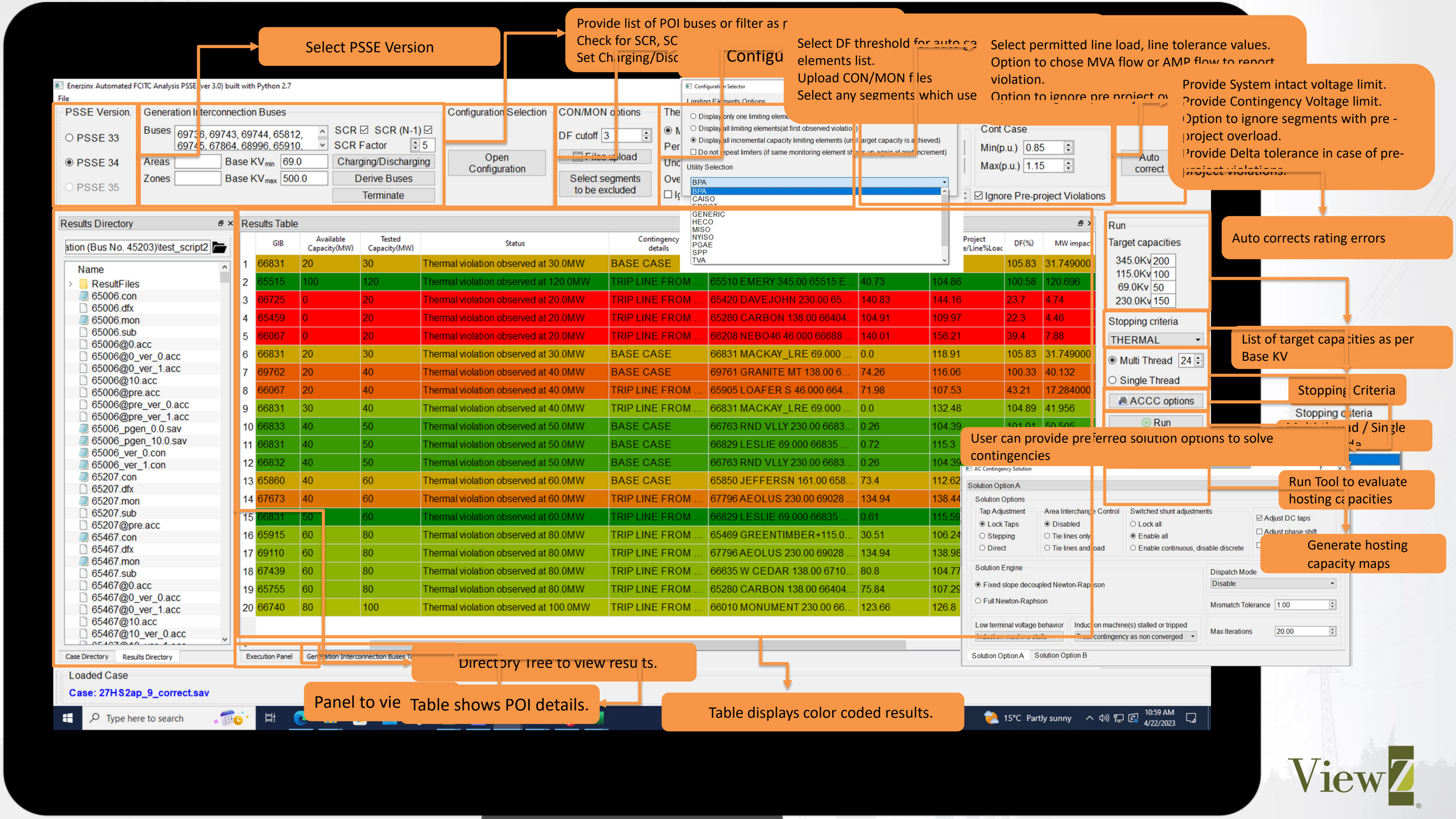




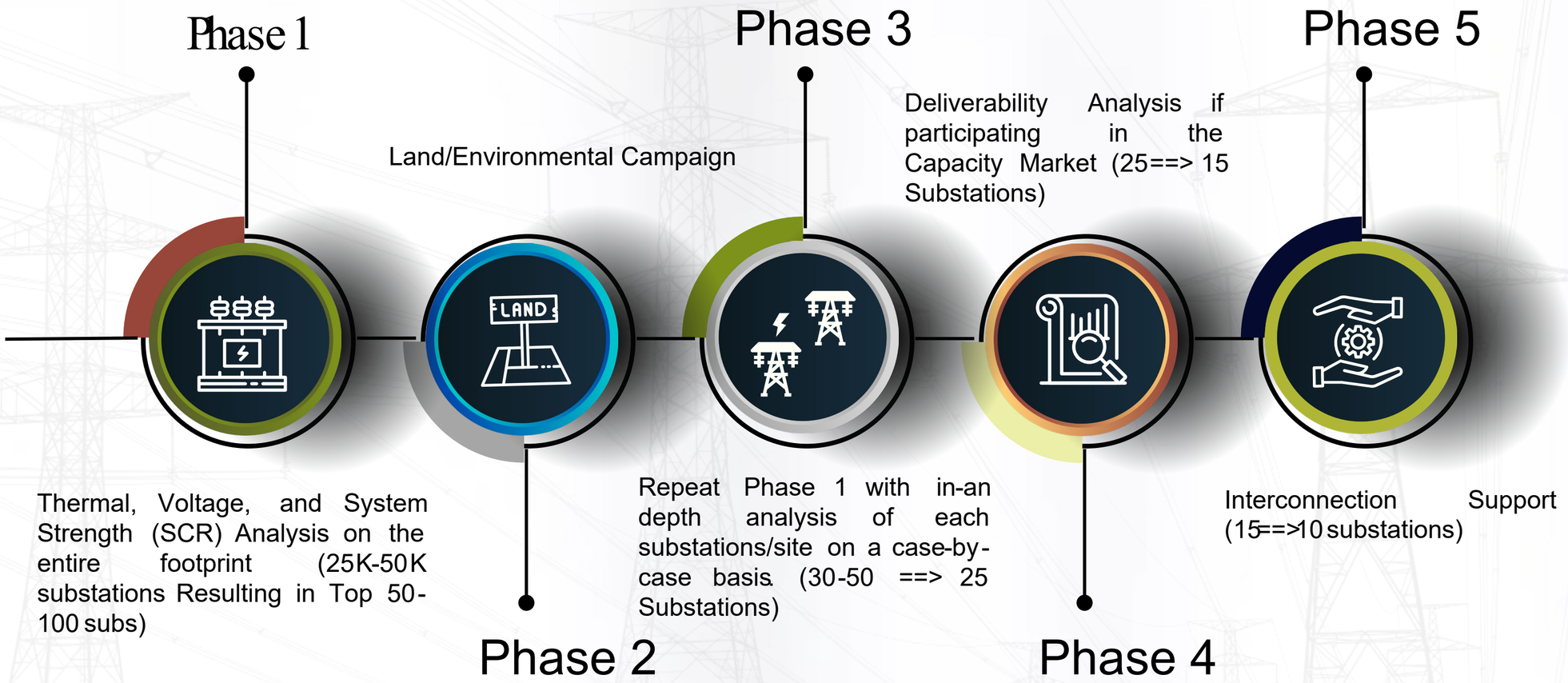
GIB	135665
GIBName	BNNT-161
English Name	Bennet 161
BaseKV	115
Lattitude	42.3076
Longitude	-77.6573
Summer_90_10 Discharging Results	120
Summer_90_10 Charging Results	80
Summer_50_50 Discharging Results	120
Summer_50_50 Charging Results	80
Minimum Discharging Capacity in MW	120
Minimum Charging Capacity in MW	80

ZERO IN

ViewZ


Select PSSE Version
Provide list of POI buses or filter as r
Check for SCR, SC
Set Charging/Disc
Configu
Select DF threshold for auto ge
elements list.
Upload CON/MON f les
Select any segments which use
Select permitted line load, line tolerance values.
Option to chose MVA flow or AMP flow to report
violation.
Provide System intact voltage limit.
Provide Contingency Voltage limit.
Option to ignore segments with pre -
project overload.
Provide Delta tolerance in case of pre-
project violations.
Auto corrects rating errors
List of target capacities as per Base KV
Stopping Criteria
Stopping criteria
User can provide preferred solution options to solve contingencies
Run Tool to evaluate hosting capacities
Generate hosting capacity maps
Directory Tree to view results.
Panel to vie
Table shows POI details.
Table displays color coded results.
Enerzinx Automated FCITC Analysis PSSE
ver 3.0) built with Python 2.7
File
PSSE Version
PSSE 33
PSSE 34
PSSE 35
Generation Interconnection Buses
Buses
69736, 69743, 69744, 65812,
69745, 67864, 68996, 65910,
SCR
SCR (N-1)
SCR Factor
5
Areas
Base KVmin
69.0
Zones
Base KVmax
500.0
Charging/Discharging
Derive Buses
Terminate
Configuration Selection
Open Configuration
CON/MON options
DF cutoff
3
Files upload
Select segments to be excluded
Utility Selection
BPA
BPA
CAISO
GENERIC
HECO
MISO
NYISO
PGAE
SPP
TVA
Cont Case
Min(p.u.)
0.85
Max(p.u.)
1.15
Ignore Pre-project Violations
Auto correct
Results Directory
ation (Bus No. 45203)\test_script2
Name
ResultFiles
65006.con
65006.dfx
65006.mon
65006.sub
65006@.acc
65006@0_ver_0.acc
65006@0_ver_1.acc
65006@10.acc
65006@pre.acc
65006@pre_ver_0.acc
65006@pre_ver_1.acc
65006_pgen_0.0.sav
65006_pgen_10.0.sav
65006_ver_0.con
65006_ver_1.con
65207.con
65207.dfx
65207.mon
65207.sub
65207@pre.acc
65467.con
65467.dfx
65467.mon
65467.sub
65467@.acc
65467@0_ver_0.acc
65467@0_ver_1.acc
65467@10.acc
65467@10_ver_0.acc
Case Directory
Results Directory
Results Table
GIB
Available Capacity(MW)
Tested Capacity(MW)
Status
Contingency details
Project
e/Line%Loac
DF(%)
MW impac
1 66831 20 30 Thermal violation observed at 30.0MW BASE CASE 105.83 31.749000
2 65515 100 120 Thermal violation observed at 120.0MW TRIP LINE FROM ... 65510 EMERY 345.00 65515 E... 40.73 104.86 100.58 120.696
3 66725 0 20 Thermal violation observed at 20.0MW TRIP LINE FROM ... 65420 DAVEJOHN 230.00 65... 140.83 144.16 23.7 4.74
4 65459 0 20 Thermal violation observed at 20.0MW TRIP LINE FROM ... 65280 CARBON 138.00 66404... 104.91 109.97 22.3 4.46
5 66067 0 20 Thermal violation observed at 20.0MW TRIP LINE FROM ... 66208 NEBO46 46.000 66688 ... 140.01 156.21 39.4 7.88
6 66831 20 30 Thermal violation observed at 30.0MW BASE CASE 66831 MACKAY_LRE 69.000 ... 0.0 118.91 105.83 31.749000
7 69762 20 40 Thermal violation observed at 40.0MW BASE CASE 69761 GRANITE MT 138.00 6... 74.26 116.06 100.33 40.132
8 66067 20 40 Thermal violation observed at 40.0MW TRIP LINE FROM ... 65905 LOAFER S 46.000 664... 71.98 107.53 43.21 17.284000
9 66831 30 40 Thermal violation observed at 40.0MW TRIP LINE FROM ... 66831 MACKAY_LRE 69.000 ... 0.0 132.48 104.89 41.956
10 66833 40 50 Thermal violation observed at 50.0MW BASE CASE 66763 RND VLLY 230.00 6683... 0.26 104.39
11 66831 40 50 Thermal violation observed at 50.0MW BASE CASE 66829 LESLIE 69.000 66835 ... 0.72 115.3
12 66832 40 50 Thermal violation observed at 50.0MW BASE CASE 66763 RND VLLY 230.00 6683... 0.26 104.39
13 65860 40 60 Thermal violation observed at 60.0MW BASE CASE 65850 JEFFERSN 161.00 658... 73.4 112.62
14 67673 40 60 Thermal violation observed at 60.0MW TRIP LINE FROM ... 67796 AEOLUS 230.00 69028 ... 134.94 138.44
15 66831 50 60 Thermal violation observed at 60.0MW TRIP LINE FROM ... 66829 LESLIE 69.000 66835 ... 0.61 115.59
16 65915 60 80 Thermal violation observed at 80.0MW TRIP LINE FROM ... 65469 GREENTIMBER+115.0... 30.51 106.24
17 69110 60 80 Thermal violation observed at 80.0MW TRIP LINE FROM ... 67796 AEOLUS 230.00 69028 ... 134.94 138.98
18 67439 60 80 Thermal violation observed at 80.0MW TRIP LINE FROM ... 66635 W CEDAR 138.00 6710... 80.8 104.77
19 65755 60 80 Thermal violation observed at 80.0MW TRIP LINE FROM ... 65280 CARBON 138.00 66404... 75.84 107.29
20 66740 80 100 Thermal violation observed at 100.0MW TRIP LINE FROM ... 66010 MONUMENT 230.00 66... 123.66 126.8
Execution Panel
Loaded Case
Case: 27HS2ap_9_correct.sav
Run
Target capacities
345.0Kv 200
115.0Kv 100
69.0Kv 50
230.0Kv 150
Stopping criteria
THERMAL
Multi Thread 24
Single Thread
ACCC options
Run
AC Contingency Solution
Solution Option A
Solution Options
Tap Adjustment
Lock Taps
Stepping
Direct
Area Interchange Control
Disabled
Tie lines only
Tie lines and load
Switched shunt adjustments
Lock all
Enable all
Enable continuous, disable discrete
Adjust DC taps
Solution Engine
Fixed slope decoupled Newton-Raphson
Full Newton-Raphson
Dispatch Mode
Disable
Mismatch Tolerance
1.00
Low terminal voltage behavior
Induction machine(s) stalled or tripped
Max Iterations
20.00
Solution Option A
Solution Option B
Type here to search
15°C Partly sunny
10:59 AM
4/22/2023

PROJECT DERISKING



MISO Point of Interconnection (POI) Tool

Resource Utilization

April 2023

Purpose & Key Takeaways

Purpose: Introduce and provide a demonstration of the MISO POI tool

Key Takeaways:

- MISO POI Tool is designed to help Interconnection Customers pre-screen for potential POIs
- The results are for information only and do not include voltage or stability constraints

POI - Point of Interconnection

Background

- Interconnection Customers want to get a general idea on WHERE a good POI would be for the planning horizon
- Heat Map: Better overview of the Planning Horizon system condition
- Interactive Tool provides a better customer experience

High Level Introduction of the Tool

- The results are informational only
- A tutorial on how to use the tool is provided when first launching it
- Tool can be used to pre-screen for potential POIs, to eliminate POIs with excessive thermal overloads
- It is not meant to replace any existing process, such as Preliminary Transmission Feasibility Study
- The results DO NOT include voltage or stability constraints

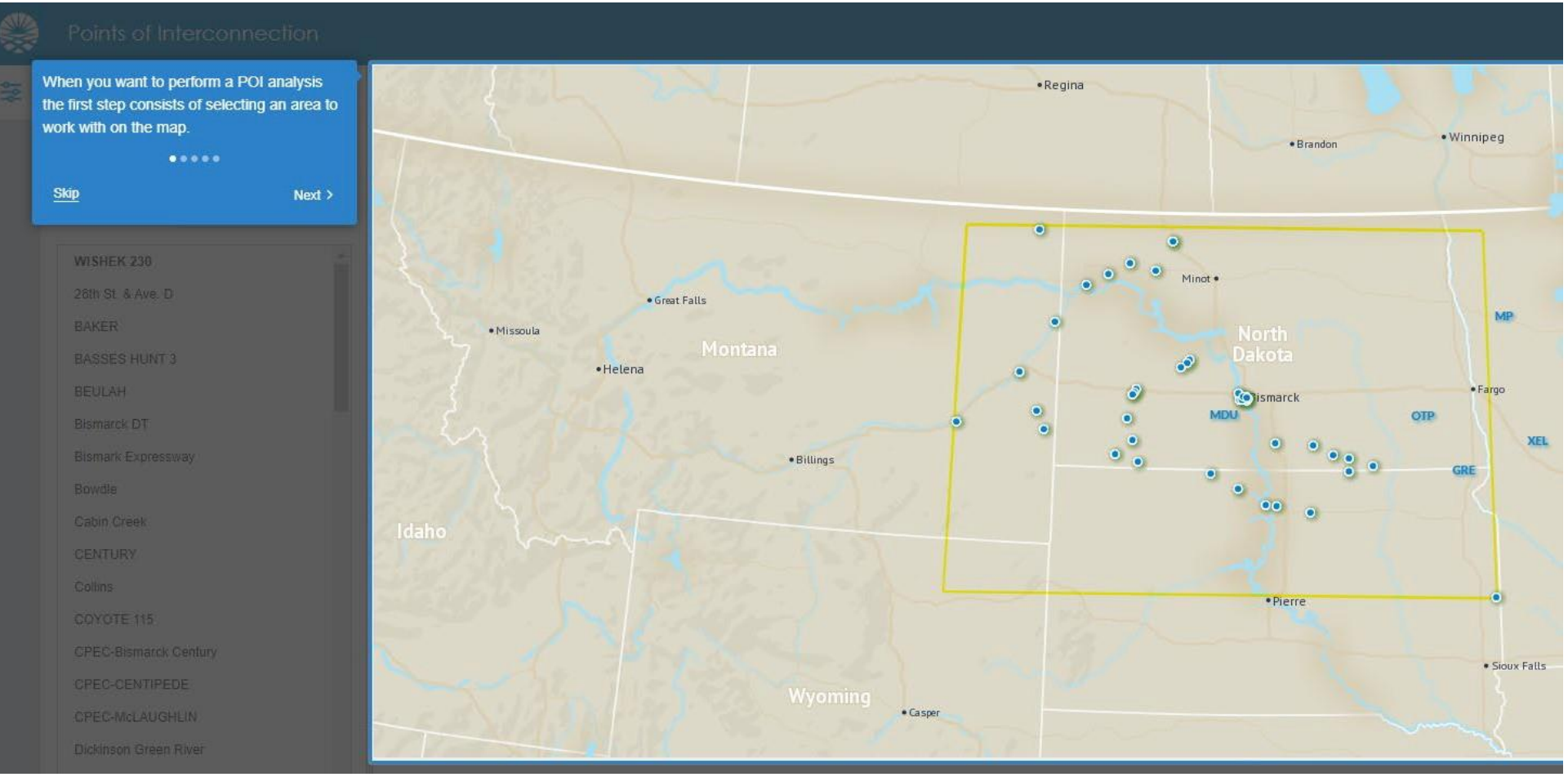
Security Concerns of the Tool

- To Protect CEII info:
- Contingency info
  - cannot be provided on a Public Website
- Transmission Lines on the Maps
  - cannot be combined to be presented in the tool
- The list of expected projects for a given POI
  - cannot be provided by the tool

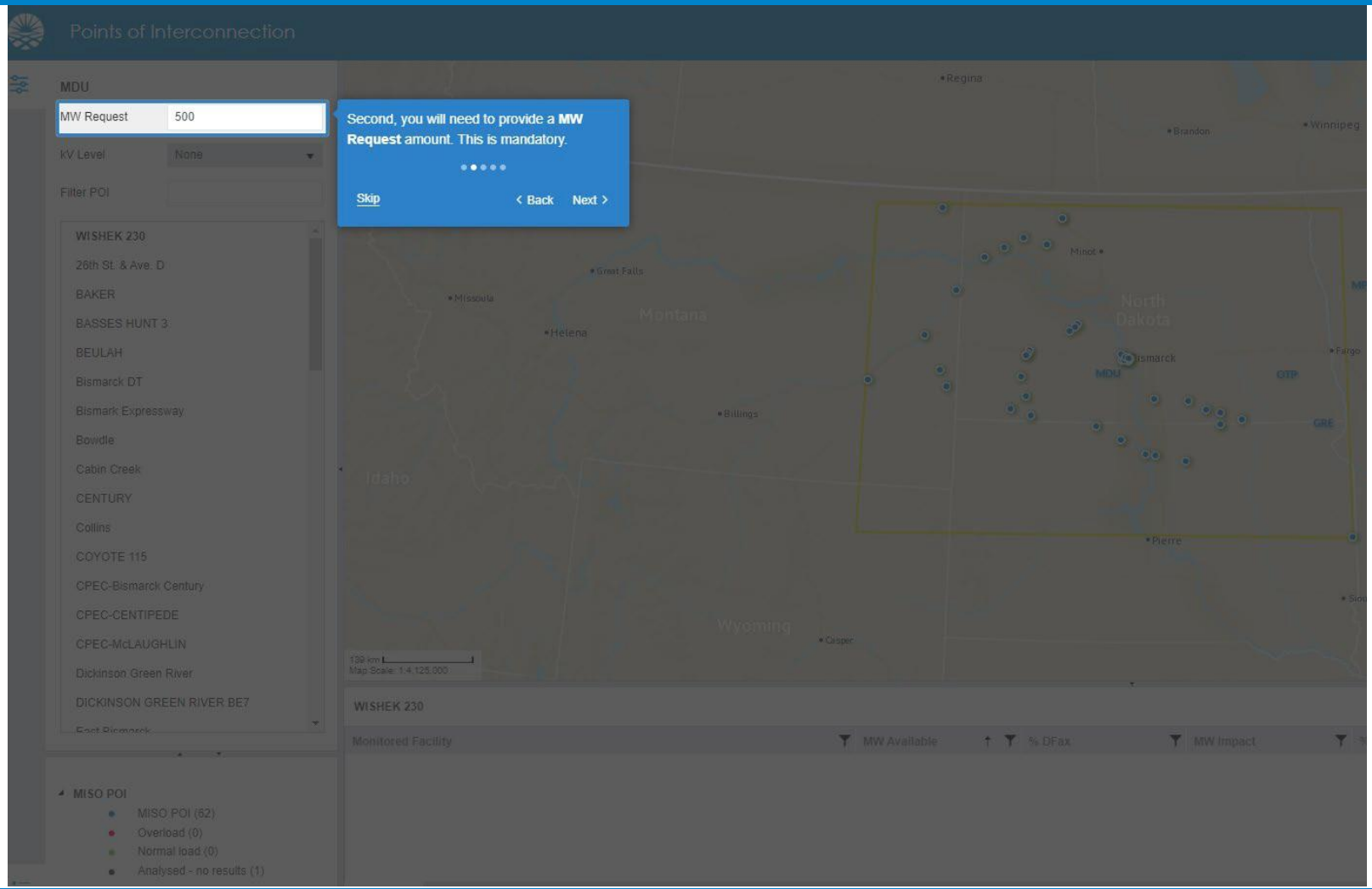
High Level Steps for using the POI Tool

1. Select an area on the map
2. Enter a MW request amount (Required)
3. Filter POI based on kV Level (Optional)
4. Select POI to see results
5. Save results (Optional)

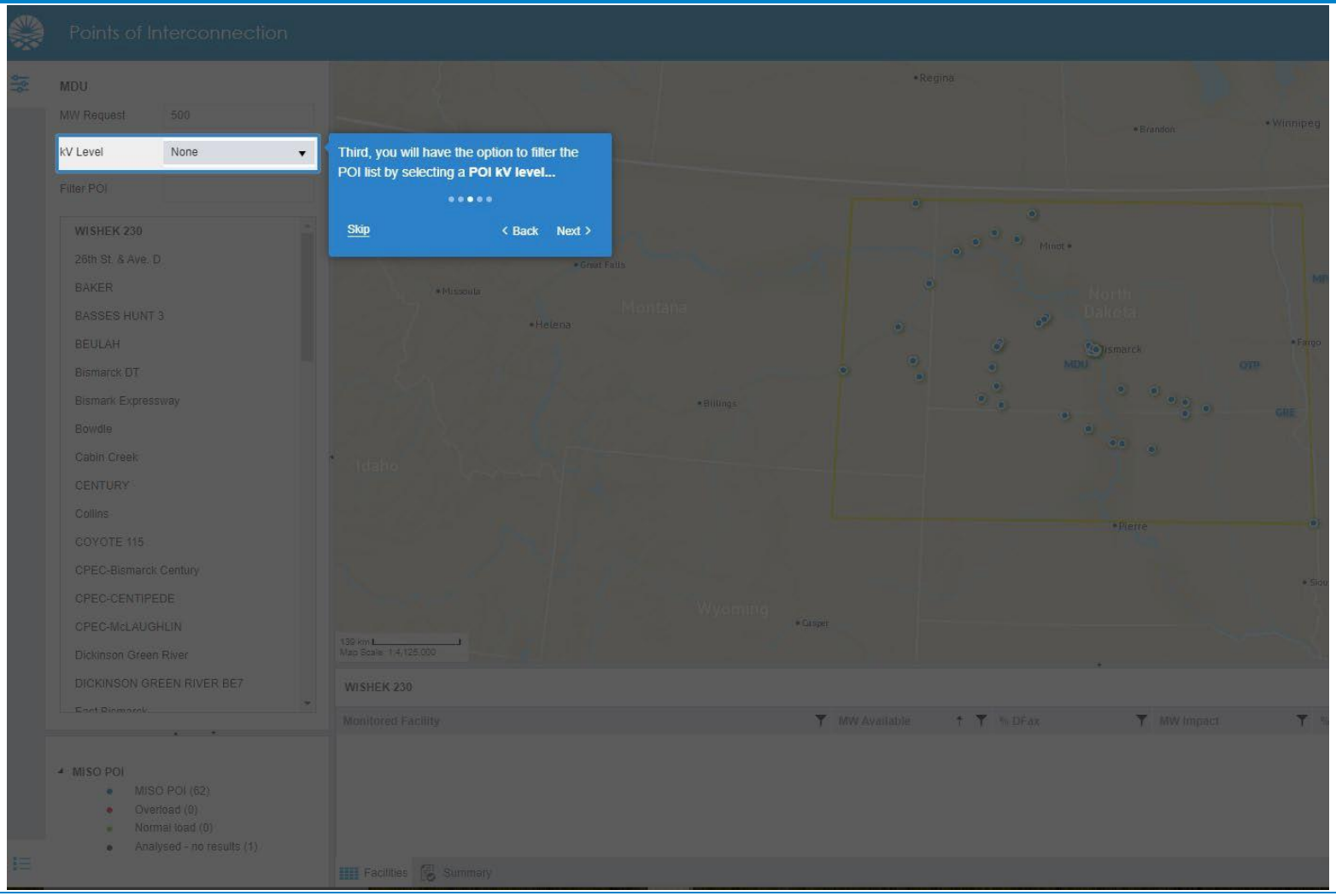
Select an Area on the Map



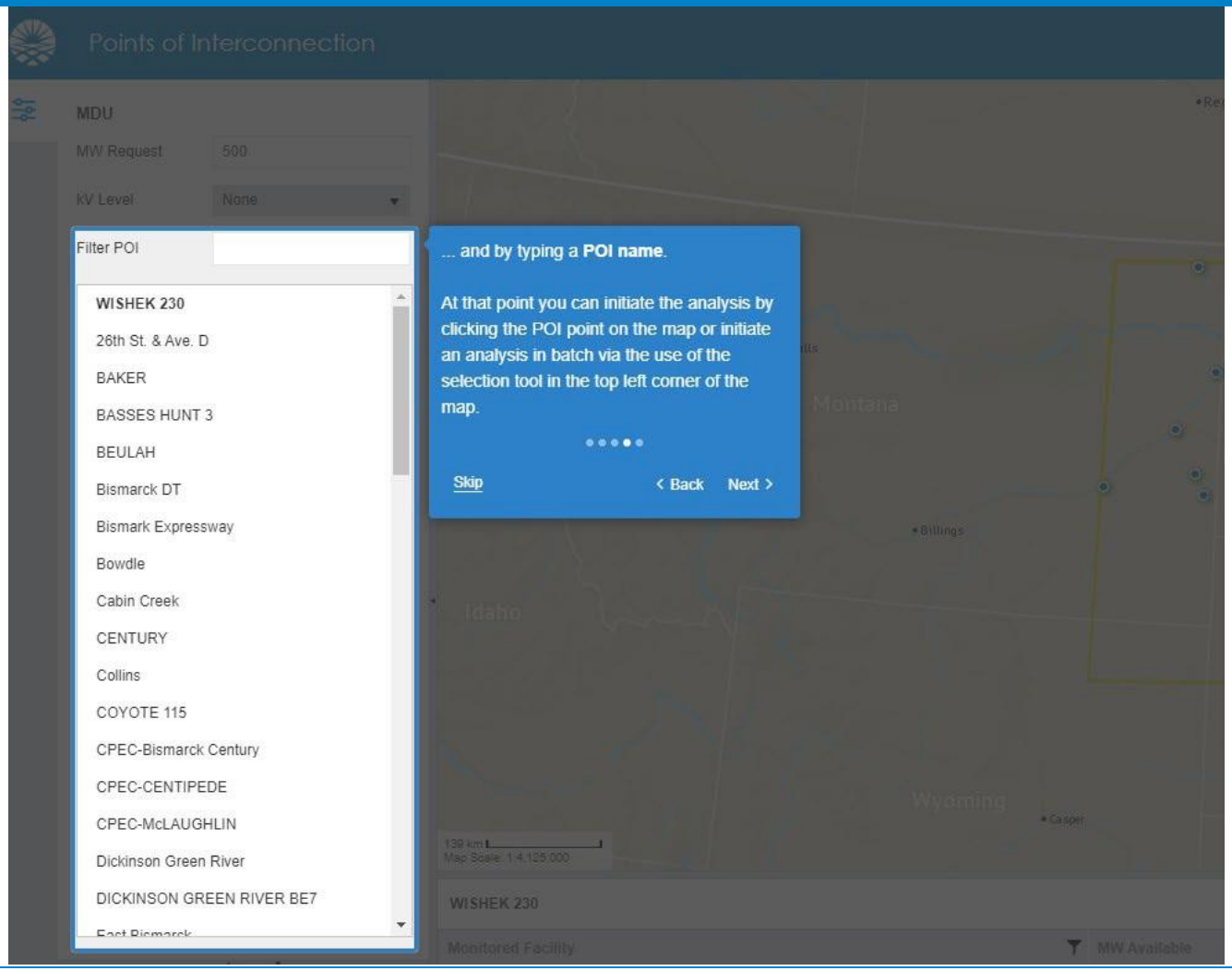
Enter a MW Request Amount (Required)



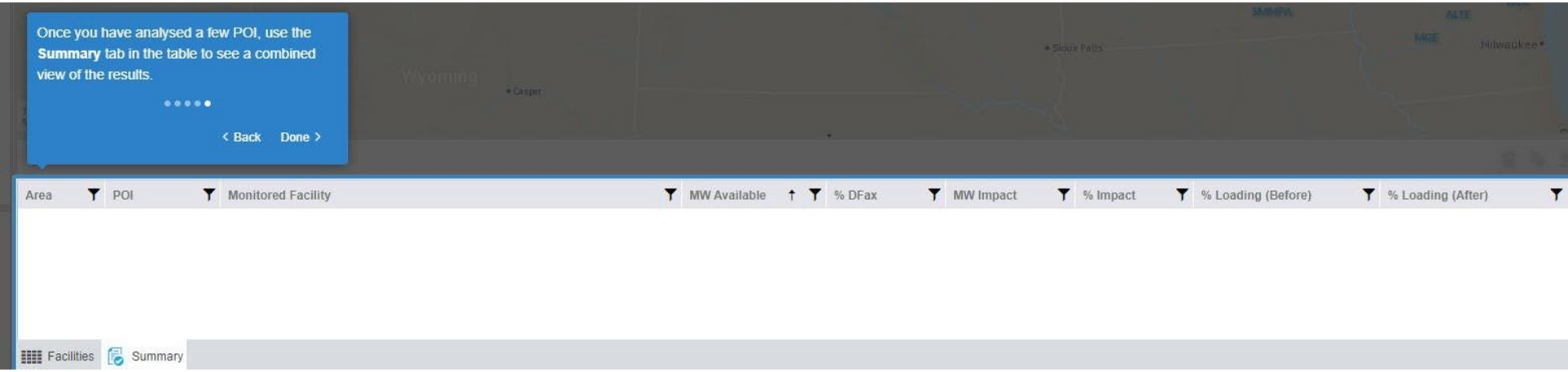
Filter POI based on kV Level (Optional)



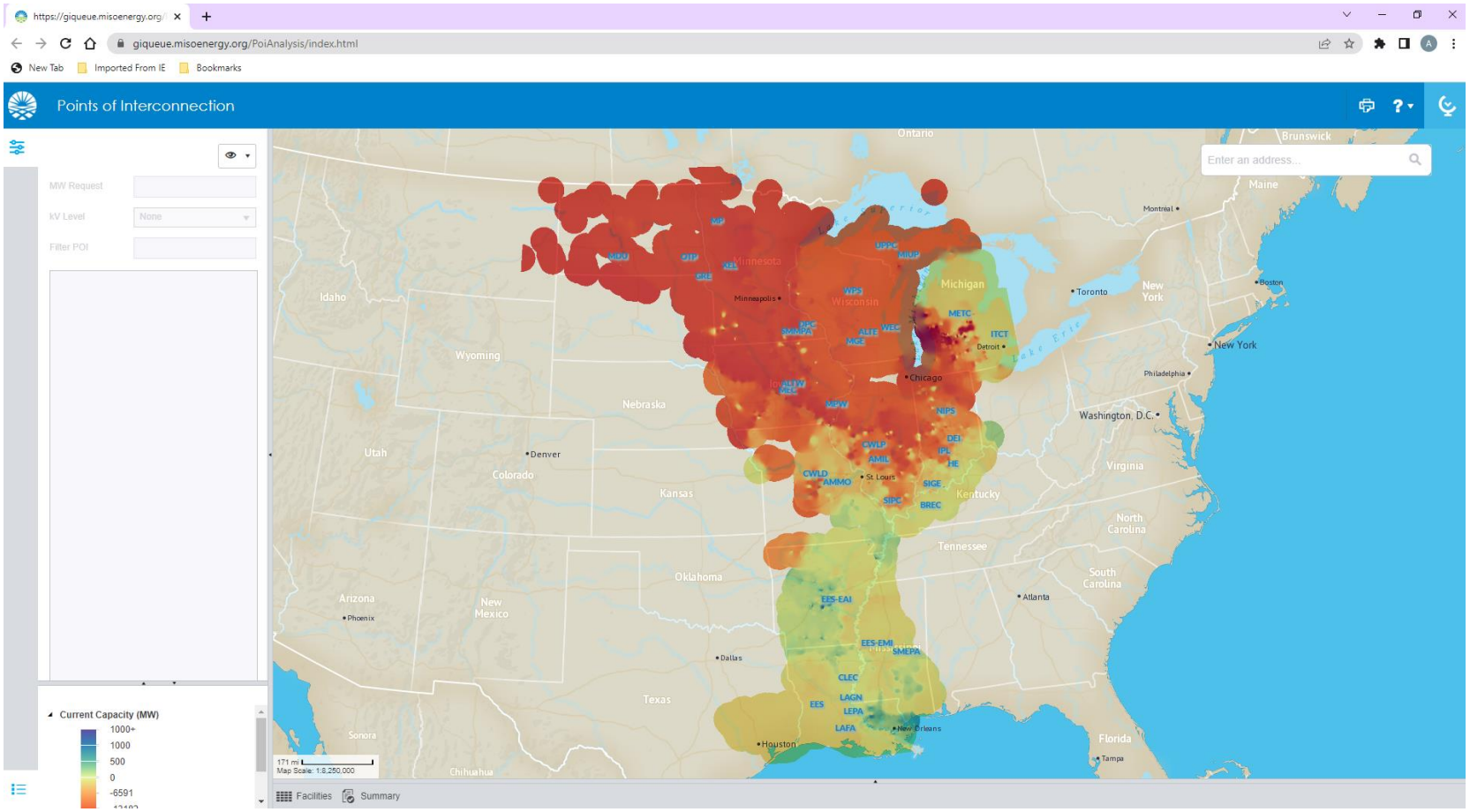
Select POI based on Name



View Results from Analysis



Link to the MISO POI Tool



[Tool Link: https://giqueue.misoenergy.org/PoiAnalysis/index.html](https://giqueue.misoenergy.org/PoiAnalysis/index.html)

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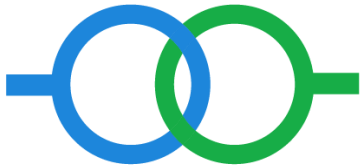

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Hosting capacity automation for the transmission system

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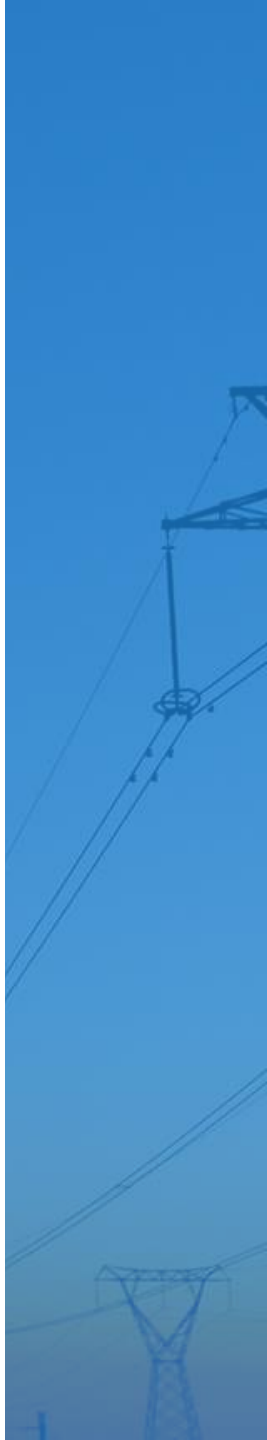
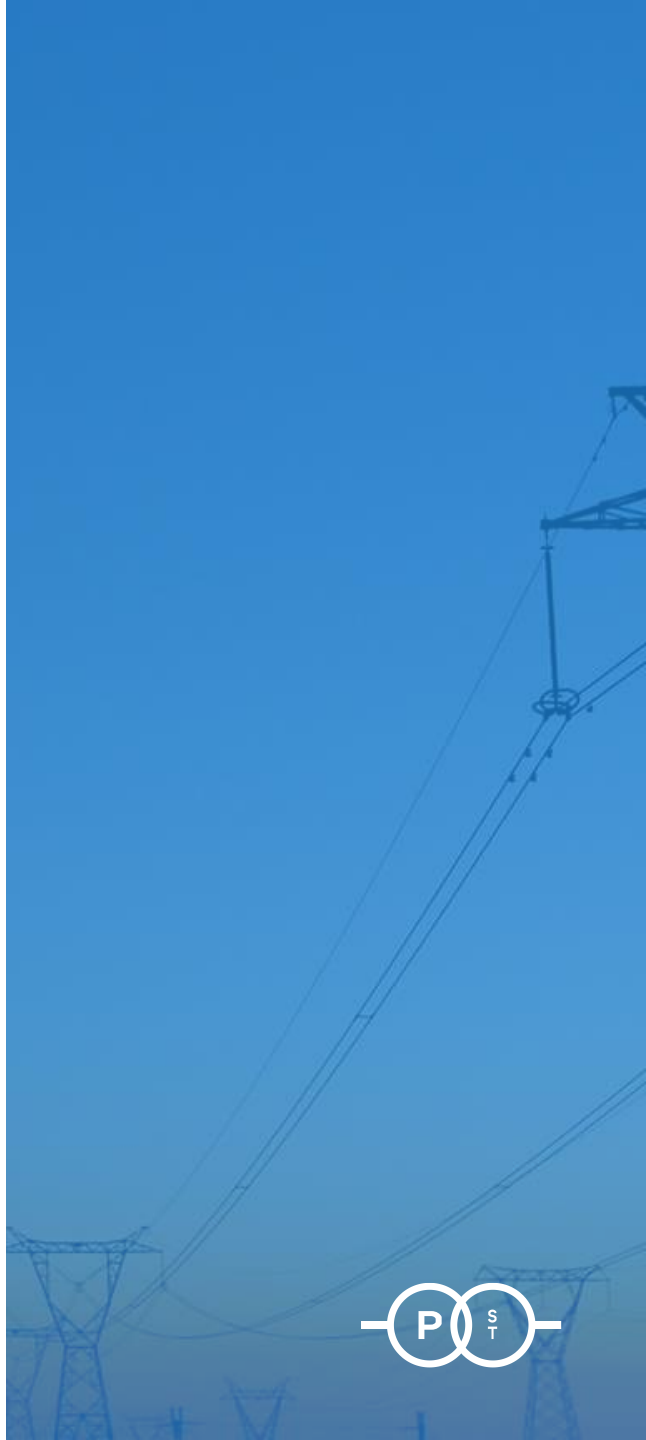


Creating and using hosting capacity maps

- Objective: give developers a tool to site and size new projects
  - Make it clear where severe grid constraints exist, ideally reducing the volume of less realistic projects for ISOs/utilities to process
- Creating such a map involves running some form of interconnection study, or at least a simplified one
  - Begin with a transmission planning model
  - Define and incorporate assumptions (pre-existing projects in the queue to include, contingent mitigation, prospective transmission projects, etc.)
  - Run a power flow study to identify flows and constraints given the model assumptions
  - Provide data to users that allows them to test the impact a new project would have on the system flows and constraints



The dynamics of interconnection queues

Queues may change daily, and every change *could* impact hosting capacity

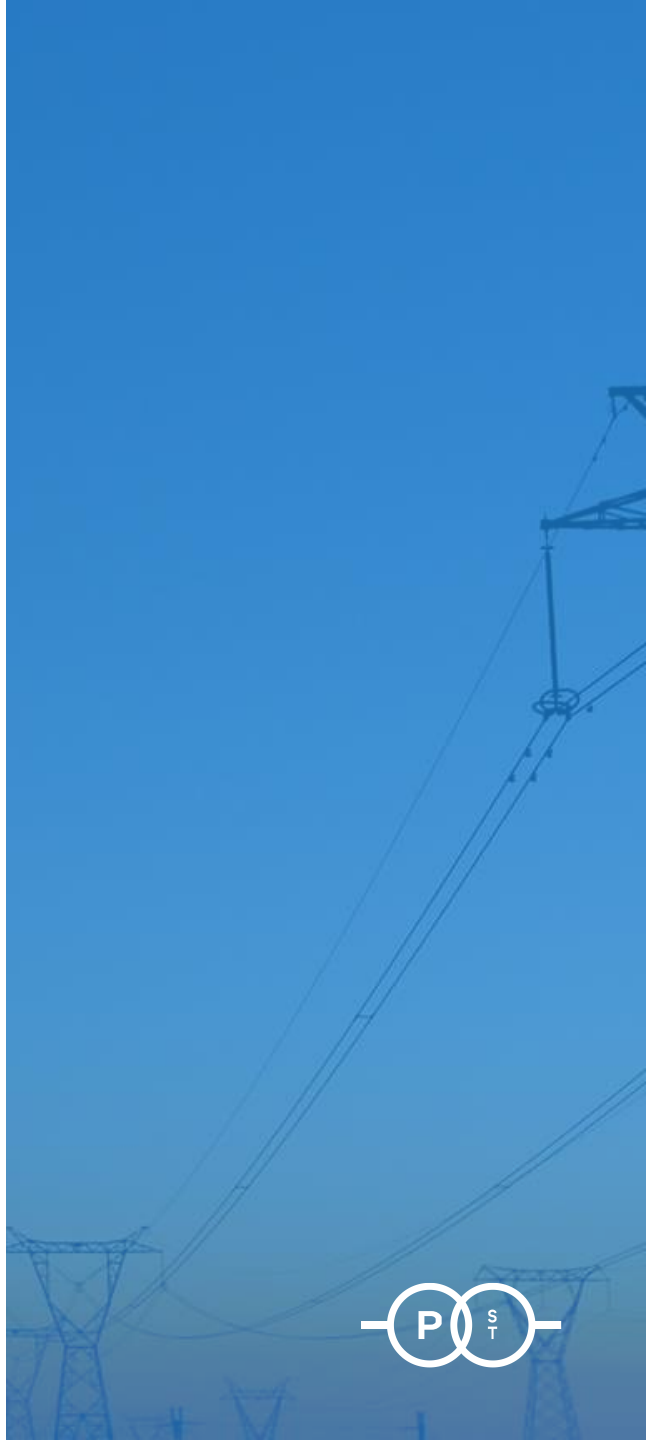
– Example: SPP queue from April – December 2022

Queue Updates	Apr-22	May-22	Jun-22	Jul-22	Aug-22	Sep-22	Oct-22	Nov-22	Dec-22	Monthly average
Projects added	1	7	53	7	9	13	2	13	3	**12**
Projects withdrawn	5	26	3	0	11	30	5	17	19	**13**
POI location updates	2	41	5	13	18	17	23	34	7	**18**
Project capacity updates [MW]	1	5	0	2	2	3	5	12	11	**5**
Service type changes (ERIS/NRIS)	2	6	0	0	13	3	3	17	31	**8**
Generator fuel type updates	1	12	0	2	5	3	11	21	11	**7**
Monthly average	**2**	**16**	**10**	**4**	**10**	**12**	**8**	**19**	**14**	

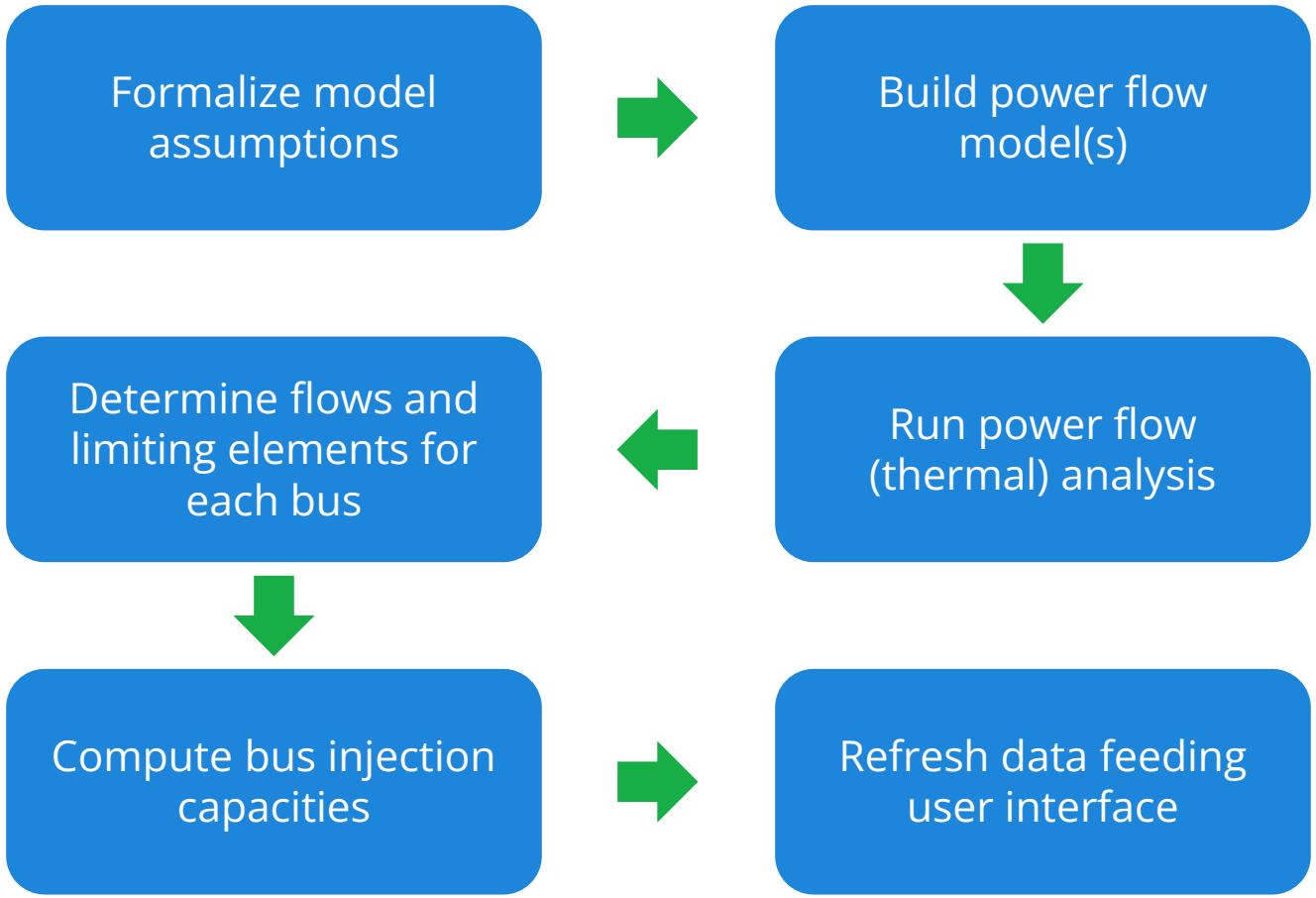
https://pearlstreet.substack.com/p/the-dynamics-of-interconnection-queues

Hosting capacity in a dynamic world

- Stale data in a hosting capacity map provides limited value
- Providing useful information to stakeholders relies on a “set and forget it” system, not “set it and forget it” data
  - Automatically update hosting capacity values given changing assumptions, without burdening ISO/utility interconnection engineers already stretched thin
- Challenge: automate the process to the point where capacity outputs can be reliably computed from model inputs

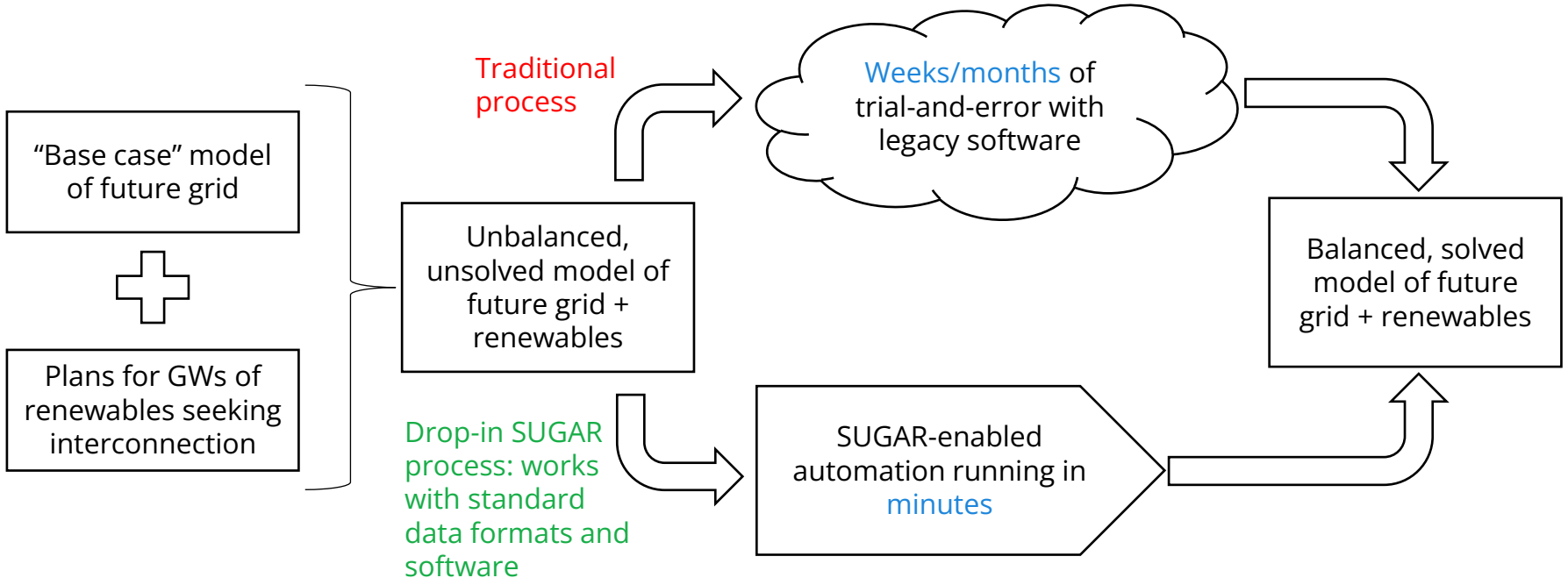


Hosting capacity system



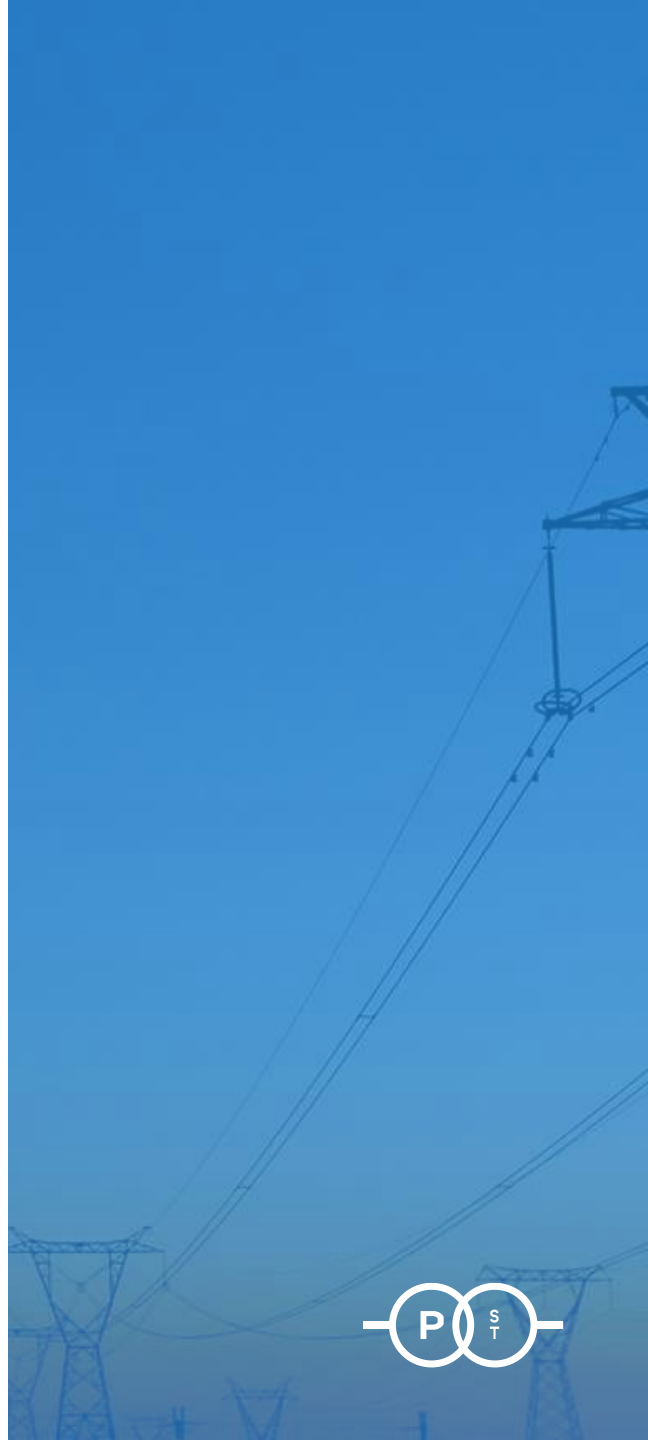
Model building automation is critical

- Modeling “big changes” applied to transmission planning models can be a time consuming, labor intensive task (especially dealing with nonconvergence)
- Pearl Street develops simulation and optimization technology (SUGAR) to automate this crucial step in grid studies
  - Example: Usage at Southwest Power Pool to dispatch and solve 50+ interconnection models in minutes



Beyond hosting capacity: capacity in N dimensions

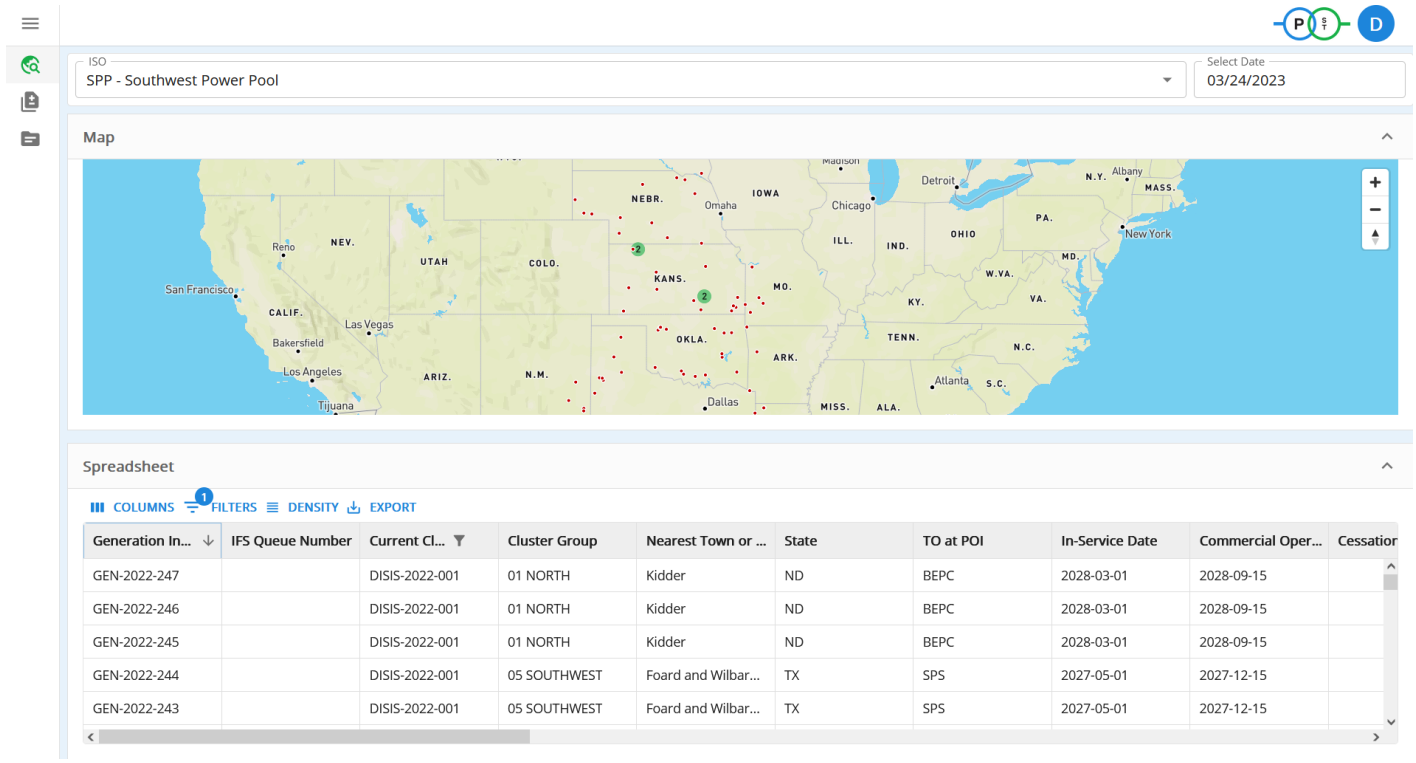
- Developers grapple with questions around interconnection to drive business decisions for current and future projects
  - "I have an interested land owner at [X], how many MWs can I build here without triggering expensive upgrades?"
  - "There are network upgrades being cost allocated across my project's cluster – is there a path forward for my project to be competitive?"
  - "How will my cost allocation change if a prior queued project with a contingent upgrade decides to withdraw?"
  - How do these answers change given the many possible scenarios involving other projects and upgrades that might occur?
- Hosting capacity is based on only one set of assumptions; developers need to test many assumptions to assess their interconnection risk



Pearl Street's Interconnection Intelligence Platform

A one-stop solution for assessing interconnection risk at scale

- Automated model building, thermal analysis, mitigation cost estimation to explore cost allocation across any number of scenarios



Generation In...	IFS Queue Number	Current Cl...	Cluster Group	Nearest Town or ...	State	TO at POI	In-Service Date	Commercial Oper...	Cessation
GEN-2022-247		DISIS-2022-001	01 NORTH	Kidder	ND	BEPC	2028-03-01	2028-09-15	
GEN-2022-246		DISIS-2022-001	01 NORTH	Kidder	ND	BEPC	2028-03-01	2028-09-15	
GEN-2022-245		DISIS-2022-001	01 NORTH	Kidder	ND	BEPC	2028-03-01	2028-09-15	
GEN-2022-244		DISIS-2022-001	05 SOUTHWEST	Foard and Wilbar...	TX	SPS	2027-05-01	2027-12-15	
GEN-2022-243		DISIS-2022-001	05 SOUTHWEST	Foard and Wilbar...	TX	SPS	2027-05-01	2027-12-15	

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Summary

- Hosting capacity maps can provide valuable insights to developers, but only if the data is regularly refreshed
- Automating the interconnection study process (or a “lite” version) is critical to keep maps up to date
- Technology solutions enable this level of automation and support scenario analysis to assess interconnection risk