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

Possibilities to Improve Interconnection Data Access & Transparency

July 18, 2024

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

Meeting Recording Announcement

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Agenda

- DOE i2X Program + Roadmap Overview
- Panel Presentations: Improving Interconnection Data Access and Transparency (60 min)
  - Joe Rand (Lawrence Berkeley National Laboratory)
  - Sarah Toth (Rocky Mountain Institute)
  - Andrew Martin (Nira Energy)
  - Kathleen Ratcliff (Federal Energy Regulatory Commission)
- Open facilitated discussion (50 min)
- Future i2x Activities & Upcoming Events (5 min)

Speakers

Joe Rand – Energy Policy Researcher, *Lawrence Berkeley National Laboratory*

Dr. Sarah Toth – Senior Associate, *Rocky Mountain Institute*

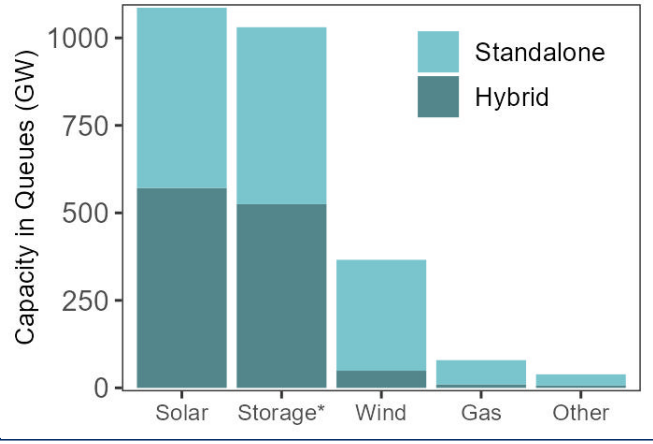
Andrew Martin – Head of Transmission and Co-founder, *Nira Energy*

Dr. Kathleen Ratcliff – Senior Policy Analyst, *Federal Energy Regulatory Commission*

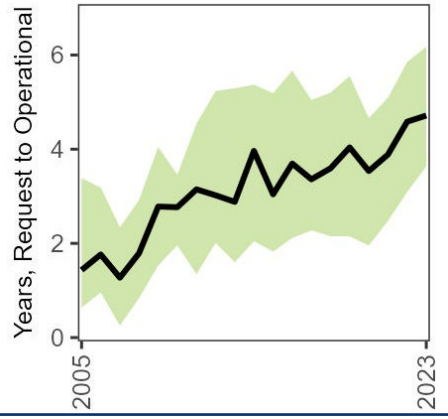
State of Transmission Interconnection

Developer interest in solar, storage, and wind is strong

- Nearly 11,600 projects with 2,600 GW actively seeking interconnection
- Active capacity in queues increased ~8X since 2014



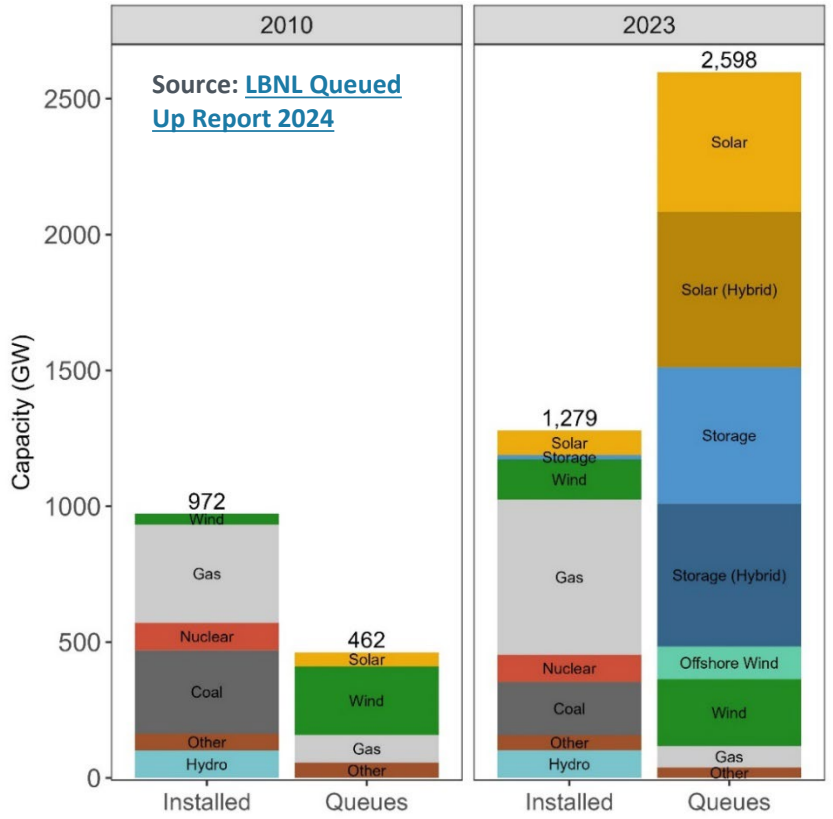
Completion rates are generally low; wait times are increasing



- For projects built in 2023, the average time from request to commercial operations is 5 years compared to 3 years in 2015 and <2 years in 2008
- Interconnection *costs* also increasing

Proposed capacity is more than 2x installed capacity!

- >95% of capacity in queues is zero-carbon



Source: LBNL's Queued Up Report 2024

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

i2X is a collaboration among DOE offices and National Labs

U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

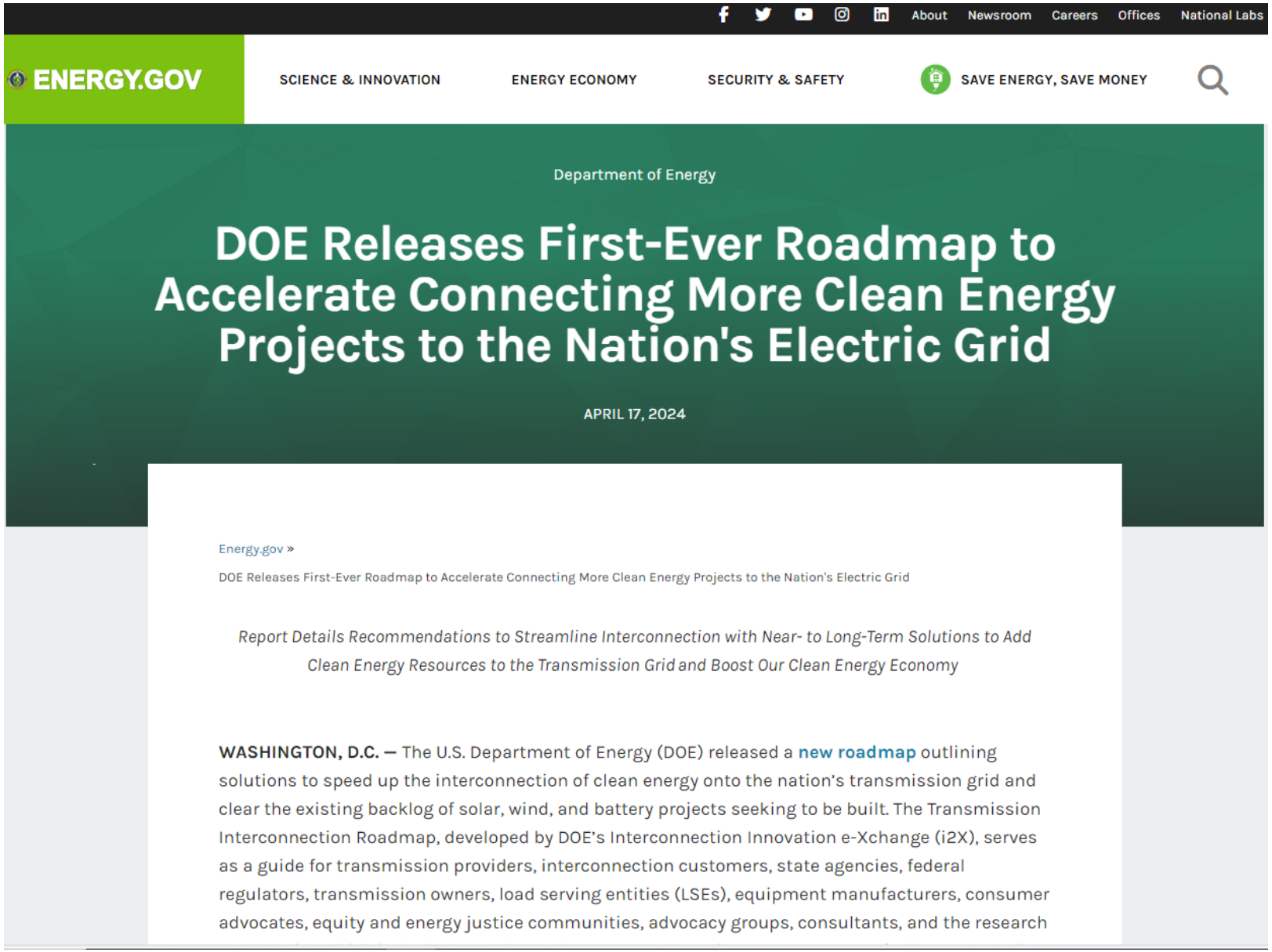
BERKELEY LAB

GDO GRID DEPLOYMENT OFFICE

Pacific Northwest NATIONAL LABORATORY

NREL Transforming ENERGY

energy.gov/i2x



www.energy.gov/i2x

Transmission Roadmap Key Components and Implementation Actors

35 solutions organized in four goals

Solutions with different implementation time frames

- *Short-term:* within 1-3 years (by 2027)
- *Medium-term:* 3-5 years (by 2029)
- *Long-term:* beyond 5 years (2030 and after)

Solutions describe collaborative actions among key actors

- Transmission providers (Utilities, ISOs, BAs)
- Regulators (FERC/NERC, State PUCs)
- Interconnection customers
- Consumer Groups
- Research community (including DOE)
- OEM and software vendors
- State, local, tribal governments
- Equity and public benefit organizations

Measurable 2030 success targets

DOE has multiple potential roles in enabling Roadmap implementation

- Convene Stakeholders
- Provide Technical Support
- Fund Research and Innovation
- Evaluate Progress

Measurable Success Targets for 2030

Evaluating success relies on accessible data for tracking and auditing!

	Target Value by 2030	Recent Value
 **Reduced interconnection process time** Average time from request to agreement	< 12 months	33 months (2022)
 **Lowered cost uncertainty** Standard deviation of interconnection costs	< $150/kW	$551/kW (2020-2021)
 **Increased Completion rates** Completion rate for projects that entered facility study phase	> 70%	45% (2016)
 **Maintained system reliability** Number of annual NERC disturbances events involving unexpected tripping of IBRs not identified in offline analysis due to IBR modeling inaccuracy	Zero	4 (2022)

Four Interconnection Goals with 35 Solutions

Goal #1: Increase Data Access and Transparency

Goal #2: Improve Process and Timeline

Goal #3: Promote Economic Efficiency

Goal #4: Maintain a Reliable, Resilient, and Secure Grid

- Solutions are a collection of strategies rather than a rigid package of prescriptive fixes.
- Some solutions are complementary: to be effective, they would need to be implemented in tandem with others.
- Other solutions are exclusive: adopting one might obviate the need for another.
- Solutions may be topically specific (e.g., Cost Allocation)

Roadmap does not assess the costs of implementing the solutions.

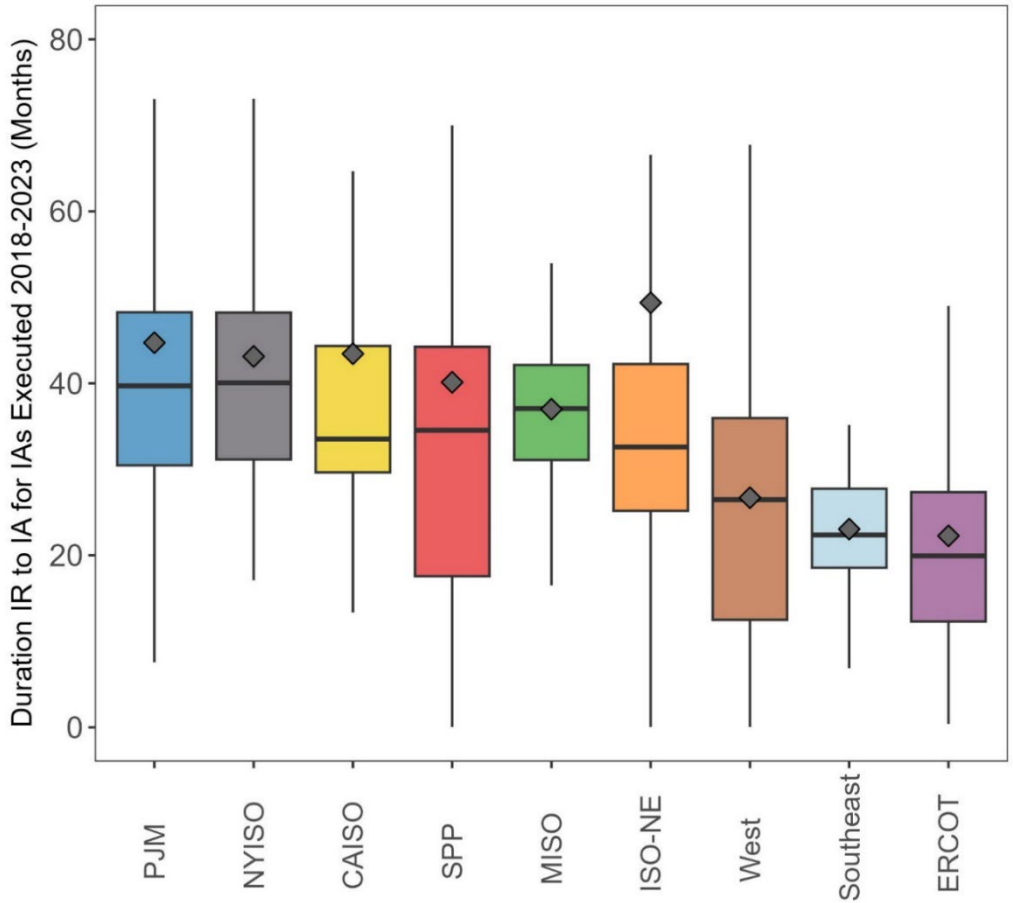
Goal 1: Data Access and Transparency

Challenge: Inadequate access to information is contributing to high volumes of interconnection requests, high withdrawal rates, and processing delays. How can improvements to data access and transparency support interconnection stakeholders?

Objectives

Key Tradeoff: Providing information to promote transparency, which takes time and resources to implement, and which must abide by security and confidentiality concerns

- Enable tracking and auditing of process performance
- Facilitate screening, optimal siting, and automation
- Improve the predictability of interconnection studies
- Reduce barriers to assess proposed projects



Solution 1.1: Improve the scope, accessibility, quality, and standardization of **data on projects already in interconnection queues**, including project attributes, cost estimates, and post-IA information.

SHORT TERM

Examples of Data Needs:

- Queue volumes
- Size and type of proposed power plants
- Hybrid plant configurations
- Dates / processing times
- Project and POI locations
- Interconnection costs (both 'POI' and 'network' costs)
- Post-GIA data (timelines, costs, progress)

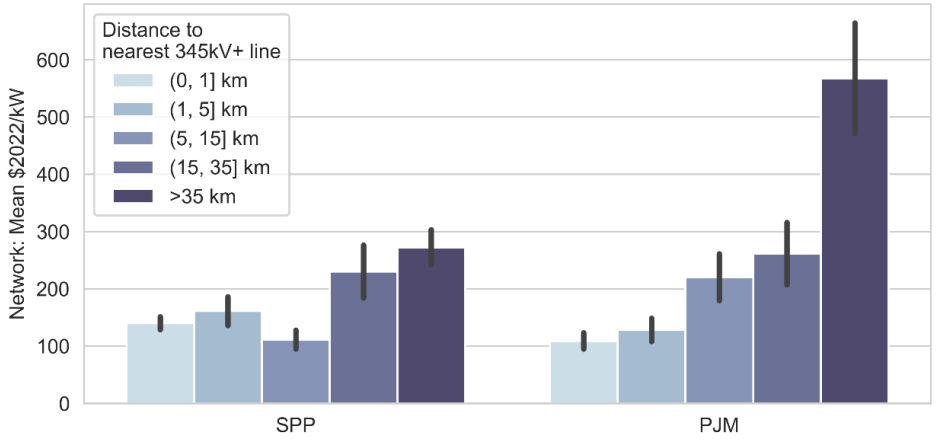
■ = Fully & publicly available
■ = Partially available
■ = Inaccessible

Example Data Users

- Regulators
- Transmission providers
- Resource developers / interconnection customers
- Software & solution providers
- Research / academic

Example Data Use-Cases

- Monitor interconnection processes and outcomes
- Track, assess, and audit reforms
- Inform siting decisions
- Support interconnection process automation
- Evaluate justice and equity metrics and outcomes



	SPP					PJM				
Project count	300	83	93	104	131	141	174	226	115	235
Mean nameplate MW	227	193	162	187	178	178	103	65	111	66

Average interconnection network upgrade costs by distance to the nearest high-voltage transmission line, SPP and PJM projects 2019-2023.
**Unreleased draft analysis by LBNL*

Solution 1.2: Enhance the scope, timeliness, accuracy, and consistency of **interconnection study models and modeling assumptions** that transmission providers make available to interconnection customers.

SHORT TERM

Examples of Data Needs:

- Base cases
- Study models
- Modeling assumptions
- Transmission line length & routing
- Substation locations
- Generation plant locations
- Age and technical information on transmission equipment

■ = Fully & publicly available
■ = Partially available
■ = Inaccessible

Process Improvement Needs:

- Improve information coverage, relevance, accuracy, standardization, and access
- Better alignment between data updates and interconnection study cycles
- More consistent processes for accessing critical infrastructure (CEII) data

Use Cases and Benefits:

- Using consistent data, criteria, and methods across interconnection studies could allow for automation, and improve transparency and confidence in studies
- Increase the number of interconnection study suppliers, reducing costs
- Potential for fee-based, automated, detailed studies (like AEMO, see Fig.)

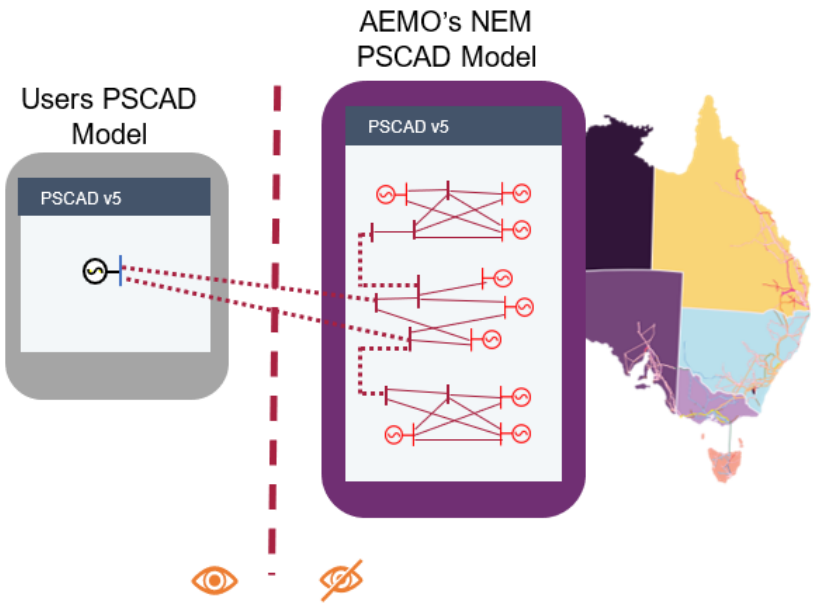


Illustration of the Australian Energy Market Operator (AEMO) Connections Simulation Tool.
Allows users to confidentially run studies in AEMO's model

Solution 1.3: Develop tools to manage, analyze, and visualize transmission and interconnection data made available in first two solutions, while ensuring secure data-sharing processes.

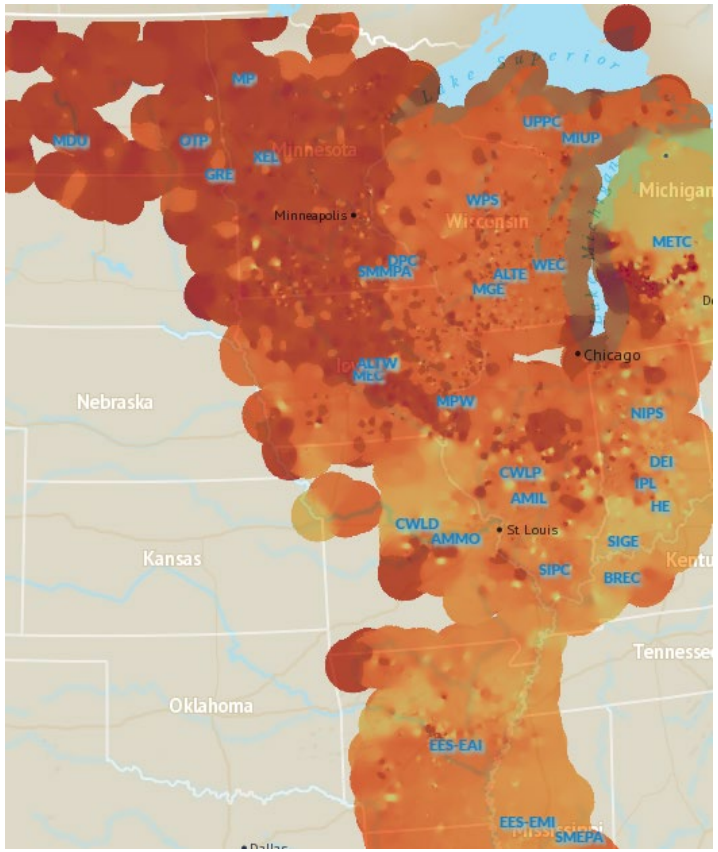
MEDIUM TERM

Heatmaps:

- Hosting capacity maps (a.k.a. “heatmaps”) are now required from all transmission providers under Order 2023
- This is a great step for increased transparency!
- But existing heatmap tools have several limitations
  - Stale data
  - No user control to test assumptions
  - One size fits all - not dynamic or evolving

Expanding Tools Beyond Heatmaps

- Compliance with Order 2023 is priority, but transmission providers should also consider more sophisticated tools
- Several software providers have developed tools and systems that enable more automated, up-to-date, user-controlled, and confidential injection capacity calculations
- With increasing penetration of inverter-based resources, more transparency of grid system dynamics and stability is needed (i.e., beyond just thermal ratings)
- Improving, expanding, and harmonizing these tools could reduce speculation and enhance competition



MISO “Points of Interconnection” heatmap. FERC Order 2023 requires public, interactive heatmaps for all transmission providers

Speakers

Dr. Sarah Toth – Senior Associate, *Rocky Mountain Institute*

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Website: energy.gov/i2X
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Discussion and Q&A

Website: energy.gov/i2X
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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

Current DOE Actions to Implement Roadmap Solutions

Solar and Wind Interconnection for Future Transmission (SWIFTR) Funding Opportunity - Released March 19

i2X Forum for Implementing Reliability Standards for Transmission (i2X FIRST)

i2X Roadmap outreach and technical assistance

Collaboration among DOE Offices and other federal and state agencies

Discuss, envision, and implement solutions

Upcoming i2X Solution eXchanges

September 19 - Promote Economic Efficiency

October 24 - Improve Process and Timeline

December 3 - Maintain a Reliable, Resilient and Secure Grid

i2X Forum for Implementing Reliability Standards for Transmission (i2X FIRST)

i2X FIRST is a series of monthly interactive meetings to facilitate the adoption of new and recently updated standards relevant for interconnected clean energy resources like solar and wind energy.

Upcoming dates:

- July 30 | 11 a.m.- 1 p.m. ET | Virtual
- Aug 20 | 11 a.m.- 1 p.m. ET | Virtual
- Sep 24 | 11 a.m.- 1 p.m. ET | Virtual

Thank you for joining and participating

Website: energy.gov/i2X
Email: i2x@ee.doe.gov

INTERCONNECTION INNOVATION e-XCHANGE
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Order No. 2023: Improvements to Generator Interconnection Procedures and Agreements – Data Access, Transparency, and Security

Disclaimer:

- **Any opinions expressed in this presentation are the presenter's own, and do not necessarily represent the views of the Federal Energy Regulatory Commission or any Commissioner**

Need for Reform

- The Commission found that existing interconnection procedures and agreements were insufficient to ensure that interconnection customers are able to interconnect to the transmission system in a reliable, efficient, transparent, and timely manner
- Persistent generator interconnection queue backlogs
  - Over 10,000 active requests (2,000+ GW) in queues at the end of 2022
  - Typical time spent in queues before COD increasing from 2.1 years (for generating facilities built in 2000-2010), to 3.7 years (2010-2021), to ~5 years (2022)
  - Of the ~2,200 interconnection studies completed in 2022, 68% were issued late; another ~2,500 studies were delayed as of Q4 2022 (*i.e.*, ongoing and past their deadline)
- Interconnection customers have a high degree of uncertainty regarding the cost of interconnection
- Commenters overwhelmingly agreed that there was a need to reform the Commission's *pro forma* interconnection procedures and agreements

Order No. 2023 Reforms

- Reforms to Implement a First-Ready, First-Served Cluster Study Process
  - **Public Interconnection Information**
  - **Cluster Study Process**
  - Allocation of Network Upgrade Costs for Interconnection Customers in Clusters
  - Financial Commitments and Readiness Requirements
  - Transition Process
- Reforms to Increase the Speed of Queue Processing
  - **Affected System Study Process**
  - Study Delay Penalties
- Reforms to Incorporate Technological Advancements
  - **Increasing Flexibility in the Generator Interconnection Process**
  - **Evaluating Alternative Transmission Technologies in the Generator Interconnection Process**
  - **Modeling and Performance Requirements for Non-Synchronous Generating Facilities**

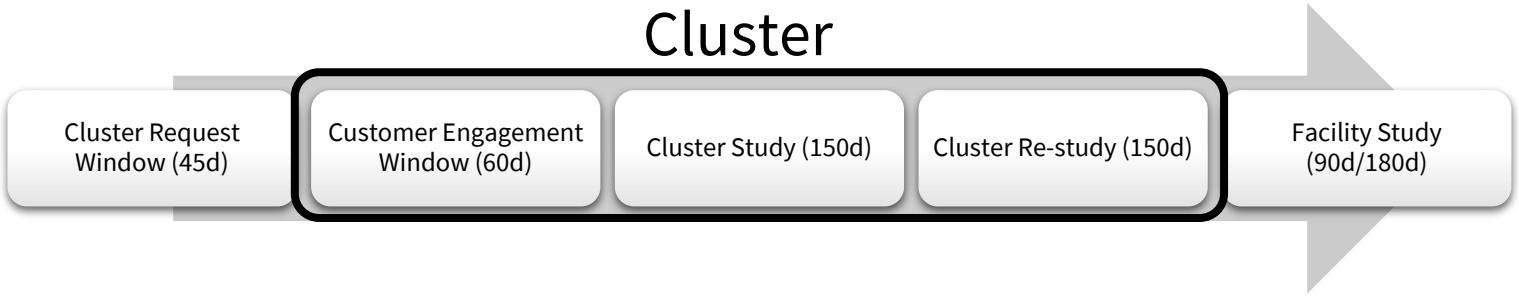
Public Interconnection Information ("Heat Map")

Interconnection customers often enter the queue to obtain information about the costs to interconnect generating facilities at specific points of interconnection because that information is difficult to obtain outside of the interconnection process.

- Transmission providers will post on their website an interactive visual representation of estimated capacity available at each point of interconnection in their footprint
- The visual representation will estimate the impact of adding a proposed generating facility at a specific point of interconnection
- Transmission providers will update this information within 30 days after each cluster study and restudy

Cluster Study Process

Previously, the pro forma LGIP required transmission providers to study each interconnection request individually and sequentially.



- Order No. 2023 now requires:
  - All interconnection requests must be submitted during an annual cluster request window; all interconnection customers in a cluster will be considered equally queued
  - During the customer engagement window, the transmission provider will post details about the cluster and hold a scoping meeting with all interconnection customers in the cluster
  - The cluster study process includes a built-in restudy period, which may be triggered when a higher- or equally-queued interconnection customer withdraws
  - Interconnection requests are still studied individually at the facilities study stage

Affected System Study Process

Order No. 2023 remedies a lack of a standard affected system study process and related standard agreements.

- Jurisdictional transmission providers must follow a standard, uniform affected system study process
  - Process includes set timeframes for: initial notification of affected system, decision whether to study potential affected system impacts, and affected system study itself (which will be conducted as a 150-business day cluster study)
- New *pro forma* affected system study agreements and *pro forma* affected system facilities construction agreements must be used
- Jurisdictional transmission providers must study all affected systems interconnection requests as requests for Energy Resource Interconnection Service

Increasing Flexibility in the Generator Interconnection Process

Order No. 2023 removes certain barriers to proposed generating facilities that use battery storage technology and hybrid configurations.

- More than one generating facility may co-locate on a shared site to share a single interconnection request
- Interconnection customers may add a generating facility to an existing interconnection request if there is no change to the originally requested interconnection service level
- Surplus interconnection service will be available after executing (or requiring the unexecuted filing of) an LGIA rather than only after a generating facility enters commercial operation
- Interconnection customers may request that interconnection studies use more accurate operating assumptions for electric storage resources (whether standalone, co-located generating facilities, or part of a hybrid generating facility) when transmission providers study charging behavior

Evaluating Alternative Transmission Technologies in the Generator Interconnection Process

Prior to Order No. 2023, transmission providers were not required to consider any specific transmission technologies. The Commission concluded that the evaluation of alternative transmission technologies could reduce interconnection time and costs.

- Transmission providers must evaluate the use of the following alternative transmission technologies during the study process:
  - Advanced conductors
  - Advanced power flow control
  - Static synchronous compensators
  - Static VAR compensators
  - Synchronous condensers
  - Transmission switching
  - Tower lifting
  - Voltage source converters
- Transmission providers are only required to evaluate whether these technologies could be used, but not required to deploy them

Modeling of Non-Synchronous Generators

Accurate and validated models are necessary to minimize study delays and ensure the appropriate identification of network upgrades.

- Interconnection customers must provide accurate models of the generating facility with the interconnection request that includes:
  - A validated, user-defined dynamics model
  - An appropriately parameterized generic library dynamics model, with a block model diagram of the inverter and plant control systems, as listed in an included table or as otherwise approved by WECC
  - Validated electromagnetic transient (EMT) model if the transmission provider performs EMT studies
- Interconnection customers must update these models as they make modifications to their interconnection request

Interconnection Workshops Highlight Transparency

- On June 27, 2024, FERC issued a supplemental notice regarding a staff-led workshop on interconnection issues (September 10-11, 2024). Day 2 of the panel will feature:
  - Efficiencies Panel 1, the generator interconnection process, will evaluate the potential for increased efficiency throughout the generator interconnection process (excluding topics covered in Efficiencies Panels 2 and 3), such as, for example, providing additional pre-application data to interconnection customers or establishing fast-tracking processes for interconnection requests at points of interconnection with fewer system constraints.
  - Efficiencies Panel 2, automation, will assess opportunities for greater efficiency in the processing and study of interconnection requests by automating different steps in the process and using advanced computing technologies such as artificial intelligence to shorten the timeline from interconnection request to interconnection agreement.
  - Efficiencies Panel 3, post-generator interconnection agreement construction phase, will discuss opportunities for greater efficiency, transparency, and accountability in the design, construction, and operation of interconnection facilities and network upgrades.

Data transparency lessons learned from evaluating GETs in PJM

Presentation to i2X

Sarah Toth, PhD

July 18, 2024

Contents

GETs can enable faster and cheaper interconnection of new resources

GETting Interconnected in PJM, RMI, February 2024*

Deploy GETs (cost: $100M)

GETs are hardware and software tools that increase the efficiency of the grid

- Advanced Power Flow Controls (PFCs)
- Dynamic Line Ratings (DLR)
- Topology Optimization (TO)

Interconnect 6.6 GW of clean energy

Using GETs as network upgrades supports faster and cheaper interconnection of new resources

- +Solar
- +Storage
- +Wind

Save $1B annually

GETs and the lower-cost, carbon-free generation they enable could result in:

- $1B in annual production cost savings
- 12M tons of avoided CO2 emissions

*based on analysis conducted by Quanta Technologies

As grid data becomes more specific it also becomes more sensitive

Additional guardrails are necessary to protect cyber and physical security

RTOs guard their data carefully to protect grid infrastructure

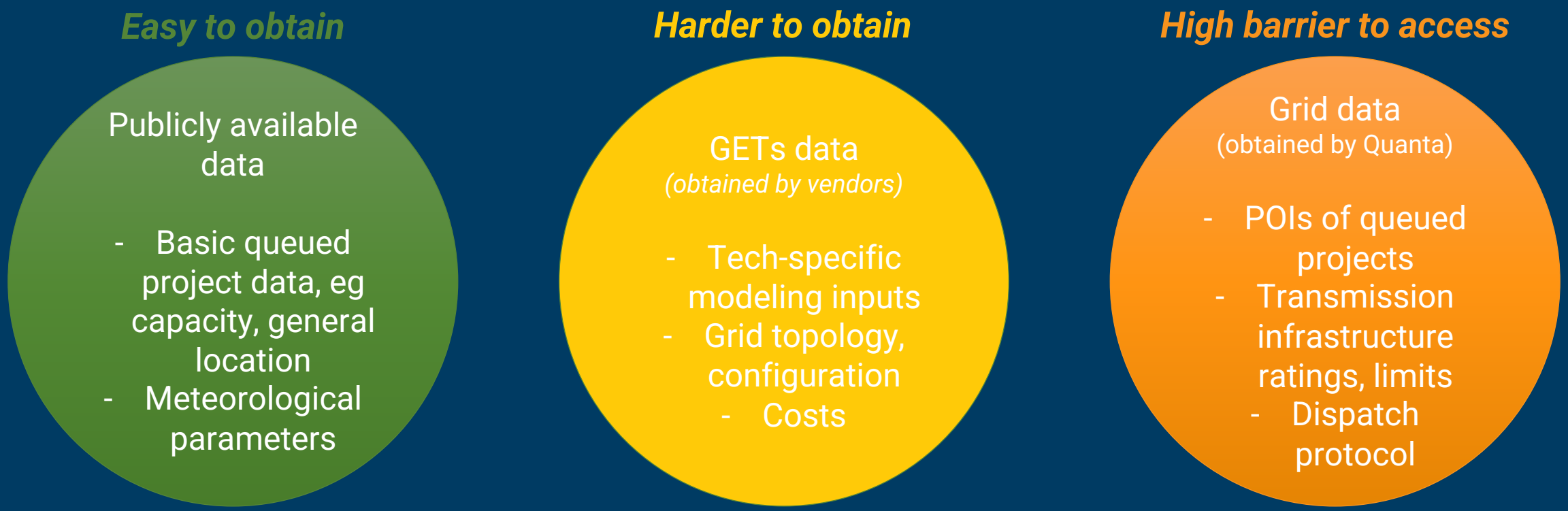
Developers seek some grid data to guide their development and come up with solutions to grid needs

Highly sensitive national-security type data (CEII) is available only to companies that need to have it and are registered with the RTO

Back to the beginning – in our analysis of GETs, we asked:

Can GETs be reliably used as network upgrades in interconnection in PJM?

Data needs:



Quanta respected all NDAs in their collection and use of grid data

Quanta's rigorous analysis assessed the viability of GETs as interconnection network upgrades

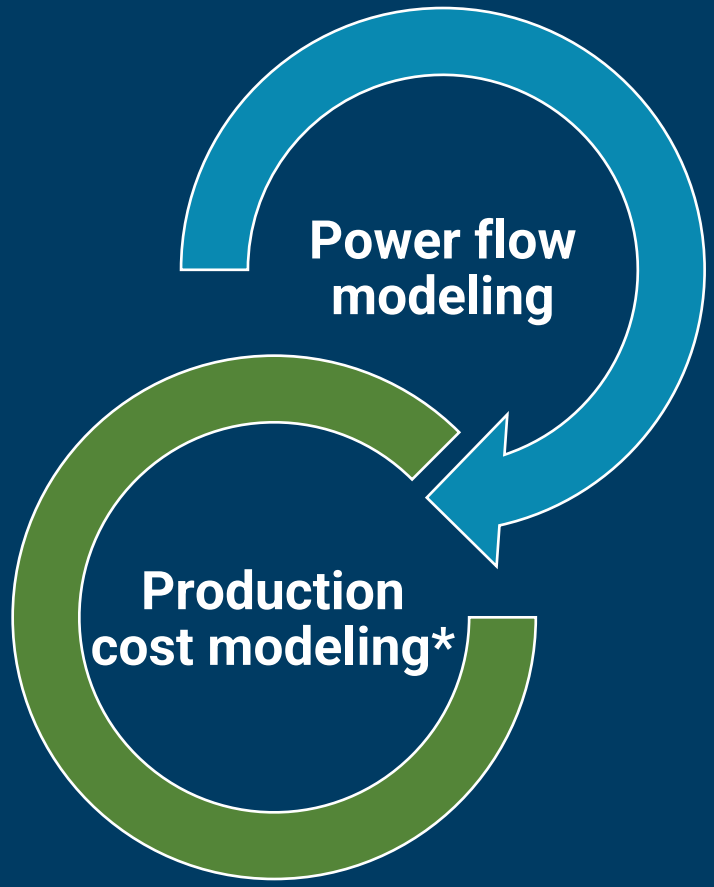
Data

Queued generation:
Capacity through Transition Cycle 1

5 states:
Pennsylvania, Ohio, Illinois, Indiana, and Virginia

3 future years:
2026, 2028, and 2030

3 grid conditions:
Summer peak, winter, and light-load



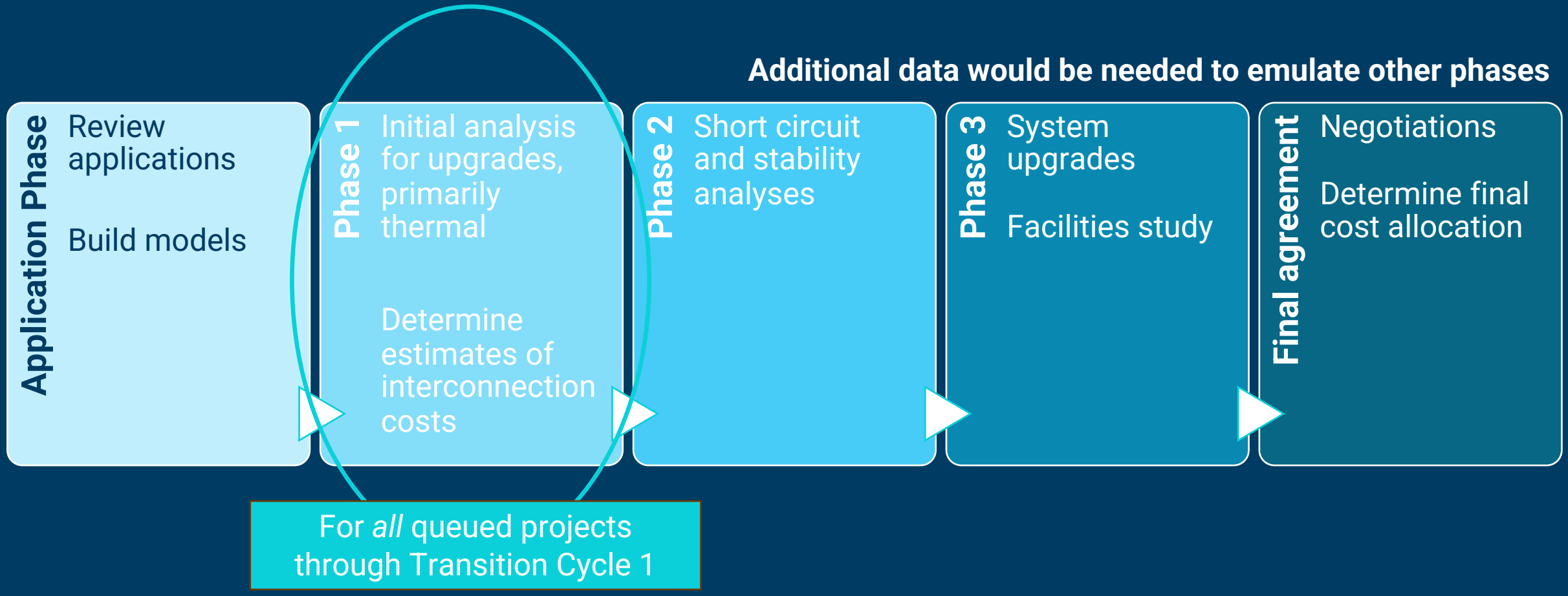
Queued generation and GETs were incorporated into a power flow model (PSSE) & contingency analysis (TARA) to assess thermal overload violations

Cost and emissions benefits were quantified in ProMOD

**Not typically included in interconnection modeling; included in this analysis to showcase benefits*

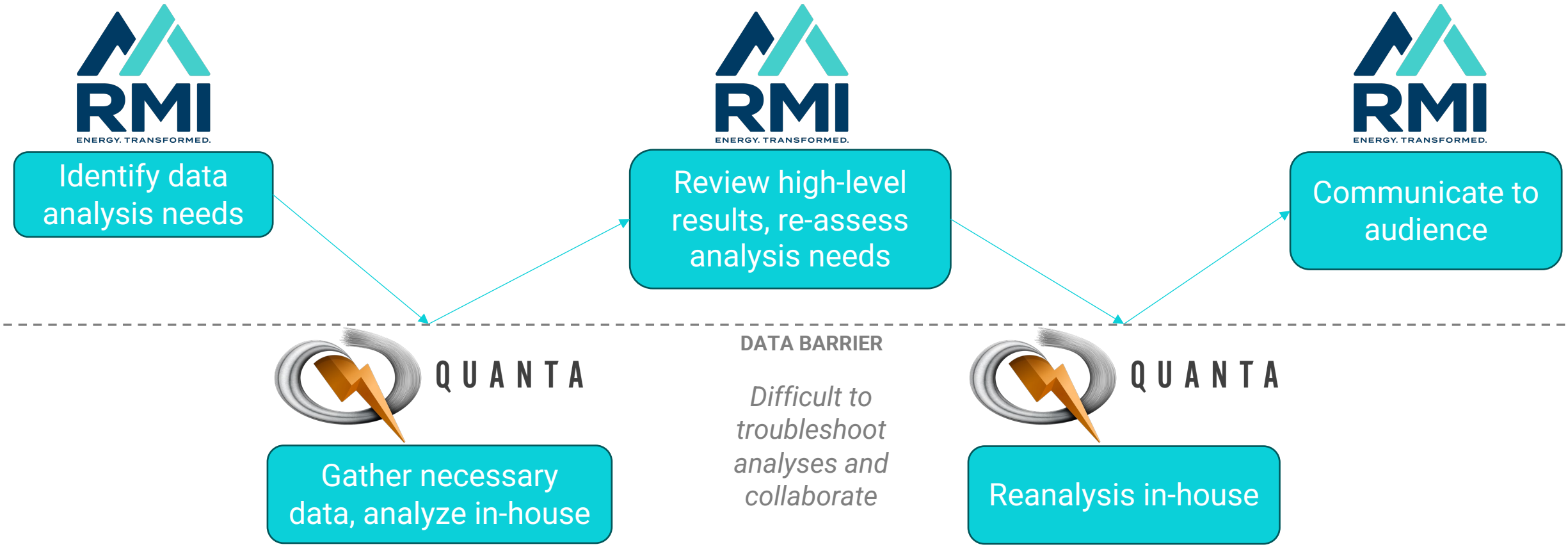
Source: Quanta analysis

Analysis of data sought to replicate PJM's study process – only thermal power flow to manage scope



PJM IPRTF presentation,

Only our analytical partner, Quanta, could access some of the grid data needed



Independent analysis, though limited by lack of transparency, is a helpful tool to audit industry practices

Data accessibility, linkage, and transparency are crucial to successful third-party analyses

Complexity and high access barriers limit interconnection study models and modeling assumptions to only experienced professionals with need

- This is the basis of the business model for experienced consulting agencies that conduct this work
- This increases the need for the 'insider' perspective that an RTO engineer can bring to a developer (evidenced in high rates of RTO experts going to work for developers/consultancies)

Information asymmetry shortchanges independent analyses at the outset

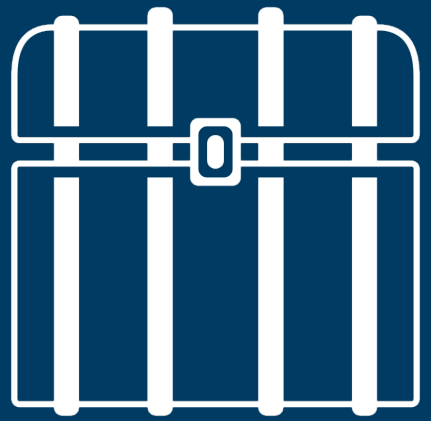
- It's difficult to collaborate on data analysis when a party can only see high-level summaries of results
- A lack of data access and linkage makes it virtually impossible to follow-up on deployment expectations and make comparisons post-analysis

Independent analysis is a helpful tool to audit processes and put theories and expectations into perspective

- As it stands, interconnection today is only a snapshot reliability analysis – we would never have understood the economic benefits of different network upgrades unless a third party asks and answers this question.
- Uncovered some opportunities for improvement to "industry standard" software, ensure it's aligned with new best-in-class alternatives

Could we create a secure middle ground?

- PJM and other RTOs have taken some great first steps toward improving data transparency, such as with transmission capacity heatmaps (e.g., PJM's Queue Scope tool)
- Occasionally, developers and third parties need more up-to-date or in-depth data than what is currently provided in those tools
- Are there opportunities to develop a platform to support this while protecting Critical Energy/Electric Infrastructure Information (CEII)?



A secure environment, updated and guarded by RTOs, for developers/consultants to assess solutions and projects

Thank you

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