i2X Studies, Tools, and Interconnection Consistency and Harmonization

Regional Studies: ERCOT & MISO

i2X STITCH | 06/23/2026

ESIG

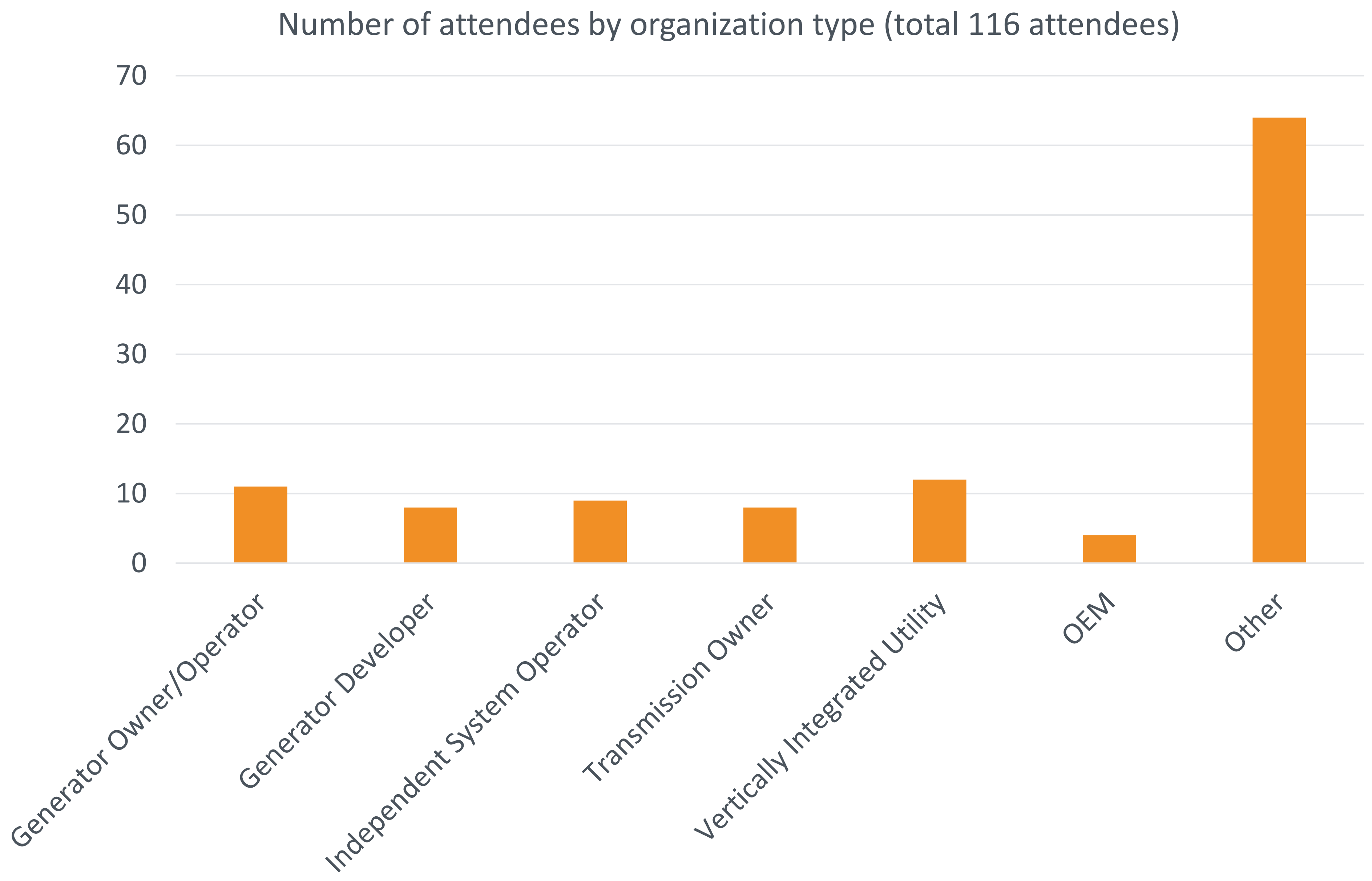
ELEVATE ENERGY CONSULTING

BERKELEY LAB

i2X INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

A DOE initiative supported by the Office of Critical Minerals and Energy Innovation (CMEI)

The first half of this meeting is being recorded and may be posted on ESIG's website. 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 consent to recording and use of your voice or image.



"Other" category includes Consultants, Research Organizations and Regulators

i2X STITCH June 23rd Regional Meeting MISO & ERCOT – Agenda

1. **Meeting Introduction:** Julia Matevosyan, ESIG
2. **MISO Interconnection Study Process:** Alyssa Hickey, MISO
3. **Developer Perspective on MISO Interconnection Study Process:** Vish Sankaran, Engie
4. **ERCOT Interconnection Study Process:** Jenifer Fernandes, ERCOT
5. **Developer Perspective on ERCOT Interconnection Study Process:** Vish Sankaran, Engie
6. **Audience Q&A and Discussion**, led by Julia Matevosyan, ESIG & Sirisha Tanneeru, Elevate Energy Consulting

Key Goals and Outcomes from i2X STITCH

- To advance interconnection study practices across U.S. regions by identifying opportunities for harmonization, standardization, and automation to improve the speed, transparency, and reliability of generation and storage interconnections.
- The Forum will convene the industry stakeholders and synthesize insights from meetings into a technical whitepaper that defines actionable pathways for consistent and efficient interconnection study processes nationwide.
- The presentation portion of these meetings will be recorded and posted, and presentation slides will be shared.
- Regional study processes, challenges and gaps, recommended practices and harmonization opportunities will be summarized in the whitepaper, published by the end of the meeting series, in February 2027

i2X STITCH Leadership Team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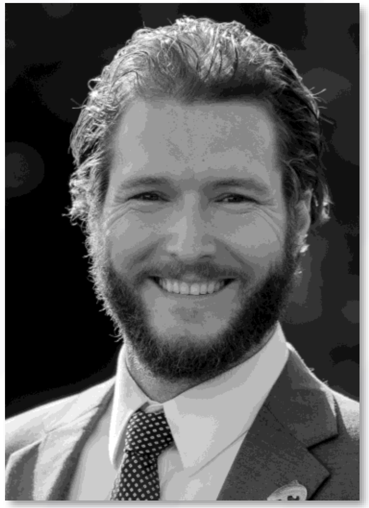

Sirisha Tanneeru, Elevate Energy Consulting

i2X STITCH Meetings – Preliminary Agenda

1. May 26th, 2026, 11 a.m.- 1 p.m. ET: Kick-Off Meeting
2. **June 23rd, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process (MISO, ERCOT)**
3. July 28th, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (CAISO, WECC utility)
4. August 18th, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (NYISO, ISO-NE, non-ISO utility)
5. September 22nd, 2026, 11 a.m.- 1 p.m. ET: Regional Study Process Cont. (SPP, **PJM**)
6. October 20th, 2026, 11 a.m.- 1 p.m. ET: Automation and Data Harmonization
7. November 17th, 2026, 11 a.m.- 1 p.m. ET: Industry Advisor Perspectives and Other Topics
8. January 26th, 2026, 11 a.m.- 1 p.m. ET: Final Paper Presentation
9. March 22nd, 2026, hybrid 1-day event during ESIG Spring Workshop, San Diego, California: Interconnection Studies and Harmonization Workshop

Follow ESIG i2X STITCH website: https://www.esig.energy/i2x-initiatives/#i2x-STITCH for meeting materials & recordings and for future meeting details, agendas, and to register!

Core Reliability Study Assumptions

In our regional meetings, we ask the speakers to cover:

- Base case development assumptions
- Model year and seasonal selection
- Generation dispatch methodology
- Source-sink assumptions
- Contingency selection
- Stability fault definitions
- Short-circuit evaluation methods
- Network upgrade mitigation practices
- Cost allocation methodologies

DOE i2x What Else?

- **I2x FIRST (Forum for the Implementation of Reliability Standards for Transmission) –** Continue with Season 3 to facilitate understanding and adoption of new and recently updated standards relevant for existing and newly interconnecting inverter-based resources.

- **i2x Technical Assistance Hours -** provide technical assistance to interconnection stakeholders focused on adoption of a harmonized and/or comprehensive interconnection requirements or standards. One-one sessions with ESIG and Elevate Energy Consulting for key interconnection stakeholders.

https://www.esig.energy/i2x-initiatives/

i2X Interconnection Cost Reduction Solutions for Transmission

Are you a Transmission Provider that could use help with Advanced Interconnection Modeling for GETS, Data Centers, or EMT Simulations: This DOE i2X funded $4 Million Program administered through Energywerx will fund experts in bulk electric power system modeling and innovative transmission techniques (Voucher Providers) to provide services to transmission providers (Voucher Recipients) including modeling support and training.

iCRS-T Details

Then here's your To-Do List:

- Scan QR Code and Check out the Opportunity
- Find the Capabilities that you need
- Complete a short application
- Ask Questions and Get Answers

Opportunity Closes July 23rd

Act Now!

energywerx

INTERCONNECTION INNOVATION e-XCHANGE
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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*
6. *Please go to slido to ask questions: slido.com and enter event code **STITCH2***

Mutual Respect . Collaboration . Openness

MISO

MISO Interconnection Study Process

i2x STITCH Meeting 2: Regional Study Processes

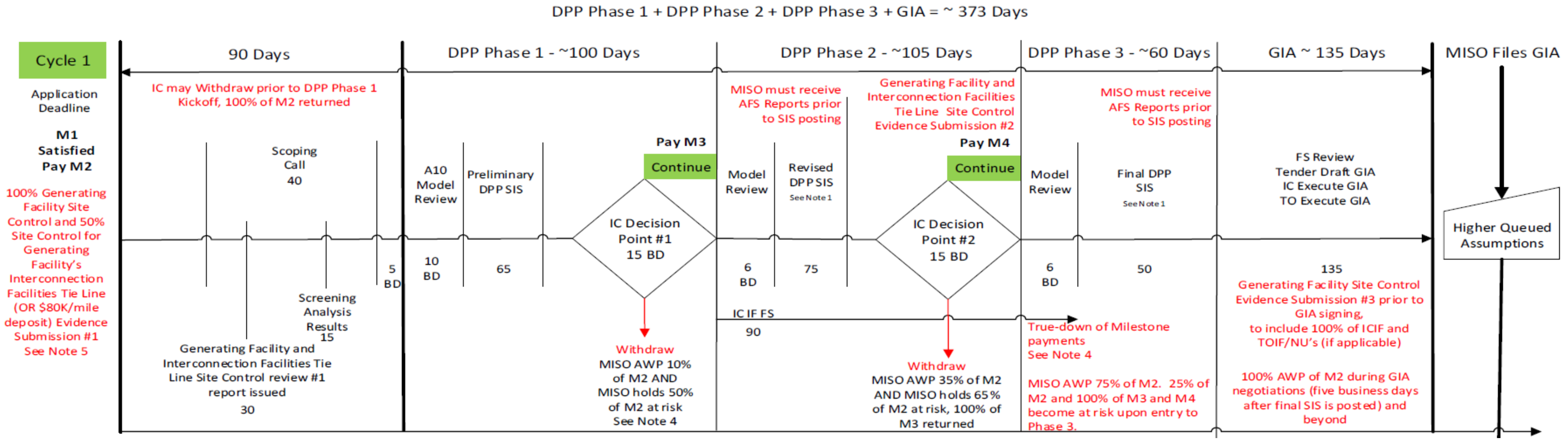
Executive Summary

- MISO's Definitive Planning Phase (DPP) Process consists of three phases with increasing milestone payments
- The scope of the System Impact Study (SIS) performed increases with each phase
- The SIS provides planning level estimates for network upgrades identified as required for full interconnection service
- Facility studies identify the cost and timing to build the network upgrades identified in the SIS
- The Generator Interconnection Agreement is the goal

Interconnection Studies in MISO's Attachment X

- **Definitive Planning Phase (DPP)**
- Expedited Resource Addition Study (ERAS)
- Retirement, Replacement, and Surplus
- Affected System and Joint Targeted Interconnection Queue
- Provisional Generator Interconnection
- Facilities Modification

MISO's Definitive Planning Phase Process



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Model Development

Base Case Assumptions

- Updated base MTEP model used as starting point for SIS
- Does not have higher queued or current study interconnection requests or upgrades added
- Based on latest five-year-out MTEP LBA dispatched case (summer peak and summer shoulder)
- Approved MTEP Appendix A and Long Range Transmission Planning (LRTP) projects included

Bench Case Development

- Updates to the base models to create the bench include:
  - Removal of inactive Interconnection Requests (i.e. post-GIA withdrawals) and their associated network upgrades
  - Interconnection Requests with GIAs executed prior to kickoff but not already included in the base model
  - Retirement, replacement, and surplus projects approved prior to kickoff
  - Facility modification requests approved prior to kickoff
  - Active higher queued interconnection requests without an executed GIA

Bench Case Development

- Updates to the base models to create the bench include:
  - Final (i.e. Phase 3 or later) higher queued network upgrades
  - Non-study Interconnection Requests are added to the bench model and dispatched in accordance with BPM-015 Table 6-1. Existing generation (i.e. generation online and dispatched in the base model) in MISO Classic and MISO South is scaled down to accommodate the increase in generation in those areas, respectively.
  - Study Interconnection Requests are added to the bench model but modeled as out of service and not dispatched.

Study Case Development

- Existing and higher queued generation (i.e. non-study generation) in MISO Classic and MISO South is scaled down to accommodate the increase in generation in those areas, respectively.

Generation Dispatch Methodology

- See 6.1.1.1.2 Table 6-1 for details regarding fuel type dispatch percentages per seasonal model and relevant footnotes
- While not explicitly stated, MISO historically excludes nuclear generation from the sink subsystem
- There is a separate Network Resource Interconnection Service System Impact Study, and those assumptions are outlined in BPM-015 Appendix C

Source-Sink Assumptions

- When generation in MISO Classic (i.e. non-South areas) is ramped up, generation in MISO Classic is scaled down. Similarly, when generation in MISO South (i.e. non-Classic areas) is dispatched, generation in MISO South is scaled down.
- Generation ramped up in the NR analysis is offset by generation MISO-wide (i.e. MISO Classic and South)

Scope of the Definitive Planning Phase

Contingency and Fault Selection

- For steady state analysis, MISO starts with the contingencies provided with the MTEP year/season. Those contingencies are updated to consider changes in topology.
- For stability analysis, MISO starts with the faults provided for the MTEP year/season. Those faults are updated to consider changes in topology.
- Members of the ad-hoc group may propose contingencies or faults for consideration.

Studies Included in the Definitive Planning Phase Process

- System Impact Study (SIS)
  - Performed on a cluster basis
  - The scope of the study varies based on the phase
  - Identifies constraints and mitigations (often network upgrades)
  - Provides cost estimates for each network upgrade and cost allocation per Interconnection Request
- Facility Studies
  - Performed by the Transmission Owner
  - Two Types: Interconnection Facility Studies and Network Upgrade Facility Studies
  - These studies identify the cost and timing to construct the network upgrades

Analyses Included in the Definitive Planning Phase Process

- Steady state thermal and voltage
- Reactive Factor (PF) Requirement and Low Voltage Ridge Through (LVRT)
- Deliverability
- Short circuit
- Stability and Electromagnetic Transient (EMT) studies
- Local Planning Criteria (LPC)
- Contingent Facilities (A10)

Short-Circuit Evaluation Methods

- Performed by the Transmission Owner
- Per BPM-015 Section 6.1.2, Short circuit analysis will generally include determining the fault current contribution from the new Generating Facility and its Network Upgrades under three-phase fault and single line to ground fault conditions. The study will identify any circuit breaker(s) that would need to be replaced to accommodate fault currents from the proposed Generating Facility.

Network Upgrade Mitigation

- MISO proposes a mitigation based on the results of the analysis, often in conjunction with the Transmission Owner
- MISO provides an opportunity for members of the ad-hoc group (Interconnection Customers, Transmission Owners, and Affected Systems) to provide alternative mitigations in accordance with requested guidelines and practices.
- MISO coordinates with Transmission Owners to determine the final cycle portfolio (steady state, stability, short circuit, etc.).
- Transmission Owners provide cost estimates in accordance with Phase expectations.
- Facility studies are started during Phase 2 and restudied as needed.

Cost Allocation Methodologies

ERIS and NRIS Steady State Thermal

- See BPM-015 Section 6.1.1.1.8 for the criteria used to determine constraints
- BPM-015 Section 6.1.1.1.10 outlines network upgrade cost allocation
- If the model is unable to solve under the contingency (non-convergence), MISO uses the DC loading to determine cost allocation for the network upgrade that resolves the constraint.
- If the model solves under system intact or contingency conditions, MISO uses the AC loading to determine cost allocation for the network upgrade that resolves the constraint.

ERIS and NRIS Steady State Thermal

- Current Study Interconnection Requests that meet mitigation criteria participate in cost allocation, regardless of iteration. That is, if a network upgrade is identified as resolving a constraint tagged to a certain monitored element, any Interconnection Request which meets mitigation criteria on that monitored element will participate in cost sharing for that network upgrade.

- MISO reviews the worst MW Impact (MWI) for the Interconnection Requests participating in cost sharing for the network upgrade that resolves the constrained monitored element. MISO sums the worst MWI per Interconnection Request to find the total MWI for that network upgrade.

- The cost allocation percentage for an Interconnection Request for a particular network upgrade is their worst MWI divided by the total MWI for that network upgrade. The cost allocation is the percentage multiplied by the network upgrade cost estimate.

ERIS Voltage

- See BPM-015 6.1.1.2. and 6.1.1.1.10.2 for details regarding voltage constraint allocation and network upgrade cost allocation
- MISO identifies voltage constraints in accordance with Monitored bus voltages must get 0.01 worse in reference to their defined limits as established by the Transmission Owner's Local Planning Criteria. These "harmers" share in cost allocation for the network upgrade that resolves the constraint.
- The Cost allocation of voltage constraint driven Network Upgrades will be determined by the pro rata share of the voltage impact each project has on the most constrained bus under the most constraining contingency.
- The voltage impact of each project will be calculated by locking all voltage regulating equipment in the model and then backing out each project one at a time to identify each project's impact to the constraint.
- In severe instances of voltage collapse where projects cannot be backed out one at a time, they will be added one at a time to determine their impact to the constraint.

Stability

- Per BPM-015 6.1.1.1.10.3, Network Upgrades will be cost allocated based on the pro rata share of the total MW request of all the projects causing instability. The project(s) causing instability will be determined by backing out each project one at a time to identify each project's impact to the constraint.

Other Types of Cost Allocation

- Complex Cost Allocation - Serves as method of cost allocation across analysis types (thermal, voltage, and stability) where cost is allocated based on the ratio share of the total cost of the independent mitigation types. See 6.1.1.1.10.4 for details.
- Backbone Network Upgrade Cost Allocation – Cost is allocated based on the pro rata share of the MW contribution of DPP projects on the constraints being alleviated by the GI Backbone Upgrades. See 6.1.1.1.10.5 for details.
- Shared Network Upgrade Cost Allocation Eligibility – for when it is not practical to bring the IR under study into a Multi-Party Facility Construction Agreement (MPFCA) for the upgrade. See 6.1.1.1.11.

MISO is the electric grid operator for the central United States. We ensure power flows reliably and efficiently across 15 states and the Canadian province of Manitoba. Additionally, MISO facilitates the buying and selling of electricity in its region and partners with its stakeholders to plan the grid of the future.

45 million people depend upon the work we do and the service we provide 24/7/365.

Learn more and follow MISO at:

misoenergy.org

LinkedIn: Midcontinent ISO

Generation Interconnection Studies in MISO

A Developer and Generator Owner's Perspective on process milestones, study methods, assumptions, tools, and opportunities for harmonization.

Presented for ESIG i2X STITCH

JUNE 23, 2026 | MISO | i2X STITCH

We are a global energy company with local presence

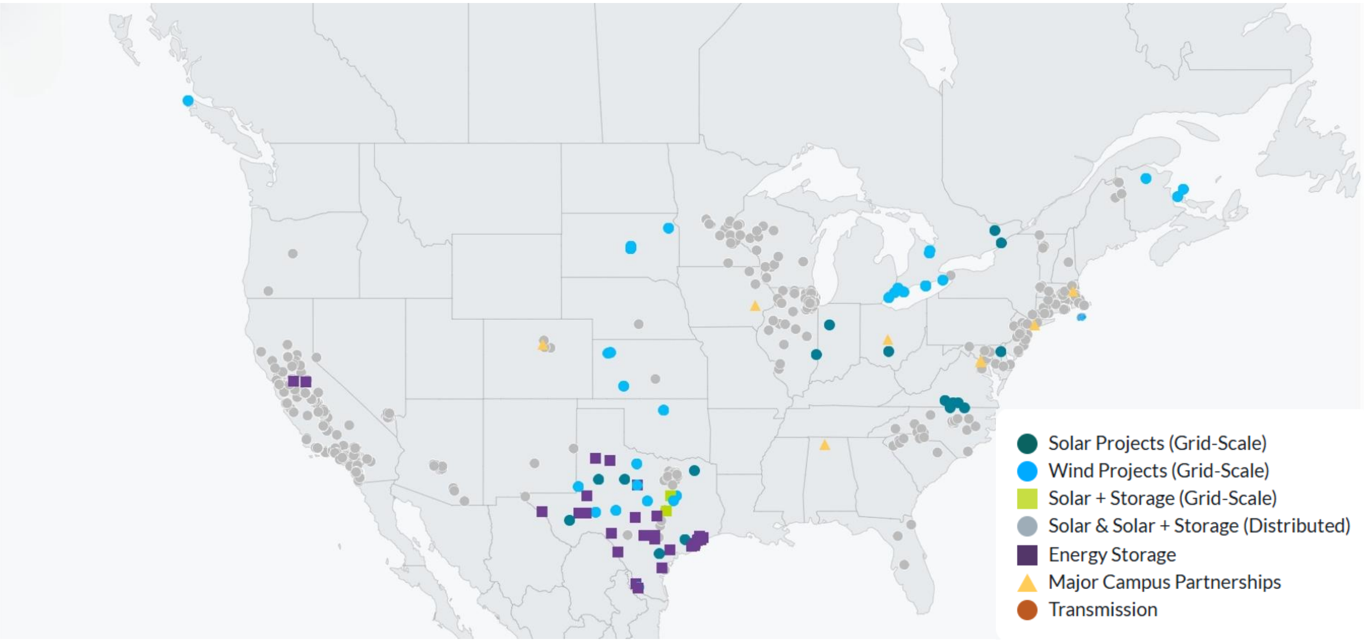
Globally		North America
170+ yrs	Heritage	50+ yrs
90,000+	Employees	2,000+
$60.9B ~ €71.9	2025 Revenue	$5.1B
57+ GW	Renewable Capacity	11+ GW (wind, solar, and storage combined)
4.8 GW	2025 Corporate PPAs	1.5 GW

Data as of Q1 2026

Overview of our North America projects and scale

With a robust pipeline of growth projects ahead

100+	communities with active operations, projects or development
11+ GW	wind, solar, and storage assets in operation or under construction
$28B	ENGIE's total investment plan in renewable projects in the US by 2030
35k+	commercial and industrial retail energy supply customers
~3M	U.S. homes can be powered annually by the clean electricity generated from our renewable portfolio.



Data as of Q1 2026

MISO's DPP | End-to-End

Process Milestones

1. **Application**
   M1/M2 milestones, D1/D2 deposits, site control
2. **DPP-1**
   Preliminary System Impact Study + Decision Point 1 (~140 days)
3. **DPP-2**
   Revised SIS + Interconnection Facilities Study + Decision Point 2 (~80 days)
4. **DPP-3**
   Final SIS + Network Upgrade Facilities Study
5. **GIA**
   Negotiate Generator Interconnection Agreement; MISO files with FERC

Takeaway

DP1 and DP2 are significant commitment gates. Each requires committing more capital and accepting cost exposure before the next, more refined study results are known.

POI selection, pre-screen analysis, and more importantly, model quality is paramount to capture exposure.

A 200 MW queue position would require nearly $2M to be committed prior to Cycle 1. If that project withdraws during GIA negotiations, it will forfeit over 85% of that commitment. This does NOT include any potential network upgrade cost exposure milestone payments that are posted in the form of LCs.

Context Developers Are Operating in

MISO by the Numbers

~200 GW	~373 Days	~73%
Across all active DPP cycles	From DPP Phase I to GIA	Historical Queue Attrition

The developer's reality

MISO's queue is large, oversubscribed, and delayed. Network upgrade cost exposure is hard to manage when there are multiple queue cycles active and each higher-queued cycle could have a significant impact on the later cycles.

Recent reforms (queue cap, higher milestone deposits, higher withdrawal penalties, site-control requirements) could help reduce speculative projects. However, network upgrade costs are still the single biggest variable that is hard to forecast with high levels of certainty.

DPP Queue Cycle Status

The Dreaded Restudy Loop

Five DPP cycles active simultaneously

DPP-2020	DPP-3 · 2 projects still in re-study
DPP-2021	DPP-2 / DPP-3 · GIA in progress
DPP-2022	DPP-1 / DPP-2 · ~52 GW
DPP-2023	DPP-1 / DPP-2 · ~37 GW
DPP-2025	DPP-1 · ~78 GW submitted

Why Re-Studies Hurt Developers

- A withdrawal in a higher-queued cycle impacts the more recent cycles as cost and upgrade scope can change. This is a major concern; especially after a developer has committed at several levels (interconnection, off-take/PPA, milestones).
- Cost creep is unpredictable and yet, unavoidable. A DPP-2020 project in re-study saw an increase from an Affected System Study that was never in any of the previous DPP reports.
- Each re-study adds months and can trigger new GIAs and new security postings.
- Addressing this MUST be a collaborative effort. While there cannot be perfect foresight, the unpredictability of late-stage impacts needs to be thought through.

Impact of Recent Queue Reforms

Some Starting To Work

Queue Cap

FERC-approved, began with DPP-2025, caps each region at 50% of non-coincident peak load

~78 GW

~170 GW in DPP-2022 and ~123 GW in DPP-2023. With queue cap, DPP-2025 queue was at ~78 GW

Site Control

50% route control required, 50% switchyard footprint control required, 100% site control before GIA execution (facility, gen-tie, switchyard)

Some clarity is established but "success" is too early to tell

It's a given that the queue cap has limited the number of entries into the DPP-2025 and beyond cycles. But the withdrawal rate isn't proven yet and shortening of study timelines would not be noticeable until the backlog is cleared.

While reforms help DPP-2025 and beyond, higher-queued cycles are still faced with significant delays (DPP-2020 projects now are realistically expecting a 2030 and beyond COD).

Impacts Beyond Interconnection Queue

Understanding The Full Lifecycle From Queue Position to a Financeable Asset

Study to an Investment

- Interconnection study outputs (network upgrade cost + scope + service level) feed straight into the project financial model.
- That model sets PPA price and structure and the upgrade cost is baked into the $/MWh the off taker is asked to accept.
- A COD milestone target is locked to the study timeline and drives the entire delivery schedule the PPA is written against.
- Financing, equipment procurement and final investment decision all hang off these same study-derived numbers.

Downstream Impacts of Studies

- A network-upgrade cost increase between phases can push $/MWh above the off-taker's ceiling and makes the PPA unattainable.
- A re-study that slips COD forces PPA restructuring. Delivery dates, penalties and guaranteed-output terms all reopen. Projects counting on capacity revenue could take a significant hit.
- Interconnection risk stacks on top of policy/permitting risk (ex: wind FAA approval, tax incentives, etc.) that the developer is carrying in parallel.

Option Developers Use To De-Risk Queue

Interconnection Tools and Pathways

Software / Shadow Studies

With higher withdrawal penalties and financial commitments, screening prior to queue submittal has become critical. Software such as Orennia, Nira, EnergyInsite help analyze potential impacts. Conducting detailed shadow studies with queue attrition is also invaluable.

Surplus / Generator Replacement

Surplus has become an extremely viable solution to bypass the delays in the interconnection queue process. It also provides certainty from a network upgrade cost perspective. Some developers can strategically leverage the replacement process to acquire/transfer capacity rights (a real commodity lately).

Expedited Resource Addition Study

While the excitement around this option was high, it seems to have dwindled down. ERAS is also facing delays, and the stringent requirements make it harder for most fuel types to be successful.

Impact of TO Self-Funding Election

Financial Impact Over 20-Year Period

Return on Equity

Developers pay the TO’s FERC-approved ROE stacked on top of the upgrade cost.

Security on Undepreciated Balance

Developers must post security against the undepreciated balance that can type of capital for years.

NPV Cost Rises Sharply

Developers have testified at FERC that self-funding can roughly double the initial cost that is more than enough to kill the financials of a project.

FERC Scrutiny

A 2024 FERC show-cause order is examining whether many of the ISOs under their jurisdiction have self-funding rules that are just.

Key Takeaways

What Does A Collaborative and Holistic Approach Could Look Like

- Queue reform helped in reducing the size and could potentially shrink the study timeline. However, the focus must now be on model quality and analysis.
- While AI-driven tools allow for an accelerated delivery of results, the accuracy is a work in progress and must be improved to identify realistic mitigation solutions.
- Cost transparency is key. Clear communication of impacts from one footprint to another and impacts from affected system studies would help in managing late-stage cost creep.
- Hopeful vision – while several avenues exist today and are being worked on to optimize the results and the process, we are still treating the symptoms and not the root cause. A study process that has been in place for years is no longer applicable for the industry we have become.

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ERCOT Interconnection Studies

Jenifer Fernandes
Resource Integration, ERCOT

June 23, 2026

Outline:

- ERCOT Interconnection Overview
- Base case: SSWG, SPWG and DWG
- Full Interconnection Study
- Cost allocation for Generation Interconnection

Key Takeaways

- ERCOT studies interconnections to ensure reliability under a connect-and-manage model — local upgrades only, with congestion managed in real-time operations.

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ERCOT’s Interconnection Overview

ERCOT studies new resources to confirm the grid stays reliable when they connect.

Not a queue

Each project advances through the interconnection process on its own

Connect & manage

Generations is connected and managed by congestion management during real time operations.

Driveway, not highway

“Driveway” is built during Interconnection Process. “Highway” determined through Planning Process

Deliverability not guaranteed

Studies ensure reliability; developers accept curtailment risk.

Typical timeline: 18–30 months for large generation (≥10 MW) · 8–12 months for small generation (<10 MW), excluding supply/construction delays.

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Screening and Full Interconnection Studies

Screening Study is conducted by ERCOT and results submitted to the developers for projects that request GIM only application. Once the Full Interconnection study application is submitted, then it kicks off the study process with the interconnecting lead Transmission Service Provider (TSP).

FULL INTERCONNECTION STUDY (FIS)

Security Screening Study → Steady-state | Short-circuit | Stability | Facility

Then proceeds to →

- Quarterly Stability Assessment (QSA)
- Registration & modeling (RIOO)
- Energization, synchronization, commissioning

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Base case for Screening and Full Interconnection Study

THREE COORDINATED BASE CASES

Steady State Working Group (SSWG)

Steady-state working group power-flow case

System Protection Working Group (SPWG)

System protection working group short-circuit case

Dynamics Working Group (DWG)

Dynamics working group stability case

Base case development: The Steady-State Working Group (SSWG) process

The SSWG is a non-voting working group whose members include representatives from ERCOT Transmission Service Providers (TSPs) and ERCOT staff. The main objective of SSWG is to produce steady state seasonal and future steady-state base cases, and GIC system models. The SSWG meets twice a year to accomplish these tasks, and at other times during the year as needed to resolve any impending power-flow modeling issues or to provide technical support to the Reliability Operating Group (ROS)

WHAT GETS BUILT

- Cases are created annually and updated biannually at fixed intervals through out the year.
- The SSWG Cases are created by SSWG each year and consist of the following:
    - Eight seasonal cases starting with the SPG cases representing on-peak and off-peak conditions for the four seasons of the next year beyond the year the cases are built.
    - Six future year cases representing summer on-peak conditions with the first year beginning two years beyond the year the cases are built.
    - One future year case representing high renewable and minimum load conditions.
    - One future year case representing minimum load conditions.
    - One future year case representing off-peak conditions
    - Two future year cases representing peak Net Load generation and load conditions
- SSWG Case seasons are defined as follows:
    - SPG: March, April, May
    - SUM: June, July, August, September
    - FAL: October, November
    - WIN: December, January, February

HOW IT'S BUILT

Network Model Management System (NMMS)

↓

Topology processer (TP) case

↓

Model on demand (MOD) base case +
Planning Model Change Request (PMCRs) & Profiles

↓

SSWG Cases

Each cycle an incremental update (MOD File Builder) re-syncs the cases to NMMS. Tools: MOD, PSS®E.

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Base case development: SSWG- Dispatch Methodology

- Existing and planned units owned by Non-Opt-In Entities (NOIE) are dispatched according to the NOIE dispatch spreadsheets submitted to ERCOT on a biannual basis; unless a NOIE requests that their units are to be dispatched according to the order that is described below or do not submit a NOIE dispatch.
- Private network generation is also dispatched independently. The units are dispatched to meet their load modeled in the case.
- The import/export contributions of the DC Ties will be set based on historical data to the extent that the contributions are consistent with those indicated in the most recent Capacity, Demand and Reserves (CDR) Report.
- Wind units are dispatched in accordance with Appendix B, Method for Calculating Wind Generation Levels in SSWG Cases, to extent that the dispatch is consistent with the regional contributions indicated in the CDR Report.
- Solar units are dispatched at a level consistent with the CDR Report.
- Transmission Energy Storage Resources are dispatched at a level determined by ERCOT consistent with assumptions used in the Regional Transmission Planning cases where possible . For all other cases, Transmission Energy Storage Resources units shall be online for voltage support with no real power contributions.
- Units that are solely for black start purposes are to be modeled in the SSWG Cases; however, these units should not be dispatched. Black Start units are designated with a unit ID of “BS”.
- All other transmission level units are dispatched using an economic-simulation software package.

SSWG CASE	NOTES	TRANSMISSION IN-SERVICE DATE
(YR+1) SPG1	1	April 1, (YR+1)
(YR+1) SPG2	1	April 1, (YR+1)
(YR+1) SUM1	1	July 1, (YR+1)
(YR+1) SUM2	1	July 1, (YR+1)
(YR+1) FAL1	1	October 1, (YR+1)
(YR+1) FAL2	1	October 1, (YR+1)
(YR+2) WIN1	1	January 1, (YR+2)
(YR+2) WIN2	1	January 1, (YR+2)
(YR+2) SUM1	2	July 1, (YR+2)
(YR+2) PNL1	1, 4	July 1, (YR+2)
(YR+3) SUM1	2	July 1, (YR+3)
(YR+4) MIN	3	January 1, (YR+4)
(YR+4) HRML	5	January 1, (YR+4)
(YR+4) SUM1	2	July 1, (YR+4)
(YR+4) PNL1	1, 4	July 1, (YR+4)
(YR+4) FAL1	1	October 1, (YR+4)
(YR+5) SUM1	2	July 1, (YR+5)
(YR+6) SUM1	2	July 1, (YR+6)
(YR+7) SUM1	2	July 1, (YR+7)

Base case development: SSWG- Contingency Database

ERCOT compiles the contingency definitions submitted by the TSPs into a single database, exchanged only in an approved Excel format. ERCOT does not author the data — it validates submissions and posts the finalized lists.

WHAT IT IS & KEY RULES

- **Single source —** a compilation of TSP-submitted contingency definitions, exchanged only via the standard Excel column format.
- **ERCOT's role —** does not create or edit TSP data; runs topology and data-entry checks that flag errors for the TSP to correct.
- **Ownership —** a TSP may submit changes only for its own company; rows with a null Submitter or TOContingencyID are ignored; defaults apply for missing or invalid values.
- **Cadence —** reviewed with each SSWG case build; off-cycle updates accepted on request.

UPDATE PROCESS (EACH PASS)

1. ERCOT sends the current list with invalid entries highlighted.
2. TSPs return a complete, corrected list (agreed timeline & format).
3. ERCOT imports — overwriting the TSP's prior set — verifies, and issues a change log.
4. Repeat each pass; on finalization, ERCOT posts the list on the MIS.
5. Contingency files generated for MUST, PSS®E, PowerWorld, UPLAN & VSAT — invalid definitions excluded.

Validated against the SSWG Cases: ERCOT confirms each device in a definition exists in the latest SSWG Cases, using the definition's start/stop dates to pick which case years to check; mismatches are reported back per submission.

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Base case development: SSWG- Contingency Database

What TSPs submit — NERC events plus ERCOT-specific categories — and the checks ERCOT runs before a definition enters the contingency files.

WHAT GETS SUBMITTED

Category	Definition
NERC P1–P7	Planning & extreme events (TPL-001 Table 1); at minimum the most severe
ERCOT_1	Common-tower outage (PG §4.1.1.1)
ERCOT_98	Common-tower — both circuits out for maintenance
ERCOT_NonBES	60–100 kV element(s), most severe (not ERCOT_1)
ERCOT_LL	Large Load outage (PG §6.10)
ERCOT_CCT	Loss of an entire combined-cycle plant (ERCOT-submitted)

Definitions account for existing and planned protection systems, including backup/redundant schemes.

ERCOT'S VALIDATION

Data-entry checks

Duplicate device; inconsistent contingency name

Invalid date selection; invalid bus selection

Invalid element identifier

NERC or ERCOT category missing

Topology checks (vs. SSWG case)

Bus, branch, switching device, transformer, generator, or shunt not found in the base case

Definitions failing any check are flagged invalid and excluded from the posted files.

Planning Guide Section 6.9 — Interconnection milestone

Meeting PG 6.9 is a key milestone in the generation interconnection (GIM) process — required to qualify for entry into the Quarterly Stability Assessment (QSA) and for submittal into the Network Operations Model.

6.9(1)

- All data required to perform the SSS and/or FIS (FIS column of the Resource Registration Glossary).
- TCEQ-approved air permits and a Declaration of Adequate Water Supplies.
- SGIA, a financially binding agreement, or MOU/EC.

6.9(2)

- All data provided in the planning column of the Resource Registration Glossary.
- Establishes the resource in the planning models for steady-state, stability, and short-circuit study work.

Short-circuit base case: The System Protection Working Group (SPWG)

The FIS short-circuit study draws on the SPWG short-circuit (fault-duty) base cases — built in ASPEN OneLiner, on a 100 MVA base, and refreshed annually.

WHAT GETS BUILT

- **Case set —** a Current Year (CY) case plus five Future Years (CY+1 through CY+5); CY cases finish by March, future-year cases by June.
- **In-service rule —** everything expected in service by June 30 of the case year, with generators that meet Planning Guide Section 6 modeled in the right case.
- **Tied to SSWG —** pre-fault generator reference voltages and angles come from the SSWG summer peak case of the same year.

HOW IT'S BUILT

RARF generator data + TSP submissions

↓

Change files (.CHF) / PSS®E converted to ASPEN

↓

ASPEN OneLiner — incremental, pass-based build

↓

SPWG short-circuit cases

Mutual impedance and multi-owner tie lines are coordinated each cycle.
Tools: ASPEN OneLiner (PSS®E accepted, then converted).

IBR modeling & fault analysis: wind and solar are represented as current-limited generators (Type-3 and Type-4) — ungrounded, so no zero-sequence contribution, rising to ~2.5× full-load current and settling to ~1.1–1.2×. ASPEN's Bus Fault Summary computes three- and single-phase fault currents across 12,000+ buses, compared pass-over-pass and year-over-year.

Stability base case: The Dynamic Working Group (DWG) Process

The FIS stability study draws on the DWG dynamic "flat-start" cases — detailed dynamic models layered onto SSWG cases, built each year once the SSWG cases post.

WHAT GETS BUILT

- **Three flat-start cases —** built concurrently for next-year NERC TPL-001 planning: Near-Term On-Peak (Y+3 SUM1), Near-Term Off-Peak (Y+4 HRML), and Long-Term On-Peak (Y+7 SUM1).
- **Flat-start criteria —** each case initializes error-free and holds frequency, voltage and power steady over a 20-second run with no disturbance.
- **Schedule —** DWG sets the schedule in June and builds after the SSWG cases post; ERCOT is the flat-start coordinator.

HOW IT'S BUILT

SSWG base case (posted ~May)

↓

Add detailed dynamic models (.dyr, user models)

↓

Flat-start check — 20-second, no-disturbance run

↓

DWG dynamic base cases

Members update and screen data (load model, Zsource, MBASE); changes feed back to SSWG. Results and the Stability Book post to ERCOT MIS.

Contingency assumptions & study criteria: a dynamic contingency database sets breaker clearing times (normal, stuck-breaker, relay-failure) and impedance-swing assumptions. Performance is judged on angular and voltage stability, damping, cascading and uncontrolled islanding (ERCOT Planning Guide §4); generator ride-through per Nodal Operating Guide §2.9 and frequency relaying per §2.6.

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Security Screening Study (SSS)

The SSS is a high-level, steady-state study which includes power-flow and transfer studies, based on the proposed Commercial Operation Date (COD) and a single Point of Interconnection (POI). The results of the study provides an indication of the likely operational limits on the real power output of the resource accounting for other known generation in the area, before significant transmission additions or enhancements may be required. The study reports also indicates whether the project is susceptible to Sub-Synchronous Resonance.

HOW THE SCREEN IS SET UP

- **Cases by COD** — SSWG summer + High Renewable Min Load (HRML) cases for the project's interconnection year (e.g., COD 7/1/2027 → SUM 2028 + 2028 HRML).
- **Stress the area** — add the new generator at the proposed POI and dispatch nearby generation to high levels.
- **Base case security** — N-1 AC contingency analysis.
- **Post-interconnection N-1** — run for both Summer and HRML conditions.

SCREENING OUTPUTS

120%

of the new generator's capacity is tested

Transfer limits

Limiting element

Limiting contingency

Shift factors

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Full Interconnection Study — Steady State

Uses the SSWG case selected by COD, with applicable planned generators added in the area (PG 6.9 and other); nearby units dispatched at high output.

WHAT THE TSP ANALYZES

- **Study area –** determined by the TSP
- **Study cases**: Summer Peak Case and HRML Case modified to reflect known changes.
- **PG 6.9(1):** Generators meeting PG 6.9 are added.
- **Contingencies & outages —** ERCOT1, ERCOT2, ERCOT3, ERCOT4 and NERC P0–P7 contingencies
- **Thermal & voltage —** monitors for overloads and voltage violations across the study area.

WHAT THE TSP IDENTIFIES

Outcomes of the study

- Additional facilities or upgrades needed to connect.

- System limitations preventing full output of the generator.

- New voltages or thermal loadings directly attributable to the proposed plant.

Full Interconnection Study — Short-Circuit

Uses the ERCOT System Protection Working Group (SPWG) case selected by COD.

WHAT IT FINDS

- **SPWG base case —** selected by project COD for fault-duty analysis.
- **Fault current —** TSP will determine the maximum available fault currents at the interconnection substation for determining switching device interrupting capabilities and protective relay settings
- **Equipment adequacy —** confirms switching-device interrupting capability and relay settings remain valid.

DRIVES

Max available fault current
at the interconnection substation

Switching-device duty
Interrupting capability checked

Relay settings
Protective relay coordination

Full Interconnection Study — Stability

Uses the latest ERCOT Dynamics Working Group (DWG) Summer Peak and High Renewable Min Load (HRML) base cases

TRANSIENT STABILITY STUDY

- **TSP performs —** transient stability studies to meet NERC Standards, Protocols, Planning and Operating Guides applicable to the generator or to the ERCOT system
- **IE provides to start —** RIOO substation details, dynamic files, and the MQT Report
- **PG 6.9(1) —** Addition of Proposed Generation to the Planning Models, in the area of the study shall be dispatched at full net output in at least one of the scenarios/cases evaluated by the lead TSP. The dispatch level may be reduced to respect any published stability limits or to reach a power flow solution.
- **Contingencies —** identifies instability for specific P1–P7 and extreme P7+P7 contingencies.
- **Study results —** If the TSP identifies instability (other than instability identified for extreme events) in the stability portion of the FIS:
    - The IE and TSP shall investigate alternative solutions to resolve the instability through changes to the proposed generator and report their findings to ERCOT
    - If ERCOT determines that changes to the proposed generator are not feasible, the TSP shall investigate a transmission improvement to resolve the instability and report its findings to ERCOT.
    - If ERCOT determines that a proposed transmission improvement is feasible to resolve the identified instability, the TSP shall proceed with implementing the transmission improvement

PERFORMANCE EVALUATED

Angular stability
Units stay in synchronism

Voltage stability
Voltages recover within criteria

Frequency
No excessive frequency excursions

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Full Interconnection Study — Facility

The facility study provides complete details of the transmission and substation facilities needed to connect a generator to a new or existing substation on the ERCOT grid.

DELIVERABLES

Conceptual design
Design descriptions of the required facilities

Construction milestones
Schedule to build the interconnection

Cost estimates
Estimated cost of the transmission/substation work

COST THRESHOLD

> $25M

in transmission facility cost triggers an ERCOT Economic Study

Economic Study
Determines the annual production-cost savings and annual generator revenue reduction resulting from the project addition.

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Cost allocation for generation interconnection

Historical model

- Interconnection costs socialized to load.
- Generator funds only its own interconnection facilities (the "driveway").

→

Reform: HB 1500 / PUC Project NO.55566

- Costs above the allowance are assigned directly to the interconnecting resource.

Questions?

Resource Integration: https://www.ercot.com/services/rq/integration

Generation Interconnection Studies in ERCOT

A Developer and Generator Owner's Perspective on process milestones, study methods, assumptions, tools, and opportunities for harmonization.

Presented for ESIG i2X STITCH

JUNE 23, 2026 | ERCOT | i2X STITCH

We are a global energy company with local presence

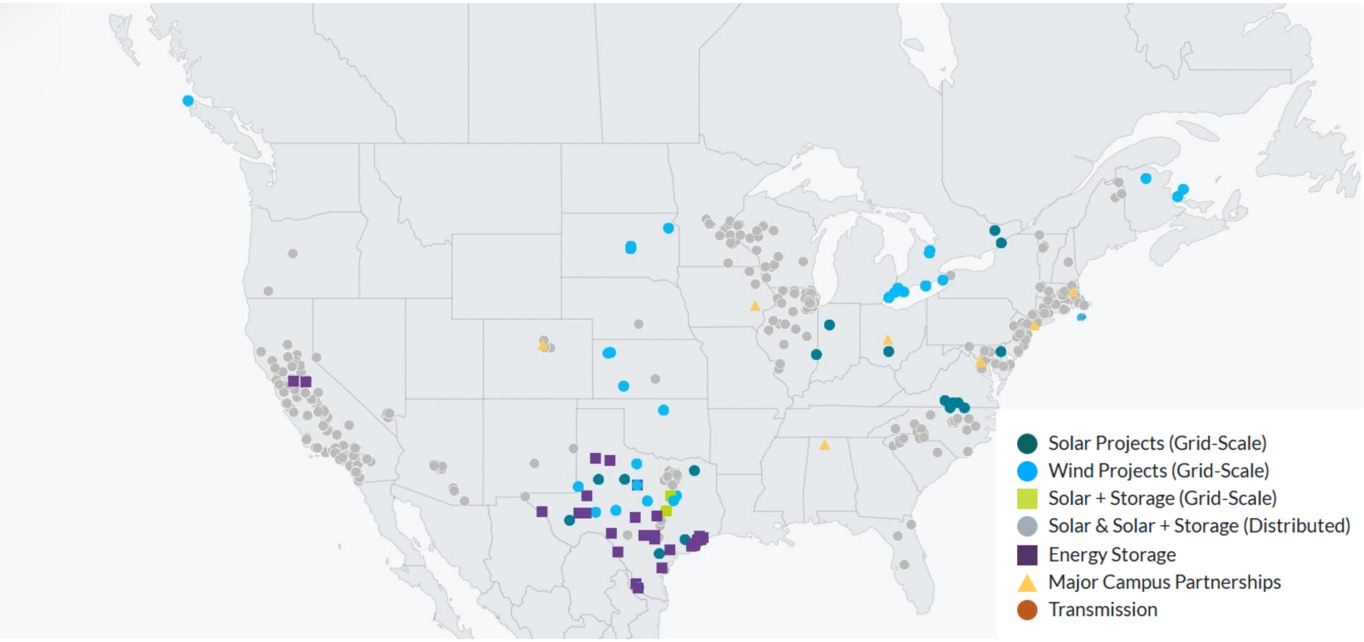
Globally		North America
170+ yrs	Heritage	50+ yrs
90,000+	Employees	2,000+
$60.9B ~ €71.9	2025 Revenue	$5.1B
57+ GW	Renewable Capacity	11+ GW (wind, solar, and storage combined)
4.8 GW	2025 Corporate PPAs	1.5 GW

Data as of Q1 2026

Overview of our North America projects and scale

With a robust pipeline of growth projects ahead

- **100+** communities with active operations, projects or development
- **11+ GW** wind, solar, and storage assets in operation or under construction
- **$28B** ENGIE's total investment plan in renewable projects in the US by 2030
- **35k+** commercial and industrial retail energy supply customers
- **~3M** U.S. homes can be powered annually by the clean electricity generated from our renewable portfolio.



Data as of Q1 2026

Context Developers Are Operating in

Why ERCOT Is Different

~1-2 years **Queue study process**	**+400 GW** **Proposed large load**	**+$20B** **Proposed Transmission Improvements**

The developer's reality

ERCOT's "Connect-and-Manage" has been discussed at great length. And they are trading guaranteed deliverability for speed.

Since generation does not require regional transmission network upgrades, they clear the studies quickly. However, basis exposure can be significant, and the developer bears it on the commercial side of things.

Exponential demand growth is reshaping the planning and the grid in its entirety.

ERCOT's Interconnection Process

Process Milestones

1. **GINR** — Submit queue position (RIOO). Accepted within ~10 BD.
2. **Screen** — Security screening of system impact (~3 months).
3. **FIS** — Full interconnection study by TSP. Initiated right after screening.
4. **SGIA** — Negotiate & execute standard GIA with the TSP.
5. **COD** — QSA, model data to ERCOT, commissioning, testing, operations.

Takeaway

The screening study and FIS can run concurrently. There is no annual cluster window, and requests are processed on a rolling basis. Large load queue process (the Batch Process) has shifted the developer's view on how to tackle ERCOT.

Strategy and market intelligence is paramount to success in ERCOT.

Modernization Reshaping ERCOT Study

Study Tools and Automation

EMT Modeling

RARF model data feeds SSWG / DWG / SPWG planning models. Model quality gate stability sign-off.

Batch Process

A parallel effort reshaping the planning backdrop for generators. Load addition and transmission buildout.

Model Data

System reinforcements are now central to a clean FIS and energization. This includes reactive power support capability.

Developer Impact

Emerging Pressure Points

What Helps Development

- Fast, predictable timelines (~1–2 yr) and no annual cluster window keep projects on a financeable schedule
- No mandated network-upgrade cost allocation removes the single biggest project-killer seen in other ISOs
- Concurrent Screening + FIS and rolling intake compress the critical path
- Screening Study lets developers price curtailment risk before the FIS commitment

Emerging Pressure Points

- Curtailment / congestion risk is borne by the developer and is rising as IBR density grows
- Explosive large-load (data center) growth competes for the same transmission headroom
- Stability / SSR / system-strength constraints increasingly shape viable POIs
- Model and reactive-capability quality now central to a clean FIS and energization

Connect-and-manage trades upgrade cost for developer-borne curtailment

Because ERCOT does not require broad network upgrades, the cost shows up later as curtailment — and most PPAs settle “as-produced,” so curtailed energy simply isn't paid. This is the central economic risk an ERCOT developer underwrites.

8+ TWh

wind & solar curtailed across ERCOT in 2024

~22%

of West Texas renewables curtailed behind the export constraint

~1.2 GW

average curtailment every hour, Panhandle & West worst

60%

lost output at the most-affected individual sites

Data-center Demand Is Reshaping The ERCOT Grid

ERCOT is now processing an enormous large-load queue alongside generation. The two compete for the same transmission headroom — and a new, parallel study/cost-allocation regime (SB6, Batch process) is being built around it.

~233 GW large-load queue

Up nearly 300% in a year; 70%+ data centers vs ~432 GW of generation requests (77% solar & storage).

SB6 (June 2025)

Standardized large-load interconnection (≥75 MW), study fees, cost allocation, disclosure of duplicate requests, emergency curtailment authority.

Batch / staged energization

ERCOT studies how much load existing infrastructure can serve; service may be limited until upgrades complete.

What it means for generators

Competition for headroom, more co-location / BTM offtake interest, and a planning backdrop in flux while rules are written.

The fastest-growing source of study constraints for IBRs

As IBR density rises, weak-grid / low-short-circuit conditions push stability, SSR and system-strength issues to the center of the FIS. These increasingly determine which POIs are viable.

Weak-grid / low SCR

High IBR concentration in low-short-circuit areas raises control-interaction and voltage-stability risk.

SSR screening

Sub-synchronous resonance screening can trigger a dedicated SSR study and drive equipment / control requirements.

EMT modeling quality

Accurate, validated EMT models are increasingly the gate for stability sign-off and model quality is on the critical path.

Reactive & ride-through

Reactive-capability and ride-through performance must be designed in early to clear the FIS and energize cleanly.

Takeaways from ERCOT's Process

Speed and Deliverability

Rolling, concurrent studies and curtailment-managed access are replicable; ERCOT's single-state, no-FERC-jurisdiction structure is not.

Curtailment-risk transparency

Standardized, comparable curtailment / congestion metrics would let developers price node risk consistently across regions.

Model & data standards

Align IBR dynamic / EMT model requirements and reactive-capability templates so one model set serves multiple markets.

Stability & system-strength screening

Common system-strength / SSR screening methods would harmonize the fastest-growing source of study constraints.

Portal & status interoperability

RIOO-class portals with consistent status and milestone data reduce cross-region tracking overhead for portfolios.

Large-load coordination

Shared frameworks for load-vs-generation transmission allocation as data-center demand reshapes every region.

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