Proactive Planning for Generation Interconnection

A Case Study of SPP and MISO

DEVELOPED IN CONJUNCTION WITH ESIG PROACTIVE PLANNING TASK FORCE

PRESENTED BY

The Brattle Group

T. Bruce Tsuchida

Long Lam

Adam Bigelow

Jadon Grove

WITH

EnerNex

David Mueller

Sarina Adhikari

SEPTEMBER 2022

Brattle

Disclaimer

- This report was developed in conjunction with the Energy Systems Integration Group (ESIG) Proactive Planning Task Force with support from the Southwest Power Pool (SPP), Midcontinent Independent System Operator (MISO), and ESIG stakeholders. We would like to thank these supporters for providing insights, experience, and data, which were all invaluable in completing this study. All results and any errors are the responsibility of the authors and do not represent the opinion of The Brattle Group (Brattle), EnerNex, or its clients.
- The analyses that we provide here are necessarily based on assumptions with respect to conditions that may exist or events that may occur in the future. Most of these assumptions are based on publicly-available industry data. Brattle, EnerNex, and their clients are aware that there is no guarantee that the assumptions and methodologies used will prove to be correct or that the forecasts will match actual results of planning or operations. Our analysis, and the assumptions used, are also dependent upon future events that are not within our control or the control of any other person, and do not account for certain regulatory uncertainties. Actual future results may differ, perhaps materially, from those indicated. Brattle and EnerNex do not make, nor intend to make, nor should anyone infer, any representation with respect to the likelihood of any future outcome, and can not, and do not, accept liability for losses suffered, whether direct or consequential, arising out of any reliance on our analysis. While the analysis that Brattle and EnerNex are providing may assist ESIG members and others in rendering informed views of how proactive transmission planning could help integrate additional amounts of renewable resources, it is not meant to be a substitute for the exercise of their own business judgments.
- This Report may be redistributed. If only a portion of Report is redistributed, the redistributed portion(s) must be accompanied by a citation to the full Report.

About the *Study*

This study (*Study*) aims to quantify the benefits of applying proactive-ness to the current Generation Interconnection (GI) process using SPP and MISO as a testbed.

- Proactive-ness in GI can be done in a number of ways. This *Study* looks at three levels of proactive-ness through:
  - Increasing the number of projects to include in the GI cluster study to develop transmission solutions. In general, more projects would lead to lower per-project costs because of economies in scope and scale.
  - Improving coordination of the Affected Systems Study (AFS) process.

Levels	Proactive-ness	Description
Level 1	Low	Status quo, where GI studies are performed on an annual basis.[*1]
Level 2	Medium	GI studies are performed looking at multiple years (3 years) of projects.[*2]
Level 3	High	GI studies are performed looking at multiple years (5 years) of projects, together with an improved AFS process.[*3]

Higher numbers / darker shade of blue indicate higher levels of proactive-ness.

- The *Study* estimates the benefits of proactive-ness by comparing the average GI costs of the three levels.
  - For convenience (and easier understanding), we have labeled **Level 1** as studying a single year, **Level 2** as 3 years, and **Level 3** as 5 years of GI queues, largely because one of the key consideration is the volume of projects considered.
  - We also refer to the 1, 3, and 5 years as the Study Window.

*1: For this *Study* we looked at recent (within the last 5 years) GI studies.
*2: For this *Study* we bundled projects from the existing GI queues that have not yet been studied by the RTOs.
*3: Level 3 utilizes the MISO/SPP Joint Target Interconnection Queue study (JTIQ) that looked at projects estimated for 5 years.

Report Structure

This *Study* looks at how the Generation Interconnection (GI) process can benefit from a higher level of proactive planning.

- This Report has the following five sections (and appendices):
  - Section 1: Executive Summary
  - Section 2: Introduction to the Interconnection Process

    This section provides an overview of the current GI process. It is background information needed to understand the *Study*.
  - Section 3: Growing Challenges with the Interconnection Process

    This section provides an overview of the current industry trend and the problems associated with it that is leading to this *Study* on proactively planning the GI process. Together with Section 2, it describes the reasoning for this *Study*.
  - Section 4: Study Scope and Analysis Approach

    This section discusses how the *Study* compares the GI costs for three levels of proactive-ness (based on the number of GI requests by expanding the Study Window and a coordinated AFS process), using MISO and SPP regions/sub-regions as testbeds. JTIQ that this *Study* utilizes as a representative example for the highest level of proactive-ness compared is introduced in this section, too.
  - Section 5: Study Results

    This section summarizes the qualitative findings of the *Study* and includes additional quantitative analyses related to these findings, and to the latest FERC GI NOPR (RM22-14-000).
- Sections 2 through 5 start with a section summary slide.

Table of Contents

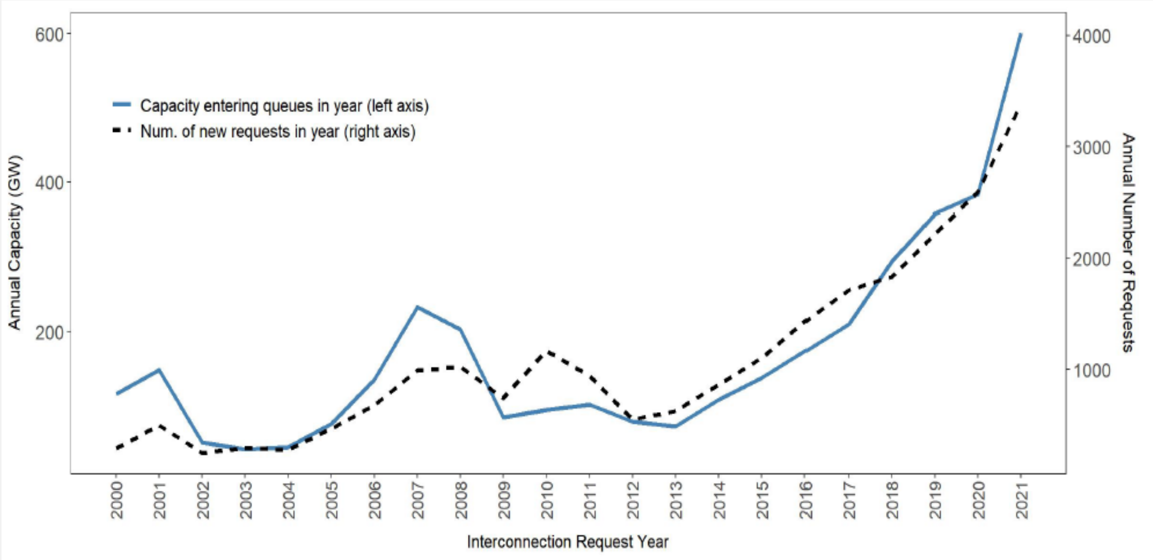
Table of Contents

Industry Trend - More Renewables Wanted

As of end of 2021, there were over 1,000 GW of generation and ~420 GW of storage in the Generation Interconnection (GI) queue.[*1]

- Approximately 8,100 active Interconnection Requests (IR), largely renewables.
  - This is ~3x of the IR counts observed 5 years ago.
  - Nearly 930 GW of the proposed generation is from renewables (676 GW of solar and 247 GW of wind, including 77 GW of offshore wind).
  - Gas generation largely accounts for the balance.
  - Many projects show in-service dates by end of 2024 (within 3 years).
    - 80% of solar (537 GW), 56% of wind (138 GW), 72% of storage (307 GW), and most of gas show in-service dates by end of 2024.

Total Capacity and IR Counts in GI Queue by Year



- For comparison, the combined peak load for the lower 48 states today is only ~760 GW.[*2]

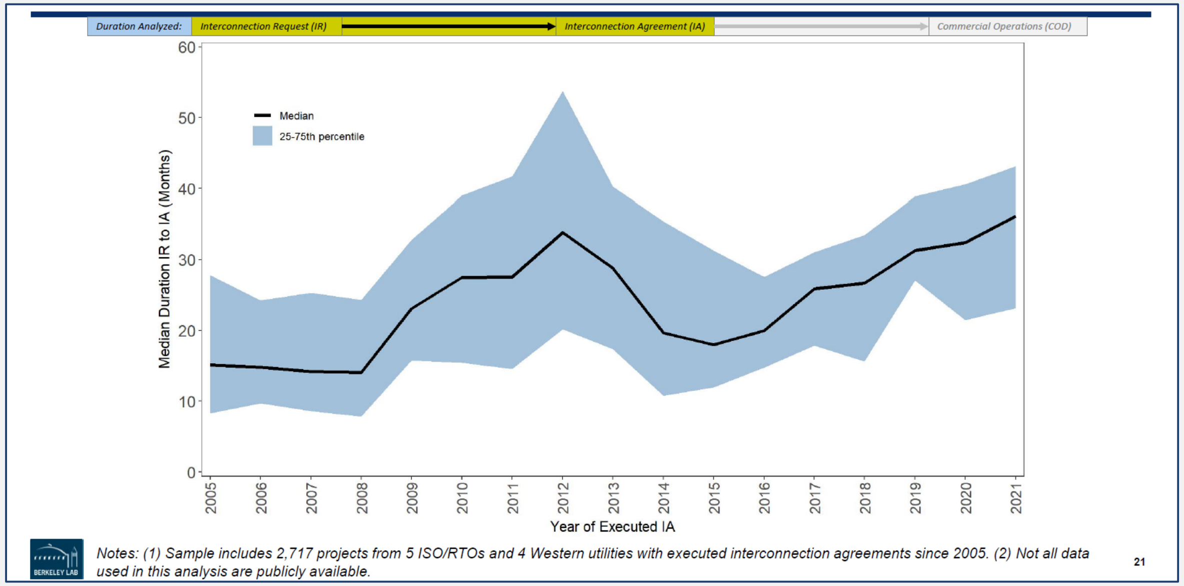
*1: Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021, Lawrence Berkeley National Laboratory (LBNL), published April 2022 (LBNL Study) analyzes interconnection queue as of end of 2021 for 7 RTO/ISO and 35 utilities, which collectively represent >85% of U.S. electricity load.
*2: NERC 2021 Long-Term Reliability Assessment estimates peak load in lower 48 to add up to ~760 GW.

Industry Trend - Longer Waiting Time in the GI Queue

Waiting time in the GI queue is becoming longer.

- The average waiting time today (from 2016 through 2020) is about 4 years.
  - The typical duration of projects in queues before reaching commercial operation increased from just over 2 years for those built in 2000-2010 to almost 4 years for those built in 2011-2021.*1
  - The average time between IR and interconnection agreement (IA) (i.e., the full interconnection study duration) exceeded 3 years in 2021.
  - Part of this is caused by excess projects and associated withdrawals. Only ~23% of projects in the queues reached commercial operations. Completion rates are even lower for wind (~20%) and solar (~16%).*2
  - The Affected Systems Study (AFS) that requires coordination among two or more systems is another cause of delays.
- Many RTO/ISOs are experiencing large GI queue backlogs (see previous slide), suggesting further delays.
  - PJM recently proposed to pause the review of 1,200 projects (mostly solar) until 2026.

Typical Duration from IR to IA*1



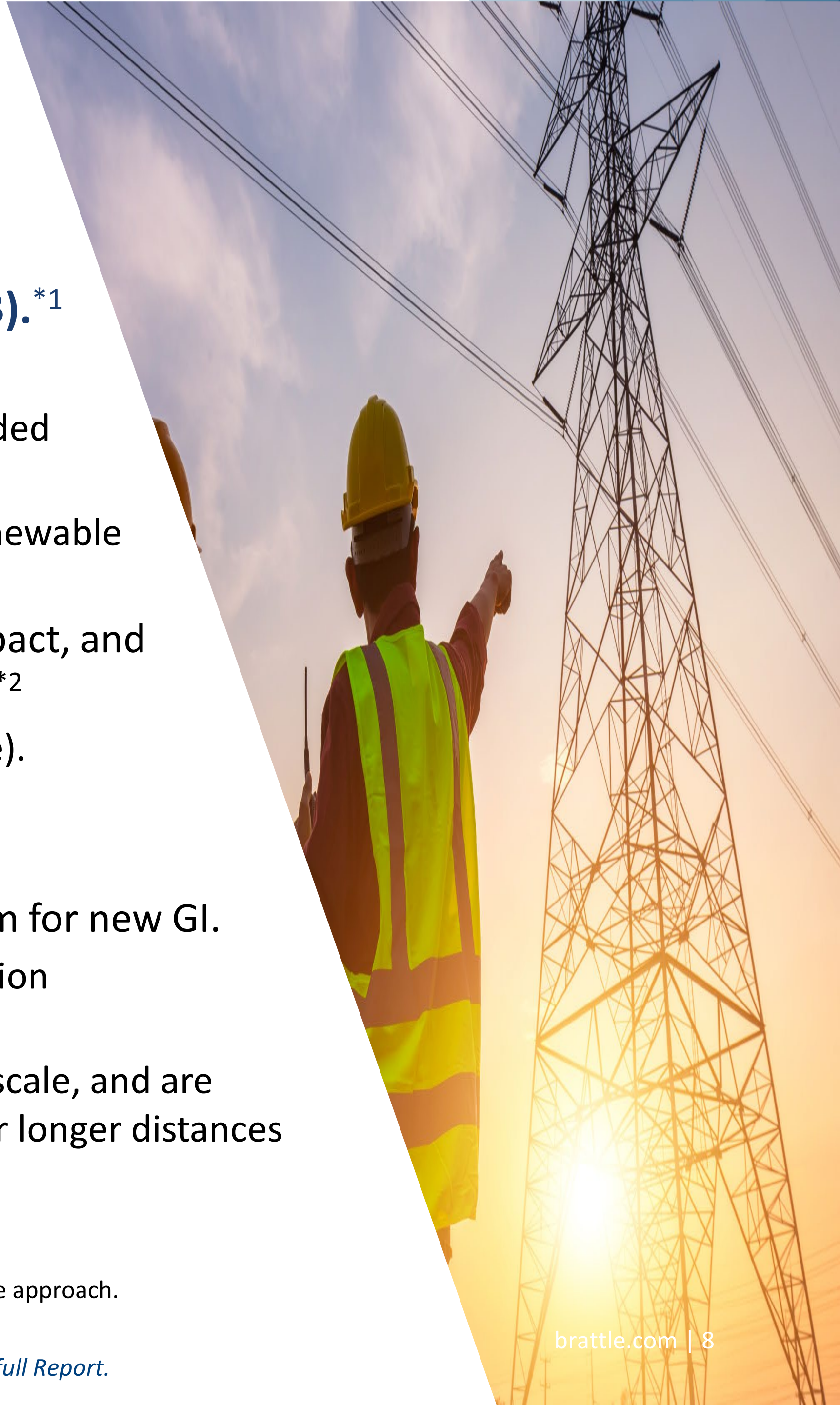
*1: LBNL Study looks at CAISO, ERCOT, NYISO, PJM, and APS to derive this.
*2: LBNL Study looks at projects completed between 2000 and 2016.

The Current GI Process

The current GI process was established nearly 20 decades ago (FERC Order 2003).*1

- Almost all new interconnecting generators at the time were natural gas-fueled.
  - The policy allowed gas-fueled generation to select interconnect points in ways that avoided transmission congestion.
  - Gas-fueled generation can interconnect in a relatively wide variety of locations while renewable resources (in particular, wind) are heavily location-constrained.
- The current GI process suggests three interconnection studies (Feasibility, System Impact, and Interconnection Facilities studies) to be performed on a first-come, first-served basis.*2
  - Many RTOs/ISOs and utilities apply the cluster approach (study multiple projects at once).
  - Studies are typically conducted on yearly (or semi-yearly) vintage level.
  - AFS is performed in parallel to the System Impact and Interconnection Facilities studies.
- In the meantime, transmission system has become over subscribed, leaving little room for new GI.
  - Renewable resources can be built much quicker than gas-fueled generation or transmission exacerbating the GI backlog issue.
  - Because renewable resources can be scaled easier, take advantage of the economies of scale, and are oftentimes built in remote locations, they tend to require more transmission capacity for longer distances (contributing to increased transmission usage/subscription).

*1: FERC Order 2003 outlines the standardized process for large generation (> 20 MW) interconnection process.
*2: FERC's June 16, 2022 Notice of Proposed Rulemaking (NOPR) (Docket No. RM22-14-000) proposes a first-ready, first-serve base approach.

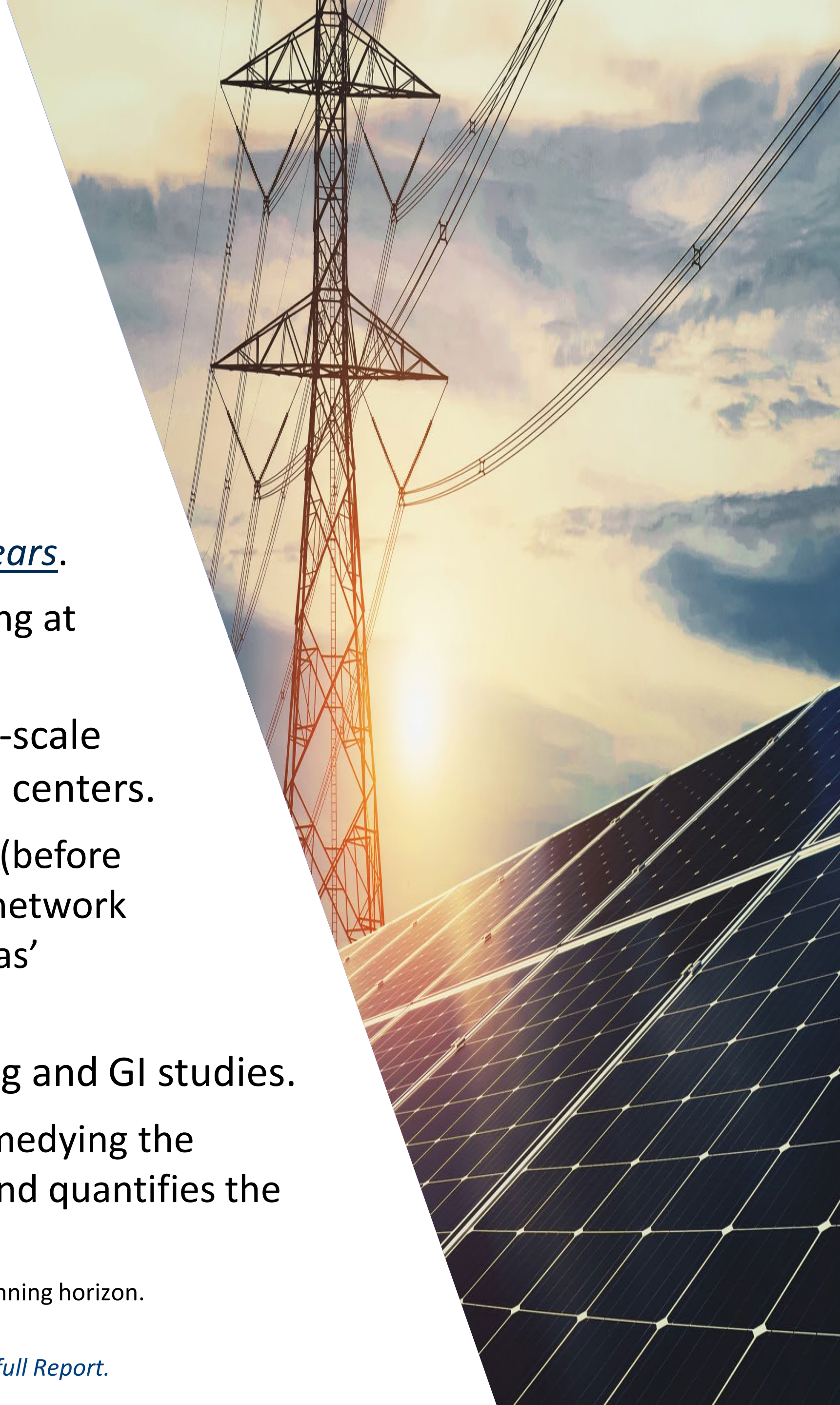


Transmission Needs to Increase Renewables

GI studies and long-term system planning studies both facilitate additional renewable buildouts—however, there is a gap.

- The gap is in both the study objective and timeline.
  - GI study objectives are to identify *least-cost* upgrades needed to provide generator interconnection. GI studies make use of reliability analysis, focusing *over the next 5 years*.
  - Long-term planning studies aim to identify options with the *largest net benefits* looking at *longer time periods (10 to 20 years)*.*1
- Building additional transmission is crucial to support the continued growth of large-scale renewables, since those resources (especially wind) are often located far from load centers.
  - Examples of successful transmission build-outs that helped integrate more resources (before they were fully subscribed) include MISO's Multi-Value Projects (MVP), SPP's 345 kV network and collector system, California's Tehachapi Renewable Transmission Project, and Texas' Competitive Renewable Energy Zone (CREZ).
- Many RTOs/ISOs recognize this gap and are trying to align the transmission planning and GI studies.
  - This *Study* analyzes if a more proactive GI approach can help bridge this gap while remedying the backlog/delay and high interconnection costs observed in the current GI processes, and quantifies the benefits as reduction in GI costs.

*1: FERC's April 21, 2022 Notice of Proposed Rulemaking (NOPR) (Docket No. RM21-17-000) proposes a minimum of 20 years as the planning horizon.



Proactive GI Approach

Will a more proactive GI approach help bridge the gap observed between GI studies and long-term transmission studies (which are both needed for integrating new resources) while remedying the backlog/delay and high interconnection costs observed in the current GI processes? If so, by how much?

- There are many ways to analyze this question. This *Study* estimates the benefits of proactive-ness by comparing the average GI costs for three different levels of proactive-ness (see next slide for the three levels) using MISO and SPP as testbeds.
- Proactive-ness is assessed by:
  - Increasing the number of projects to include in the GI cluster study, assuming more projects will lead to economies of scale and scope for the required interconnection upgrades.
    - This *Study* compares the GI costs of current GI study process (typically includes projects that filed IR in a given year) to an alternative study process that includes multiple years-worth of projects (i.e., filed IR in different years) by increasing the years/vintage of projects (Study Window).
    - The current GI study utilizes the latest (within past 5 years) GI studies performed by the RTO.
    - The alternative study process utilizes projects in the GI queue that have not yet been studied by the RTOs as part of their annual routine GI studies.
  - Improving coordination of the AFS process.
    - This *Study* utilizes results from the MISO and SPP sponsored Joint Target Interconnection Queue study (JTIQ).

Three Levels of Proactive GI Planning

Objective: Quantify benefits of proactive GI planning using a comparison across three levels of "proactive-ness."

How would studying a larger cluster (i.e., expanding the Study Window) and improving the AFS process help?

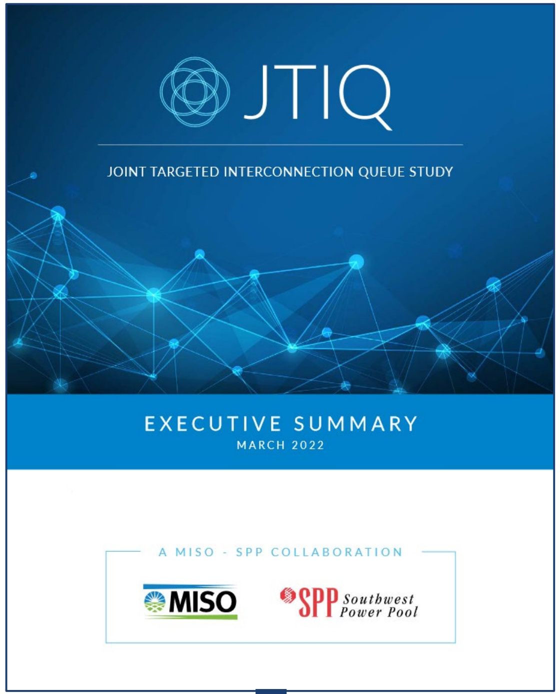
LEVEL 1: LOWER LEVEL OF PROACTIVE GI PLANNING	LEVEL 2: MEDIUM LEVEL OF PROACTIVE GI PLANNING	LEVEL 3: HIGHER LEVEL OF PROACTIVE GI PLANNING
Represents the status quo, where RTO/ISOs and utilities study GI on an annual (or semi-annual) basis.	Represents a multi-year (3 years) Study Window from the existing GI queue, rather than a single (or half a) year.	Represents a multi-year (5 year) Study Window together with a better coordinated AFS that the MISO-SPP Joint Targeted Interconnection Queue study (JTIQ) analyzed.

Example of the 3 Levels of Proactive Planning

Level 1 →	6 months or 1 year, 1,000-5,000 MW of GI projects
Level 2 →	3 years, ~10,000-15,000 MW of GI projects
Level 3 →	5 years, ~40,000 MW of GI projects

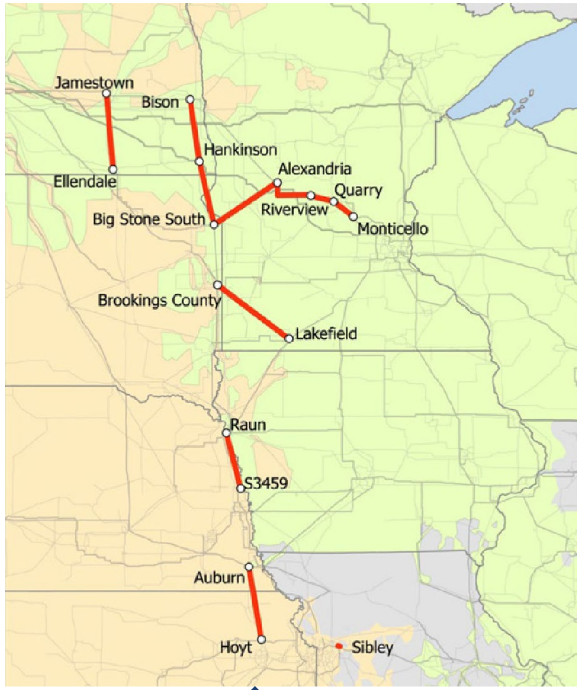
MISO-SPP Joint Targeted Interconnection Queue Study

The *Study* utilizes the MISO-SPP Joint Targeted Interconnection Queue study (JTIQ) to represent **Level 3** (higher level of proactive planning).



- JTIQ aims at building transmission network upgrades along the MISO-SPP seams to enable new GI. It represents an improved (better coordinated) AFS process.
- This is achieved by identifying transmission constraints that limit new GI, comparing best solutions, and sharing costs among generators and load. JTIQ analyzes two time horizons: 5 years ahead and 10 years ahead. This *Study* focuses on the 5 years-window.

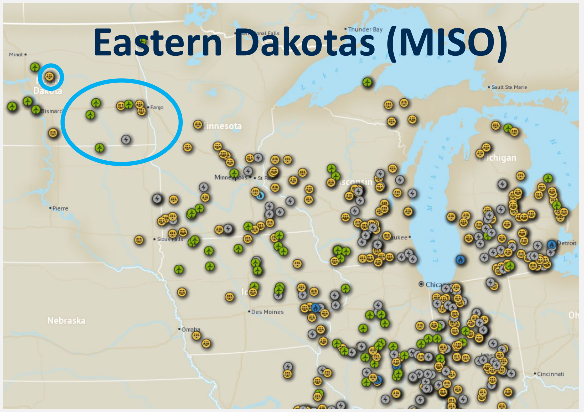
JTIQ identified seven transmission projects (JTIQ Portfolio) along the MISO-SPP seam. The JTIQ Portfolio costing $1.65 billion, fully address constraints and further allow 28.6 GW of new GI projects (Energy Resource Interconnection Service, or ERIS, equivalent), while providing $971 million in adjusted production costs (APC) savings.

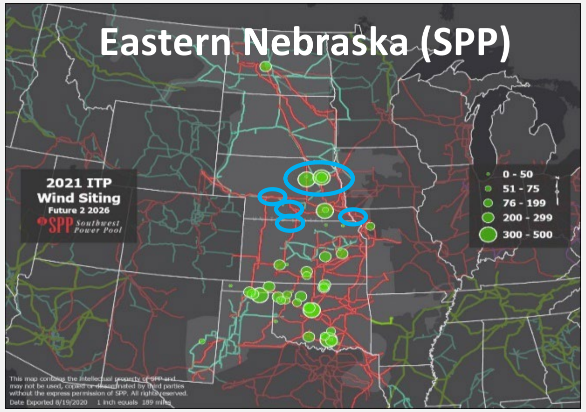


Analyzing the Benefits of Proactive Planning

1. Identify area/region to analyze.
   - The MISO and SPP regions were selected because JTIQ would represent **Level 3** (higher level of proactive-ness).
     - Within MISO/SPP, Eastern Nebraska (SPP) and Eastern Dakotas (MISO) were selected.
2. Analyze **Level 1** (lower level of proactive planning) using existing GI studies.
   - Approximately 5,000 MW of projects for MISO and SPP, respectively.
3. Develop **Level 2** (medium level of proactive-ness) case for target area/regions.
   - Create interconnection solutions for projects from 3 years of GI queue.
     - 959 MW from Eastern Nebraska and 2,290 MW from Eastern Dakotas analyzed as representative areas. Projects for the entire MISO and/or SPP regions would add up to ~15,000 MW per RTO.
     - Analyze MISO/SPP power flow cases to develop solutions (Base Case and N-1 assessments).
     - Utilize MISO/SPP generic cost estimates to tally costs for solutions developed.
4. Analyze **Level 3** (higher level of proactive planning) using JTIQ results.
   - Approximately 40,000 MW of projects for MISO and SPP, combined.
5. Calculate and compare normalized GI costs among the three levels.
   - **Level 1** (lower level) and **Level 2** (medium level) cases.
     - Potential benefits of multi-year planning (3 years) vs. single year planning.
   - **Level 2** (medium level) and **Level 3** (higher level) cases.
     - Potential benefits of difference in multi-year planning (3 years vs. 5-year planning) and improved AFS process.

Level 2 Representative Areas





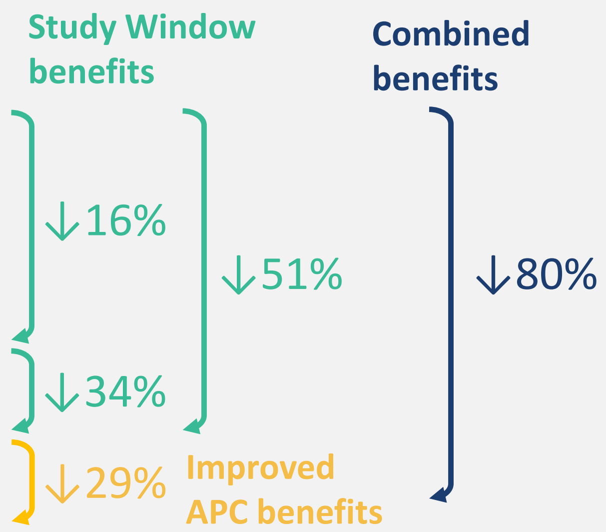
Study Results - Summary 1

Proactive GI planning provides significant cost reduction with benefits growing with expanded GI project counts and improved AFS process.

Benefits of Proactive GI Planning

Cases	Description	Study Window	MW Added	Cost ($ million)	Cost ($/kW)
LEVEL 1	SPP cluster studies (2017)	0.5 Years[*1]	5,082	$552[*2]	$109
	MISO cluster studies (2017-2018)	1 Year	5,025	$633[*2]	$126
	SPP+MISO	1 Year	10,107	$1,185	$117
LEVEL 2	SPP multiple years cluster	3 Years	960[*3]	$91	$95
	MISO multiple years cluster	3 Years	2,290[*3]	$226	$99
	SPP+MISO	3 Years	3,249[*3]	$317	$98
LEVEL 3	JTIQ	5 Years	28,600[*4]	$1,650	$58
	JTIQ – accounting for APC benefits[*5]	5 Years	28,600[*4]	$679	$24

Estimated Benefits (GI cost reduction)

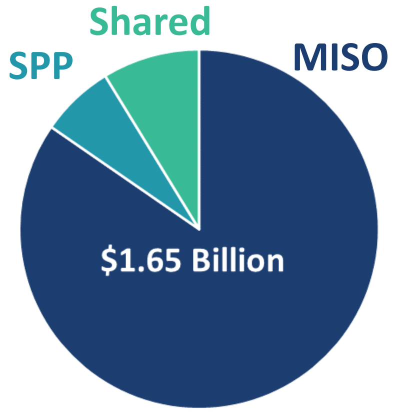


*1: SPP recently changed to 1 year study windows.
*2: Costs assume ERIS, and where noted include affected system upgrades.
*3: The MW listed here are the two representative areas (Nebraska and Dakotas) analyzed. If the entire SPP and MISO regions were studied, the projects would add up to about 10,000 - 15,000 MW per RTO.
*4: JTIQ had 40,000 MW of projects, which 28,600 MW was able to interconnect with its proposed transmission portfolio.
*5: Level 1 and Level 2 did not analyze potential APC benefits.

Study Results - Summary 2

Proactive GI planning (looking at more projects and improving the AFS process) lowers interconnection costs.

- **Level 1**: Traditional cluster windows have higher average costs than mid- and long-term proactive planning.
  - MISO (2017-2018)*1: 37 interconnecting projects, average interconnection costs of $126/kW.
  - SPP (2017)*2: 177 interconnecting projects, average interconnection costs of $109/kW.
- **Level 2**: Extending GI studies' study window from 1 to 3 years ***lowers the cost by about 16%.***
  - MISO: 10 renewable projects adding up to 2,290 MW, average interconnection costs of $99/kW.
  - SPP: 5 renewable projects adding up to 960 MW, average interconnection costs of $95/kW.
- **Level 3**: JTIQ is utilized as an example of improved AFS while also looking at 5 years-worth of GI projects, and can potentially fill the gap between transmission expansion studies and GI studies.
  - JTIQ Portfolio ($1.65 billion cost) is estimated to enable 28.6 GW of new capacity, average interconnection costs of $57.7/kW (***~50% reduction***, compared to **Level 1**).
  - JTIQ Portfolio is also estimated to reduce adjusted production costs (APC)*3 by $971 million ($724 million in MISO and $247 million in SPP) before the addition of any new GI.
  - Accounting for this APC benefit would lower the average interconnection costs to of $23.7/kW (***~80% reduction*** , compared to **Level 1**).



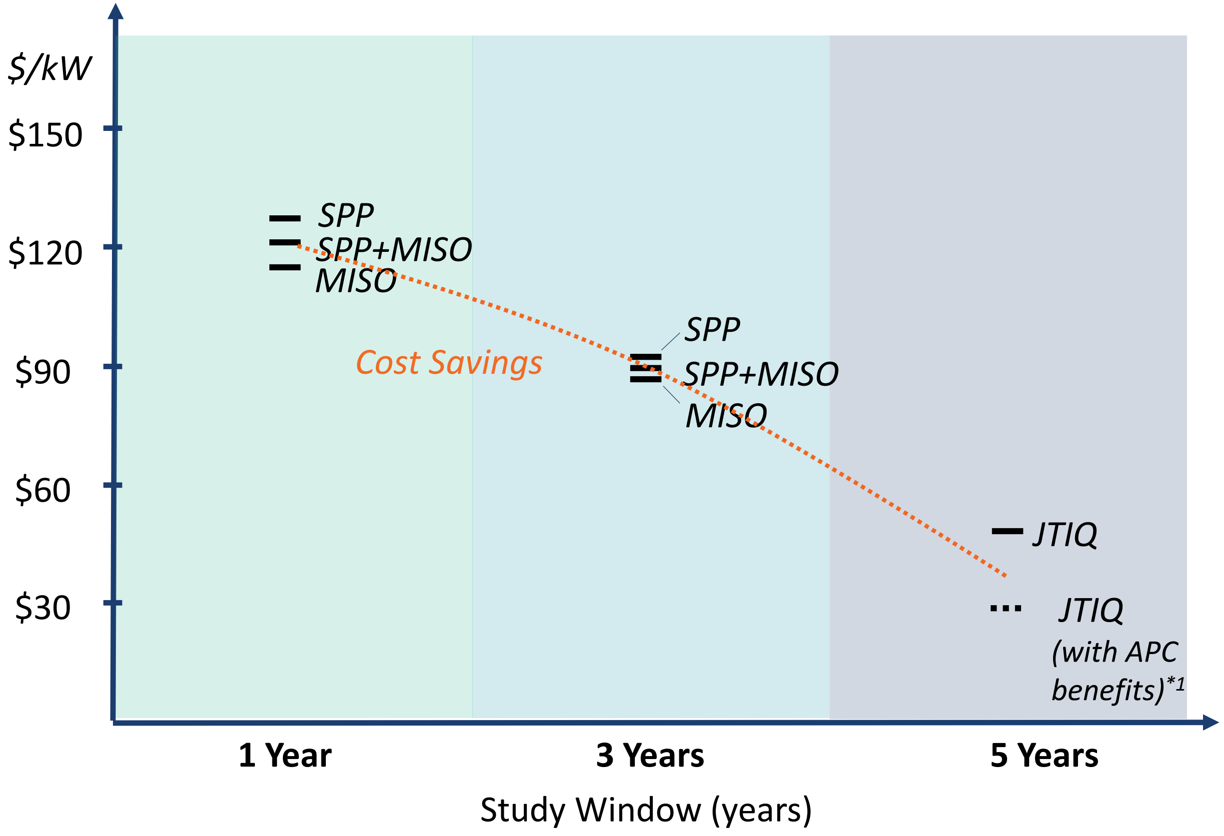
JTIQ Portfolio Costs

*1: For MISO, the Study looked at proposed projects that were part of the West region cluster. This removed the effect of projects in other regions that had significant excess transmission capacity (and thus are not representative of traditional interconnecting projects with required network upgrades).
*2: SPP impact and affected system studies for cluster windows that closed in 2018 have not been published, as of June 22, 2022.
*3: APC savings is calculated as the difference in total production costs of a generation fleet adjusted for import costs and export revenues with and without the proposed transmission upgrade as part of the transmission system

Study Results - Observations

Proactive GI planning (looking at more GI projects and improving the AFS process) reduces GI costs.

Expanding the GI projects count (i.e., expanding the Study Window) with a better coordinated AFS process can ***reduce the GI cost to nearly half***, or even ***down to a fifth*** if APC is considered. While a ***JTIQ-like proactive GI approach is ideal*** in the longer-run, expanding the GI projects count may be a suggested improvement that can be implemented quickly.



Benefits measured in GI cost reduction (%)

Benefits of expanding the Study Window

- GI project count from 1 to 3 years: 16%

Benefits of expanding the Study Window and AFS improvement

- GI project count from 1 to 5 years with AFS improvements: 51%

This suggests non-linear growth in benefits when the AFS process is improved along with increasing the project counts. However, there may be a natural limit to Study Window expansion because many IR do not go beyond 4 years in the future. (See slide 28)

- APC benefits*1 associated with improved AFS: 29%

Without a cost allocation methodology, GI customers may not see this benefit.

- Combined benefits: 80%

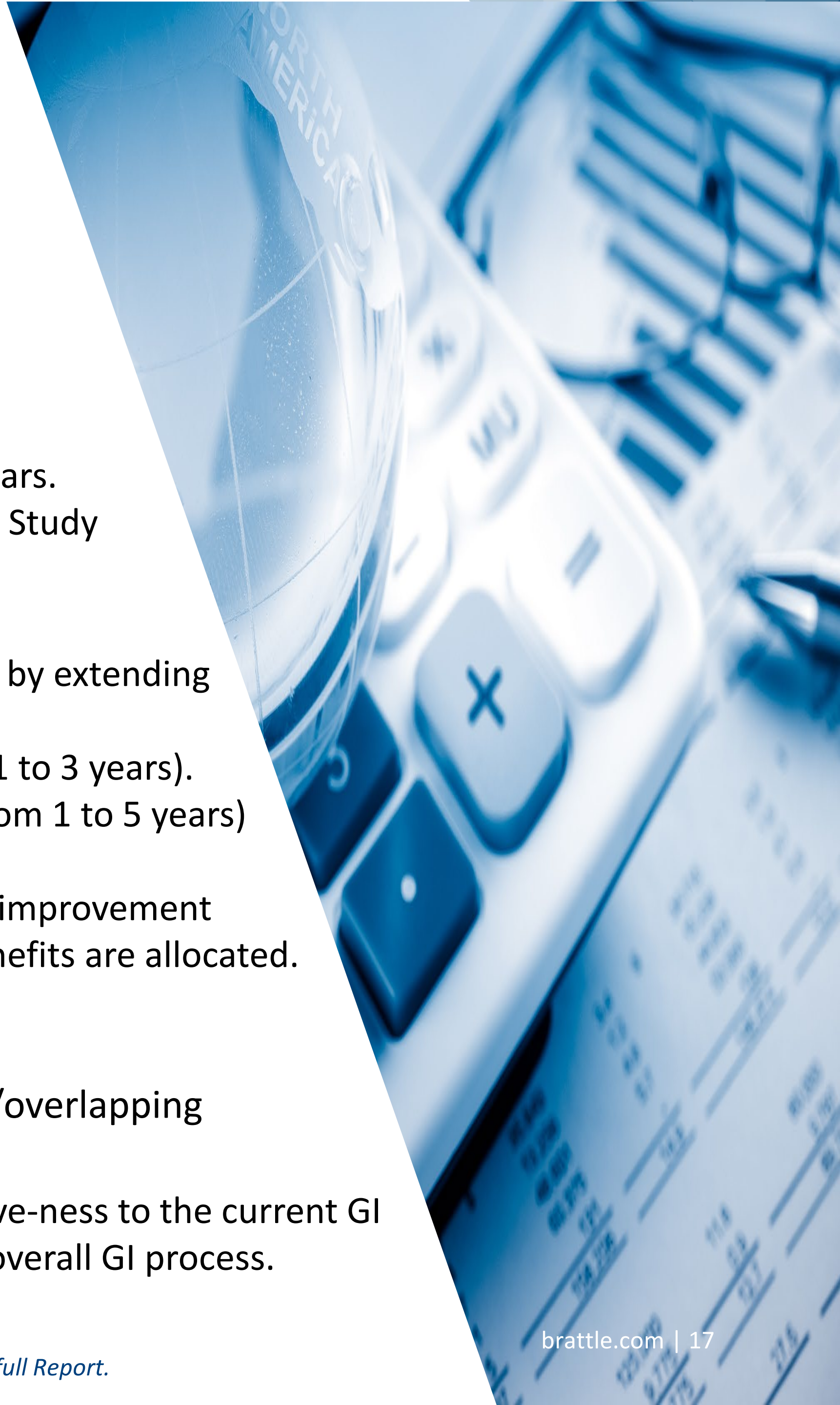
Coordinated GI planning (as represented by JTIQ) can potentially realize this level of benefits and help fill the gap between GI studies and transmission planning.

*1: Level 1 and Level 2 (1 and 3 Years Study Window) did not analyze potential APC benefits.

Study Results - Additional Assessments

Proactive GI planning can help bridge the gap between short-term GI studies and long-term transmission planning studies while reducing GI costs significantly.

- Expanding the Study Window can lead to substantial reduction in GI costs.
  - *Study* shows material reduction in GI costs with the Study Window extended to multiple years.
  - Many IRs are concentrated within the next few years (3 to 4 years or less) so expanding the Study Window for 5 years may not be practical.
- Improving the AFS process can further reduce GI costs.
  - Benefits of improved AFS process are likely equal to, or perhaps larger than those provided by extending the Study Window.
    - Study Window expansion benefit is calculated to be 16% for 2 years of extension (from 1 to 3 years).
    - The combined benefits of improved AFS and extending the Study Window by 4 years (from 1 to 5 years) is 51%.
    - If the Study Window expansion benefit is assumed linear (i.e., 16% for 2 years), the AFS improvement benefits calculate to be 19% (51% - 16% * 2 = 19%) or more, depending on how APC benefits are allocated.
  - Improving the AFS process through JTIQ led to $979 million of APC benefits.
    - Without a cost allocation mechanism, GI customers may not receive that benefit.
- These examples show how expanding the scope of the current GI studies, or combining/overlapping its scope with transmission planning, could provide significant benefits.
  - The benefits identified in this *Study* is built on the premise of incrementally adding proactive-ness to the current GI process. This should not be the ultimate goal but rather a transitional step to improve the overall GI process.



Study Results - Applications

Proactive GI planning can help bridge the gap between short-term GI studies and long-term transmission planning studies while reducing GI costs significantly.

- Expanding the Study Window can be used as a way to resolve existing backlog.
  - This *Study* bundled multiple years-worth of projects from the existing queue that have not yet been studied by the respective RTOs. Once the GI backlog is eliminated, a similar approach may not be feasible, nor practical.
- A cost allocation mechanism that allows late-comers to pay their share could allow the Study Window expansion approach to be incorporated in future GI studies.
  - Such allocation methods would likely reduce the needs for restudies and allow for expanding the GI project counts based on projected IRs or other long-term study implications.
    - This is particularly the case because over 90% of the IR are renewable resources, which are locational dependent (and thereby if a project withdraws, another one will likely come in to replace it).
    - FERC has approved tariff provisions (e.g., for MISO and NYISO) that require GI customers in later cluster studies that benefit from network upgrades completed prior to that later-in-time GI customer commencing commercial operation to partially reimburse the earlier cluster GI customer, who were responsible for the initial upgrade costs. Such policies would greatly support extending the study window.
  - Proactive transmission projects that successfully integrated large amounts of renewables have all been fully subscribed, suggesting the probability of underfunding may not be as severe.

Study Limitations

Scope: Focuses on proactive interconnection planning benefits

Intention was to evaluate multi-year planning (instead of change in study or geographical scope) together with an improved AFS process.

- This *Study* is not a substitute for an interconnection engineering study.
- *Study* analyzes generic ERIS equivalent; Network Resource Interconnection Services (NRIS) benefits may differ (costs likely higher for deliverability upgrades).
- Considered baseline scenarios – no advanced technologies (Grid Enhancing Technologies, storage, HVDC etc.) were evaluated.

Assumption: Perfect foresight and no restudies

Renewable developments often are interested in the same location, indicating withdrawn projects don't impact the GI study.

- This assumption is relevant for today where >90% of the GI queue is renewables.[*1, *2]
- When projects withdraw, similar alternatives often will take their place later (as observed in the ERCOT CREZ lines, or SPP 345 kV collector system).
- Desirable renewable locations do not change much over time.

Limit: Does not address cost allocation or other GI issues

The *Study* stops before considering cost allocation, resulting in uniform upgrade costs across projects.

- Cost allocation varies system by system and can be difficult to generalize.
- The question of who pays and its mechanics (e.g., participant funding vs. crediting) is critical in solving the interconnection backlog.
- A thorough follow-up study for specific systems would be required to better understand the implications and practical implementation of proactive planning along with cost allocation.

*1: Queued Up…But in Need of Transmission, Department of Energy: Office of Policy, April 2022
*2: FERC's June 16, 2022 NOPR (Docket No. RM22-14-000) proposes a first ready-first serve base approach, which, if realized would likely reduce restudies.

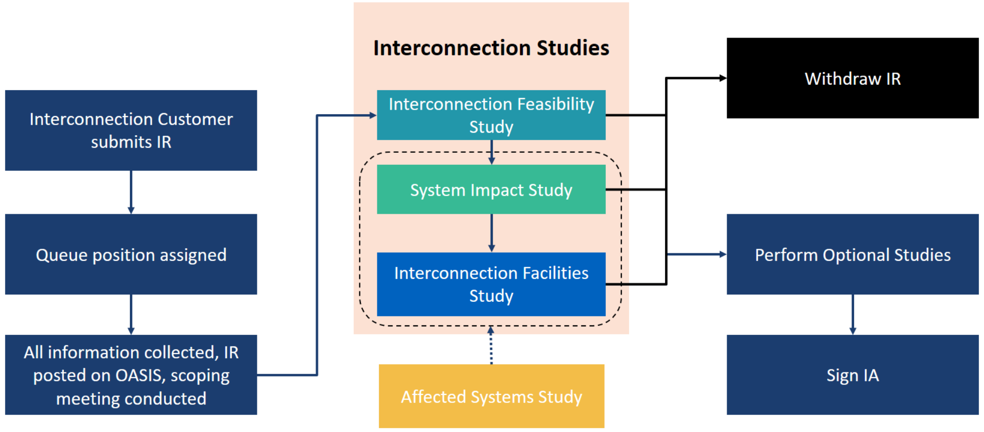
Table of Contents

Section Summary

This Study looks at how the GI process can benefit from a higher level of proactive planning.

- This section provides an overview of the current GI process.
  - An interconnection queue holds requests from customers who wish to connect generation (and other) facilities to the grid.
  - There are two interconnection types: Energy Only vs. Capacity (or Network).
  - Current GI process was largely created through FERC Order 2003.
  - Many GI studies have been performed on a first-come first-served basis for clusters of projects, typically aggregated by location and calendar year.
  - There are three main GI studies performed in series to determine impacts to the grid and cost allocation. An interconnection customer whose request completes all three studies will be granted IA.

Flow of Interconnection Studies



Overview of Current GI Process

An interconnection queue holds requests from customers who wish to connect generation (and other) facilities to the grid.*1

- Historically, the queue has largely been processed on a first-come first-served basis as each customer files their IR.*
- IRs are collected by system operators and currently reviewed on a project by project basis, or as clusters, on an annual or semi-annual basis.
- IR review includes a series of studies; each subsequent study requires additional financial commitment and provides increasingly detailed results.
- Each review typically takes higher-queued (i.e., filed earlier) projects into consideration when determining necessary grid improvements and related costs.
- Three primary studies are performed (next slide) along with auxiliary studies to determine impacts to the grid and cost allocation.
- An interconnection customer whose request completes all three studies will be granted IA.

FERC Order 2003*2

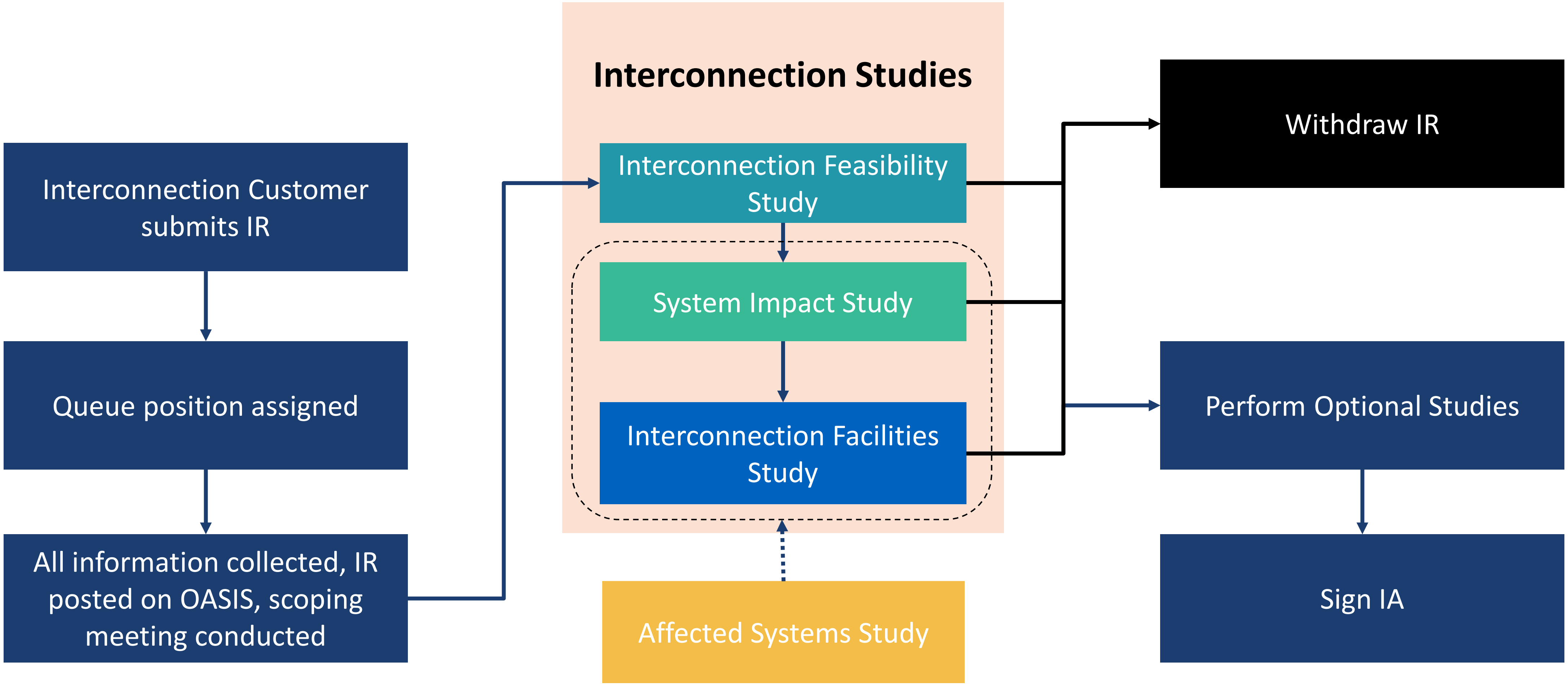
Out of concerns that the interconnection process was slow, marked by delays, and was not standardized across the country, FERC issued Order 2003. The Order created **a single set of interconnection procedures** deemed necessary to increase the development of new generation and increase competition in the energy market. Since the Order was adopted, IRs have increased dramatically, overwhelming queues across the country.

Interconnection Request Clustering

Entities (transmission providers and system operators) performing these studies have the option to **study interconnection requests as a group** (“cluster”). This allows costs of common network upgrades for all projects to be allocated among the clustered projects proportional to each project’s system impact. This, in theory, reduces the cost for each project while enabling multiple projects to be studied at once (and save time).

*1: NYISO also includes transmission in their interconnection queue and also considers “readiness” of projects in addition to their respective queue positions.
*2: FERC Order 2003 (RM02-1-000, Standardization of Generator Interconnection Agreements and Procedures) was issued July 24, 2003.

The Interconnection Queue Process (FERC Order 2003)



Three Interconnection Studies

Feasibility Study	System Impact Study	Interconnection Facilities Study
• A scoping meeting and deposit required. • A high-level look if the project is feasible at the particular interconnection point' – All existing and higher queued facilities are considered. – Results include list of facilities needed to interconnect and good-faith cost estimates.	• This is a more detailed version of the feasibility study that evaluates the impact of the proposed facility on system reliability. – Further deposit required.	• An even more detailed study identifying what equipment, construction work, etc. is needed to connect the proposed facility. – Includes estimates of the full interconnection cost and time estimates.
118-Day Process	**133 Days**	**180 day process**

Total Target Time: 431 days
Actual Time (average): 1,000 days

SPP refers to the three studies as Definitive Interconnection System Impact Studies (DISIS), Phase I, II, and III.
Similarly, MISO refers to the three studies as Definitive Planning Phase (DPP), Phase 1, 2, and 3.

Energy vs. Capacity Interconnection

Two interconnection types – Energy Only vs. Capacity (or Network).

Energy Resource Interconnection Service (ERIS)

- Allows the interconnection customer to connect its generation facilities into the transmission system to be eligible to deliver electricity using existing firm or non-firm capacity *on an as-available basis.*
- Studies are performed to ensure that grid stability is maintained when the generator interconnects.
  - Studies include short circuit/fault duty, steady state, and stability analysis.
  - Studies identify necessary upgrades to interconnect the facility to the grid without negatively affecting reliability. Studies also evaluate the maximum allowed output (at the time of the study) without requiring additional network upgrades.

This *Study* focuses on ERIS.

Network Resource Interconnection Service (NRIS)

- Allows the interconnection customer to integrate its generation facilities into the transmission system as a transmission owner would in order to serve native load and earn capacity credits *(at all times).*
- Studies are conducted to ensure that (in addition to grid stability) the generator facility is able to deliver load consistent with applicable reliability standards.
  - In addition, the system operator must study the system at peak load under a variety of stressed conditions to ensure that the aggregate of all generation can be delivered to aggregate of all load.
  - Studies identify necessary upgrades and associated costs to allow for full generator output.

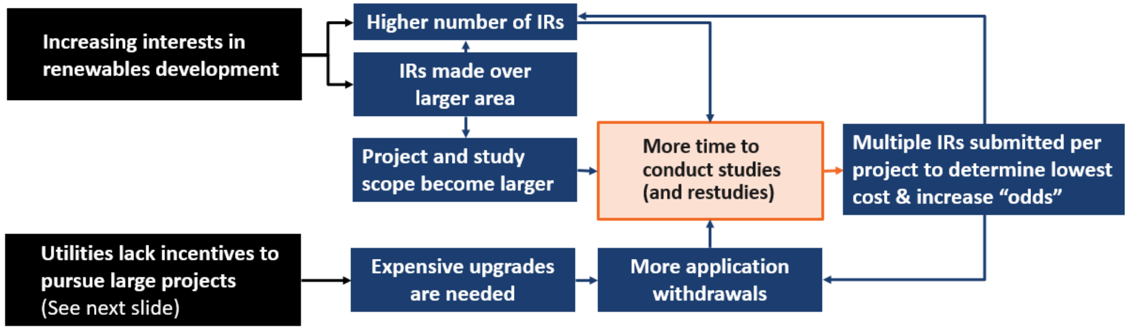
Table of Contents

Section Summary

This *Study* looks at how the GI process can benefit from a higher level of proactive planning.

- This section provides an overview of the current industry trend and the problems associated with it that is leading to this *Study* on proactively planning the GI process.
  - There is a large amount of IRs that exceeds the existing generation capacity.
  - The majority of the IRs are renewables or storage with many having online dates scheduled within the next three to four years.
  - The waiting time observed for GI has been growing to be about 4 years on average.
  - The long process time (including those for AFS) has created large GI backlogs in many RTO/ISOs.
  - The slow process and higher GI costs have led to project withdrawals. The rate of withdrawals are growing—today, only about a quarter of the projects that file IRs are realized.
  - Withdrawals lead to restudies and result in further delay, creating a negative cycle.
  - Part of the problem is that utilities do not have the incentive to develop larger transmission projects that will ultimately allow more resources to interconnect at lower costs.

Negative Cycle of GI Process

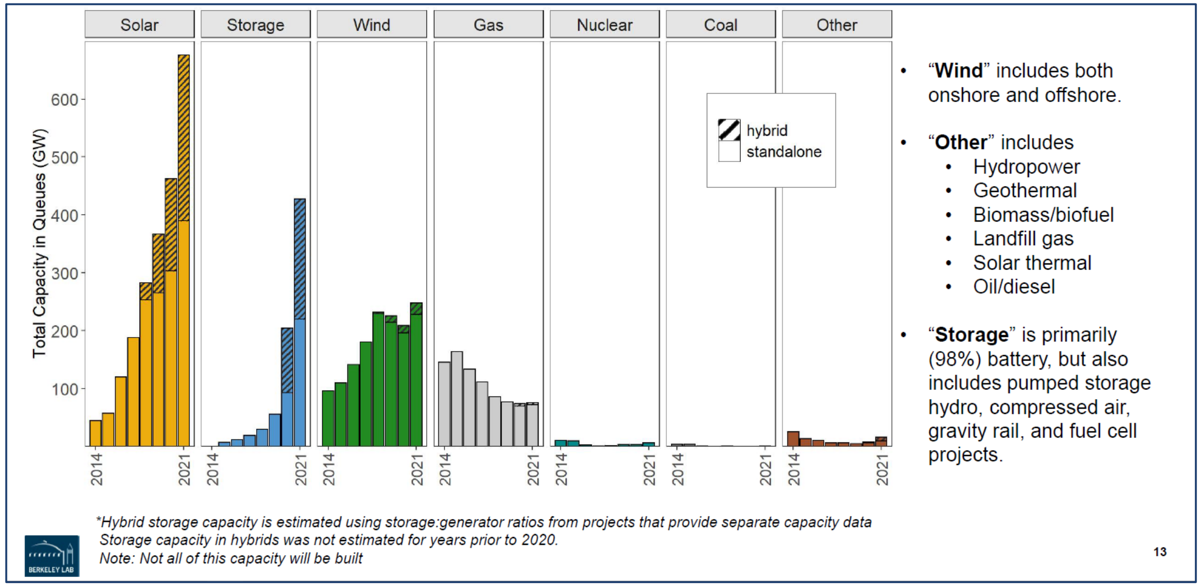


Industry Trend (LBNL Report) - 1

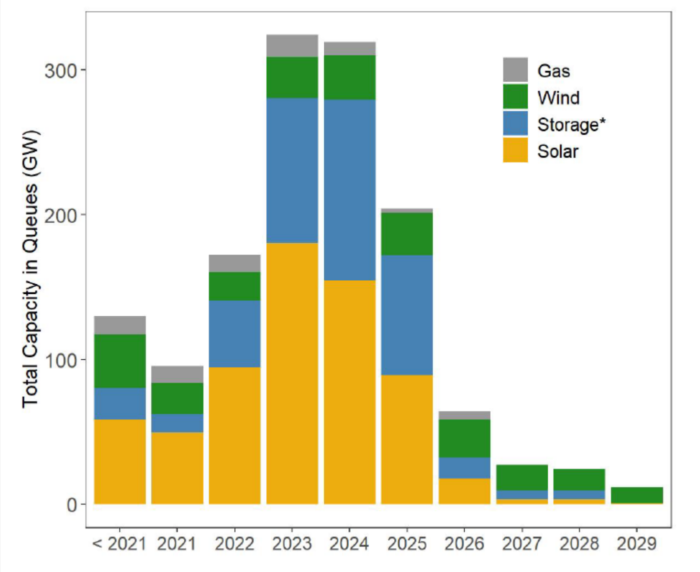
Currently over 1,000 GW of generation and ~420 GW of storage are in Generation Interconnection queue.*1

- For comparison, the combined peak load for the lower 48 states today is only 760 GW.*2
- 930 GW of the proposed generation is from renewables (676 GW of solar and 247 GW of wind, including 77 GW of offshore wind).

Interconnection Queue by Project Type*1



Total Capacity in GI Queue by In-Service Date



80% of solar (537 GW), 72% of storage (307 GW) and 56% of wind (138 GW) are proposed to come online by the end of 2024. 13% of solar projects have an IA, compared to 16% of wind and 9% of storage.

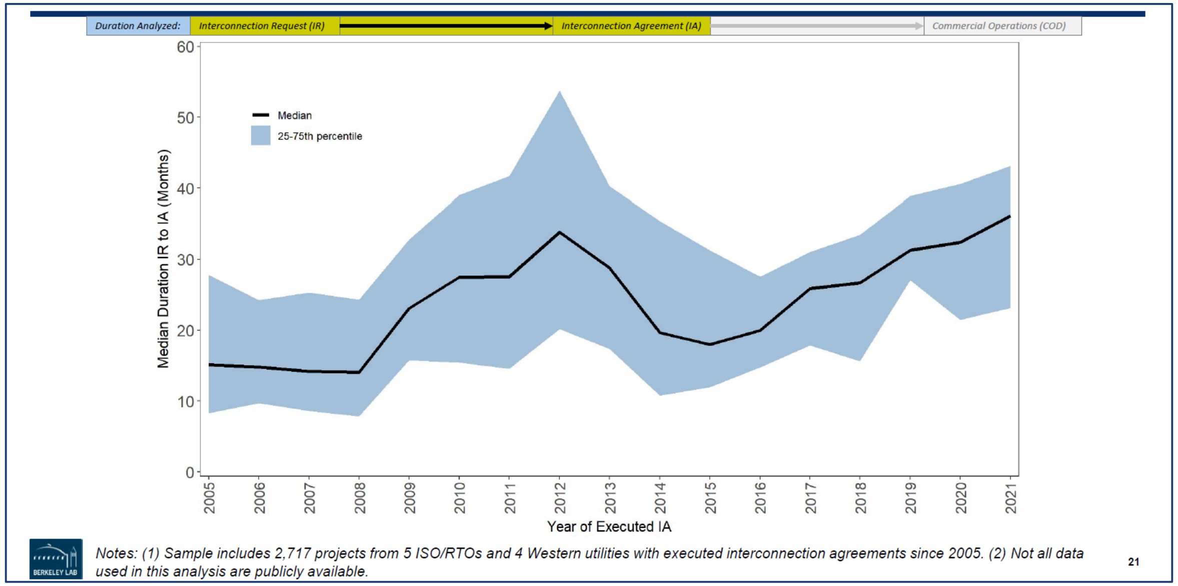
*1: 2022 LBNL Study (https://emp.lbl.gov/queues) analyzes interconnection queue as of end of 2021 for 7 RTO/ISO and 35 utilities, which collectively represent >85% of U.S. electricity load.
*2: NERC 2021 Long-Term Reliability Assessment estimates peak load in lower 48 to add up to ~760 GW.

Industry Trend (LBNL Report) - 2

Waiting time is becoming longer.

- The average waiting time today (from 2016 through 2020) is about 4 years.
  - The typical duration of projects in queues before reaching commercial operation increased from just over 2 years for those built in 2000-2010 to almost 4 years for those in 2011-2021.*1
  - The average time between IR and IA exceeded 3 years in 2021.

Typical Duration from IR to IA*1



After falling from a 2012 peak, the typical duration from IR to IA has been increasing since 2015, exceeding 3 years in 2021.

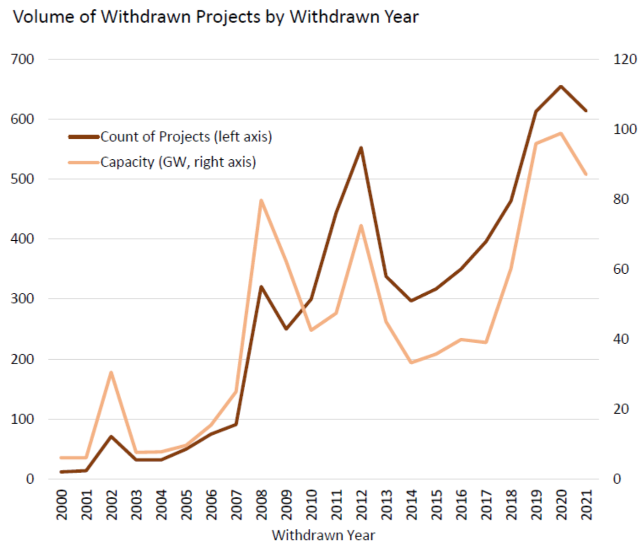
*1: LBNL Study (https://emp.lbl.gov/queues) looks at CAISO, ERCOT, NYISO, PJM, and APS to derive this.
*2: LBNL Study looks at projects completed between 2000 and 2016.

Industry Trend (LBNL Report) - 3

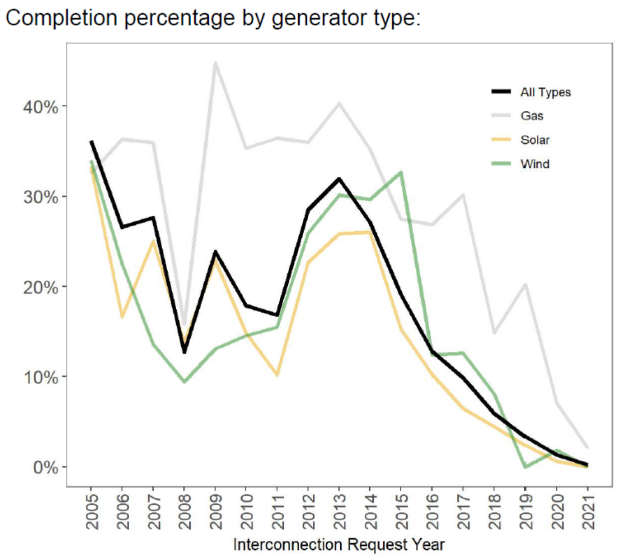
Waiting time is becoming longer.

- The average waiting time today (from 2016 through 2020) is about 4 years.
  - Part of this is caused by excess projects and associated withdrawals.
  - Only ~23% of projects in the queues reached commercial operations. *1
  - Completion rates are even lower for wind (~20%) and solar (~16%).*1

Volume of Withdrawn Projects*1

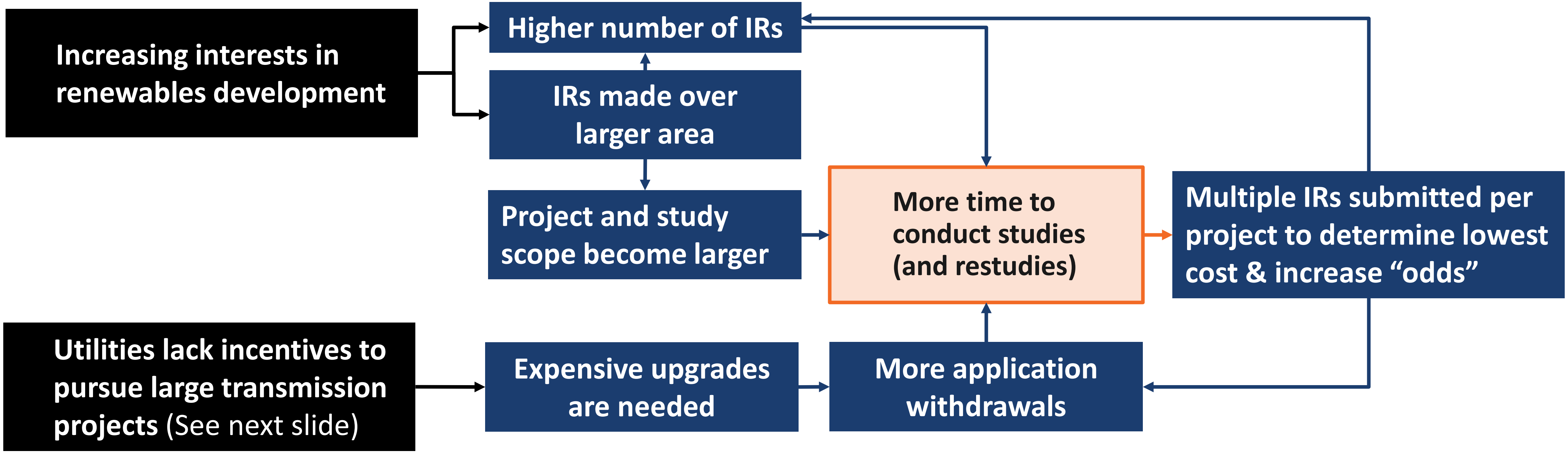


Completion Rate by Type*1



*1: LBNL Study (https://emp.lbl.gov/queues) looks at projects completed between 2000 and 2016.

The Trend Leading to Negative Feedback Loops



The growing amount of time to perform and rerun the studies increases uncertainty for developers and leads to higher financing costs, which will ultimately be passed on to customers. Typical GI costs have grown from being around or under 10% of the total project costs a few years ago to some projects being commanded near or over 50% in recent years.[1]

[1] Americans for a Clean Energy Grid, Disconnected: The Need for a New Generator Interconnection Policy, January 2021.

Utilities Lack Incentives to Pursue Large Transmission Projects

- Utilities have the Right of First Refusal (ROFR) for local transmission projects.
  - FERC Order 1000 repealed the federal ROFR requirements for federal projects.*1
  - Utilities focus on developing local projects and avoiding competition.
  - However, local transmission lines can't replace larger, regional projects needed for integrating renewables over a wider geographical area.
- Larger, regional projects require approval from multiple jurisdictions, and each entity has the power to impact the entire project.
- For regulators facing rate pressure, transmission stands out as a clear cost item that can be pared down.
- No regional integration means that utilities in certain parts of the country can rely on their own generation assets located locally, avoiding potential of stranded costs (because of higher utilization of these assets).
- Even if utilities don't proactively pursue large transmission projects, the current GI process will identify transmission projects that the system will need. This leads to higher GI costs and the negative cycle discussed in the previous slide.

While local and regional transmission planning and development can complement each other, utilities under the status quo have more incentives to pursue local transmission projects. However, large-scale transmission projects are critical to integrating the growing amount of renewable energy resources. Large-scale transmission projects will also lower GI costs (as MISO MVP have demonstrated).

*1 FERC Order No. 1000, Issued July 21, 2011

Backlog is a Ubiquitous Problem

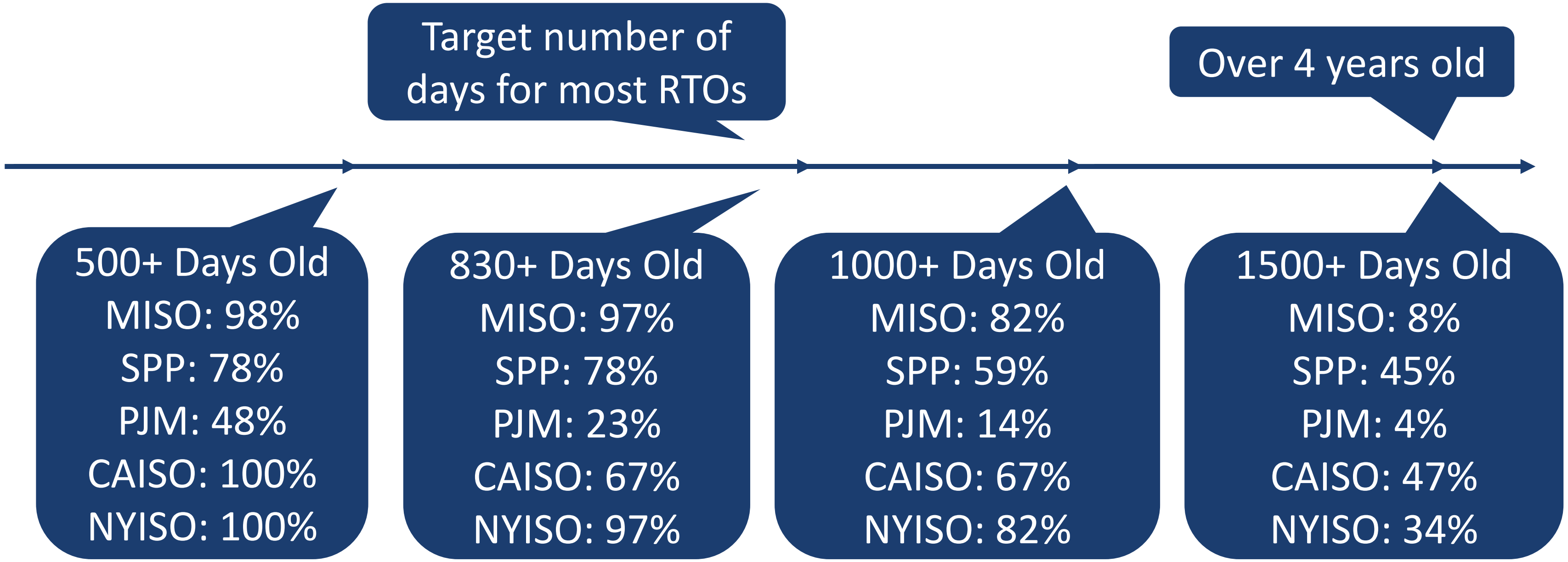
- 89% of developers consider interconnection timelines and costs to be one of the biggest barriers to achieving higher renewable goals (e.g., the DOE's goal of 40% solar by 2035.[1])

GI Duration Estimates by RTO

RTO	Estimated Time to GIA
MISO	505
SPP	485
PJM	825
CAISO	850
NYISO	505

Source: ISO GI Manuals
(e.g., PJM, MISO, etc.)

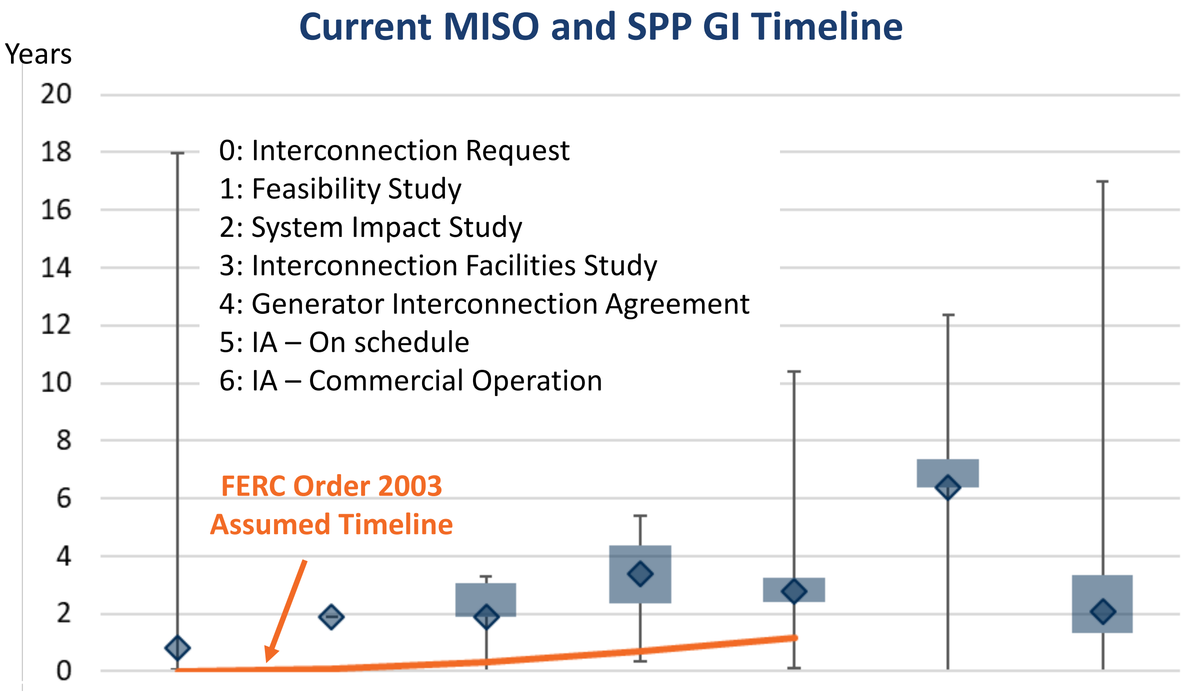
Age of Projects Currently in GI Queues



98% of MISO projects have not been completed before the 500 day mark.
The other 2% can be completed, or simply, newer.
MISO GI manual estimates 505 days to get to GIA.

[1] Standing in Line: How Congested Interconnection Queues Are Slowing Renewable Build-Out, LevelTen Energy, 2021

Backlog in MISO and SPP (Study Focus Areas)



	Stage	0	1	2	3	4	5	6
MISO	Project Counts	443	86	254	123	182	12	519
	Total Capacity	68 GW	13 GW	36 GW	21 GW	30 GW	0 GW	59 GW
SPP	Project Counts	-	-	-	616	21	85	320
	Total Capacity	-	-	-	114 GW	4 GW	15 GW	51 GW

Source: MISO GIQ, SPP GIQ, NREL Generation Interconnection Policies and Wind Power: A Discussion of Issues, Problems, and Potential Solutions

Description

- The whisker plot looks at all the projects from SPP and MISO's GI queue (as of March 2022).
- Each project in the queue is categorized to a Stage (0 through 6) based on its current position/status. Additional statistics are included in the table below the chart.
- Within each queue position the age of the project is calculated as the time between its entry into the queue and today.
- The box represents the 25th and 75th percentile and the diamond represents the median age for projects within that bucket.

Table of Contents

Section Summary

This *Study* looks at how the GI process can benefit from a higher level of proactive planning.

- This section outlines the analyses approach.
  - The *Study* compares the GI costs for three levels of proactive-ness through increasing the number of projects to include in the GI cluster study to develop transmission solutions (in general, more projects would lead to lower per-project costs because of economies in scope and scale) and improving coordination of the AFS process.

Levels	Proactive-ness	Description
Level 1	Low	Status quo, where GI studies are performed on an annual basis. This *Study* reviews GI costs from recent (historical) GI studies for MISO and SPP respectively.
Level 2	Medium	GI studies are performed looking at multiple years (3 years) of projects, taken from the existing GI queue (for projects that have not yet been studied by the respective RTOs). This *Study* analyzes GI projects for Eastern Dakotas (MISO) and Eastern Nebraska (SPP) a representative areas for MISO and SPP and develops respective interconnection solutions (through power flow analyses). Costs for each solution are assessed using generic cost assumptions provided by MISO and SPP.
Level 3	High	GI studies are performed looking at multiple years (5 years) of GI projects together with an improved AFS process. This *Study* utilizes MISO/SPP's JTIQ for the analyses.

Higher numbers / darker shade of blue indicate higher levels of proactive-ness.

Three Levels of Proactive GI Planning

Objective: Quantify benefits of proactive GI planning using a comparison across three levels of "proactive-ness."

How would studying a larger cluster (i.e., expanding the Study Window) and improving the AFS process help?

LEVEL 1: LOWER LEVEL OF PROACTIVE GI PLANNING	LEVEL 2: MEDIUM LEVEL OF PROACTIVE GI PLANNING	LEVEL 3: HIGHER LEVEL OF PROACTIVE GI PLANNING
Represents the status quo, where RTO/ISOs and utilities study GI on an annual (or semi-annual) basis.	Represents a multi-year (3 years) Study Window from the existing GI queue, rather than a single (or half a) year.	Represents a multi-year (5 year) Study Window together with a better coordinated AFS that the MISO-SPP Joint Targeted Interconnection Queue study (JTIQ) analyzed.

Example of the 3 Levels of Proactive Planning

Level 1 →	6 months or 1 year, 1,000-5,000 MW of GI projects
Level 2 →	3 years, ~10,000-15,000 MW of GI projects
Level 3 →	5 years, ~40,000 MW of GI projects

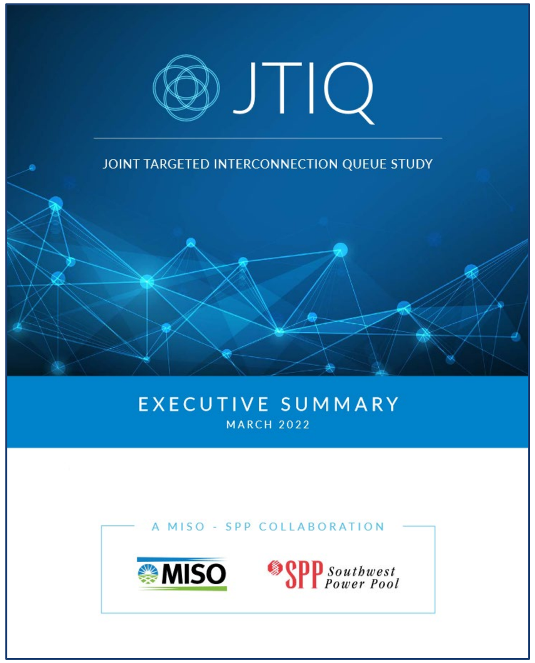
Analysis Steps of Proactive GI Planning

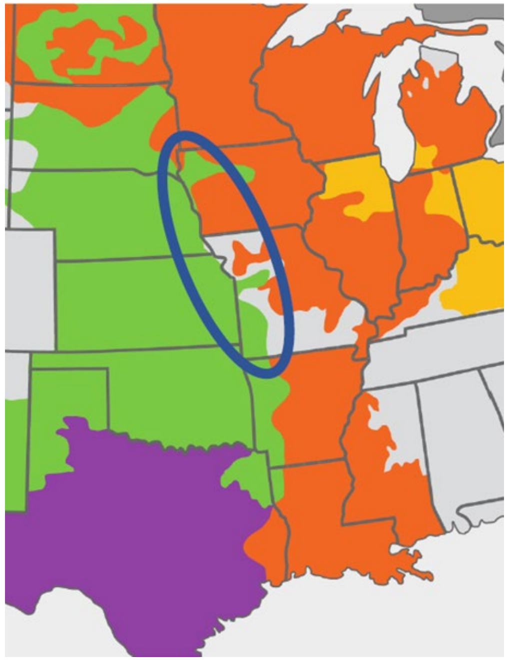
1. Identify area/region to analyze.
2. Analyze **Level 1** (lower level of proactive planning) using existing GI studies (from within the past 5 years).
3. Develop **Level 2** (medium level of proactive planning) case.
   - Create interconnection solution for projects for the target area/region for multiple (recent 3) years.
     - Analyze power flow cases to develop solutions (Base Case and N-1 assessment).
     - Utilize generic cost estimates to tally costs for solution developed.
4. Analyze **Level 3** (higher level of proactive planning).
5. Compare normalized costs ($/MW) amongst the three different levels (cases).
   - **Level 1** (lower level) and **Level 2** (medium level) cases.
     - Potential benefits of multi-year planning vs. single (or semi-) annual planning.
   - **Level 2** and **Level 3** (higher level) cases.
     - Potential benefits of difference in multi-year planning (e.g., 3 years vs. 5-year planning).
     - Account for additional benefits identified in **Level 3**.

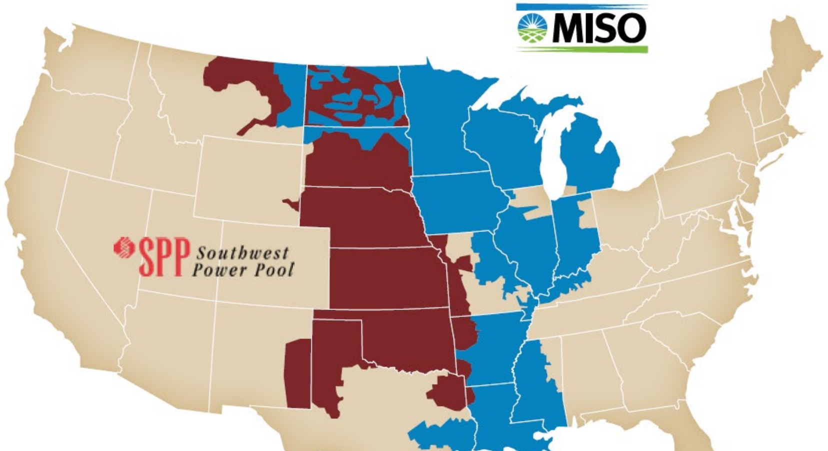
Area of Focus: MISO and SPP

The MISO and SPP regions were selected because JTIQ would represent **Level 3** (higher level of proactive-ness).

- MISO- and SPP-sponsored JTIQ identifies transmission projects required to interconnect new generating resources.
  - JTIQ focuses on areas near the MISO-SPP seam and provides an improved AFS process.
- Both markets have abundant wind resources, making them ideal for proactive planning.
  - Wind resource is location-specific, so even if one developer withdraws their interconnection application, another will replace it. This could reduce restudy needs.







MISO and SPP regions

Level 1: MISO Generator Interconnection Studies

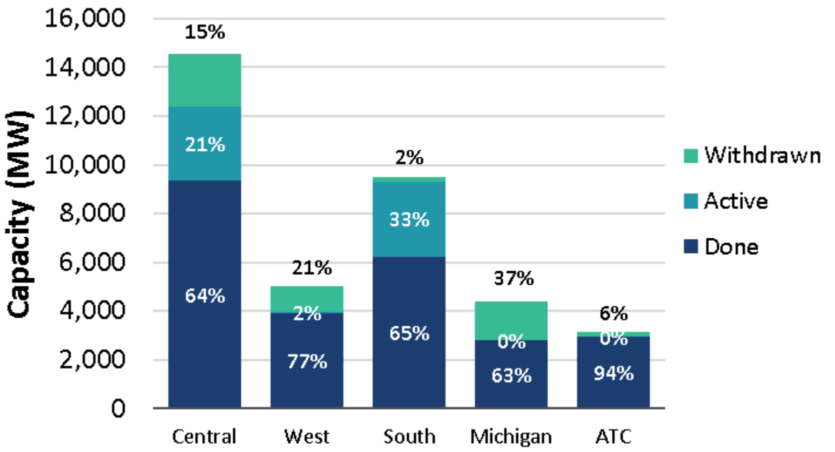
Level 1 interconnection facilities studies evaluate a cluster of proposed developments submitted during a given time period. Along with another study as part of the GI process, the transmission provider determines the necessary network upgrades (and their costs) each project is responsible for in order to connect safely and reliably.

- MISO organizes the cluster by sub-regions, including ATC (East), Central, Michigan, South, and West territories, and there is typically one primary study of each region per year.

GI Study Year	Solar Projects	Wind Projects	Other Projects[1]	Total MW
2017	61	36	11	18,431
2018	57	16	7	12,737
Total	**118**	**52**	**18**	**31,168**
Total – Still Active & Completed Projects	**82**	**15**	**15**	**25,878**

Note: MISO defines an active project as one that is valid and under the study cycle, and a complete project as one that has completed all studies. Starting with the DPP-2020 cycle, projects that withdraw following completion of Phase I feasibility studies are unable to recover 50% of their study fee ($4000/MW)

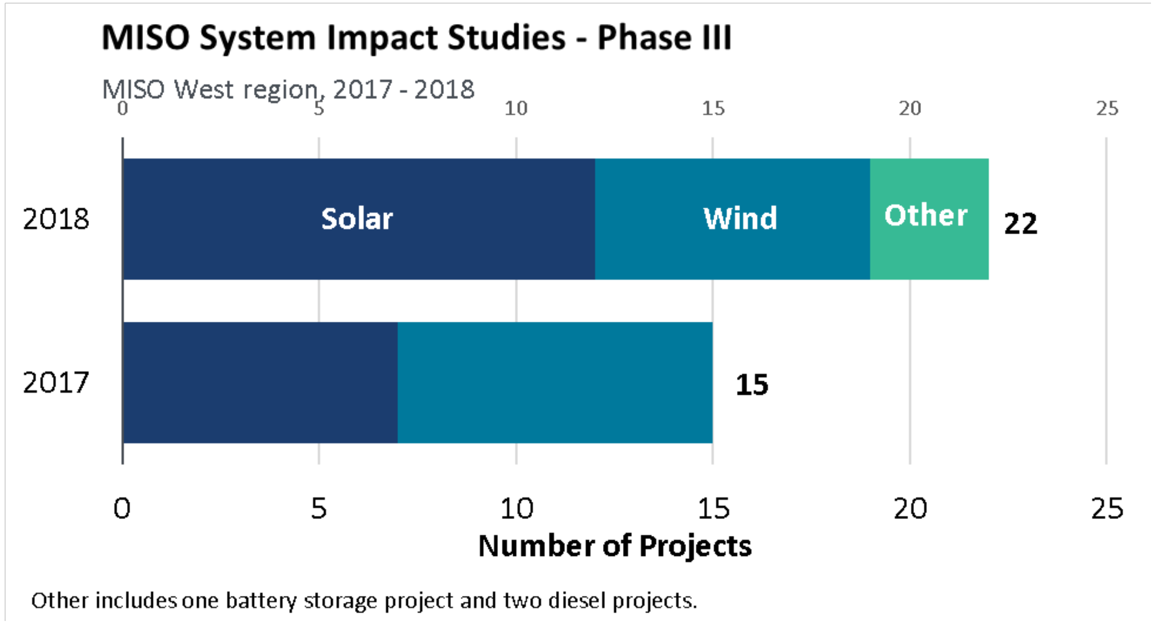
Cumulative Capacity Evaluated in MISO DPP Phase III Studies



Note: MISO Central includes IL, IN, KS, KY, and MO; MISO West includes IA, ND, MN, and SD; MISO South includes AR, LA, MS, TN, and TX; MISO East (ATC) includes WI and part of MI

[1] *Other fuel & technology types that have been studied include high-voltage DC, natural gas combined cycle plants, battery storage, waste heat recovery, diesel, hydro, and hybrid fuel types*

Level 1: MISO Definitive Planning Procedure Studies



	Interconnection Cost per kW ($/kW)	Interconnection Cost per MWh*[1]
2018	$73	$24
2017	$182	$60
Total	**$126**	**$42**

*1: Calculated for a single year based on a 25% capacity factor (CF) for solar, 40% CF for wind, and 90% CF for other resources.

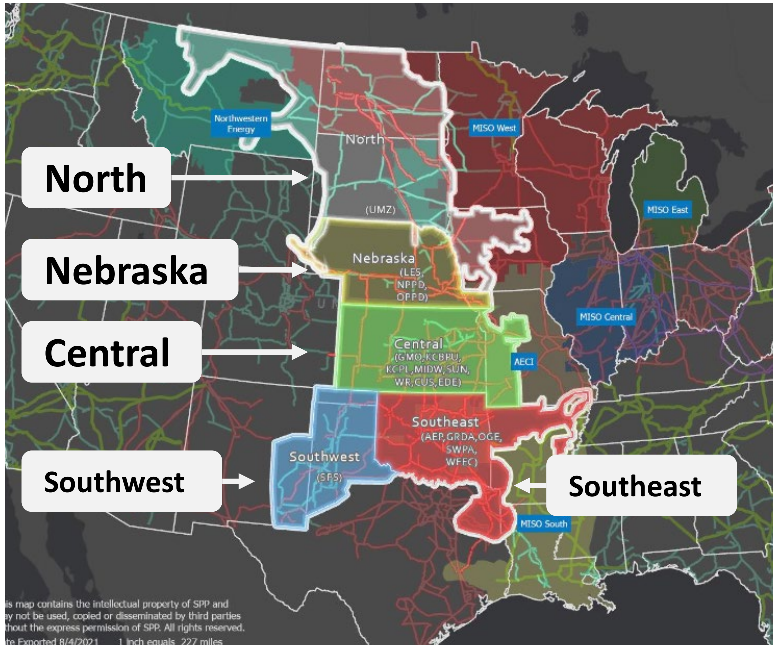
- Level 1 analysis for MISO shows the average interconnection cost (ERIS and Affected Systems) of **$126/kW** for the West region cluster.
- High cost estimates in MISO's Phase II studies often lead to withdrawn projects (12 projects in 2018 alone), and the remaining projects are less costly ($70 million/project vs. $17 million/project) because of the reduced upgrade needs.
- GI costs have been observed to go down after regional transmission projects (e.g., MVPs).

Level 1: SPP Generator Interconnection Studies

SPP also organizes requests to interconnect by the date each project entered the queue. Clusters remain open for 11 months plus 1 month for a review period.[1]

- SPP organizes the cluster by sub-regions: North, South, Central, Southeast, and Nebraska.[1]
- The latest SPP GI Study available at the time of the study was for 2017. 2018 studies have not yet been made public.

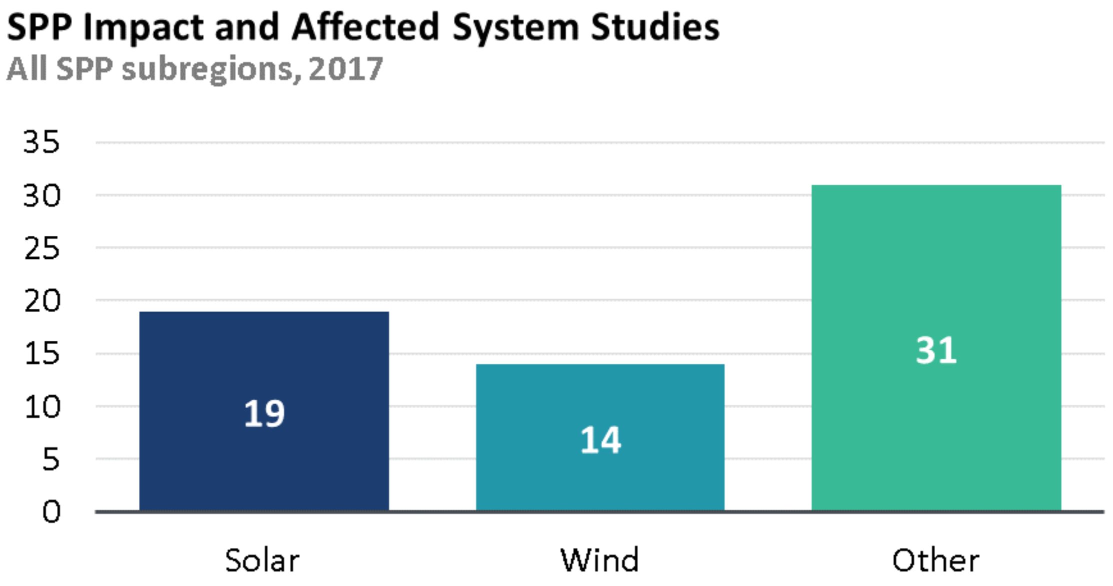
Year	Solar Projects	Wind Projects	Other Projects	Total MW
2017	14	19	0	5,082
2018	-	-	-	-
Total	**14**	**19**	**0**	**5,082**



Note: SPP North includes the Upper Missouri Zone; SPP Nebraska includes mainly NE; SPP Central includes KS and MO; SPP Southeast includes OK, TX, and AR; SPP Southwest includes the Texas Panhandle.
Source: SPP Generator Interconnection Manual (DISIS Manual), April 2022

[1] *SPP Open Access Transmission Tariff, Attachment V Section 4, January 15, 2022*

Level 1: SPP Generator Interconnection Studies



	Interconnection Cost ($/kW)	Interconnection Cost ($/MWh)*1
2017	$309	$89
2017 – Phase II costs only (excludes DISIS-2017-002)	$109	$37
2018*2	-	-

*1: Based on a 25% capacity factor (CF) for solar, 40% CF for wind, and 90% CF for other.
*2: SPP's network upgrades for 2018 cluster windows are not available, as of 6/22/2022

- **Level 1** analysis for SPP shows the average interconnection cost (ERIS and Affected Systems) of **$109/kW** for the entire SPP.

Level 2: Analyses of GI Queue Assuming a 3 Year Window

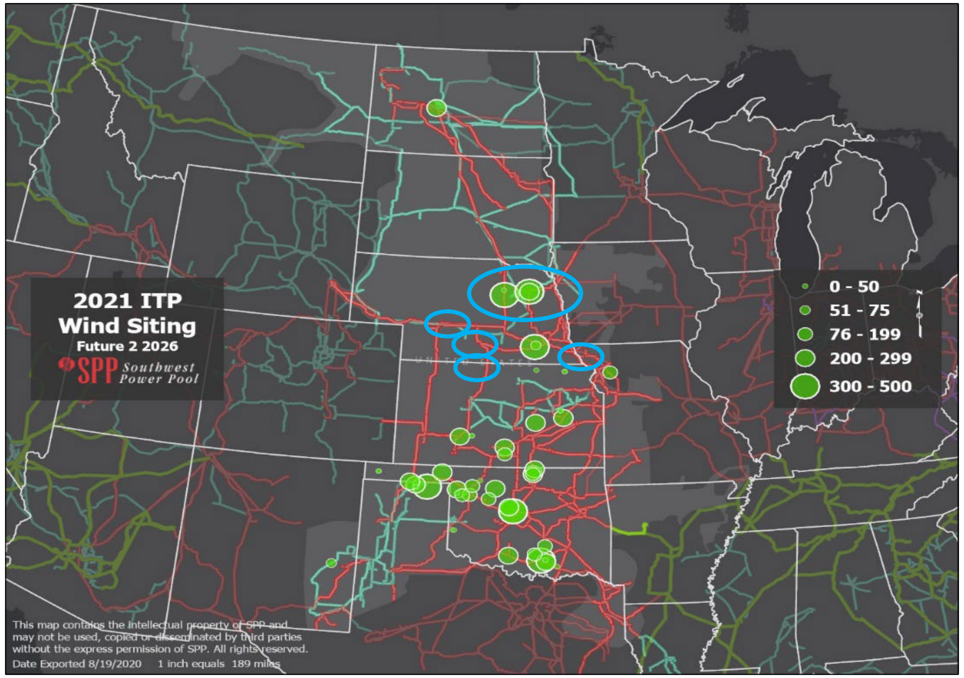
1. Identify representative systems and areas to analyze for new renewables projects	• Based on wind and solar potential and stakeholder feedback: – **Eastern Nebraska** selected for SPP – **Eastern Dakotas** selected for MISO
2. Add new renewables projects to the selected areas	• Three-year worth of projects (Level 2 planning) are extracted from the active GI Queues (2018 through 2021, depending on location).
3. Steady State Analyses (Base Case and N-1 Contingency)	• Base Case (i.e. without contingencies) and N-1 Contingency Analyses help identify thermal overloads caused by the new interconnections (and is a proxy for ERIS).
4. Identify Needed System Upgrades and Total Costs	• Transmission system upgrades needed to address thermal violations identified in Steady State Analyses. • Used public information (SPP and MISO network upgrade costs) to calculate the total costs of system upgrades. $Interconnection\ Costs\ \left(\frac{\$}{kW}\right) = \frac{Network\ Upgrades + Affected\ System\ Upgrades\ (\$)}{Project\ capacity\ (MW)} * \left(\frac{1\ MW}{1000\ kW}\right)$

Level 2: Two Study Focus Areas within MISO/SPP

Within the MISO/SPP footprint Eastern Nebraska (SPP) and Eastern Dakotas (MISO) Dakotas were selected as the representative study areas for analyzing **Level 2** (medium level of proactive planning) that expands the GI cluster study window from 1 year to 3 years.

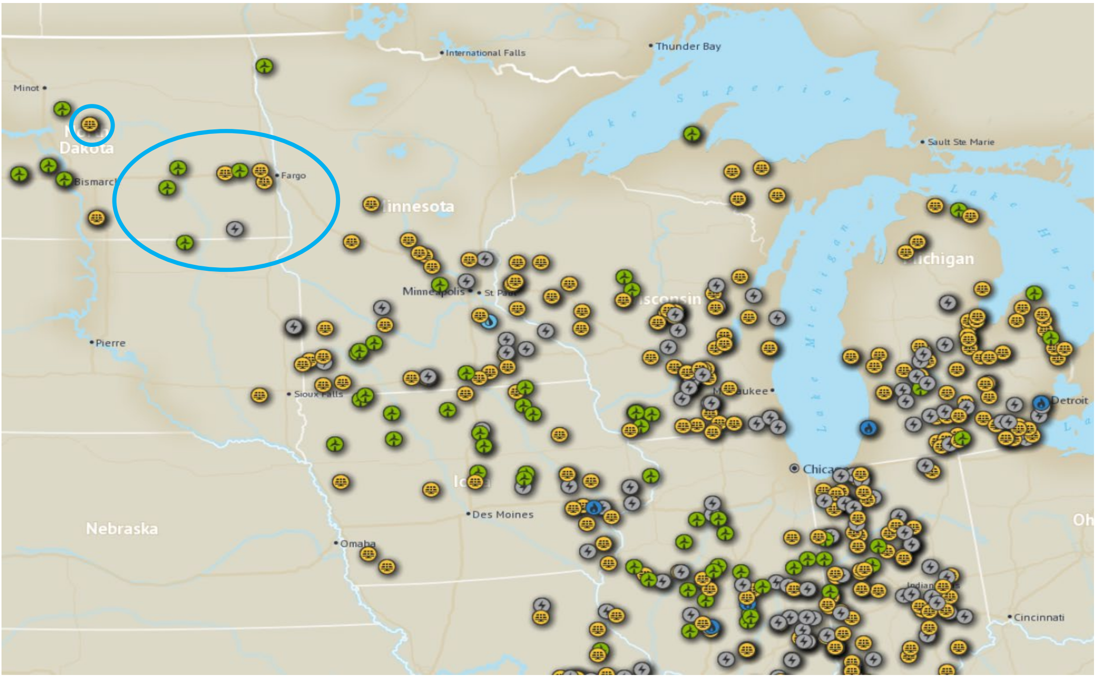
Eastern Nebraska (SPP)

959 MW of renewables project from GI queue studied



Eastern Dakotas (MISO)

2,290 MW of renewables projects queue studied



This Report may be redistributed. If only a portion of Report is redistributed, the redistributed portion(s) must be accompanied by a citation to the full Report.

Level 3: MISO-SPP JTIQ

JTIQ is a result of the RTOs' cluster study observations that showed the transmission system at (or near) its capacity and that the necessary network upgrades are too costly for individual or small groups of GI projects to proceed. JTIQ was designed to identify efficiencies between the two RTOs' GI processes.

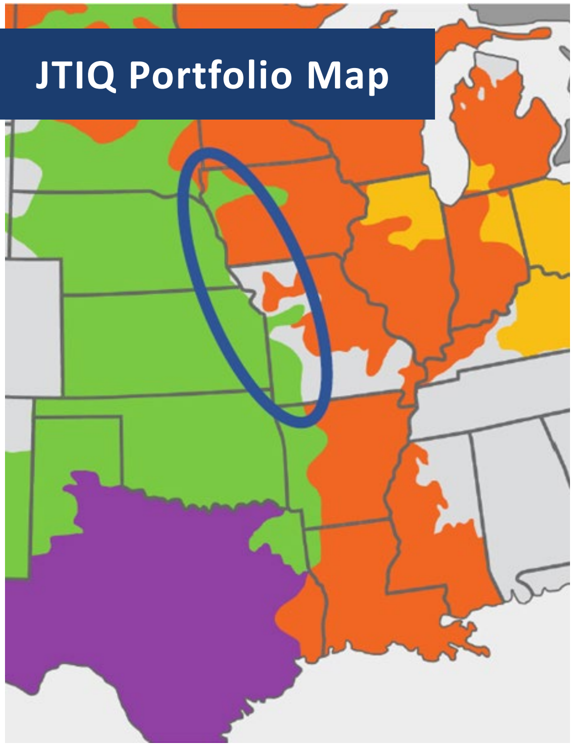
Background

- MISO and SPP cluster studies showed the transmission system at capacity.
- Necessary network upgrades were too costly for individual interconnection projects.
- Currently there are no cost-sharing approach that can facilitate construction of new transmission.
- Differences between the RTOs' GI processes and criteria contribute to delays and introduce concerns.

JTIQ Objectives

- Identify transmission solutions to resolve constraints along the MISO-SPP seam.
  - Identified transmission projects that are technically feasible and provide greater reliability and economic benefits (i.e., lower GI costs).
- Streamline and better align the GI process between MISO and SPP to reduce re-studies/delays.
  - MISO and SPP have adjusted relative queue position, tie-line upgrades, etc. for their modeling.

JTIQ Portfolio Map

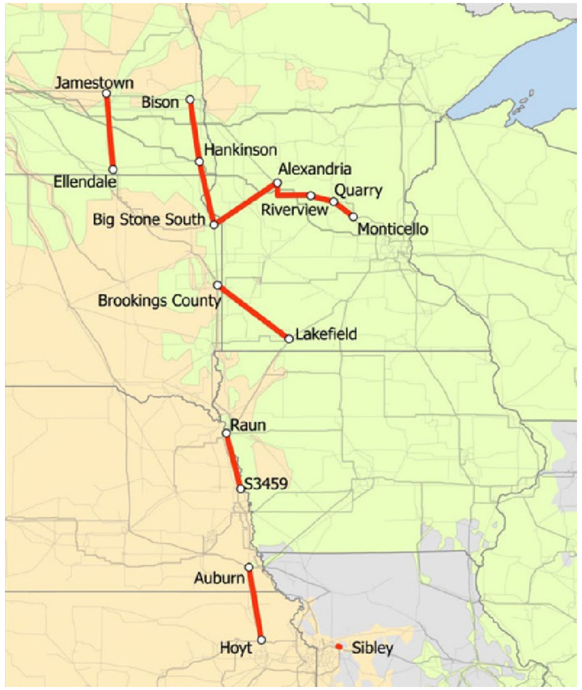


Level 3: MISO-SPP JTIQ Results

Utilize JTIQ to represent **Level 3** (higher level of proactive planning).

- JTIQ was designed to identify efficiencies between both MISO and SPP's GI processes.
  - JTIQ evaluated the new GI across large geographic portions of the SPP-MISO seam.
  - Contingency analysis indicated a large number of constraints spread all over the MISO-SPP footprint would require mitigation in order to facilitate the studied GI.
- JTIQ identified transmission projects required to address the significant transmission limitations restricting the opportunity to interconnect new generating resources near the MISO-SPP seam – JTIQ represents a better coordinated AFS process.
- The combination of projects led to the seven-project JTIQ Portfolio with a planning level estimated cost of $1.65 billion.
  - The JTIQ Portfolio is expected to fully address the set of transmission constraints and allow development of new generation (28.6 GW) along the MISO-SPP seams.

JTIQ Portfolio



JTIQ Enabled GI Capacity (GW)

JTIQ Results	Enable GI (GW)		
	MISO	SPP	Total
GI Through Resolving Existing Seams Constraints	5.4	3.5	8.9
Additional GI Enabled	12.1	7.7	19.7
Total	17.5	11.1	28.6

Table of Contents

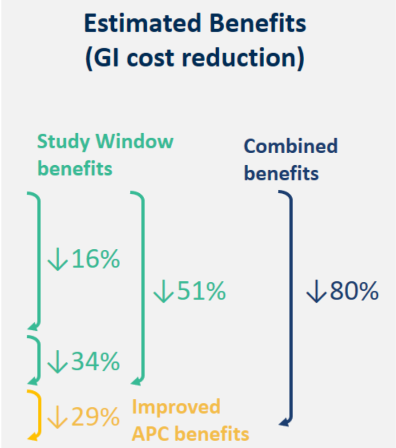
Section Summary

This *Study* looks at how the GI process can benefit from a higher level of proactive planning.

- This section summarizes the *Study* results.
  - This *Study* compares the GI costs for three levels of proactive-ness (based on the number of GI requests to study through expanding the Study Window, and an improved AFS process), using the MISO and SPP regions/sub-regions as testbeds.
  - Proactive GI planning provides significant GI cost reduction.

Key Study Results

Cases	Description	Study Window	MW Added	Cost ($ million)	Cost ($/kW)
LEVEL 1	SPP cluster studies (2017)	0.5 Years[*1]	5,082	$552[*2]	$109
	MISO cluster studies (2017-2018)	1 Year	5,025	$633[*2]	$126
	SPP+MISO	1 Year	10,107	$1,185	$117
LEVEL 2	SPP multiple years cluster	3 Years	960[*3]	$91	$95
	MISO multiple years cluster	3 Years	2,290[*3]	$226	$99
	SPP+MISO	3 Years	3,249[*3]	$317	$98
LEVEL 3	JTIQ	5 Years	28,600[*4]	$1,650	$58
	JTIQ – accounting for APC benefits[*5]	5 Years	28,600[*4]	$679	$24



*1: SPP recently changed to 1 year study windows.
*2: Costs assume ERIS, and where noted include affected system upgrades.
*3: The MW listed here are the two representative areas (Nebraska and Dakotas) analyzed. If the entire SPP and MISO regions were studied, the projects would add up to about 10,000 - 15,000 MW per RTO.
*4: JTIQ had 40,000 MW of projects, which 28,600 MW was able to interconnect with its proposed transmission portfolio.
*5: Level 1 and Level 2 did not analyze potential APC benefits.

Three Levels of Proactive Planning (Reminder)

***Study* Objective:** Quantify benefits of proactive GI planning using a comparison across three levels of "proactive-ness" measured by Study Window (outlook period, or time, to increase the GI project counts to include in the GI study), and improved AFS process.

LEVEL 1: LOWER LEVEL OF PROACTIVE PLANNING	Status quo; RTO/ISOs and utilities study GI on an annual (or semi-annual) basis. Analysis: Calculate normalized interconnection costs of projects in the most recent GI studies.
LEVEL 2: MEDIUM LEVEL OF PROACTIVE PLANNING	Multi-year study (3 years), rather than a single (or half a) year. Analysis: Create interconnection solutions for select projects in representative areas (from the existing GI queue); analyze power flow cases; and tally costs for solutions.
LEVEL 3: HIGH LEVEL OF PROACTIVE PLANNING	Multi-year study (5 years) together with an improved AFS process. Analysis: Analyze JTIQ and calculate normalized interconnection costs.

Comparing Benefits of Proactive Planning

- Areas selected for analyses are SPP and MISO to utilize their JTIQ results.
- For **Level 1**, we normalized the interconnection costs projects analyzed in the most recent GI studies (within last 5 years).
  - MISO: Across 5,025 MW of projects in the GI studies for 2017 and 2018.
  - SPP: Across 5,082 MW of projects in the GI study for 2017.
- For **Level 2** planning, we developed interconnection solutions for all GI projects in the focus areas for 3 years (projects were from existing GI queue that have not yet been studied by the respective RTOs) and used generic cost estimates to calculate average interconnection costs for the solution developed.
  - We analyzed 960 MW of projects from the SPP GI queue in Eastern Nebraska and 2,290 MW from the MISO GI queue in Eastern Dakotas.
  - We performed Steady State (Power Flow) Analysis after adding new GI projects and identified new thermal overloads in for the Base Case (without contingencies) and with contingencies (N-1).
    - Analyzed over 6,000 contingencies (>3,600 for SPP and >2,700 for MISO).
    - Observed over 40 thermal overloads (17 in SPP and 24 in MISO).
    - Identified 27 upgrade needs (8 projects for SPP and 19 projects for MISO).

- For **Level 3** planning, we relied on results from JTIQ.
  - 28,600 MW of new projects interconnected for a cost of $1.65 billion (or less when adjusted for other benefits).

Level 2 analyses approaches were developed in conjunction with MISO and SPP staff, and results were shared with MISO and SPP staff as well.

Level 1: Interconnection Costs - MISO

MISO West Region Cluster, Phase III Interconnection Costs (All Requested Projects)

For cluster windows that closed during 2017 and 2018.

	2017	2018	Total
Total Cost of Cluster Projects ($ million)	$446.3	$186.8	$633.1
New Projects Interconnecting	15	22	37
Solar	7	12	19
Wind	8	7	15
Other	0	3	3
Capacity Interconnecting (MW)	2,458	2,567	5,025
Solar	858	1,096	1,954
Wind	1,600	1,440	3,040
Other	0	31	31
Annual generation enabled from new capacity (GWh/yr)	7,485	7,690	15,175
Interconnection Cost per Project ($ million)	**$29.8**	**$8.5**	**$17.1**
Interconnection Cost per kW Capacity ($/kW)	**$182**	**$73**	**$126**
Interconnection Cost per MWh Capacity ($/MWh)	**$60**	**$24**	**$42**

Level 1: Interconnection Costs - SPP

SPP Interconnection Costs - Final (All Requested Projects)
For cluster windows that closed during 2017

	2017	2018	Total
Total Cost of Cluster Projects ($ million)	$551.8	-	$551.8
New Projects Interconnecting	64	-	64
Solar	19	-	19
Wind	14	-	14
Other	31	-	31
Capacity Interconnecting (MW)	5,082	-	5,082
Solar	2,198	-	2,198
Wind	2,885	-	2,885
Other	0	-	0
Annual generation enabled from new capacity (GWh/yr)	14,920	-	14,920
Interconnection Cost per Project ($ million)	**$8.6**	-	**$8.6**
Interconnection Cost per kW Capacity ($/kW)	**$109**	-	**$109**
Interconnection Cost per MWh Capacity ($/MWh)	**$37**	-	**$37**

Level 2: Interconnection Costs

MISO (Eastern Dakotas)

- New interconnection capacity: 2,290 MW
- Contingencies analyzed: > 2,700
- Thermal overloads: 24
- System upgrades: 19
  - Violation types include N-1 and Base Case
- Total upgrade cost: **$225.8 million ($98.6/kW)**

Control Area	Number of Upgrades	Total Upgrade Cost ($ million)
XEL	4	$56.0
GRE	1	$20.3
OTP	8	$99.2
MDU	6	$50.3
-	**19**	**$225.8**

SPP (Eastern Nebraska)

- New interconnection capacity: 960 MW
- Contingencies analyzed: > 3,600
- Thermal overloads: 17
- System upgrades: 8
  - All N-1 violation types
- Total upgrade cost: **$91.4 million ($95.3/kW)**

Control Area	Number of Upgrades	Total Upgrade Cost ($ million)
WERE	1	$18.2
KCPL	6	$70.4
NPPD	1	$2.8
-	**8**	**$91.4**

Level 3: JTIQ Results

- JTIQ combines MISO and SPP GI studies *AND* enhances the transmission system at the seams of the two systems.
  - This is enhancing the AFS process.
- JTIQ Portfolio (seven transmission projects with a cost of $1.65 billion) enabled 28.6 GW of new GI.
  - JTIQ initially studied the 8.9 GW of projects from the GI queue, then later assessed that the systems can accommodate an additional 19.7 GW of GI once the JTIQ Portfolio is added.
  - JTIQ Portfolio is estimated to reduce adjusted production costs (APC) by $971 million ($724 million in MISO and $247 million in SPP) before the addition of any new GI.
  - JTIQ results can be interpreted in several ways (see next slide).

JTIQ Supplemental Analyses Findings (not considered as part of this *Study*)

- 60% of the constraints that would otherwise be assigned to GI customers in MISO (over $65 million of assigned network upgrade costs) and 44% of the constraints that would otherwise be assigned to GI customers in SPP (over $301 million of assigned network upgrade costs) for mitigation could be addressed by the JTIQ Portfolio.
- JTIQ Portfolio is expected to have no adverse impact (no new constraints observed after inclusion).

Level 3: JTIQ Results - Interpretation

- JTIQ results can be interpreted in several ways. Two bookend interpretations are used for this *Study*:
  1. 28.6 GW of new GI cost $1.65 billion: GI cost of $57.7/kW.
     – The most simplest and straightforward approach. Any additional benefits (e.g., APC benefits) will not be considered as an offset to GI costs (as is in many cases today). Projects do not necessarily need to build in the same year or cluster.*1
  2. 28.6 GW of new GI cost $679 million (i.e., $1.65 billion adjusted by $971 million APC benefits): GI cost of $23.7/kW.
     – Assumes a cost allocation mechanism that allows for GI customers to benefit from (or load to pay for) the APC benefits. If the cost allocation mechanism allows for GI customers to share half of the APC benefits with load, the GI cost would be $40.6/kW.

JTIQ Enabled GI Capacity (GW)

JTIQ Results	Enable GI (GW)		
	MISO	SPP	Total
GI Through Resolving Existing Seams Constraints	5.4	3.5	8.9
Additional GI Enabled	12.1	7.7	19.7
Total	17.5	11.1	28.6

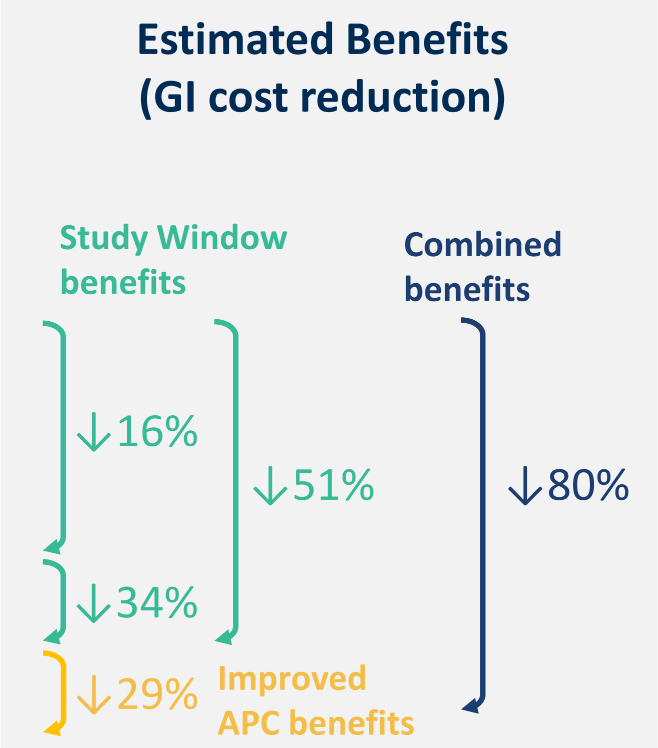
*1: FERC has approved tariff provisions (for MISO and NYISO) that require interconnection customers in later cluster studies that benefit from network upgrades completed prior to that later-in-time GI customer commencing commercial operation to partially reimburse the earlier cluster GI customer, who were responsible for the initial upgrade costs.

Study Results - Summary 1

Proactive GI planning provides significant cost reduction with benefits growing with expanded GI project counts and improved AFS process.

Benefits of Proactive GI Planning

Cases	Description	Study Window	MW Added	Cost ($ million)	Cost ($/kW)
LEVEL 1	SPP cluster studies (2017)	0.5 Years[*1]	5,082	$552[*2]	$109
	MISO cluster studies (2017-2018)	1 Year	5,025	$633[*2]	$126
	SPP+MISO	1 Year	10,107	$1,185	$117
LEVEL 2	SPP multiple years cluster	3 Years	960[*3]	$91	$95
	MISO multiple years cluster	3 Years	2,290[*3]	$226	$99
	SPP+MISO	3 Years	3,249[*3]	$317	$98
LEVEL 3	JTIQ	5 Years	28,600[*4]	$1,650	$58
	JTIQ – accounting for APC benefits[*5]	5 Years	28,600[*4]	$679	$24

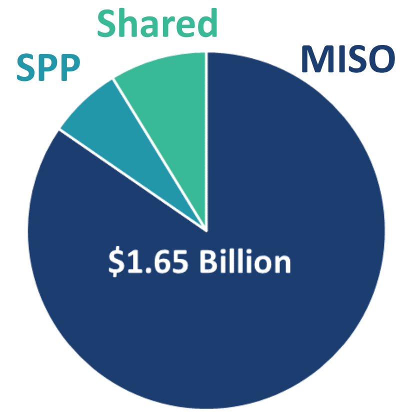


*1: SPP recently changed to 1 year study windows.
*2: Costs assume ERIS, and where noted include affected system upgrades.
*3: The MW listed here are the two representative areas (Nebraska and Dakotas) analyzed. If the entire SPP and MISO regions were studied, the projects would add up to about 10,000 - 15,000 MW per RTO.
*4: JTIQ had 40,000 MW of projects, which 28,600 MW was able to interconnect with its proposed transmission portfolio.
*5: Level 1 and Level 2 did not analyze potential APC benefits.

Study Results - Summary 2

Proactive GI planning (looking at multiple years) lowers interconnection costs.

- Traditional cluster windows have higher average costs than mid- and long-term proactive planning.
  - MISO (2017-2018)*1: 37 interconnecting projects, average interconnection costs of $126/kW.
  - SPP (2017)*2: 177 interconnecting projects, average interconnection costs of $109/kW.
- Extending GI studies' Study Window by 2 years (from 1 to 3 years) lowers GI costs by about 16%.
  - MISO : 10 renewable projects adding up to 2,290 MW, average interconnection costs of $99/kW.
  - SPP : 5 renewable projects adding up to 960 MW, average interconnection costs of $95/kW.
- JTIQ is utilized as an example of proactive planning that fills the gap between transmission expansion studies (10 or 20 years) and GI studies.
  - Considers a five-year window of queue projects for optimal planning.
  - Provides an improved AFS process and identifies seven transmission upgrades to the MISO-SPP seam that will alleviate capacity constraints and high cost thresholds for individual interconnecting projects: $1.65 billion.
- JTIQ portfolio is estimated to enable 28.6 GW of new capacity with average GI costs of $57.7/kW.



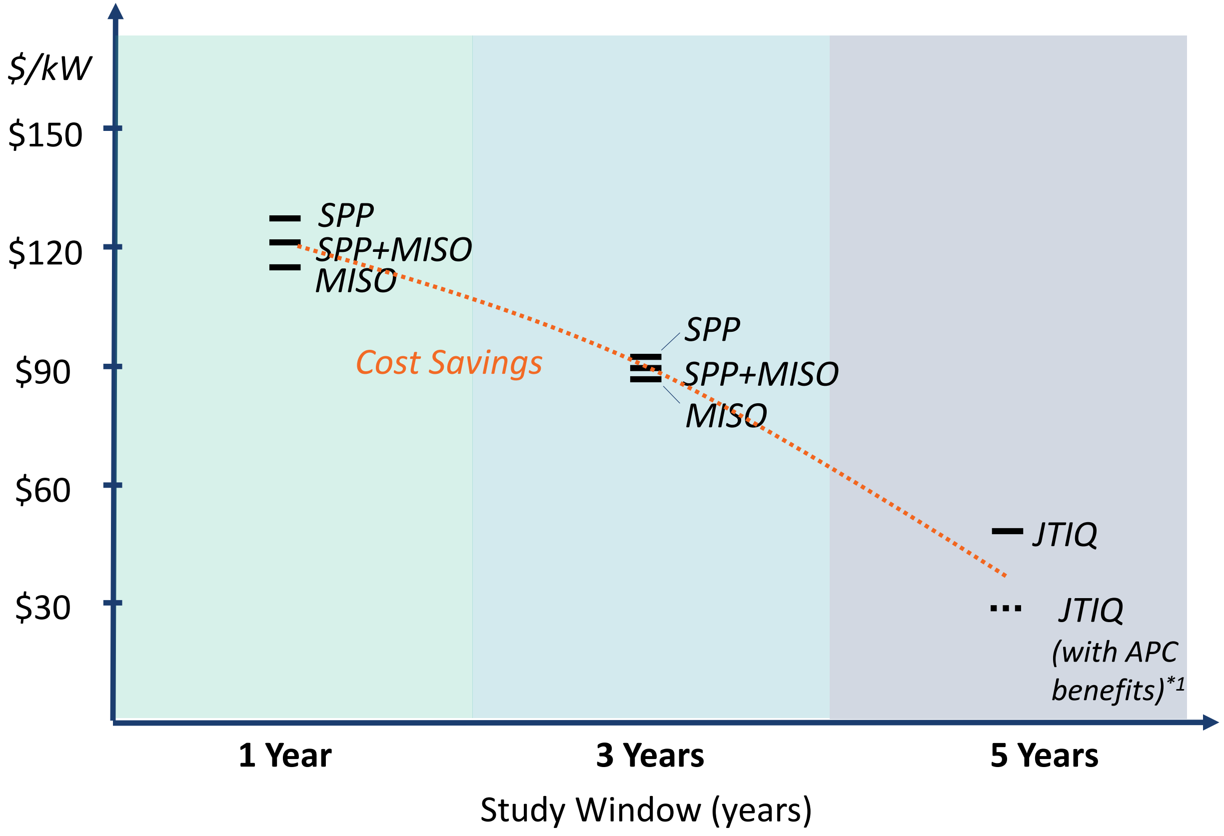
JTIQ Portfolio Costs

*1: For MISO, the Study looked at proposed projects that were part of the West region cluster. This removed the effect of projects in other regions that had significant excess transmission capacity (and thus are not representative of traditional interconnecting projects with required network upgrades).
*2: SPP impact and affected system studies for cluster windows that closed in 2018 have not been published, as of June 22, 2022.

Study Results - Observations

Proactive GI planning (looking at more GI projects and improving the AFS process) reduces GI costs.

Expanding the GI projects count (i.e., expanding the Study Window) with a better coordinated AFS process can ***reduce the GI cost to nearly half***, or even ***down to a fifth*** if APC is considered. While a ***JTIQ-like proactive GI approach is ideal*** in the longer-run, expanding the GI projects count may be a suggested improvement that can be implemented quickly.



Benefits measured in GI cost reduction (%)

Benefits of expanding the Study Window

- GI project count from 1 to 3 years: 16%

Benefits of expanding the Study Window and AFS improvement

- GI project count from 1 to 5 years with AFS improvements: 51%

This suggests non-linear growth in benefits when the AFS process is improved along with increasing the project counts. However, there may be a natural limit to Study Window expansion because many IR do not go beyond 4 years in the future. (See slide 28)

- APC benefits*1 associated with improved AFS: 29%

Without a cost allocation methodology, GI customers may not see this benefit.

- Combined benefits: 80%

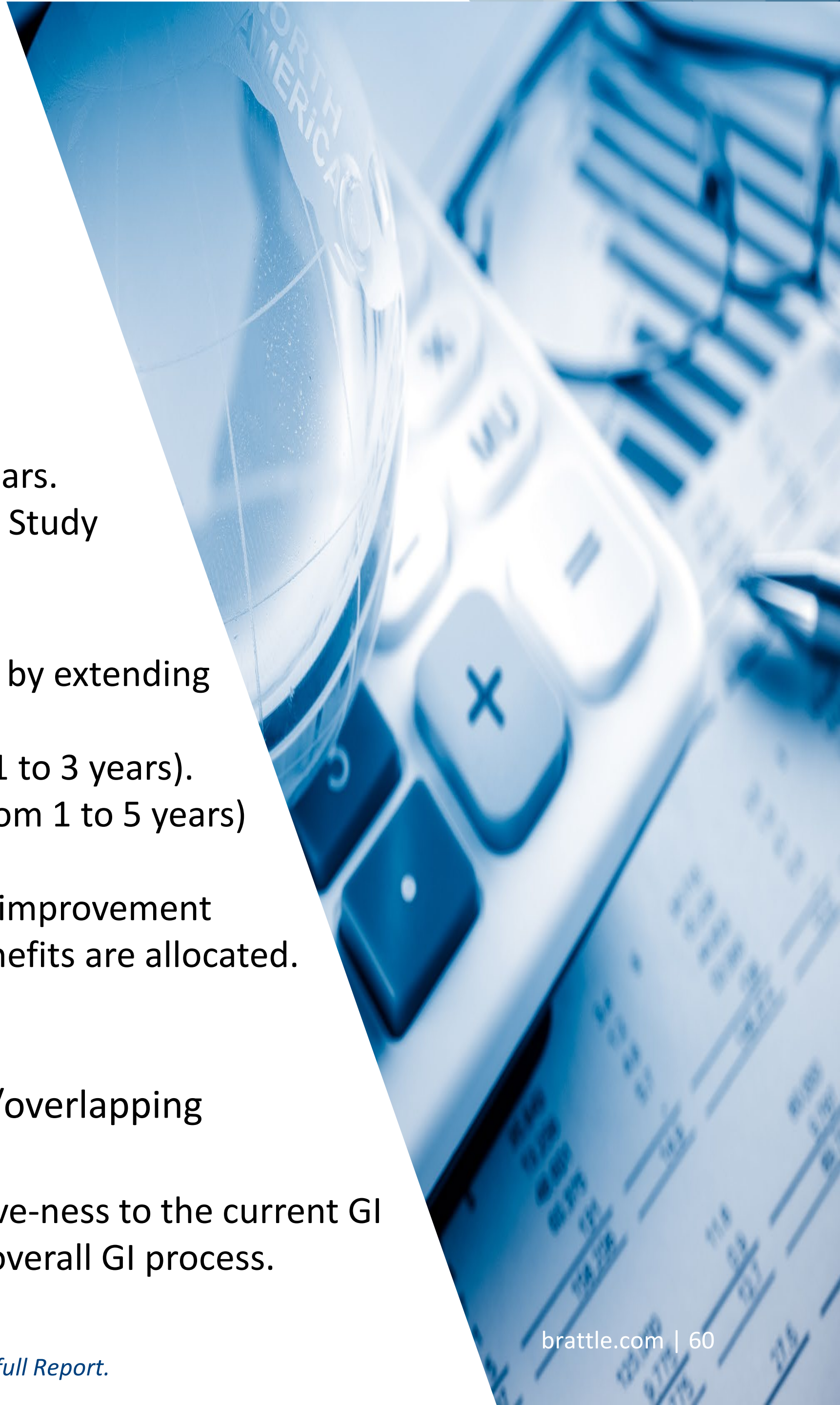
Coordinated GI planning (as represented by JTIQ) can potentially realize this level of benefits and help fill the gap between GI studies and transmission planning.

*1: Level 1 and Level 2 (1 and 3 Years Study Window) did not analyze potential APC benefits.

Study Results - Additional Assessments

Proactive GI planning can help bridge the gap between short-term GI studies and long-term transmission planning studies while reducing GI costs significantly.

- Expanding the Study Window can lead to substantial reduction in GI costs.
  - Study shows material reduction in GI costs with the Study Window extended to multiple years.
  - Many IRs are concentrated within the next few years (3 to 4 years or less) so expanding the Study Window for 5 years may not be practical.
- Improving the AFS process can further reduce GI costs.
  - Benefits of improved AFS process are likely equal to, or perhaps larger than those provided by extending the Study Window.
    - Study Window expansion benefit is calculated to be 16% for 2 years of extension (from 1 to 3 years).
    - The combined benefits of improved AFS and extending the Study Window by 4 years (from 1 to 5 years) is 51%.
    - If the Study Window expansion benefit is assumed linear (i.e., 16% for 2 years), the AFS improvement benefits calculate to be 19% (51% - 16% * 2 = 19%) or more, depending on how APC benefits are allocated.
  - Improving the AFS process through JTIQ led to $979 million of APC benefits.
    - Without a cost allocation mechanism, GI customers may not receive that benefit.
- These examples show how expanding the scope of the current GI studies, or combining/overlapping its scope with transmission planning, could provide significant benefits.
  - The benefits identified in this Study is built on the premise of incrementally adding proactive-ness to the current GI process. This should not be the ultimate goal but rather a transitional step to improve the overall GI process.



Study Results - Applications

Proactive GI planning can help bridge the gap between short-term GI studies and long-term transmission planning studies while reducing GI costs significantly.

- Expanding the Study Window can be used as a way to resolve existing backlog.
  - This Study bundled multiple years-worth of projects from the existing queue that have not yet been studied by the respective RTOs. Once the GI backlog is eliminated, a similar approach may not be feasible, nor practical.
- A cost allocation mechanism that allows late-comers to pay their share could allow the Study Window expansion approach to be incorporated in future GI studies.
  - Such allocation methods would likely reduce the needs for restudies and allow for expanding the GI project counts based on projected IRs or other long-term study implications.
    - This is particularly the case because over 90% of the IR are renewable resources, which are locational dependent (and thereby if a project withdraws, another one will likely come in to replace it).
    - FERC has approved tariff provisions (e.g., for MISO and NYISO) that require GI customers in later cluster studies that benefit from network upgrades completed prior to that later-in-time GI customer commencing commercial operation to partially reimburse the earlier cluster GI customer, who were responsible for the initial upgrade costs. Such policies would greatly support extending the study window.
  - Proactive transmission projects that successfully integrated large amounts of renewables have all been fully subscribed, suggesting the probability of underfunding may not be as severe.

Study Results - Other Proposals

Various other solutions have also been proposed to alleviate the growing GI queue, including:

- Perform consolidated transmission and GI planning.
- Impose a substantial penalty for withdrawing interconnection requests.
- Require queue position maintenance fee and/or increase study fees.
- Make site control requirements more stringent.
- Emulate the streamlining of gas pipeline permitting system to transmission so to reduce the hurdles.*1

The recent FERC NOPR titled Improvements to Generator Interconnection Procedures and Agreements (Docket No. RM21-17-000) proposes several of these solutions, among others.

In addition, RTOs and FERC have proposed changes and offered recommendations to reduce backlog.

- Both MISO and SPP have proposed changes to reduce their backlogs (see appendix).
- JTIQ also describes changes that MISO and SPP adopt or plan to adopt to streamline the interconnection processes – the current plan is to update/repeat JTIQ every two years.
- MISO and SPP also mutually agreed (through the JTIQ process) to change their relative GI queue priority from a first-come, first-serve basis to first-ready, first-serve basis for GI cluster studies.

*1: The Natural Gas Act requires FERC to lead the interstate natural gas pipeline permitting processes and coordinate with federal, state, and local agencies that have statutory and regulatory authority over various environmental laws and regulations.

FERC GI NOPR Considerations - Concerns and Proposals

FERC on June 16, 2022 issued a Notice of Proposed Rule Making titled Improvements to Generator Interconnection Procedures and Agreements (Docket No. RM21-17-000).

FERC's five key concerns of the current GI approach:

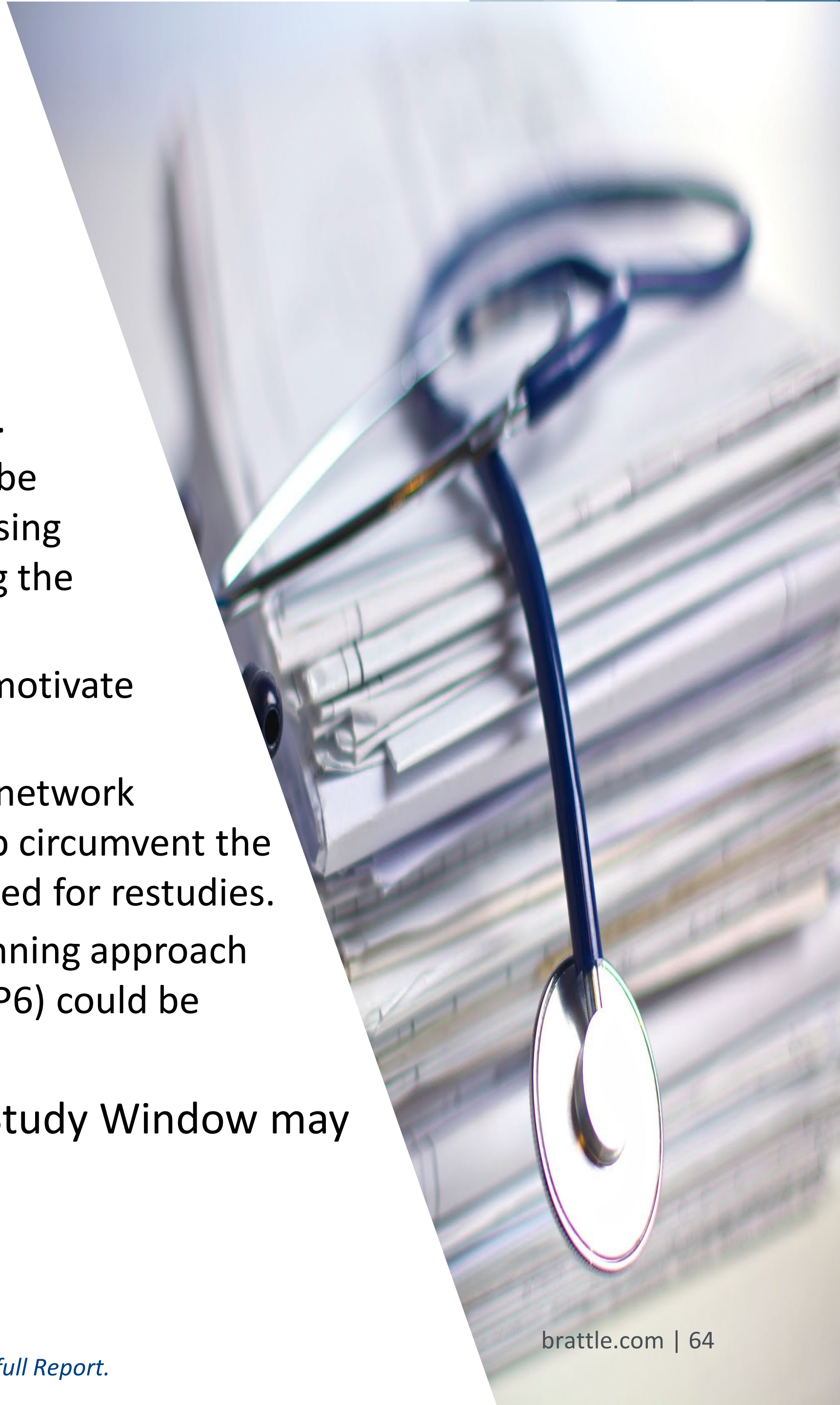
- C1. The information (or lack thereof) available to prospective interconnection customers and the commitments required of them to enter and progress through the interconnection queue;
- C2. The reliance on a serial first-come, first-served study process and the standard to which transmission providers are held for meeting interconnection study deadlines;
- C3. The protocols for affected systems studies;
- C4. The provisions for studying new or hybrid (co-located) generation technologies and considering alternative transmission technologies; and
- C5. The performance requirements for inverter-based technologies, including wind, solar, and electric storage facilities.

FERC's proposals to address these five concerns:

- P1: Creating an optional information interconnection study process that would include cost estimates.
- P2: Replacing the first-come, first-serve GI study process with a first-ready, first-served cluster study process.
- P3: Increasing financial commitments and readiness requirements (and withdrawal penalties) for GI projects.
- P4: Allocating network upgrade cluster costs based on a proportional impact method and require a cost allocation method for sharing network upgrade costs among all cluster participants for shared benefits, including those in earlier and later cluster studies.
- P5: Standardizing and accelerating the AFS process.
- P6: Placing standards (and penalties) imposed on transmission providers for meeting study timelines.

FERC GI NOPR Considerations - Relevance

- Extension of GI study window or scope illustrated in this Study can help with the FERC GI NOPR proposals:
  - The approach (extended Study Window) can be used for the informational study (P1).
  - The approach (extended Study Window and improved AFS process) and benefits can be realized through the first-ready, first-served proposal (P2). This combined with increasing readiness requirements (P3) would likely reduce withdrawals and make implementing the extended Study Window easier.
  - The scope benefits associated with improved AFS process analyzed in this Study can motivate standardizing the AFS process (P5).
  - A mechanism (that some RTOs already have in place today) that allows for allocating network upgrade costs, including those in earlier and later cluster studies (P4), would also help circumvent the potential short-comings of the approach (extending study window)—the potential need for restudies.
  - Finally, although not exclusively discussed as part of the Study, if the proactive GI planning approach illustrated can speed up the process, the speed of processing and timeline standard (P6) could be addressed (even if partially).
- While a JTIQ-like approach is recommended in the longer-run, extending the Study Window may be a suggested improvement that can be implemented quickly.



Study Limitations

Scope: Focuses on proactive interconnection planning benefits

Intention was to evaluate multi-year planning (rather than change in study or geographical scope)

- This study is not a substitute for an interconnection engineering study.
- Study analyzes generic ERIS equivalent; NRIS benefits may differ (costs likely higher for deliverability upgrades).
- Considered baseline scenarios – no advanced technologies (Grid Enhancing Technologies, storage, HVDC etc.) were evaluated.

Assumption: Perfect foresight and no restudies

Renewable developments often are interested in the same location, meaning withdrawn projects don't impact the study

- This assumption is relevant for today where >90% of the GI queue is renewables.[1, 2]
- When projects withdraw, similar alternatives often will take their place later (as observed in the ERCOT CREZ lines, or SPP 345 kV collector system).
- Desirable renewable locations do not change much over time.

Limit: Does not address cost allocation or other GI issues

The study stops before considering cost allocation, resulting in uniform upgrade costs across projects

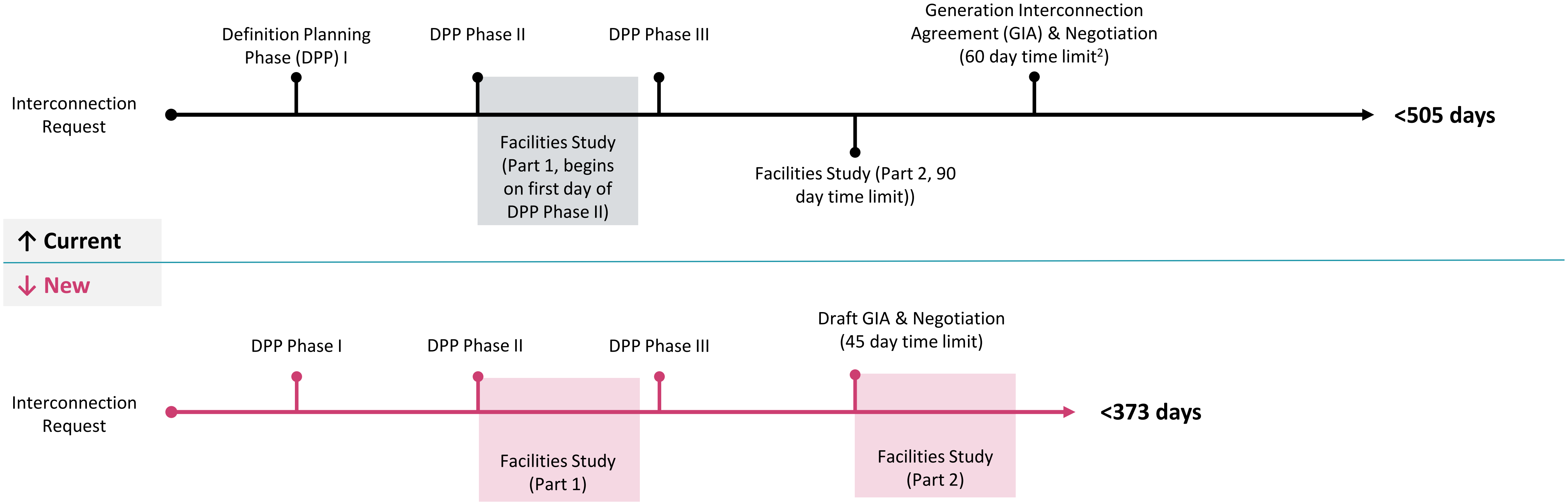
- Cost allocation varies system by system and can be difficult to generalize.
- The question of who pays and its mechanics (e.g., participant funding vs. crediting) is critical in solving the interconnection backlog.
- A thorough follow-up study for specific systems would be required to better understand the implications and practical implementation of proactive planning along with cost allocation.

1: Queued Up…But in Need of Transmission, Department of Energy: Office of Policy, April 2022
2: FERC's June 16, 2022 NOPR (Docket No. RM22-14-000) proposes a first ready-first serve base approach, which, if realized would likely reduce restudies.

Table of Contents

MISO Backlog Mitigation

On March 15, 2022, FERC Order ER22-661-000 approved MISO's proposed Tariff revisions that reform their generator interconnection procedure (GIP), finding that they are *"just, reasonable, and not unduly discriminatory or preferential because they will shorten the length of MISO's GIP timeline."*[1]



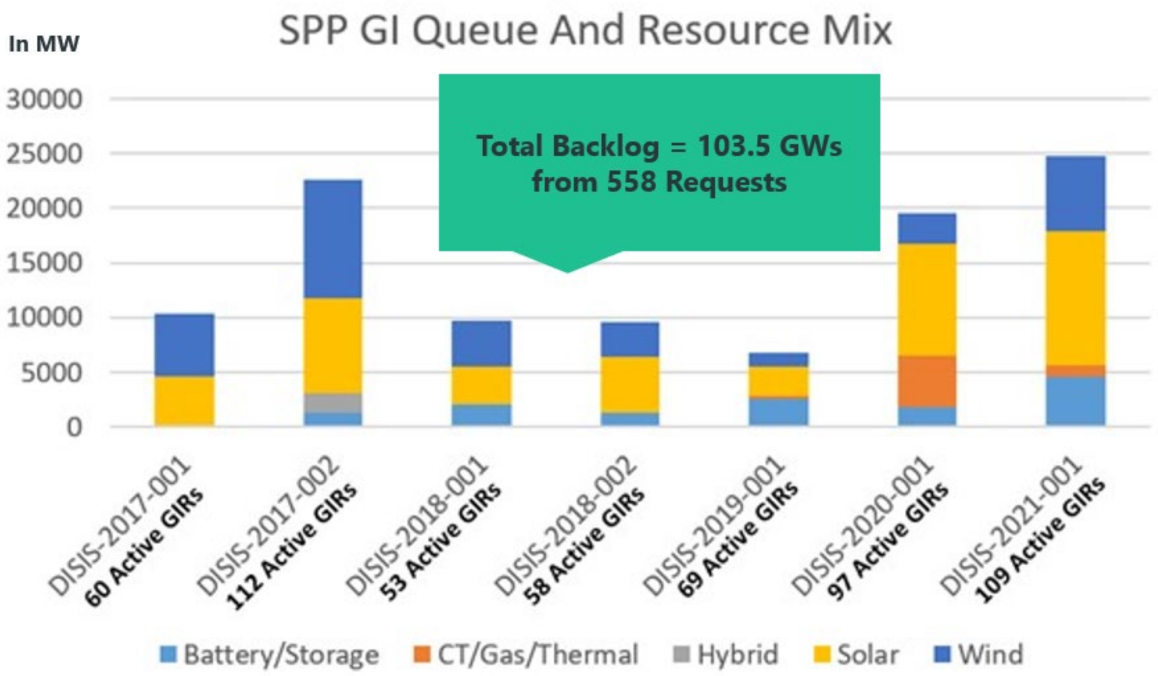
[1] FERC Order ER22-661-000

[2] Longer if a facilities construction agreement or multi-party facilities construction agreement is required.

SPP Backlog Mitigation

SPP's Strategic and Creative Re-Engineering of Integrated Planning Team (SCRIPT) was tasked with developing multiple policy solutions to modify the transmission planning process. SCRIPT was organized in August 2020, with the goal of producing recommendations by October 2021.[1]

- Resulted in some of the very same ideas as MISO's expedited GIP incorporates:
  - Coinciding studies (including beginning the facilities studies as part of Phase 2)
  - Move GIA negotiation earlier
- Other recommendations:
  - Increase non-refundable financial commitments to discourage withdrawals that necessitate restudies
  - Adjust existing and future clusters:
    - Leave 2022's open until 2021's is completed
    - Combine clusters (2018 and 2019) for more efficient studies



Source: SCRIPT Report and Recommendations, September 24, 2021.

[1] Staff Recommendation to the SPP Board of Directors, SPP, August 31, 2020.

Glossary

AFS: Affected Systems study
APC: Adjusted Production Cost
CREZ: Competitive Renewable Energy Zone
DPP: Definitive Planning Phase
DISIS: Definitive Interconnection System Impact Study
ERIS: Energy Resource Interconnection Service
ESIG: Energy Systems Integration Group
FERC: Federal Energy Regulatory Commission
GI: Generation Interconnection
IA: Interconnection Agreement
IR: Interconnection Requests
JTIQ: Joint Targeted Interconnection Queue Study
LBNL: Lawrence Berkeley National Laboratory
MISO: Midcontinent Independent System Operator
MVP: Multi-Value Projects
NOPR: Notice of Proposed Rule Making
NRIS: Resource Interconnection Services
ROFR: Right of First Refusal
SPP: Southwest Power Pool

Clarity in the face of complexity

Brattle