Proactive Planning for Generation Interconnection

A Case Study of SPP and MISO

DEVELOPED IN CONJUNCTION WITH ESIG PROACTIVE PLANNING TASK FORCE

PRESENTED BY

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About the Study

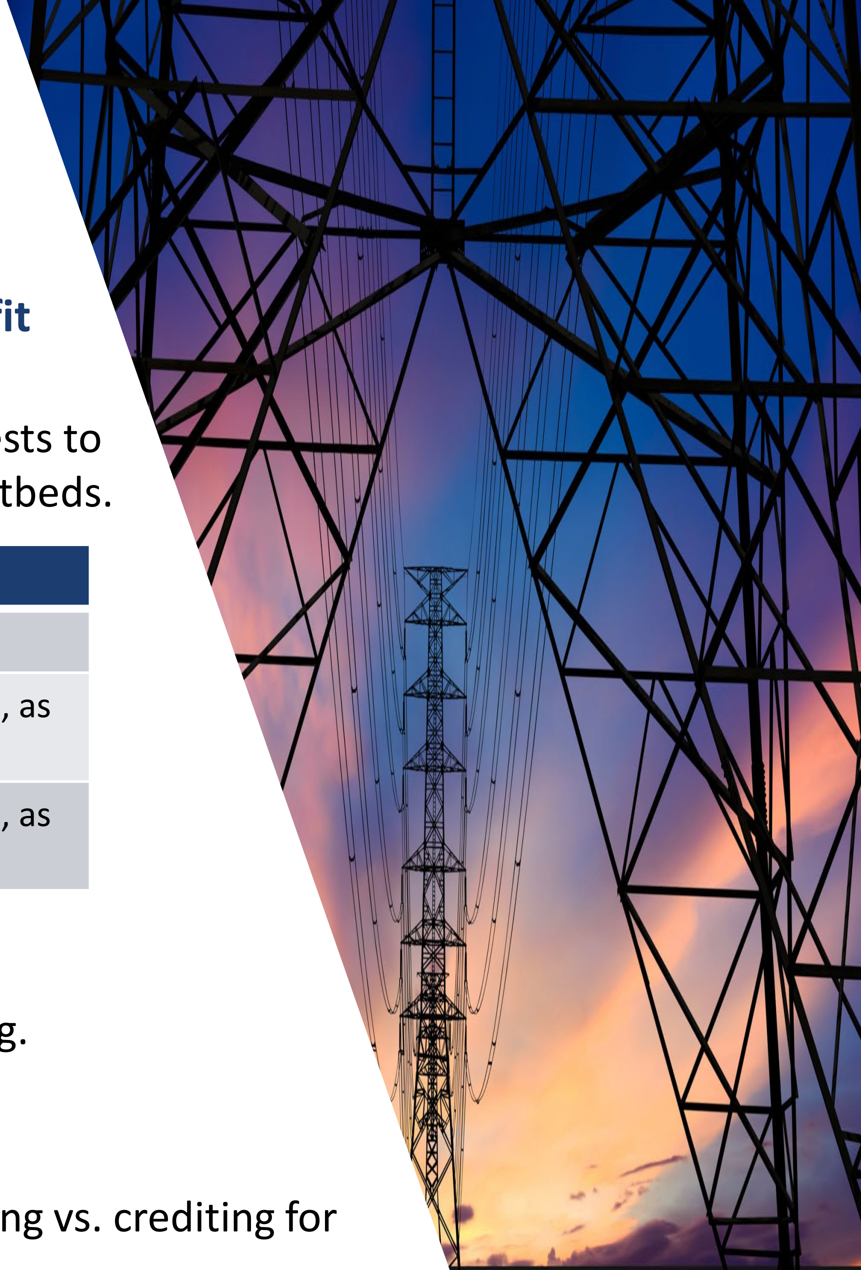
This Study looks at how the Generation Interconnection (GI) process can benefit from a higher level of proactive planning.

- The Study looks at three levels of proactive-ness (based on the number of GI requests to study, by including more years), using the MISO and SPP regions/sub-regions as testbeds.

Levels	Proactive-ness	Description
Level 1	Low	Status quo, where GI studies are performed on an annual basis.
Level 2	Medium	GI studies are performed looking at multiple years (3 years) of projects, as identified today.
Level 3	High	GI studies are performed looking at multiple years (5 years) of projects, as identified today, together with other transmission enhancements.

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

- This Study attempts to illustrate (and quantify) the benefits of proactive GI planning.
  - It is not a substitute for an interconnection engineering study.
  - It does not consider restudies as part of the process.
  - It does not address cost allocation or the current provisions for participant funding vs. crediting for interconnection-related upgrades.

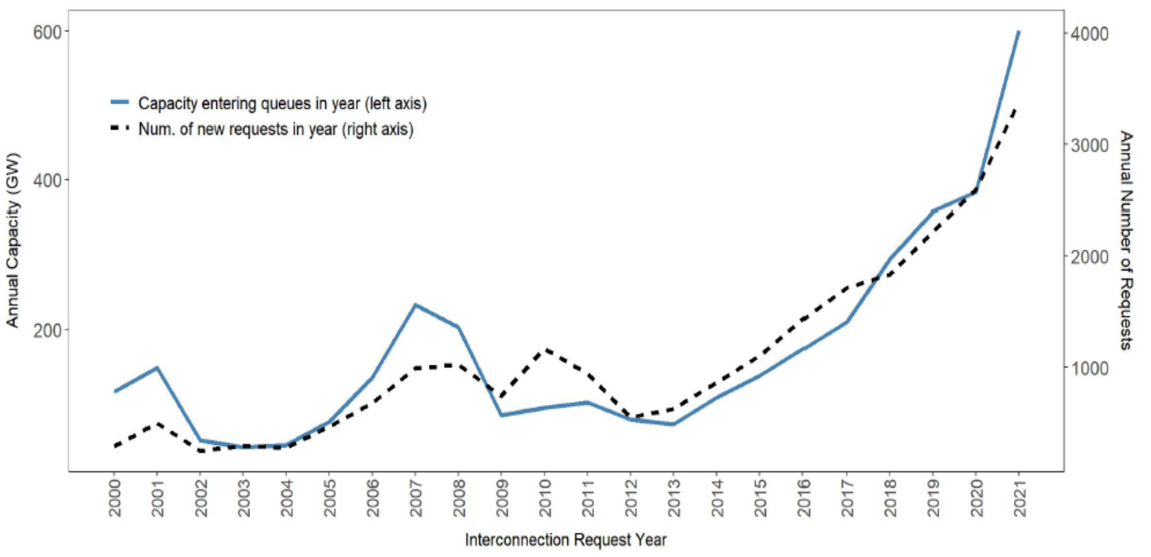


Industry Trend - More Renewables Wanted

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

Total Capacity and IR Counts in GI Queue by Year



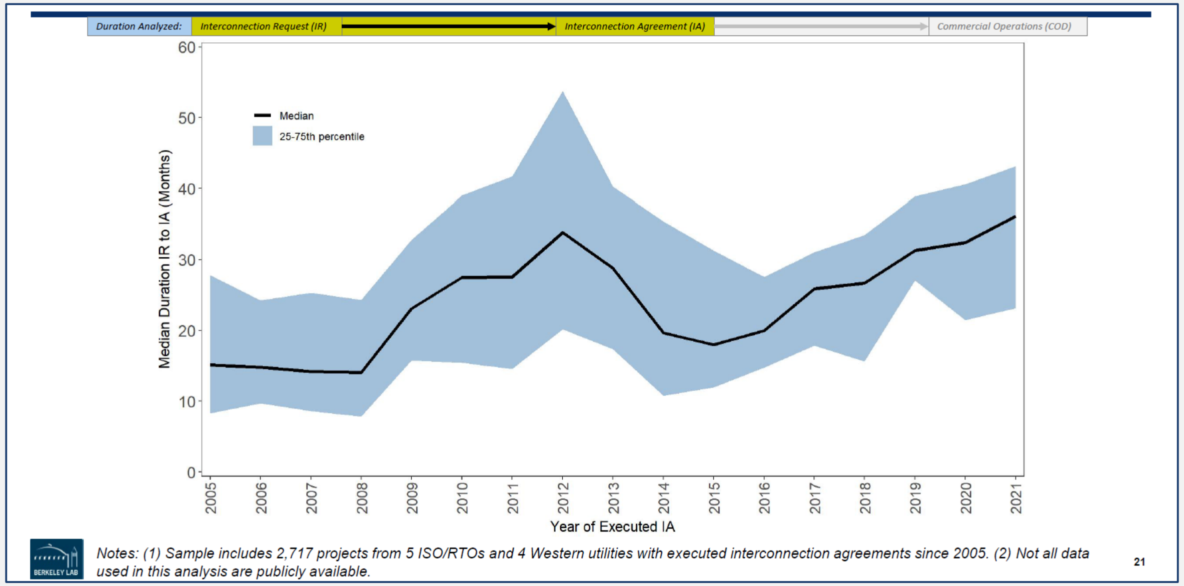
*1: Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021, Lawrence Berkeley National Laboratory (LBNL), published April 2022 (LBNL Study) analyzes interconnection queue as of end of 2021 for 7 RTO/ISO and 35 utilities, which collectively represent >85% 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
- Many RTO/ISOs are experiencing large GI queue backlogs, 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



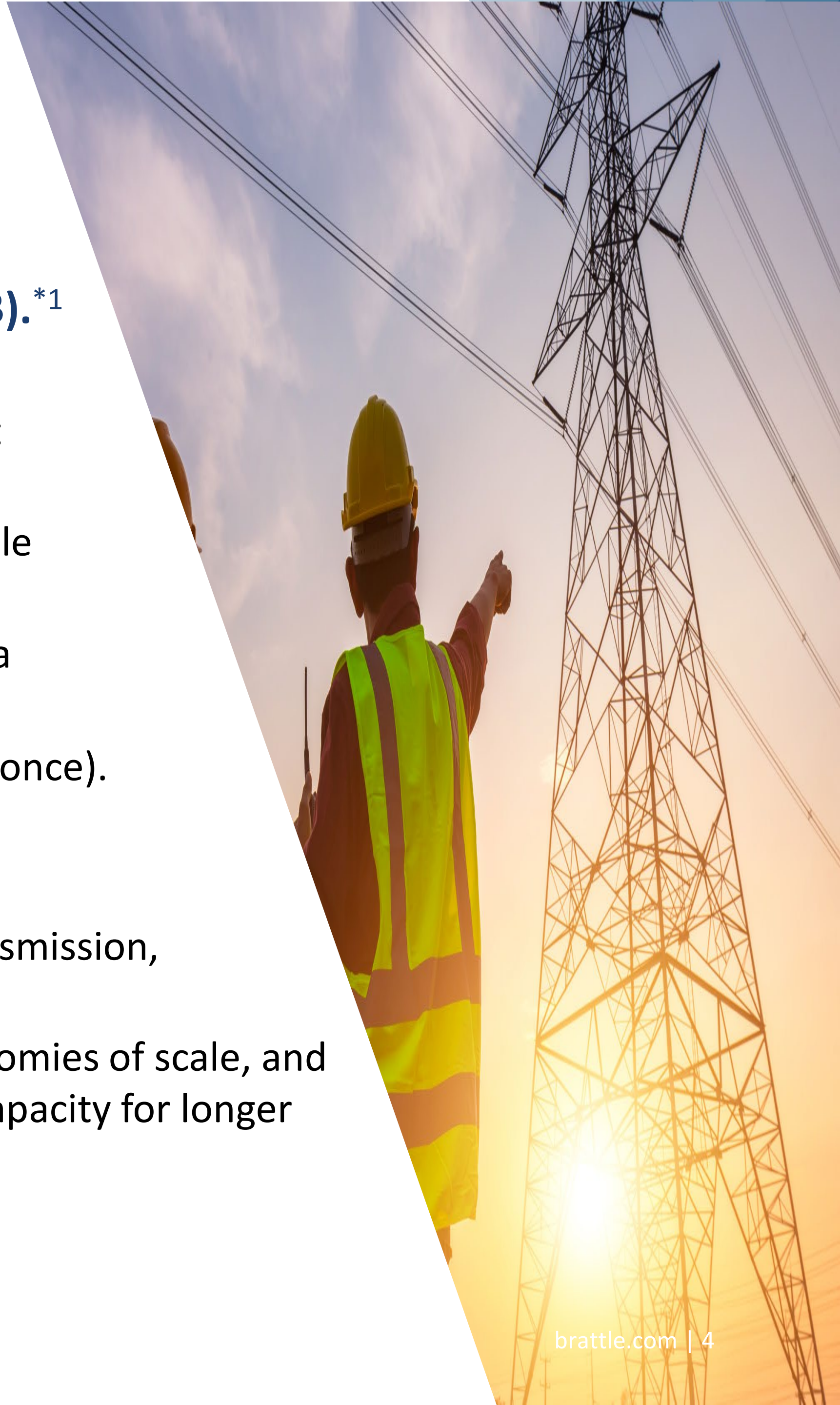
*1: LBNL Study looks at CAISO, ERCOT, NYISO, PJM, and APS to derive this.
*2: LBNL Study looks at projects completed between 2000 and 2016.

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) is heavily location-constrained.
- The current GI process requires three interconnection studies to be performed on a first-come, first-served basis.[*2]
  - Many RTOs/ISOs and utilities apply cluster approach (studying multiple projects at once).
  - Studies are typically conducted on yearly (or semi-yearly) vintage level.
- In the meantime, transmission system has become over subscribed.
  - Renewable resources can be built much quicker than gas-fueled generation or transmission, exacerbating this issue.
  - Because renewable resources can be scaled easier and take advantage of the economies of scale, and are oftentimes built in remote locations, they tend to require more transmission capacity for longer distances.

*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.



Gap in Transmission Planning and GI

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

- 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 different studies.

Will a more proactive GI approach help bridge this gap while remedying the delay and high interconnection costs observed in the current GI processes? If so, by how much?

- Proactive-ness can be for ***time (study window)*** and ***scope*** of the GI studies (among others).
  - In particular, extending the study window would increase the project counts, which through the GI cluster study transmission upgrades are optimized.

*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.

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 (by expanding the GI study scope to include more future projects in the queue) help?

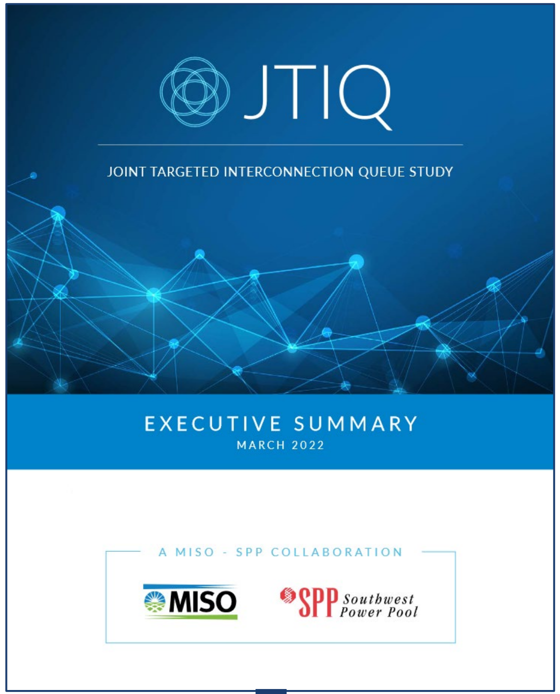
LEVEL 1: LOWER LEVEL OF PROACTIVE GI PLANNING	LEVEL 2: MEDIUM LEVEL OF PROACTIVE GI PLANNING	LEVEL 3: HIGHER LEVEL OF PROACTIVE GI PLANNING
Represents the status quo, where RTO/ISOs and utilities study GI on an annual (or semi-annual) basis.	Represents a multi-year (3 years) study window from the existing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

Illustrative Example of the 3 Levels of Proactive Planning (SPP)

Level 1 →	6 months, 1,000-5,000 MW of interconnection projects
Level 2 →	2-3 years, ~15,000 MW of interconnection projects
Level 3 →	5 years, ~40,000 MW of interconnection projects

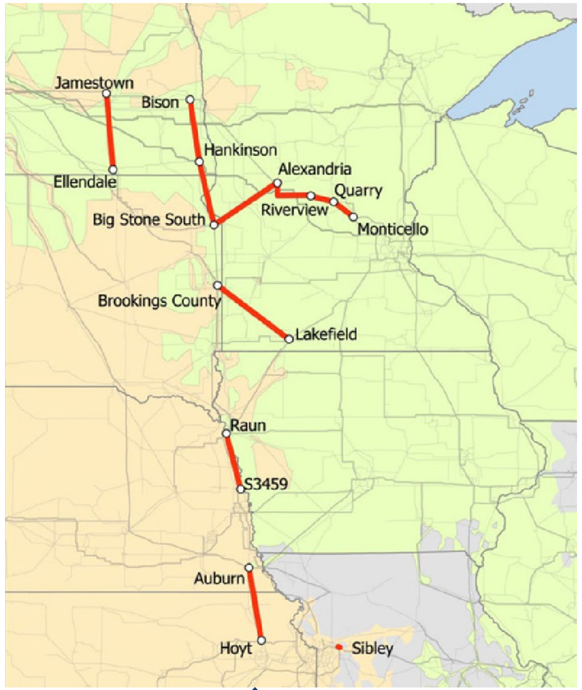
MISO-SPP Joint Targeted Interconnection Queue Study

Utilize the MISO-SPP Joint Targeted Interconnection Queue (JTIQ) study 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.
- 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.

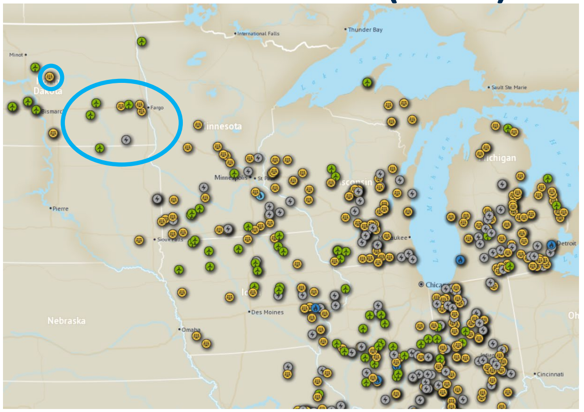
JTIQ identified seven transmission projects (JTIQ Portfolio) along the MISO-SPP seam costing $1.65 billion, which fully address constraints and further allow 28.6 GW of new GI projects (Energy Resource Interconnection Service, or ERIS, equivalent).



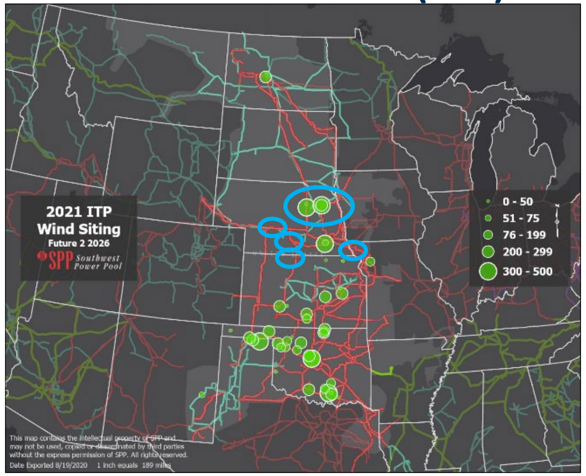
Analyzing the Benefits of Proactive Planning

1. Identify area/region to analyze.
   - The MISO and SPP regions were selected because the JTIQ study 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.
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.
     - 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 the JTIQ study results.
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).
     - Additional benefits of difference in study scope identified in the JTIQ Study.

Eastern Dakotas (MISO)



Eastern Nebraska (SPP)

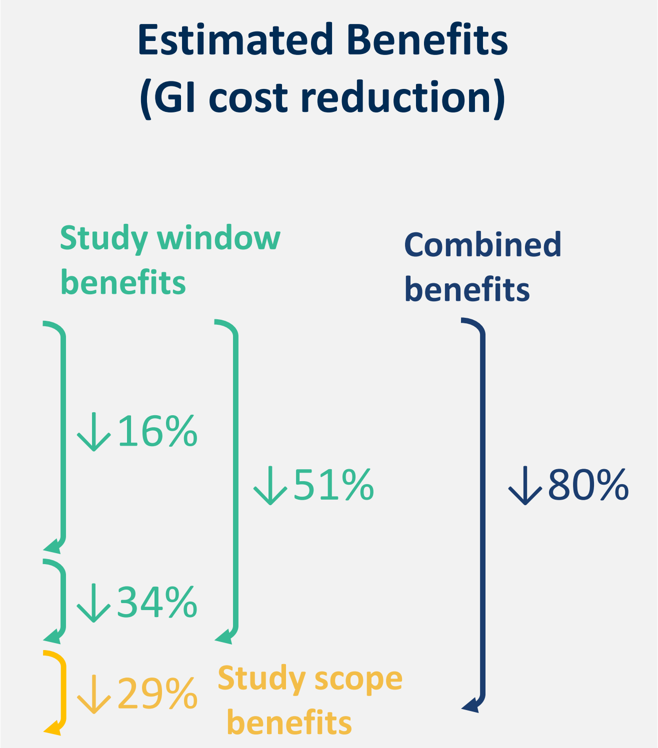


Study Results - Summary 1

Proactive GI planning provides significant cost reduction time-wise (benefits potentially growing exponentially with expanded study window of the GI studies) and scope-wise.

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	$91	$95
	MISO multiple years cluster	3 Years	2,290	$226	$99
	SPP+MISO	3 Years	3,249	$317	$98
LEVEL 3	JTIQ	5 Years	28,600	$1,650	$58
	JTIQ – adjusting for APC benefits	5 Years	28,600	$679	$24

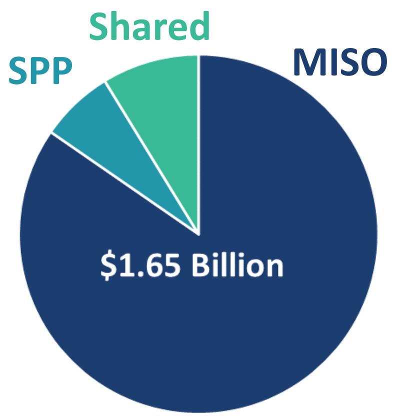


Notes:
*1: SPP recently changed to 1 year study windows.
*2: Costs assume ERIS, and where noted (*) include affected system upgrades.

Study Results - Summary 2

Proactive GI planning (looking at multiple years) 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**: The JTIQ Study is utilized as a prime example of proactive planning that fills the gap between transmission expansion studies (10 or 20 years) and GI studies.
  - The 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).***
  - The JTIQ Portfolio is also 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.
  - Accounting for this APC benefit would lower the average interconnection costs to of $23.7/kW ***(~80% reduction)***.



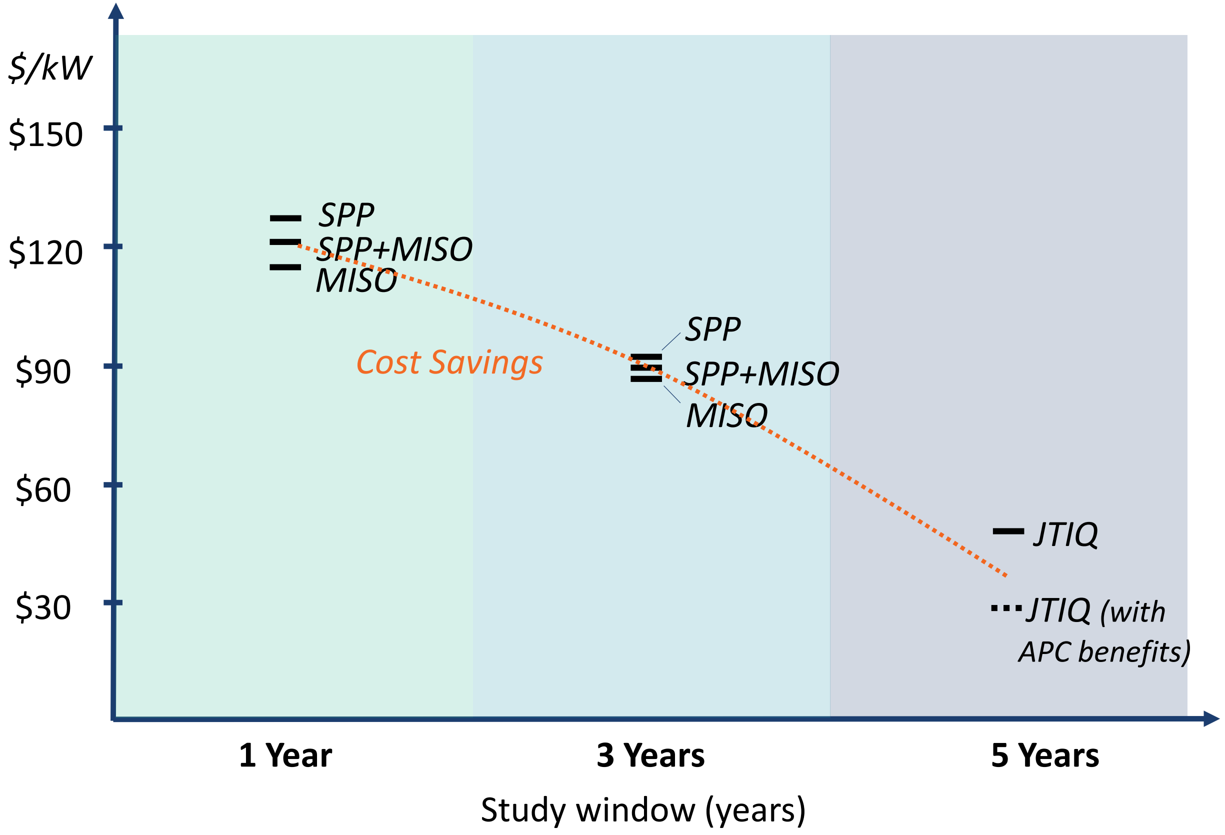
JTIQ Portfolio Costs

*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 reduces GI costs with expansion of study window and scope (non-linearly).

Extending the study window from 1 to 5 years could ***reduce the GI cost to nearly half***, or even ***down to a fifth*** if GI and other transmission needs are coordinated. While a ***JTIQ-like proactive GI approach is recommended*** in the longer-run, extending the study window may be a suggested improvement that can be implemented quickly.



Benefits measured in GI cost reduction (%)

Study window extension benefits

- By 2 years (from 1 to 3 years): 16%
- By 4 years (from 1 to 5 years): 51%

This suggests exponential growth in benefits as study window is expanded. However, there may be a natural limit because many renewable IR do not go beyond 4 to 5 years in the future. (See slide 26)

- Study scope extension (APC) benefits: 29%

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

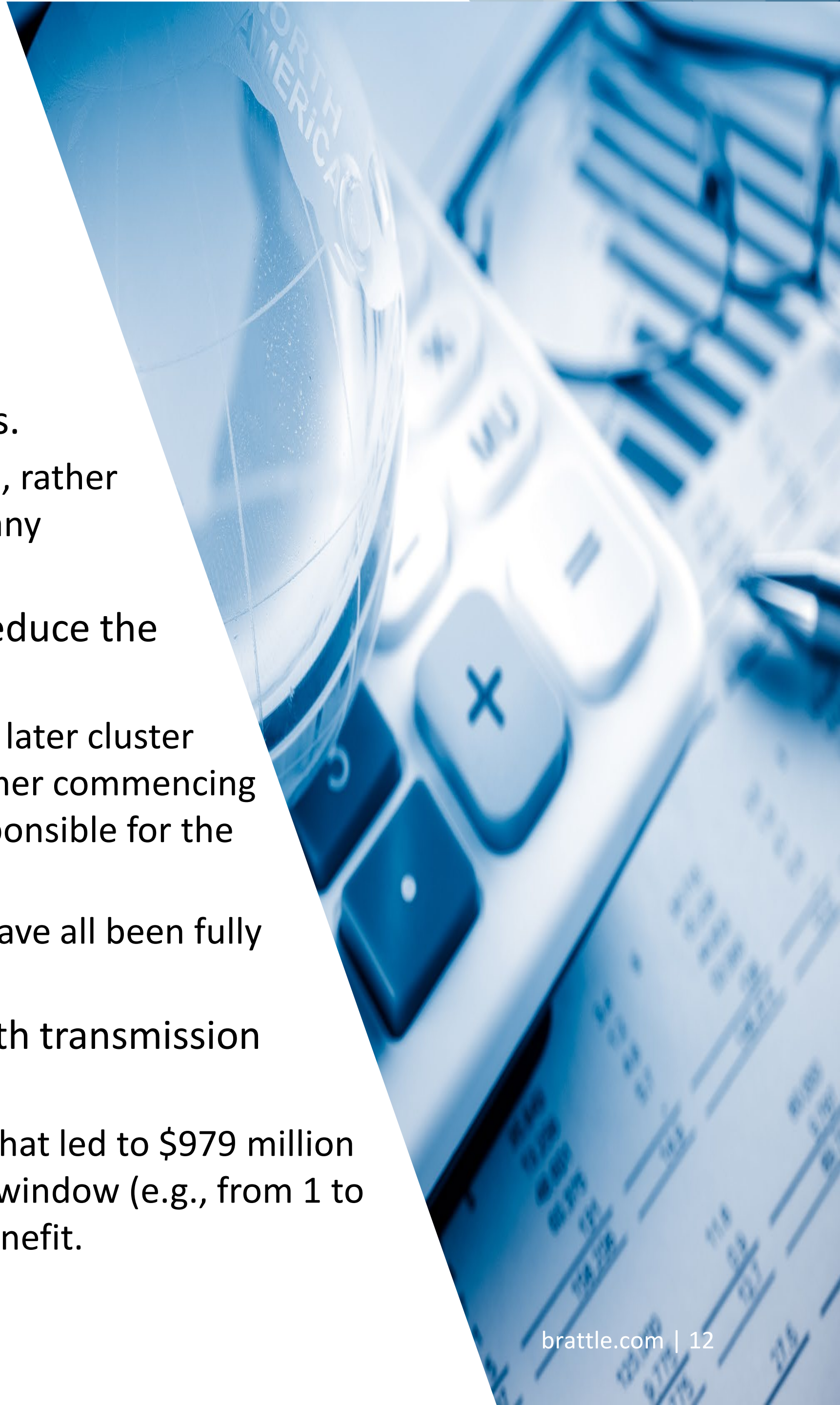
- Combined benefits: 80%

The combined benefit is what coordinated GI planning (as represented by JTIQ) can potentially realize. This approach helps fill the gap between transmission planning and GI studies.

Study Results - Qualitative 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.

- Study shows expanding the study window can lead to substantial reduction in GI costs.
  - Study shows non-linear reduction in GI costs with the GI study window extended to 5 years, rather than 3 years, from the current single year process. This may not always be true because many renewable IRs are concentrated within the next few years (<5 years).
- A cost allocation mechanism that allows late-comers to pay their share would likely reduce the needs for restudies and allow for extending study windows.
  - 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 be minimal.
- Expanding the scope of the current GI studies, or combining/overlapping its scope with transmission planning, could further reduce GI costs.
  - Study illustrates expanding the study scope (represented by the AFS-like approach of JTIQ that led to $979 million APC benefits) could provide benefits that are equal to, or higher than expanding the study window (e.g., from 1 to 3 years.) However, without an allocation mechanism, GI customers may not receive that benefit.



Study Limitations

Scope: Focuses on proactive interconnection planning benefits

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

- 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, 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 and 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 an appendix):
  - 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 including more years), using the MISO and SPP regions/sub-regions as testbeds. The section also introduces the JTIQ study that this Study utilizes as a representative example for the highest level of proactive-ness compared in this Study.
  - 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).


PROACTIVE PLANNING STUDY

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