Possibilities to Improve the Economic Efficiency of Interconnection Processes

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

September 19, 2024

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

Meeting Recording Announcement

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Agenda

- DOE i2X Program + Roadmap Overview (10 min)
- Panel Presentations: Improving Economic Efficiency of Interconnection (60 min)
  - Fritz Kahrl (Lawrence Berkeley National Laboratory)
  - Tyler Norris (Duke University)
  - Mario Hayden (Enel)
  - Jeff Billinton (CAISO)
- Open facilitated discussion (45 min)
- Future i2x Activities & Upcoming Events (5 min)

Speakers

Fritz Kahrl – Affiliate, *Lawrence Berkeley National Laboratory*

Tyler Norris – Doctoral student, *Duke University*

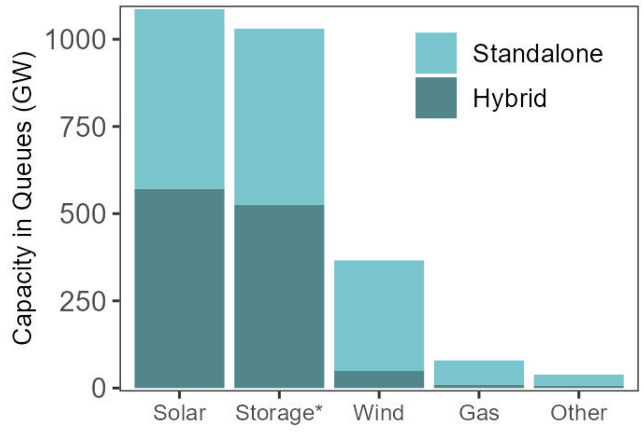
Mario Hayden – Director, Transmission, *Enel North America*

Jeff Billinton – Director, transmission infrastructure planning, *California ISO*

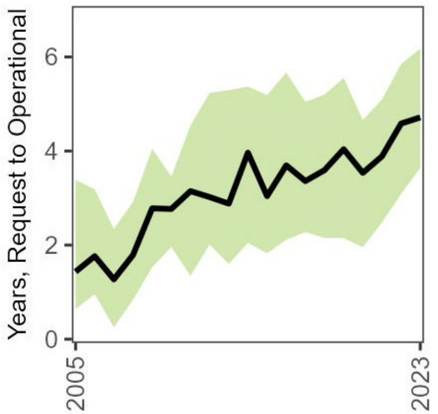
State of Transmission Interconnection

Developer interest in solar, storage, and wind is strong

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



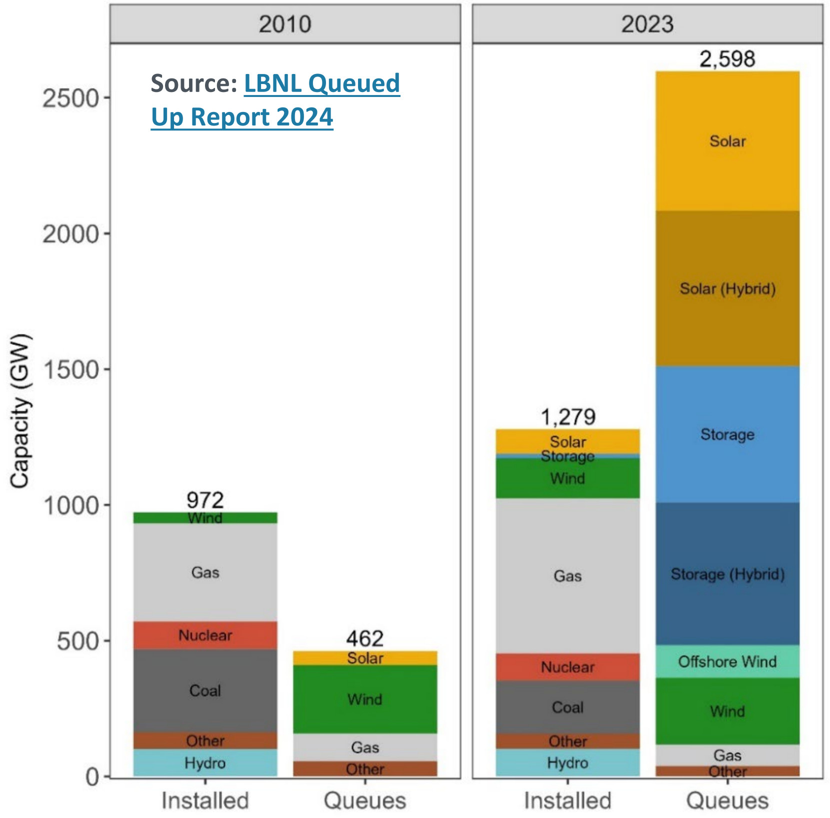
Completion rates are generally low; wait times are increasing



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

Proposed capacity is more than 2x installed capacity!

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



Source: LBNL's Queued Up Report 2024

Interconnection Innovation e-Xchange (i2X)

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

Stakeholder Engagement

Nation-wide engagement platform and collaborative working groups

Data & Analytics

Collect and analyze interconnection data to inform solutions development

Strategic Roadmap

Create roadmap to inform interconnection process improvements

Technical Assistance

Leverage DOE laboratory expertise to support stakeholder roadmap implementation

i2X is a collaboration among DOE offices and National Labs

U.S. DEPARTMENT OF ENERGY

Energy Efficiency & Renewable Energy

BERKELEY LAB

GDO GRID DEPLOYMENT OFFICE

Pacific Northwest NATIONAL LABORATORY

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Department of Energy

DOE Releases First-Ever Roadmap to Accelerate Connecting More Clean Energy Projects to the Nation's Electric Grid

APRIL 17, 2024

Energy.gov »
DOE Releases First-Ever Roadmap to Accelerate Connecting More Clean Energy Projects to the Nation's Electric Grid

Report Details Recommendations to Streamline Interconnection with Near- to Long-Term Solutions to Add Clean Energy Resources to the Transmission Grid and Boost Our Clean Energy Economy

WASHINGTON, D.C. — The U.S. Department of Energy (DOE) released a **new roadmap** outlining solutions to speed up the interconnection of clean energy onto the nation's transmission grid and clear the existing backlog of solar, wind, and battery projects seeking to be built. The Transmission Interconnection Roadmap, developed by DOE's Interconnection Innovation e-Xchange (i2X), serves as a guide for transmission providers, interconnection customers, state agencies, federal regulators, transmission owners, load serving entities (LSEs), equipment manufacturers, consumer advocates, equity and energy justice communities, advocacy groups, consultants, and the research

www.energy.gov/i2x

Transmission Roadmap Key Components and Implementation Actors

35 solutions organized in four goals

Solutions with different implementation time frames

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

Solutions describe collaborative actions among key actors

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

Measurable 2030 success targets

DOE has multiple potential roles in enabling Roadmap implementation

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

Measurable Success Targets for 2030

Evaluating success relies on accessible data for tracking and auditing!

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

Four Interconnection Goals with 35 Solutions

Goal #1: Increase Data Access and Transparency

Goal #2: Improve Process and Timeline

Goal #3: Promote Economic Efficiency

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

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

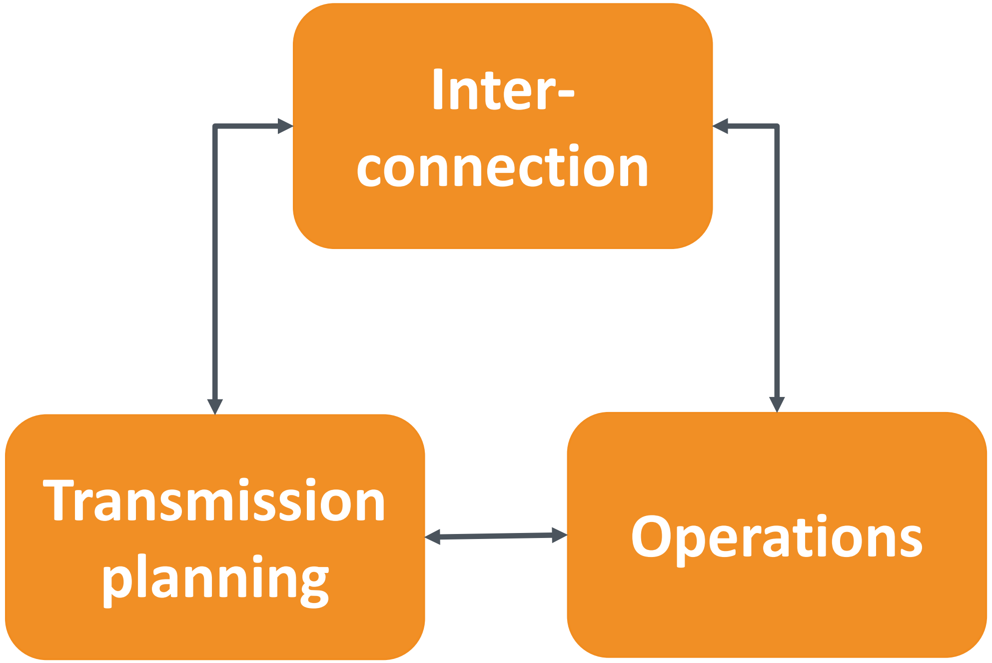
Roadmap does not assess the costs of implementing the solutions.

Goal 3: Promote Economic Efficiency

Challenge: Interconnection and transmission planning are closely related, though often not closely coordinated. How can coordination be improved to keep costs low for consumers and more fairly allocate costs?

Objectives for Solutions that Promote Economic Efficiency

- Improve cost allocation and economic signals to inform siting and resource development
- Rightsize transmission investments
- Keep costs low for electricity consumers
- Ensure openness and competitive access to the transmission network



Topical Area 1 – Cost Allocation

Expanding options for interconnection service and proactive transmission investments should reduce uncertainty and improve allocative efficiency

Solution 1: Explore options for identifying and allocating the costs of proactive transmission investments, including different options for state, federal, and participant funding

SHORT TERM

Solution 2: Ensure that generators have the option to elect energy-only interconnection and be re-dispatched rather than paying for network upgrades

MEDIUM TERM

Solution 3: Explore and evaluate options for delinking the interconnection process and network upgrade investments to increase up-front interconnection cost certainty

LONG TERM

Key tradeoff: Balancing uncertain interconnection cost outcomes with the need to provide appropriate incentives for resource siting and efficient use of current transmission system

Topical Area 2 – Coordinating Interconnection and Transmission Planning

Aligning assumptions and process timelines between interconnection and transmission planning ensures solutions that are more efficiently identified in transmission plans are not triggered in the interconnection process

Solution 1: More closely align data inputs, assumptions, and process timing between interconnection and transmission planning processes

MEDIUM TERM

Key tradeoff: Transmission facilities not selected through long-term planning could be triggered by less efficient interconnection processes; however, coordination between different groups within an organization can be difficult, imperfect, and time intensive

Topical Area 3 – Interconnection Studies

Expanding options for interconnection service and proactive transmission investments should reduce uncertainty and improve allocative efficiency

Solution 1: Evaluate all effective mitigation options during interconnection studies, incorporating alternative transmission technologies as well as control options for inverter-based resources

SHORT TERM

Solution 2: Continue to develop and harmonize new, transparent best-practice study methods to adapt to a changing generation mix and changes in load as well as to facilitate consistent outcomes across transmission providers

MEDIUM TERM

Solution 3: Explore options to allow interconnection customers to self-fund and provide their own interconnection studies, subject to transmission provider oversight, rules, and requirements

LONG TERM

Key tradeoff: Changing generation mix requires study method updates, which take time and resources to implement

Speakers

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Website: energy.gov/i2X
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INTERCONNECTION INNOVATION e-XCHANGE
U.S. DEPARTMENT OF ENERGY

Discussion and Q&A

Website: energy.gov/i2X
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U.S. DEPARTMENT OF ENERGY

Virtual Meeting Code of Conduct during Discussion

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

Mutual Respect . Collaboration . Openness

Discussion topics:

1. **Energy-only interconnection service:** Would such a service be an attractive option for developers if it were faster and lower cost? How would operators manage congestion and delivery risk? Are there opportunities for participant (e.g., state, developer) funding of transmission beyond currently available mechanisms?
2. **Proactive transmission planning:** Will enhancements in transmission planning and better coordination between interconnection and transmission planning help to clarify and manage the risks of different kinds of transmission service for market participants?

Selection of DOE i2X Actions to Implement Roadmap Solutions

- **Solar and Wind Interconnection for Future Transmission (SWIFTR) Funding Opportunity**
- **i2X Forum for Implementing Reliability Standards for Transmission (i2X FIRST)**
- **i2X Roadmap outreach and technical assistance**
- **Collaboration among DOE Offices and other federal and state agencies**

Discuss, envision, and implement solutions

Upcoming i2X Solution eXchanges

October 31 - Improve Process and Timeline

December 3 - Maintain a Reliable, Resilient and Secure Grid

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

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

Upcoming dates:

- Sep 24 | 11 a.m.- 1 p.m. ET | Virtual
- Oct 24 | All-day | hybrid with ESIG
- Nov 26 | 11 a.m.- 1 p.m. ET | Virtual

Thank you for joining and participating

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

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

Improving the Economic Efficiency of Interconnection Processes

09/19/2024

Mario Hayden
Director, Transmission
Enel North America
i2X Solution e-Xchanges: Promoting Economic Efficiency in Interconnection

Agenda

01. Context

02. “Connect and Manage” – ERCOT’s Approach to ERIS

03. Electing ERIS vs. NRIS as an Interconnection Customer

04. Generation Interconnection and Transmission Planning Coordination

05. Closing Remarks

Context

FERC Order 2023

- FERC Order 2023 adopted generation interconnection reforms that included:
  - Transitioning from "First-Come, First-Served" Serial Interconnection Processes to "First-Ready, First-Served" Cluster Study Processes
  - Mechanisms intended to increase the speed of processing interconnection queues and mitigate challenges involved with affected system studies
  - Calls for evaluating alternative technological technologies such as GETs in the cluster studies
  - Model quality and performance requirements for Non-Synchronous Generators

- FERC facilitated a staff-led workshop on September 10-11, 2024 to build upon the reforms in Order No. 2023, and to some extent Order No. 1920

Context

Industry Engagement

- Enel has been an active contributor to various industry forums, reports, and requests for comments to inform rule-makings including, but not limited to:
  - Sessions 1 and 3 of the Joint Generator Interconnection Workshop facilitated by ESIG, NAGF, NERC and EPRI
  - The Enel Working Paper as part of our comments to the FERC for their ANOPR and NOPR informing Order No. 2023
  - The May 2023 i2X Solution e-Xchange: Managing the Bulk Power System Interconnection Study Process leading up to the DOE Transmission Interconnection Roadmap
  - Written comments for the September 2024 FERC staff-led workshop
  - Technical reviewer for the recent Grid Strategies and The Brattle Group report "Unlocking America's Energy: How to Efficiently Connect New Generation to the Grid"

"Connect and Manage"

How ERCOT Connects…

- Efficiency through lack of interdependence
- Very lost cost of entry into the interconnection process
- Typical time to GIA from initial application is 6-12 mo. From initial application to initial synchronization months three to four years, largely driven by HV equipment procurement bottlenecks
- Interconnection requests are not studied in a cluster with other generators until they qualify for the Quarterly Stability Assessment
- From 2020 to EOY 2023, ERCOT experienced a more than tripling of its installed capacity of utility-scale solar, and a nearly *17-fold* increase in installed storage capacity.

"Connect and Manage"

…and Manages

- The ERCOT Transmission Planning and Generation Interconnection processes have very limited overlap, leading to very few economic transmission projects that have been identified and approved
- Generic Transmission Constraints (GTCs) enables SCED to enforce stability constraints within a safety margin
- Interconnection customers are unable to predict and model stability issues due to the speed and volume of resources enabled by the interconnection process and restrictions on access to "Super ECEII"

Year	Value of Real Time Congestion ($ Billions)	GTC Binding Constraint Hours
2019	1.26	1401.6
2023	2.4	5,791

Source: 2023 State of the Market Report by Potomac Economics, the ERCOT IMM

“Connect and Manage”

Can (and should) it be adopted outside of ERCOT?

Directly applying “Connect and Manage” may not be appropriate for regions outside of ERCOT due to the many unique traits of the ERCOT region

Borrowing principles from “Connect and Manage” to improve ERIS across the country is likely the way to proceed!

ERIS

Reframing “As available”

- Grants interconnection service on an "as available" basis
- In some regions it is studied and cost allocated quite differently from NRIS, but in others the differences are not pronounced enough to provide much value to being an ERIS resource
- Ability to elect a standardized ERIS product in all RTOs and BAs is critical -- especially for resources with declining capacity accreditation like solar
- Reasonable Minimum Impact thresholds should be established to align identified constraints with being local to an ERIS resource
- The use of SCED studies should be used to evaluate the merits of network upgraded identified

While ERIS should be reformed to allow more efficient interconnection of much-needed generation, Enel does not encourage the *full* elimination of System Network Upgrades from the interconnection process.

NRIS

Deliverability and Capacity Rights (CIRs, CRIS, etc.)

- Most generators elect NRIS or its equivalents during the interconnection process which often come with system deliverability network upgrades with strict study criteria
- Capacity revenues in the regions with capacity markets are an important piece of the revenue stack of resources like battery storage and thermal generation
- Despite decreasing capacity accreditation for solar in regions like PJM, generators still select this interconnection service given ERIS is not consistently differentiated enough from NRIS to decline election at application
- Generators often elect to withdraw their NRIS elections due to deliverability upgrades that continue to be identified late in the interconnection process and would cause a project to be uneconomical without sufficient capacity revenues

The ability for ERIS resources to elect incremental NRIS/CIR/CRIS in later clusters is critical to account for potential future improvements to capacity accreditation and other revenue opportunities.

Generation Interconnection and Transmission Planning Coordination

- Identifying and implementing deep transmission upgrades is best handled in a Regional Planning process as opposed to the Generation Interconnection process
- Key features of a framework that tightly coordinates the interconnection queues with Regional Planning processes include:
  - Proactive, multi-value scenario-based planning to identify and implement major transmission needs in both the medium to long term
  - An Entry Fee and High Readiness Requirements to enter Regional Cluster
  - Simple cost allocation rules that holistically identify beneficiaries
  - Early identification of reasonable minimum impact thresholds and SCED/fuel-based dispatch identifying upgrades for ERIS resources

If generators are going to withdraw from the interconnection process, it is best for them to withdraw early rather than later!

Existing Proposals

- A non-exhaustive list of proposed frameworks to implement tighter coordination between Interconnection and Transmission Planning include:

  - Enel's proposals included in the Enel Working Paper and comments submitted for the FERC staff-led workshop

  - SPP's proposed Consolidated Planning Process

  - The Grid Strategies and Brattle "Unlocking America's Energy" report

Closing Remarks

Where We Go From Here

- Reasonable and standardized minimum thresholds for assigning local upgrade costs to ERIS resources are key to balance the speed of moving through the queue with ensuring ERIS resources have responsibility for funding upgrades that align with “as available” principles

- While regional differences will always be present in the nuances surrounding interconnection, the unique strengths and expectations of ERIS vs NRIS/capacity resources should clearly differentiate how each are treated in the interconnection process and always allow requests for incremental NRIS/capacity rights to be elected in a parallel or later cluster

- Early upgrade determinations for ERIS, high readiness requirements, and tighter coordination between Regional Transmission Planning and Interconnection processes will reduce the need use of the interconnection queues to discover upgrade costs

- Beneficiaries of transmission ultimately pay either directly or indirectly, and costs should be allocated based on a holistic view of what it means to be a beneficiary. Using the generation interconnection process to build deep upgrades is highly inefficient and has cascading effects such as study result delays and late-stage cost uncertainty faced by interconnection customers


Thank you

Energy-only Interconnection Performance Across the U.S.

i2X Solution e-Xchange Season 2:

Promoting Economic Efficiency in Interconnection

Tyler H. Norris

September 19, 2024

Duke UNIVERSITY

GRACE Lab

A Grid that is Risk-Aware for Clean Electricity

Duke | NICHOLAS SCHOOL *of the* ENVIRONMENT

Our research

Our research explores, assesses, and proposes technological, policy, and market approaches to contribute to the pursuit of sustainability, affordability, reliability, and justice in the energy sector.

Primary research areas

- Characterizing sources of uncertainty that increase power systems' financial and reliability risk and designing risk management tools and strategies.
- Examining the attributes and characteristics of different electric power technologies and the possibilities and advantages of designing flexible policy mechanisms that consider the decision-making process and real options valued by those regulated.
- Assessing the economic, environmental, and reliability potential of electric power technologies, mainly related to their operational flexibility, the uncertainty that affects their outcomes, and the implications for the systems where they are integrated.

Nicholas School of the Environment, Duke University

Network vs. Energy Interconnection Service

	Network Resource Interconnection Service (NRIS)	Energy Resource Interconnection Service (ERIS)
Capacity Treatment	• Provides capacity designation • Capacity subject to ELCC downrate	• Not eligible for capacity designation (exceptions for firm transmission service)
Energy Treatment	• Eligible to participate in energy markets • Subject to security-constrained economic dispatch (SCED)	
Curtailment Priority	• Equivalent treatment in ISO/RTO energy markets • Potentially different treatment in non-ISO/RTOs	
Study Criteria	• Full TPL-001 contingencies and local stress cases	• Varies widely

Key Factors Influencing ERIS Studies

- Treatment of ERIS in interconnection studies is shaped by a complex interplay of parameters (see table).

- The spectrum of potential ERIS study approaches is thus broad, ranging from restrictive to more accommodating models.

- ERCOT represents the most flexible end of this spectrum, however, at least two other ISO/RTOs employ similar methods for studying energy-only requests.

Study Parameter	Issue
Generator dispatch	What is the assumed dispatch level for the ERIS generator?
Load & generation cases	Which load and generation cases are studied for ERIS generators?
Contingency categories	Which TPL-001 contingency categories are applied to ERIS generators?
Mitigation options	When is redispatch or alternative mitigation considered to address an injection constraint?
Minimum impact thresholds	What level of system impact triggers cost allocation for ERIS generators?
Cost allocation methods	Which network upgrade costs are allocated to ERIS generators?

Spectrum of ERIS Treatment

Less Restrictive ⟷ More Restrictive

Category #1

ERIS treatment:

- Thermal and non-thermal network impacts managed via operations
- No network upgrade costs assigned to interconnection customer

Examples:

- ERCOT

Category #2

ERIS treatment:

- Thermal network impacts managed via operations
- No thermal network upgrade costs assigned to interconnection customer

Examples:

- CAISO
- NYISO

Category #3

ERIS treatment:

- Limited management of network impacts via operations
- Thermal and non-thermal network upgrade costs assigned to interconnection customer
- Variation in DFAX thresholds, contingencies, and redispatch

Examples:

- PJM
- MISO
- SPP
- Duke Carolinas/Progress

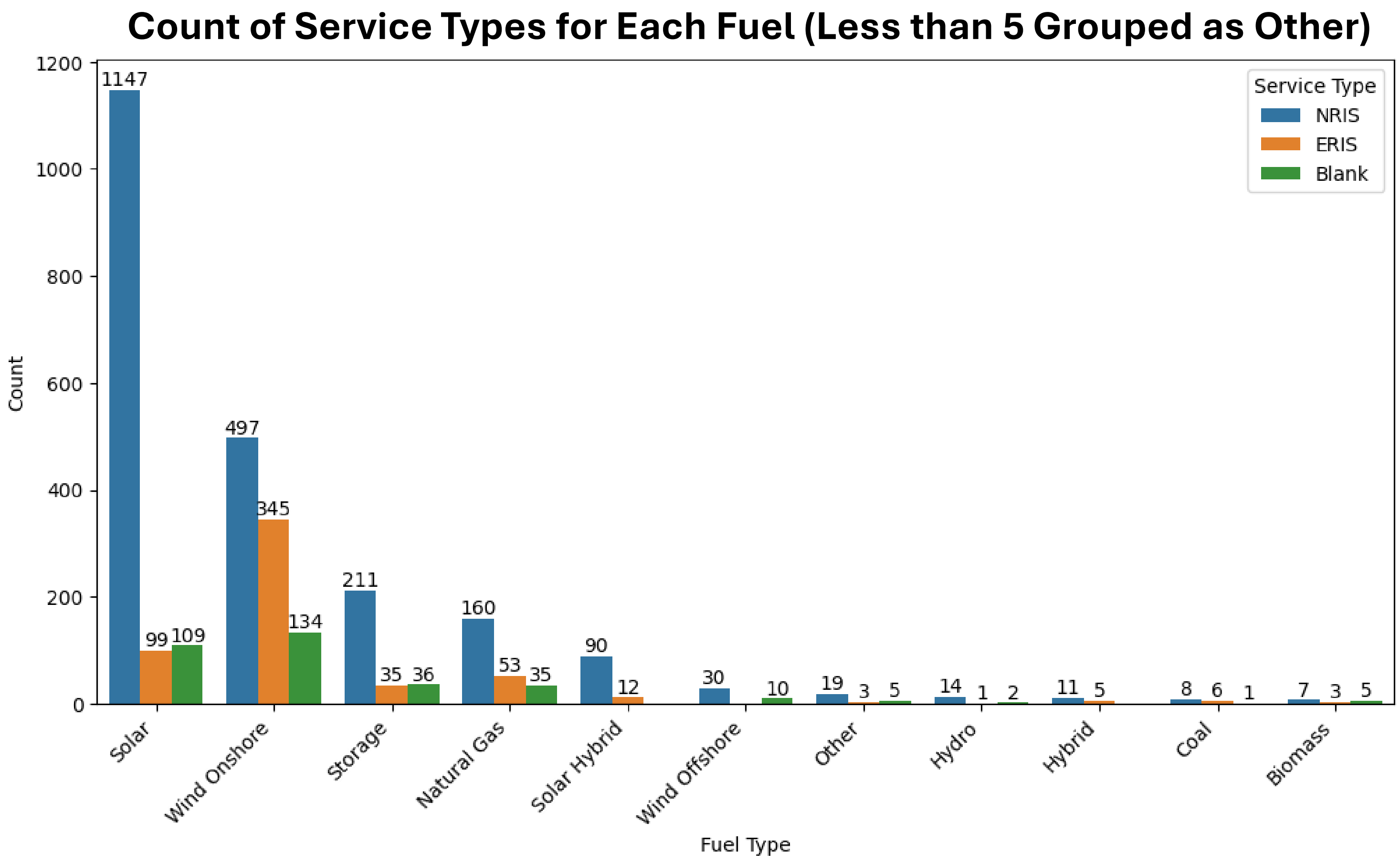
ERIS Performance: Cost

Data background: Cost analysis based on 2,697 interconnection studies with network upgrades and service information

Interconnection Cost Data	
Markets	ISO-NE, MISO, NYISO, PJM, SPP
Sample size (studies)	3,033
NRIS	2,150
ERIS	547
Unlabeled	336
Study dates	2000-2014: 16% 2015-2022: 84%
Data source	LBNL cost dataset: https://emp.lbl.gov/interconnection_costs

Other notes:

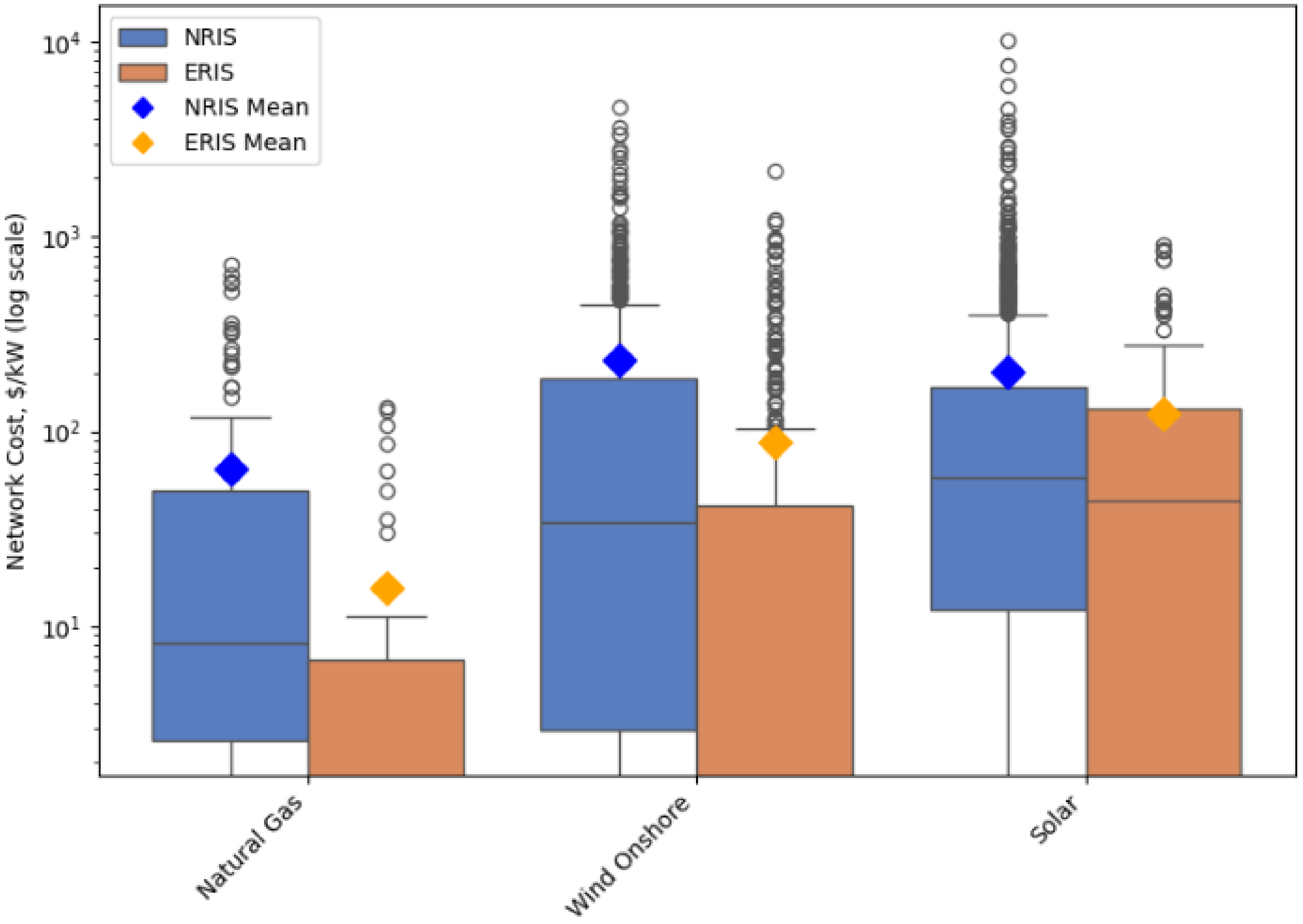
- CAISO cost data is unavailable
- ERCOT cost data is N/A, since it does not identify network upgrade costs in interconnection studies



ERIS Performance: Cost

- ERIS requests have been assigned fewer costs than NRIS requests, driven by the higher prevalence of ERIS requests assigned zero cost.
- However, the anticipated cost advantage of ERIS over NRIS does not consistently materialize.
- Solar PV generators exhibit the smallest cost difference between NRIS and ERIS studies. In MISO and SPP, average network upgrade costs for solar ERIS studies are higher than for solar NRIS studies.
- The average network upgrade cost assigned to solar ERIS requests is 60% of the cost for NRIS, with the median being 75%.

Network Upgrades Cost by Fuel & Service (Log-Scale, All Samples)

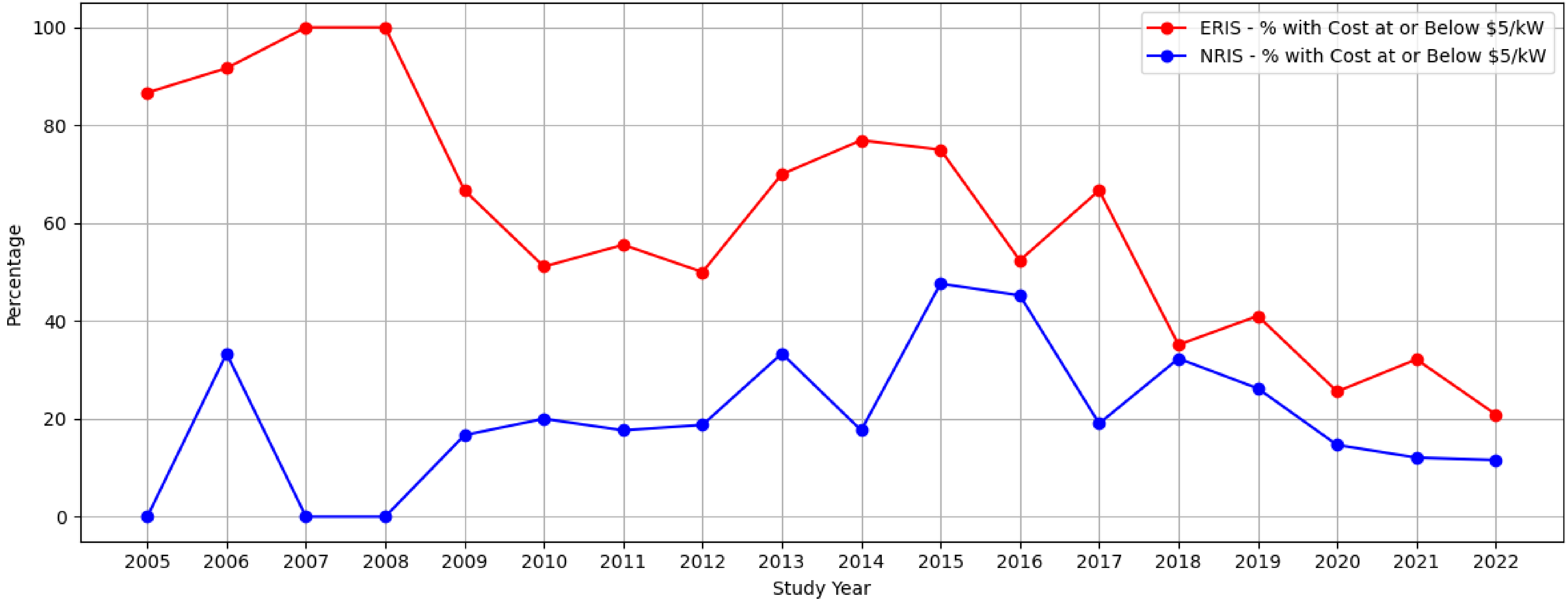


Source: Tyler Norris and Dalia Patino-Echeverri. Comments for FERC Innovations & Efficiencies in Generator Interconnection Staff-Led Workshop: FERC Docket No. AD24-9-000. August 26, 2024. https://nicholasinstitute.duke.edu/publications/comments-ferc-workshop-innovations-efficiencies-generator-interconnection

ERIS Performance: Cost

The share of ERIS studies with zero or de minimis network upgrade costs (<$5/kW) across all available studies has declined significantly over time, and in recent years it is nearly equivalent to NRIS.

Share of Studies with Network Upgrade Costs <= $5/kW (All Samples)



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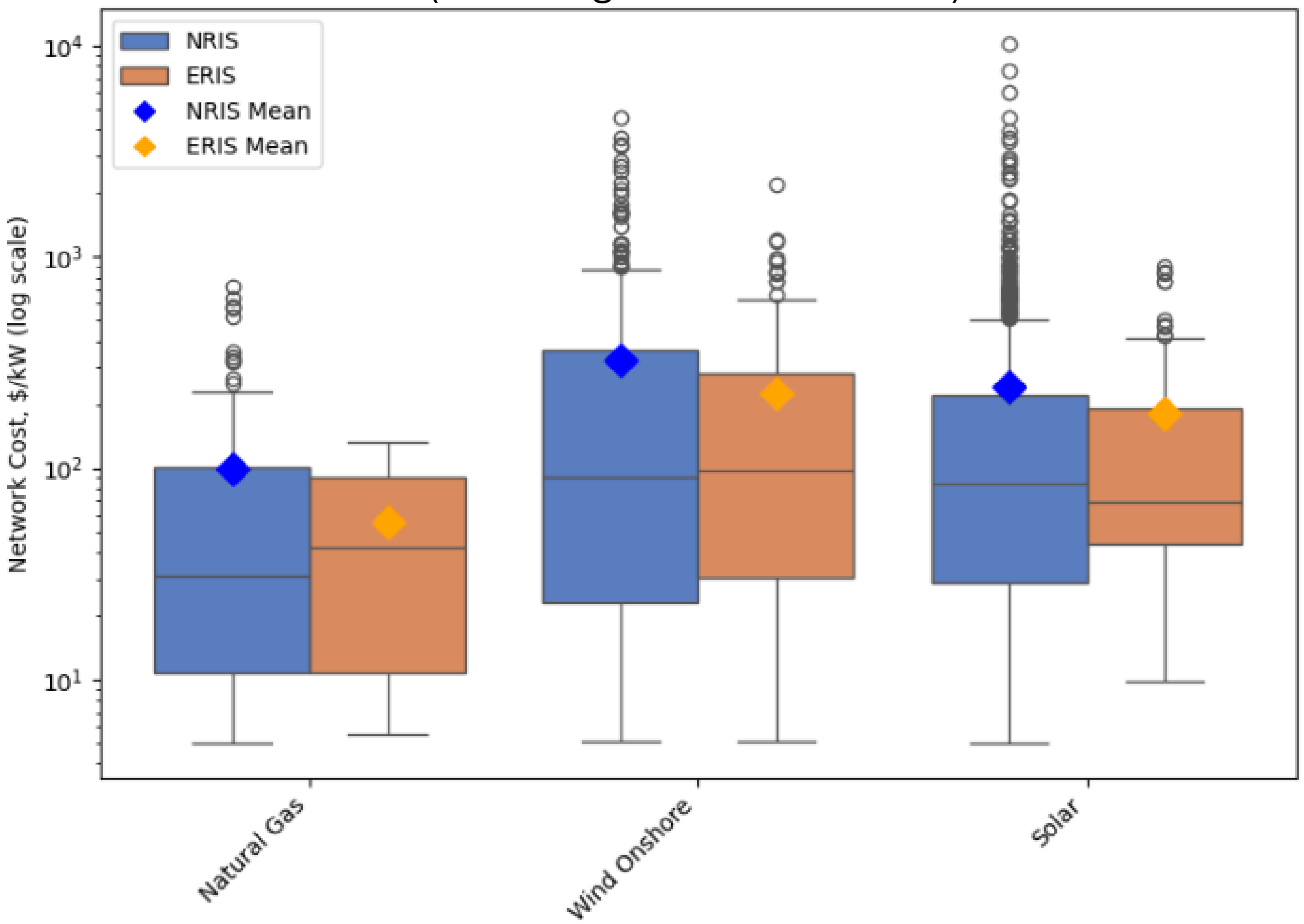
ERIS Performance: Cost

- ERIS' cost advantage diminishes to a statistically insignificant level across all fuel types when considering cases where network upgrade costs are assigned, excluding cases where zero costs are allocated. This result holds when excluding de minimis network upgrade costs below $5/kW.
- This conditional analysis reflects the growing prevalence of ERIS studies resulting in allocated network upgrades.
- When excluding studies with de minimis costs, the average network upgrade cost assigned to solar ERIS requests is 75% of the cost for NRIS, with the median being 82%
- Notably, for wind, the median upgrade cost for ERIS becomes 38% higher than for NRIS under these conditions.

Network Upgrade Cost by Fuel & Service, Log-Scale
(Excluding De Minimis Values)



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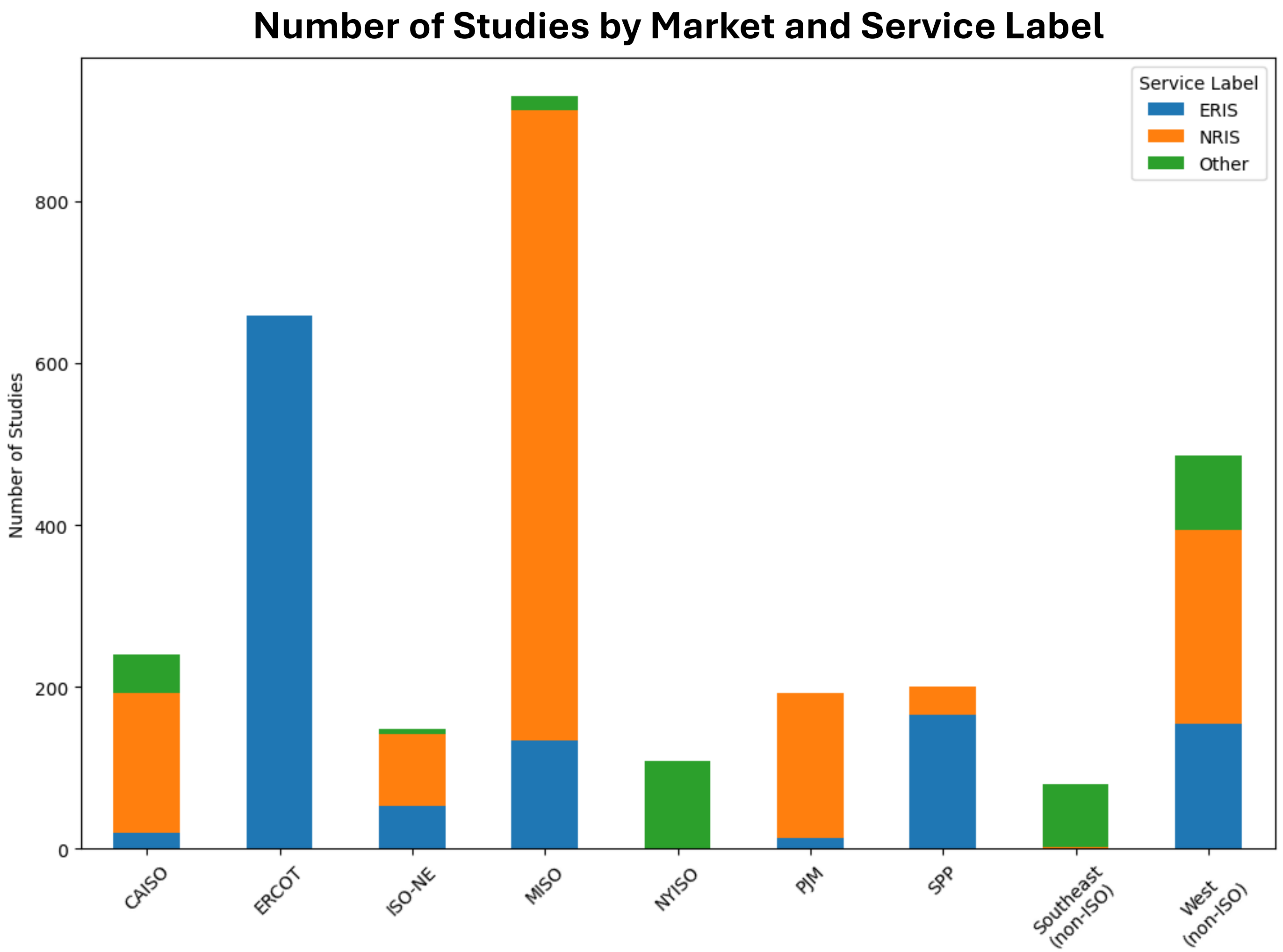
ERIS Performance: Speed

Duration analysis (IR to IA) based on 2,693 interconnection studies with date of IA execution and service label

Study Duration Dataset (Studies with Date of IA Execution)	
Markets	CAISO, ERCOT, ISO-NE, MISO, PJM, SPP, non-ISO/RTO subset
Sample size (studies)	3,042
NRIS	1,495
ERIS	1,198
Other label	349
Date of IA Execution	2010-2014: 34% 2015-2024: 66%
Data source	LBNL Queued Up: 2024 Edition

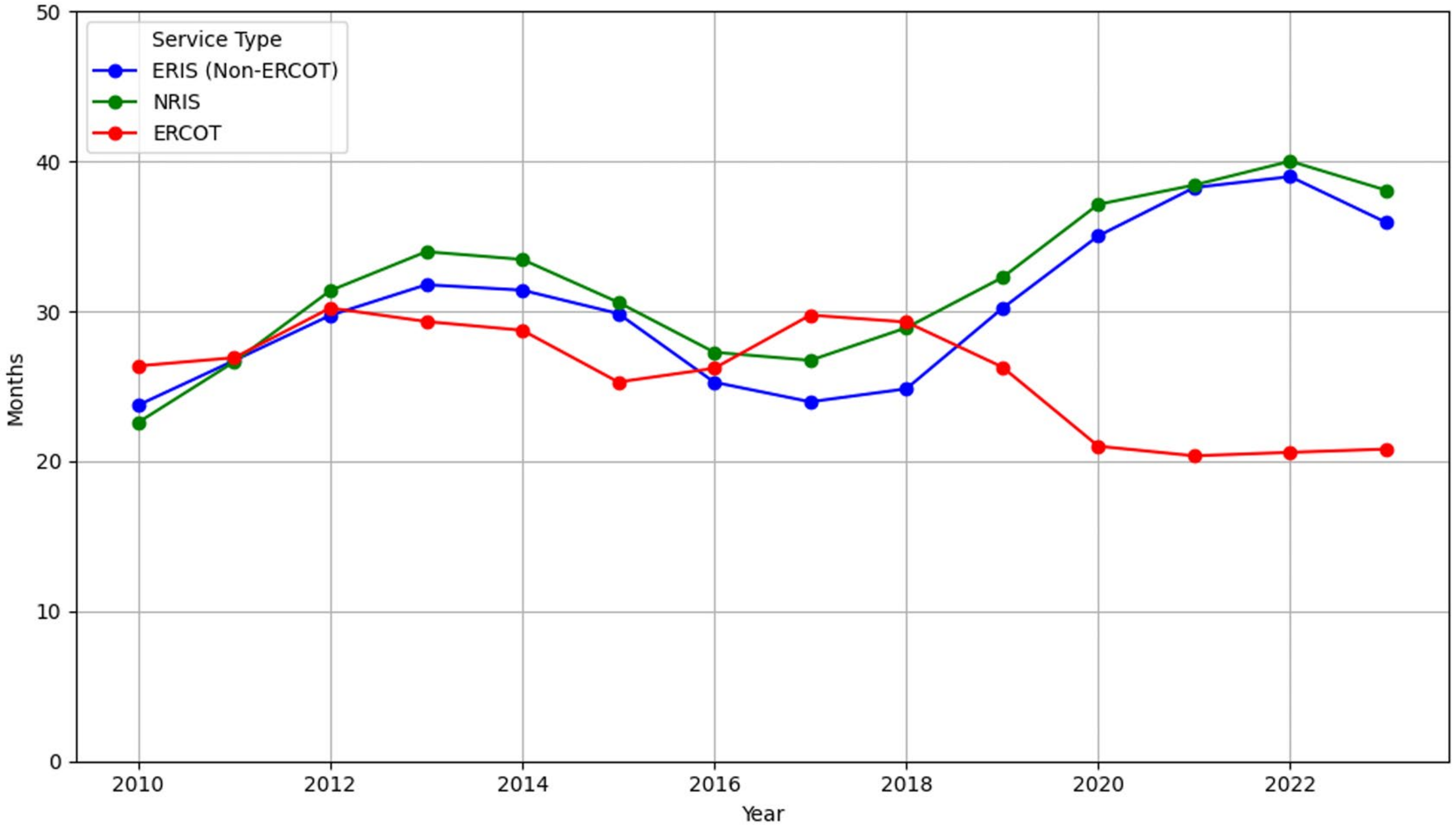
Other notes: The data provided for the NYISO and Southeast regions contained no interconnection service labels and were excluded from this analysis



ERIS Performance: Speed

- ERCOT demonstrates materially shorter processing durations than NRIS and ERIS studies outside ERCOT.
- This difference has grown over time, especially since 2018, and is statistically significant.
- Without additional data, it is difficult to discern how much of the difference in process speed between ERCOT and non-ERCOT jurisdictions is due to the length of study periods versus the response times of interconnection customers at various stages of the process.
- However, it is reasonable to assume that the similarity in study methods for ERIS and NRIS outside ERCOT, and the oft-comparable network upgrade costs, is a significant explanatory factor.

Avg. Processing Duration by Interconnection Service, IR to IA (Rolling 3yr Avg., 2010-2023)



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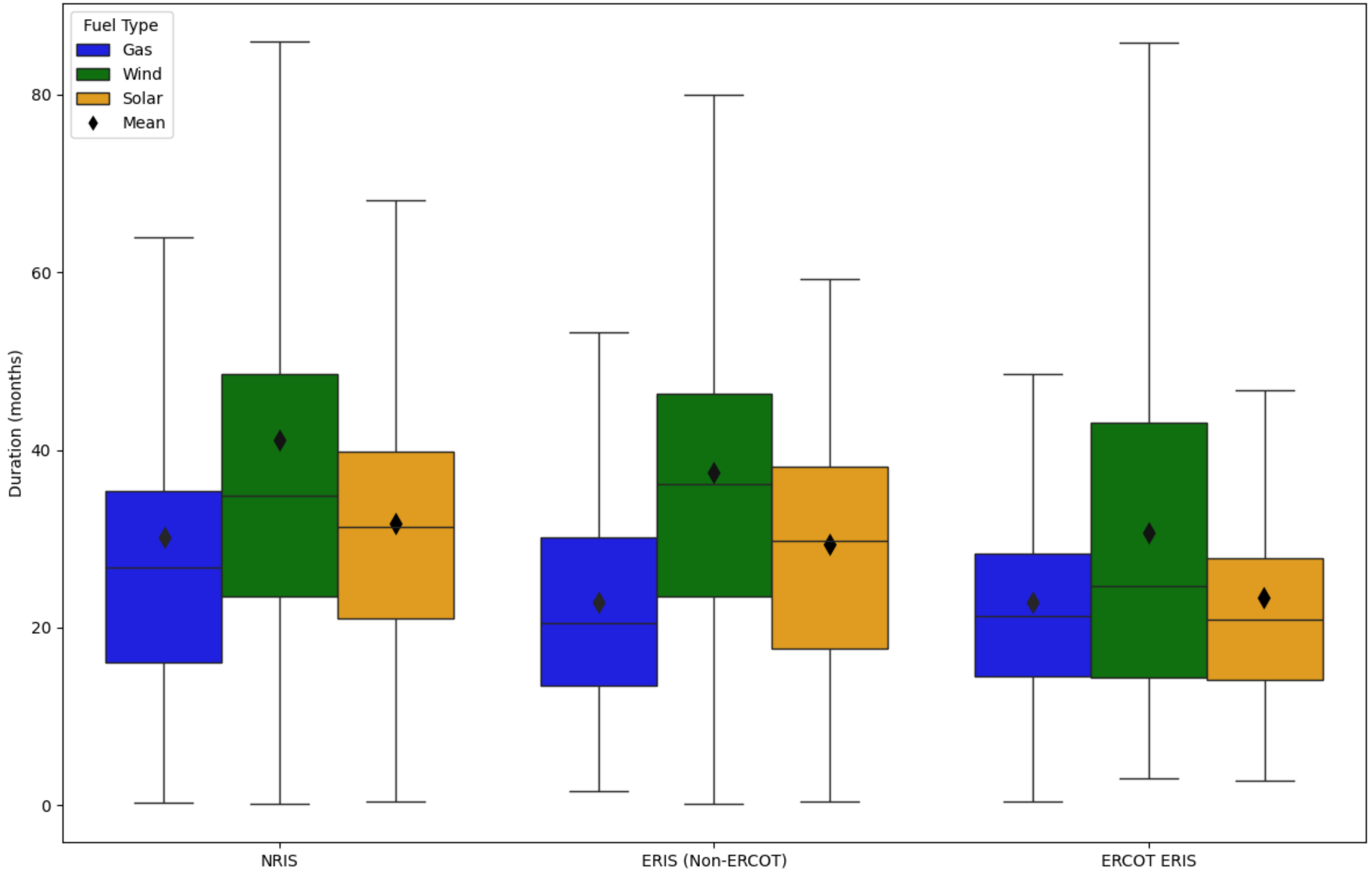
ERIS Performance: Speed

- Outside ERCOT, NRIS and ERIS requests do not demonstrate a statistically significant difference in processing speed.
- An exception is for gas generators, which have experienced shorter durations under ERIS than NRIS.
- Combining NRIS and ERIS requests in cluster studies may contribute to similarity in processing duration.

Box Plot of Study Duration by Group and Fuel Type
(Post-2009 IAs, No Outliers Plotted)



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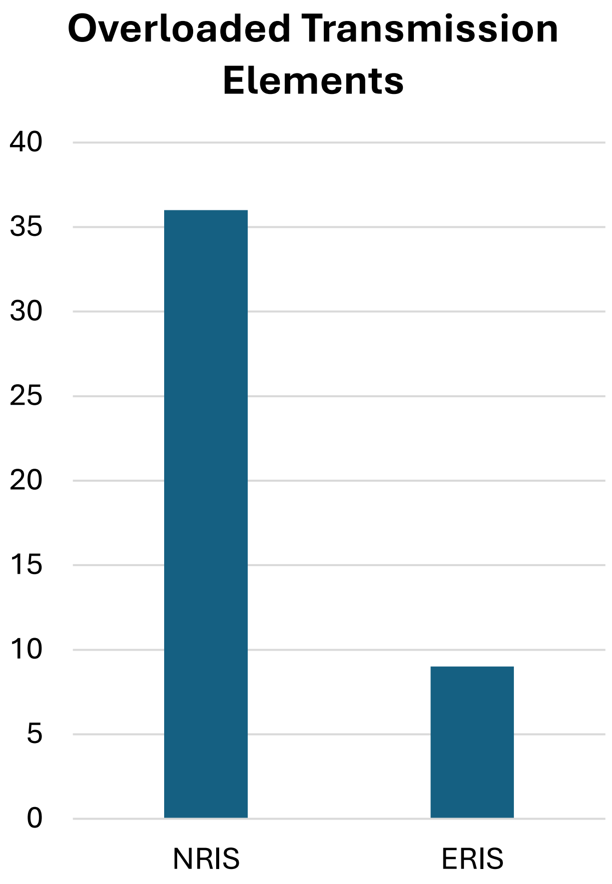
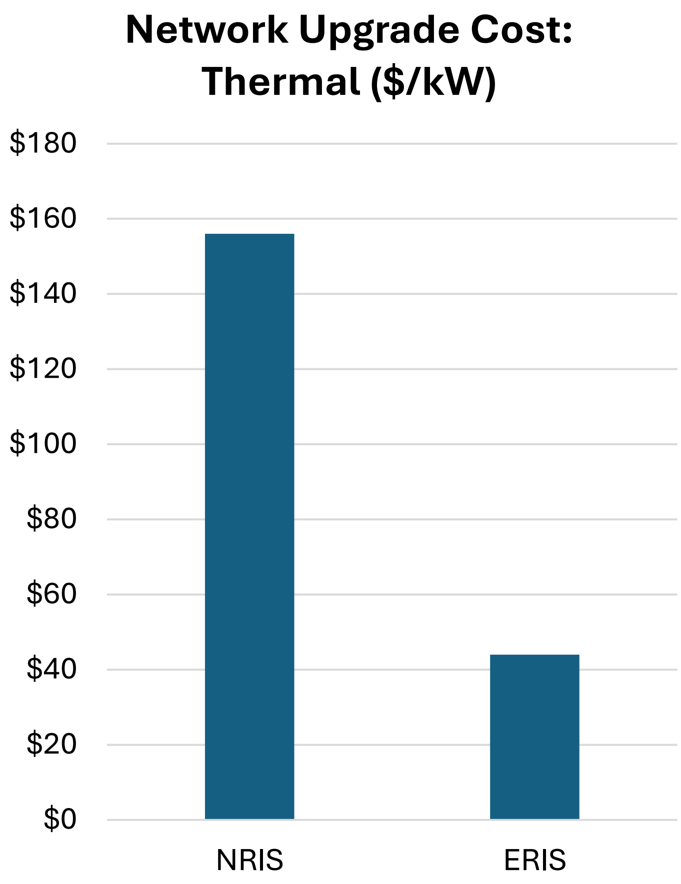
Case Study on ERIS Cost Impact

- To assess the cost impact of NRIS vs. ERIS under moderately restrictive ERIS study criteria, DukeU's GRACE Lab replicated and re-simulated a recent NRIS cluster study as ERIS.
- PowerGem's TARA software was used, and inputs relied strictly on those provided by Duke Energy Progress (DEP).
- The simulation found that switching from NRIS to ERIS for the selected utility-scale solar cluster results in the following:
    - **75% reduction in identified overloads**, including 27 separate transmission elements
    - **72% reduction in network upgrade costs** related to thermal power flow overloads
    - **Reduction of capacity-weighted costs by $112 per kW** of studied solar generation capacity
- This analysis accounted for single contingencies and did not consider alternative transmission technologies, and it did not assess stability or short circuit impacts.





Source: Tyler Norris and Ryan Watts. "Modeling the Effects of Flexible Interconnection on Solar Integration: A Case Study." Duke University GRACE Lab. Exhibit A to Pre-Workshop Comments of Tyler Norris. FERC Docket No. AD24-9-000. August 26, 2024. https://nicholasinstitute.duke.edu/publications/comments-ferc-workshop-innovations-efficiencies-generator-interconnection

Thank you!

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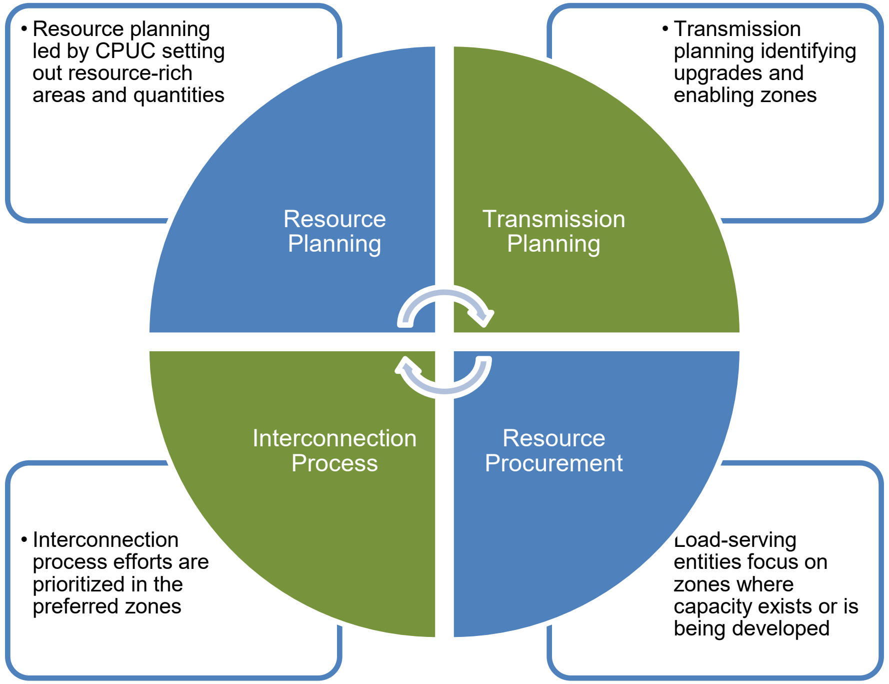
California ISO

Transmission Planning FCDS and EO

Jeff Billinton
Director, Transmission Infrastructure Planning

September 19, 2024
DOE i2X Program + Roadmap Meeting

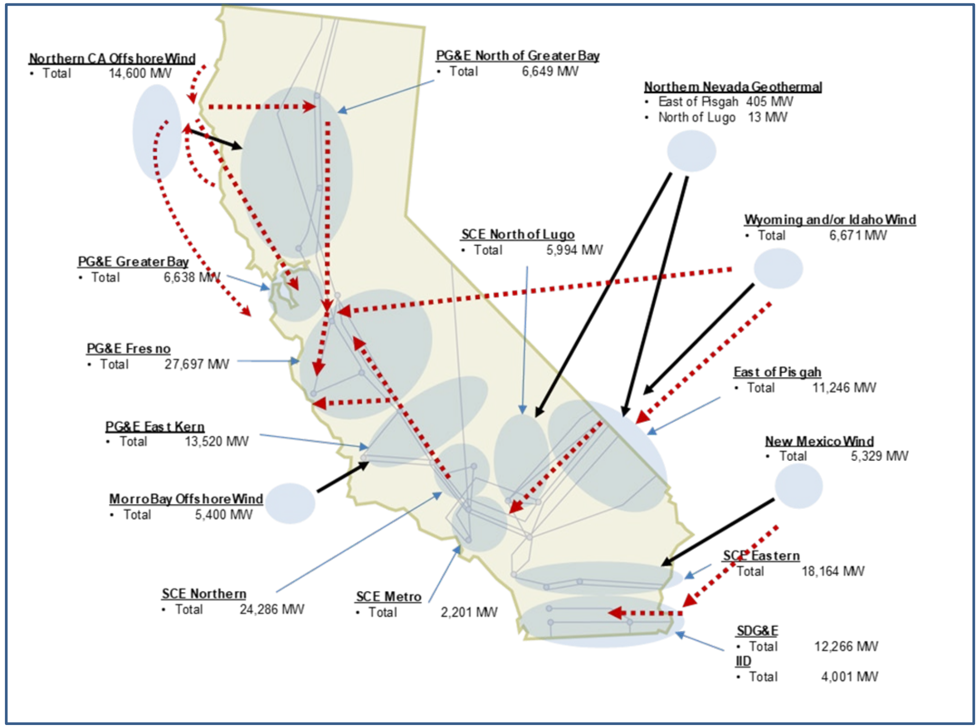
Transmission Planning and Generation Interconnection are two of four fundamental and interwoven processes:



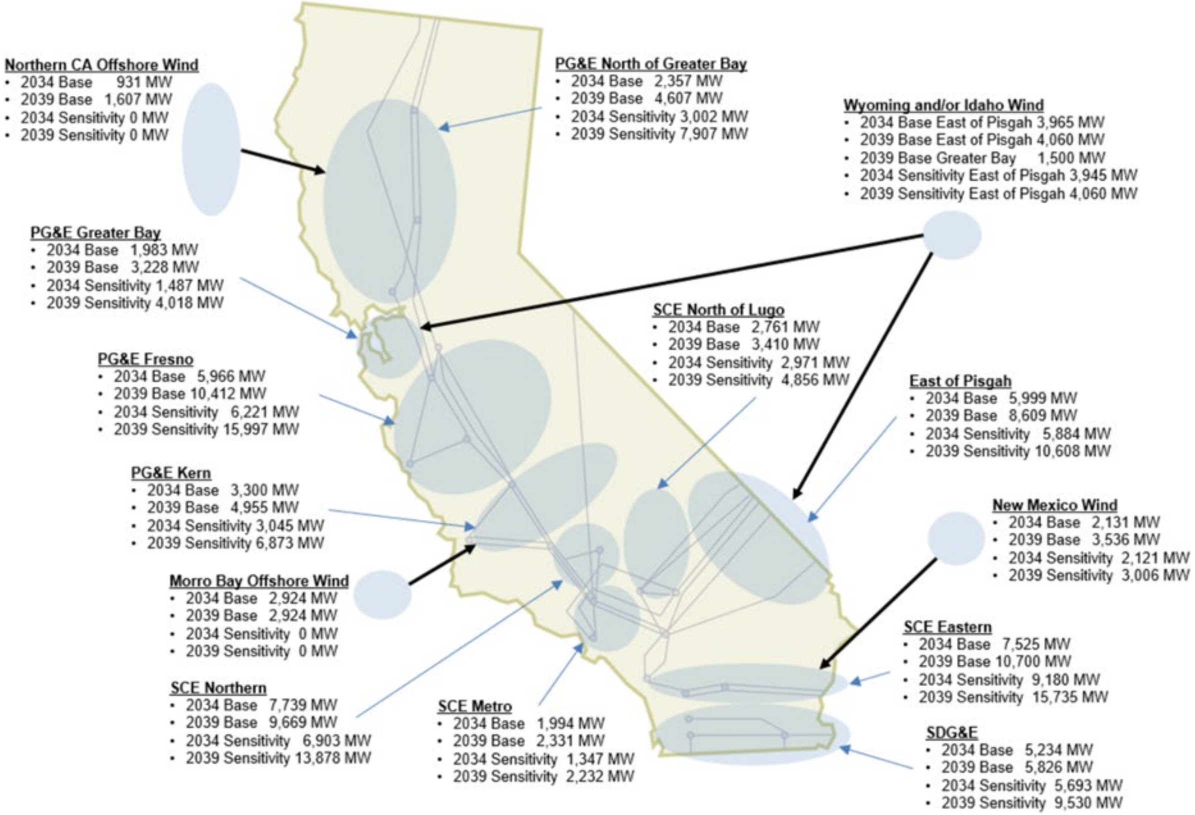
The CPUC/CEC/ISO Memorandum of Understanding signed in December, 2022 sets the strategic direction for process improvements to:

- Tighten the linkage between planning, procurement direction, and the ISO interconnection process to the greatest extent possible.
- Create formal linkage between CEC SB 100/IEPR activities and the ISO and CPUC processes
- Reaffirm the existing state agency and single forecast set coordination
- Update references to current processes and set direction to updating process documentation

ISO transmission planning process continues to uses zonal approach which enables clear direction and prioritization



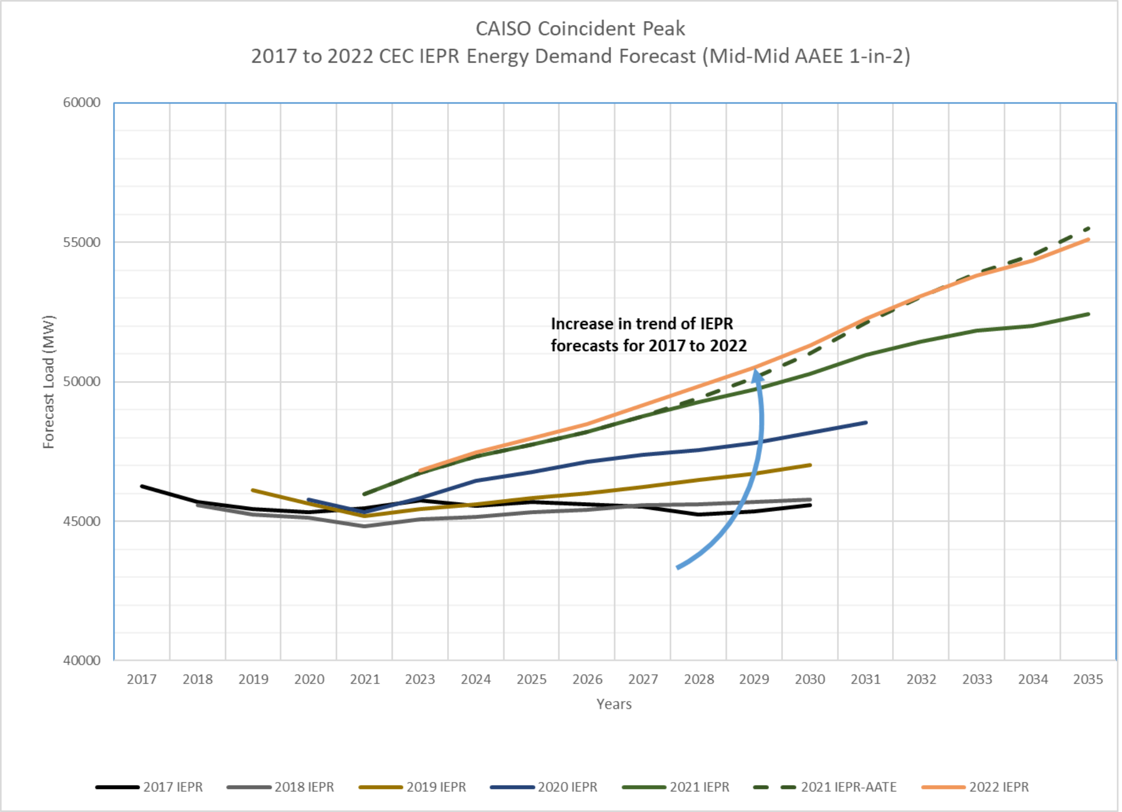
CAISO 2024 20-year Transmission Outlook



ISO 2024-2025 Transmission Planning Process

California's climate change goals are driving escalating load forecasts

The CEC's load forecast is used in both the CPUC's Integrated Resource Planning process and the ISO's transmission planning process.



The ISO uses:

- 1-year-in-10 weather event forecast for local reliability studies
- 1-year-in-5 weather event forecast for bulk system reliability-driven and policy-driven studies
- 1-year-in-2 weather event forecast for economic (market efficiency) studies

2024-2025 Transmission Planning Process
CPUC Base Portfolio – 2034 and 2039

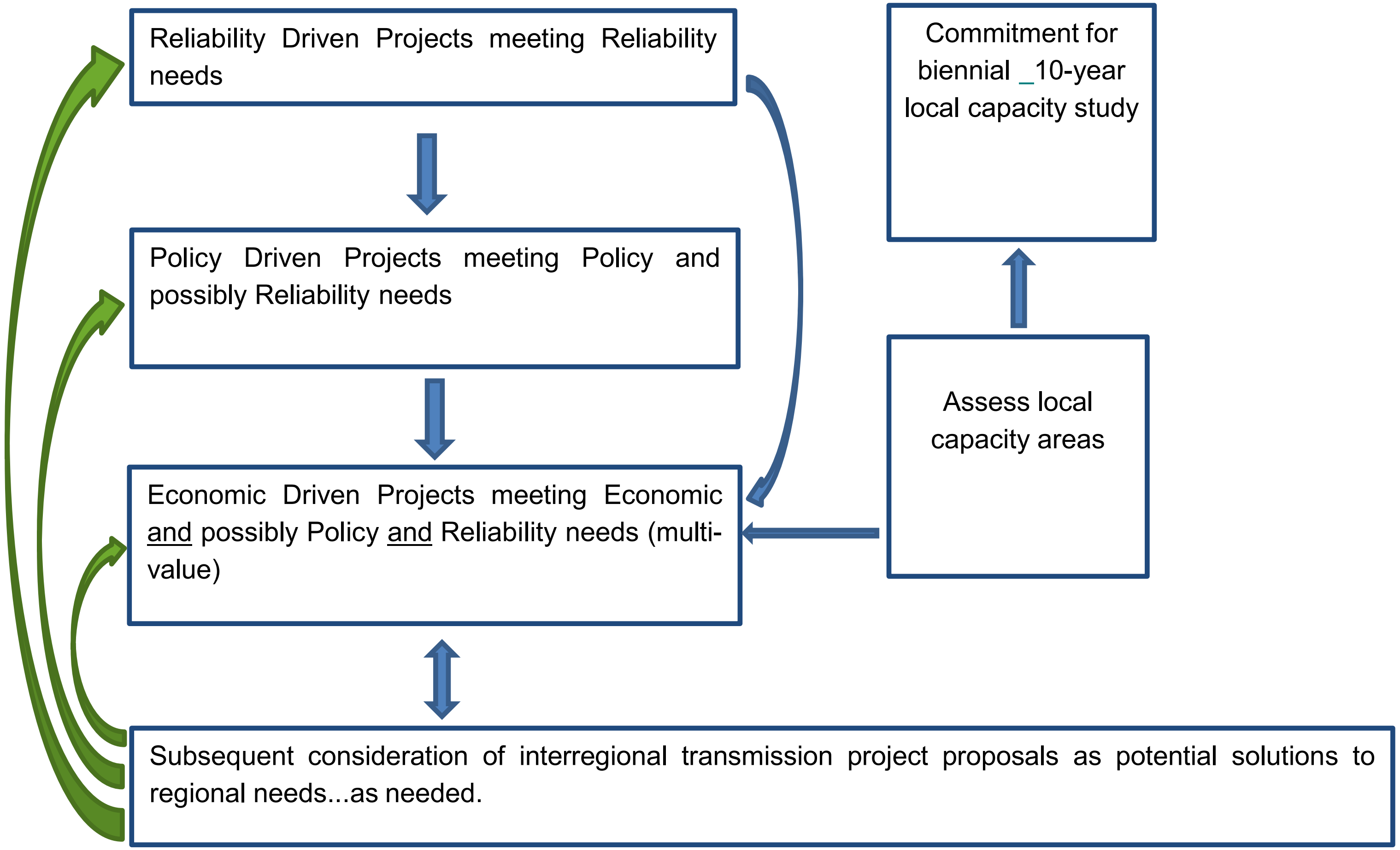
2034 — Mapped Total Resources (In-Dev & Generic)

	Geothermal	Biomass	Wind			OOS Wind	Offshore Wind	Distributed Solar	Solar			Li_Battery			LDES	Total 2034 Resources
CAISO Study Area	FCDS (MW)	FCDS (MW)	FCDS (MW)	EODS (MW)	Total (MW)	FCDS (MW)	FCDS (MW)	FCDS (MW)	FCDS (MW)	EODS (MW)	Total (MW)	4hr - FCDS (MW)	8hr -FCDS (MW)	Total (MW)	FCDS (MW)	(MW)
PG&E North of Greater Bay Study Area	144.0	97.5	777.50	319.50	1,097	-	931	37	275	320	595	293	88	382	5	**3,288**
PG&E Greater Bay Study Area	-	24.6	688	90	778	-	-	40	-	100	100	829	212	1,040	-	**1,983**
PG&E Fresno Study Area	-	20.2	394	96	490	-	-	66	2,636	869	3,505	1,554	200	1,754	130	**5,966**
PG&E Kern Study Area	-	18.0	300	10	310	-	2,924	73	680	1,301	1,981	777	142	919	-	**6,224**
SCE Northern Area	-	1.0	564	16	580	-	-	5	1,633	1,653	3,286	3,240	170	3,409	458	**7,739**
SCE Metro Study Area	-	5.6	-	-	-	-	-	27	-	-	-	1,795	167	1,962	-	**1,994**
SCE North of Lugo Study Area	-	1.5	310	50	360	-	-	11	672	910	1,582	716	90	806	-	**2,761**
East of Pisgah Study Area	875.0	-	620	-	620	3,965	-	-	1,075	1,565	2,640	1,684	180	1,864	-	**9,964**
SCE Eastern Study Area	790.0	2.6	224	100	324	2,131	-	-	810	2,649	3,459	2,680	270	2,950	-	**9,656**
SDG&E Study Area	160.0	-	1,325	239	1,564	-	-	1	700	882	1,582	1,390	100	1,490	437	**5,234**
Total 2034 Resources:	**1,969.0**	**171.0**	**5,203**	**921**	**6,123**	**6,096**	**3,855**	**260**	**8,481**	**10,248**	**18,729**	**14,958**	**1,618**	**16,576**	**1,030**	**54,808**

2039 — Mapped Total Resources (In-Dev & Generic)

	Geothermal	Biomass	Wind			OOS Wind	Offshore Wind	Distributed Solar	Solar			Li_Battery			LDES	Total 2039 Resources
CAISO Study Area	FCDS (MW)	FCDS (MW)	FCDS (MW)	EODS (MW)	Total (MW)	FCDS (MW)	FCDS (MW)	FCDS (MW)	FCDS (MW)	EODS (MW)	Total (MW)	4hr - FCDS (MW)	8hr -FCDS (MW)	Total (MW)	FCDS (MW)	(MW)
PG&E North of Greater Bay Study Area	144.0	97.5	1,677.9	319.5	1,997	-	1,607	37	430	1,115	1,545	293	488	782	5	**6,214**
PG&E Greater Bay Study Area	-	24.6	688	90	778	1,500	-	40	470	215	685	879	822	1,700	-	**4,728**
PG&E Fresno Study Area	-	20.2	394	96	490	-	-	66	3,027	3,404	6,430	1,669	1,607	3,276	130	**10,412**
PG&E Kern Study Area	-	18.0	300	10	310	-	2,924	73	1,036	2,061	3,096	777	682	1,459	-	**7,879**
SCE Northern Area	-	1.0	564	16	580	-	-	5	1,634	3,017	4,651	3,240	734	3,974	458	**9,669**
SCE Metro Study Area	-	5.6	-	-	-	-	-	34	-	-	-	1,845	447	2,292	-	**2,331**
SCE North of Lugo Study Area	-	1.5	310	50	360	-	-	27	752	1,258	2,010	746	265	1,011	-	**3,410**
East of Pisgah Study Area	875.0	-	620	-	620	4,060	-	-	1,200	3,030	4,230	2,188	696	2,884	-	**12,669**
SCE Eastern Study Area	790.0	2.6	224	100	324	3,536	-	-	1,610	4,224	5,834	2,680	1,070	3,750	-	**14,236**
SDG&E Study Area	160.0	-	1,325	239	1,564	-	-	1	700	1,219	1,919	1,390	305	1,695	487	**5,826**
Total 2039 Resources:	**1,969.0**	**171.0**	**6,103**	**921**	**7,023**	**9,096**	**4,531**	**283**	**10,858**	**19,541**	**30,399**	**15,707**	**7,115**	**22,822**	**1,080**	**77,374**

Studies are coordinated as a part of the transmission planning process



Interconnection Process - Treat Energy Only projects based on identification of need in the resource portfolios

- Energy Only (EO) projects will have two options to interconnect:
  - Reimbursement option allows EO projects in zones where the local regulatory authority portfolio identifies the need for EO resources
    - Eligible for reimbursement of the cost of reliability network upgrades
    - Capacity studied capped at 150% of EO portfolio amount for zone
  - Non-reimbursement option for all other EO resources that seek to interconnect in zones where a portfolio has not identified the need for EO resources
    - Not eligible for reimbursement of cost of reliability network upgrades
    - No cap on the number of projects studied
- *Zero* Energy Only projects submitted interconnection requests in Clusters 10-15

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