The Value of Interregional Transmission: Grid Planning for the 21st Century

PRESENTED BY

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PREPARED FOR

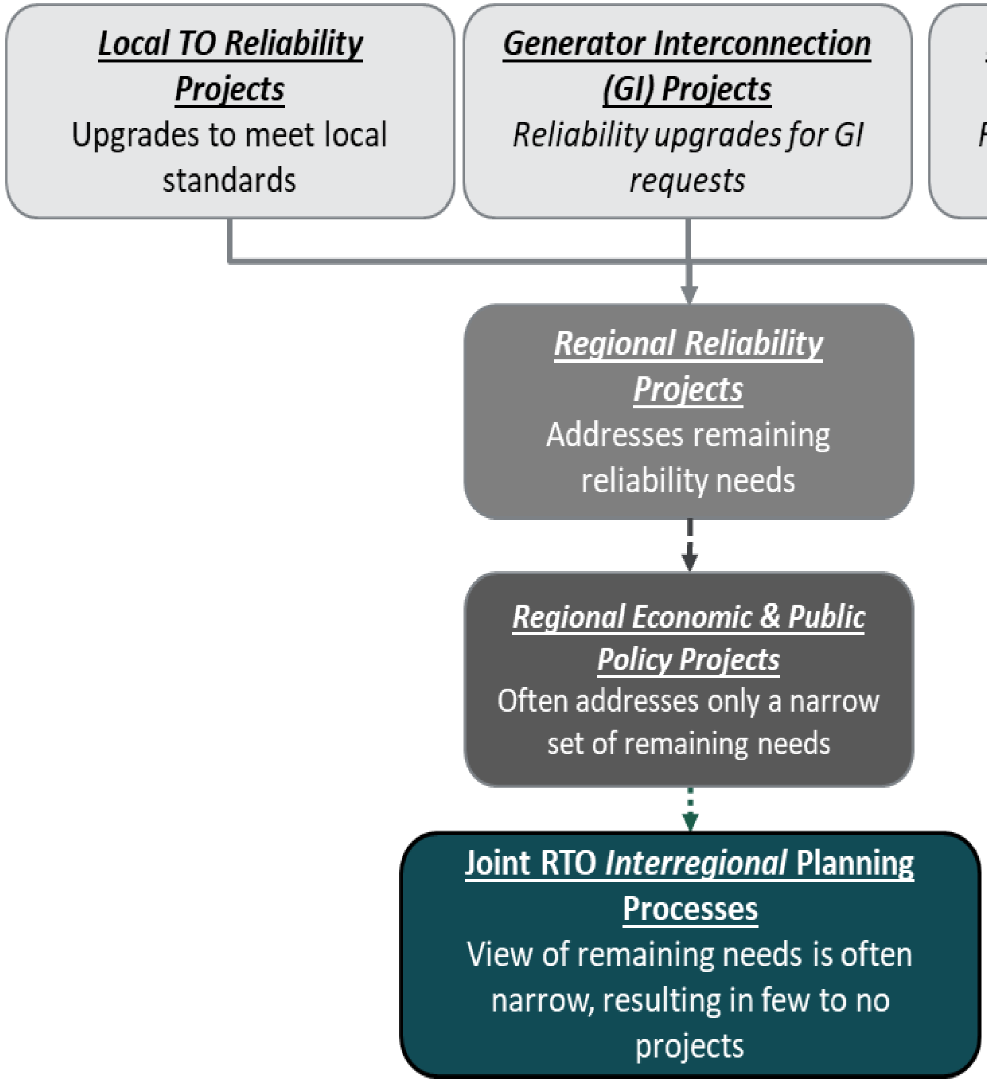
Midwestern Governors Association

MID-GRID 2023 Meeting

Little Rock,
September 27-28, 2023

Brattle

Current U.S. Grid Planning Processes are too Siloed



These solely reliability-driven processes account for > 90% of all transmission investments

- None involve any assessments of economic benefits (i.e., cost savings offered by the new transmission)
- Which also means these investments are not made with the objective to find the most cost-effective solutions
- Will yield higher system-wide costs and electricity rates

Planning for economic and public-policy projects: less than 10% of all transmission investments

Interregional planning processes are largely ineffective

- Essentially no major interregional transmission projects have been planned by grid operators in the last decade
- Regional focus on meeting reliability needs leaves no “need” for interregional transmission, even if more cost effective

Barriers to Interregional Transmission Planning

A. Leadership, Alignment and Understanding	1. Insufficient leadership from RTOs and federal & state policy makers to prioritize interregional planning 2. Limited trust amongst states, RTOs, utilities, & customers 3. Limited understanding of transmission issues, benefits & proposed solutions 4. Misaligned interests of RTOs, TOs, generators & policymakers 5. States prioritize local interests, such as development of in-state renewables
B. Planning Process and Analytics	**6. Benefit analyses are too narrow, and often not consistent between regions** 7. Lack of proactive planning for a full range of future scenarios **8. Sequencing of local, regional, and interregional planning** 9. Cost allocation (too contentious or overly formulaic)
C. Regulatory Constraints	10. Overly-prescriptive tariffs and joint operating agreements 11. State need certification, permitting, and siting

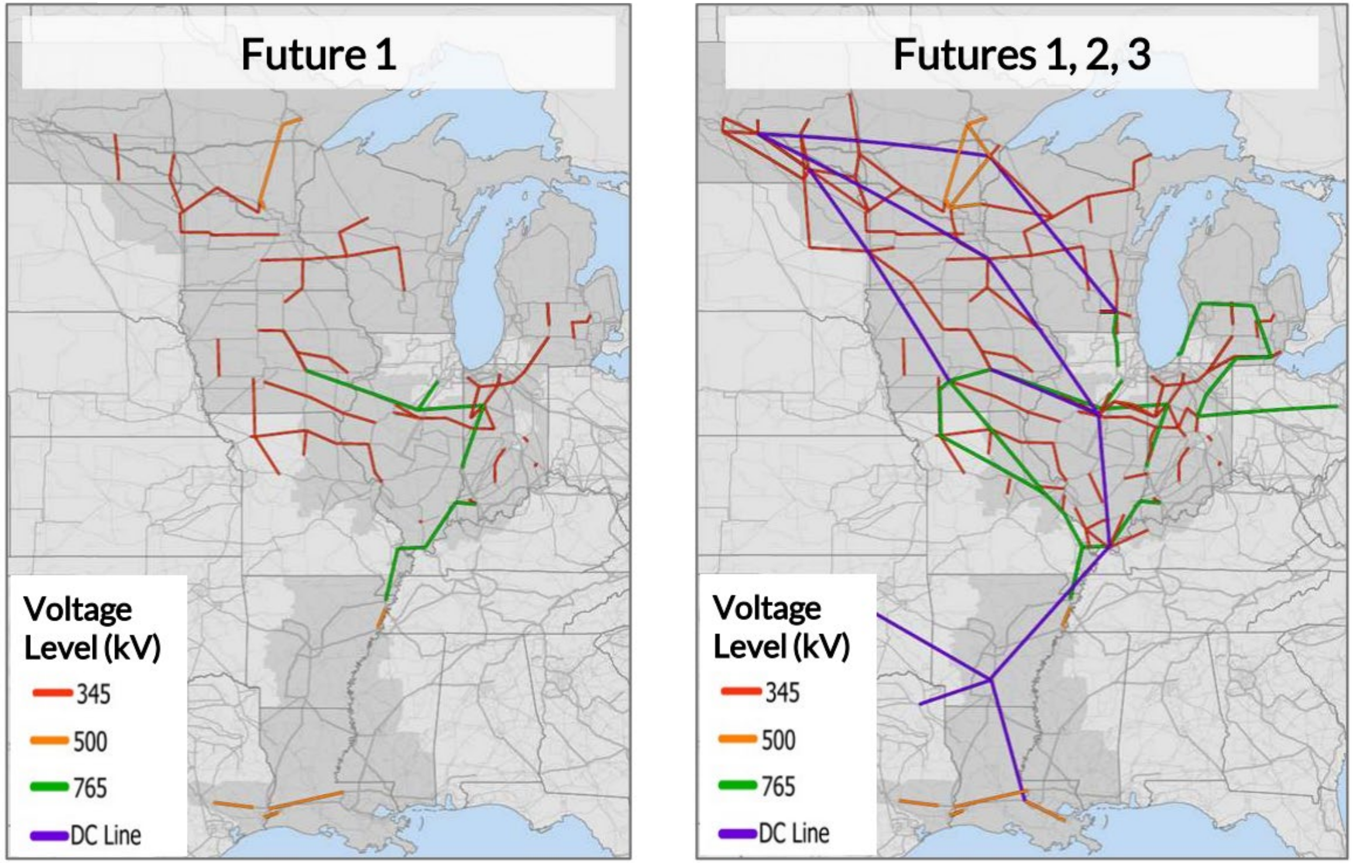
Source: Appendix A of A Roadmap to Improved Interregional Transmission Planning, November 30, 2021. Based on interviews with 18 organizations representing state and federal policy makers, state and federal regulators, transmission planners, transmission developers, industry groups, environmental groups, and large customers.

Example: Prioritizing Regional over Interregional Solutions

- MISO's new Renewable Integration Impact Assessment (RIIA) improves on many other planning studies by:
  - Establishing the need to study both policy goals and reliability goals simultaneously
  - Considering diverse future scenarios
  - Recommends a "least-regret" transmission plan (but one that does not address possibility of regret from inadequate T)
- By design, **the scope of study does not address any interregional opportunities:**
  - Despite modeling five regions in addition to MISO, the study mostly did not consider interregional transmission (see figures)
  - Even if "optimal" for MISO, it likely preempts more cost-effective interregional solutions

How would SPP-MISO-PJM wide planning results differ?

MISO's projected scope of transmission expansion needs



Source: MISO LRTP Roadmap March 2021

Understanding Transmission-Related Benefits

Wide-spread nature of benefits creates challenges in estimating them and how they accrue to different users, which also complicates cost allocation

Broad in scope, providing many different types of benefits	• Increased reliability and operational flexibility • Reduced congestion, dispatch costs, and losses • Lower capacity needs and generation costs • Increased competition and market liquidity • Renewables integration and environmental benefits • Insurance and risk mitigation benefits • Diversification benefits (e.g., reduced uncertainty and variability) • Economic development from G&T investments
Wide-spread geographically	• Multiple transmissions service areas • **Multiple states** and regions
Diverse in their effects on market participants	• **Customers**, **generators**, **transmission owners** in regulated and/or deregulated markets • Individual market participants may capture one set of benefits but not others
Occur and change over long periods of time	• Several decades (50+ years), typically increasing over time • Changing with system conditions and future generation and transmission additions • Individual market participants may capture different types of benefits at different times

Economic benefit of transmission =

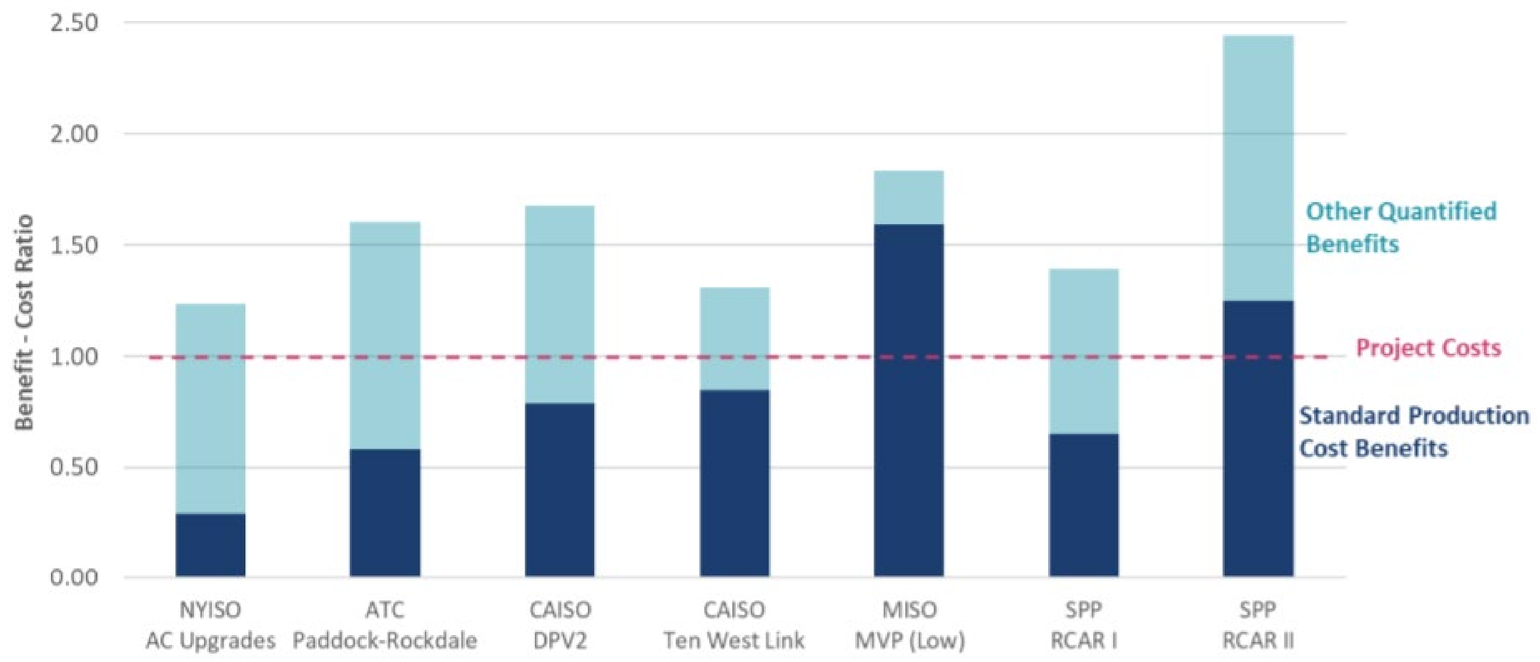
+ Cost savings that reduce overall system-wide costs faced by customers

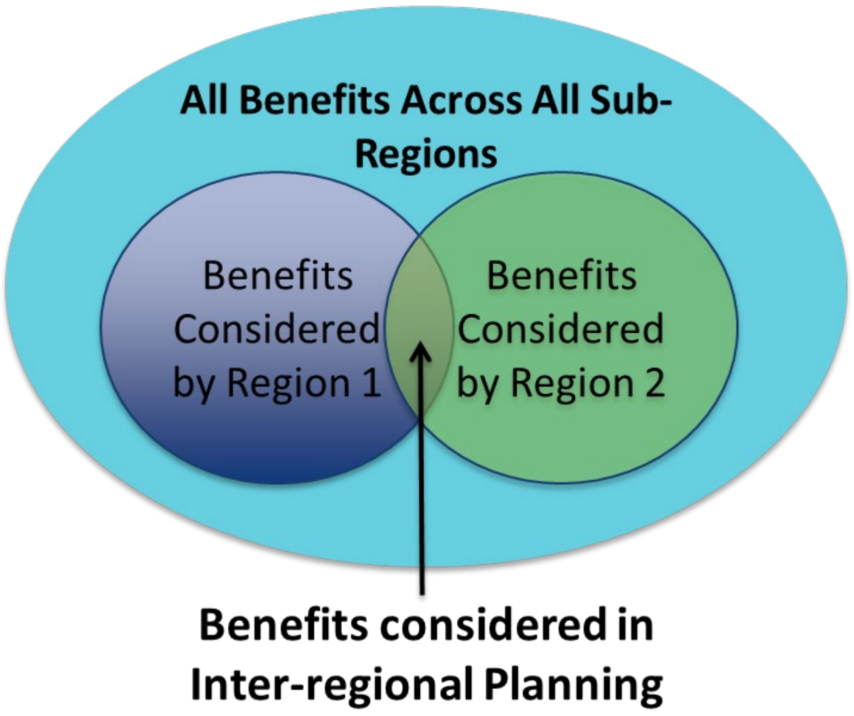
+ Economic value of added reliability

Quantifying Benefits Beyond "Production Cost" Savings

Relying solely on traditionally-quantified Adjusted Production Cost (APC) Savings results in the rejection of beneficial transmission projects – particularly for interregional planning efforts that consider an even smaller subset of benefits

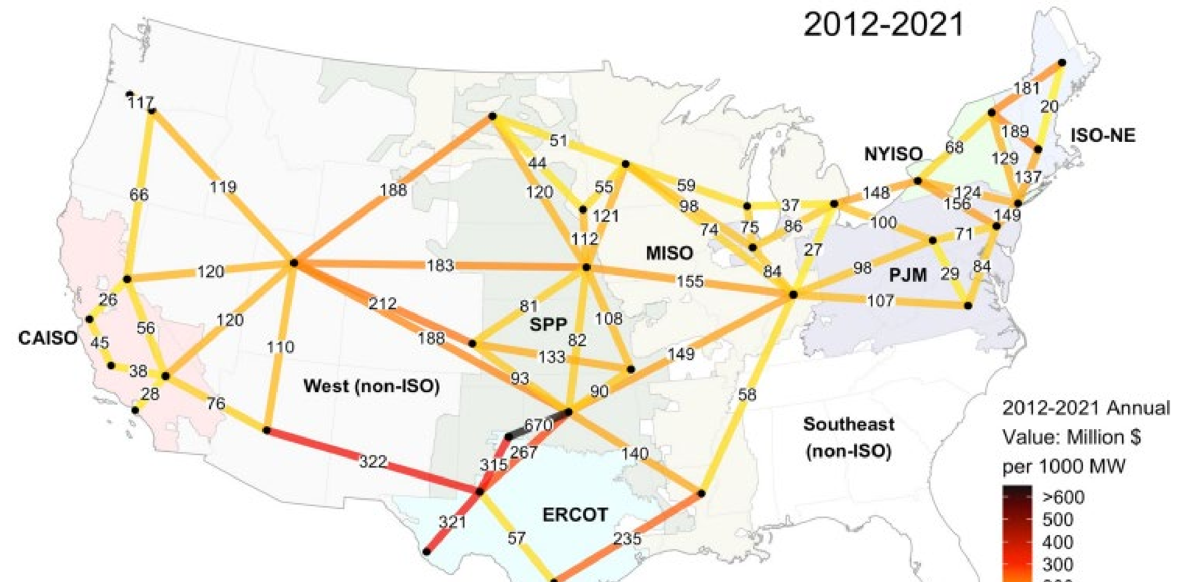
FIGURE 5. BENEFIT-COST RATIOS OF TRANSMISSION PROJECTS WITH AND WITHOUT A BROAD SCOPE OF BENEFITS



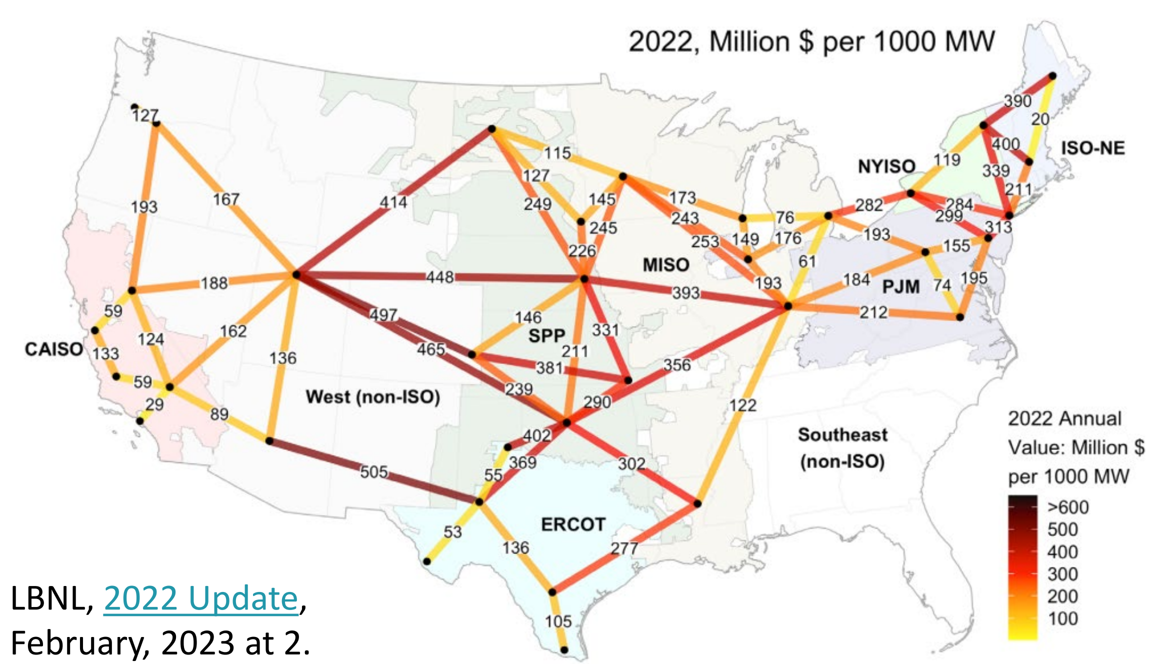


Source: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs
A Roadmap to Improved Interregional Transmission Planning.

The High Value of and Large Need for Interregional Transmission



LBNL, *Empirical Estimates of Transmission Value*, Slide 16



LBNL, 2022 Update, February, 2023 at 2.

DOE's National Transmission Needs Study identified significant interregional transmission needs based on 3 groups of scenarios:

1. **Mod/Mod** = status-quo with moderate load and clean-energy shares
2. **Mod/High** = moderate load growth but high clean-energy shares
3. **High/High** = high load and clean-energy shares

"Need" = optimal regional and interregional transmission expansion that minimize total system-wide costs

- Based on six recent national studies, 26 scenarios, and numerous sensitivities

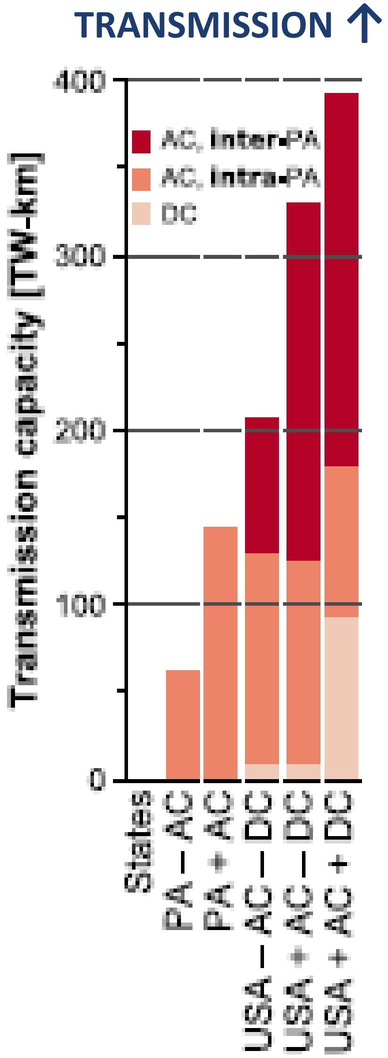
DOE's 2023 Transmission Needs Study: Interregional Needs

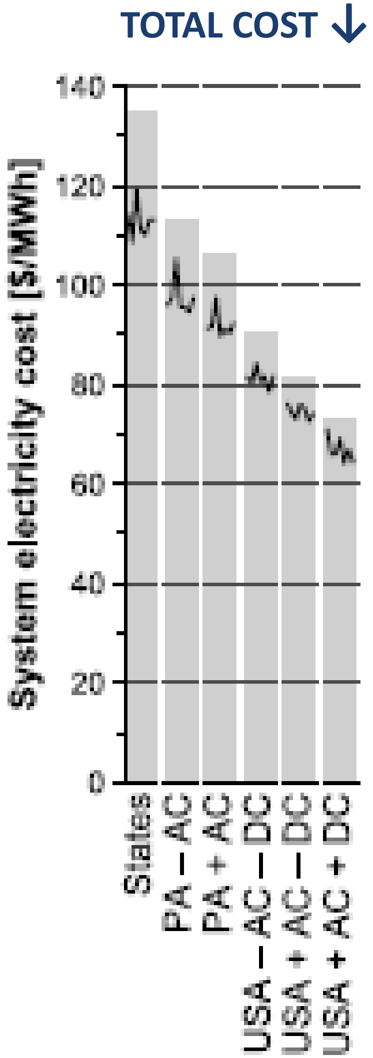
Region	2020 GW	Scenario Group	New in 2030		New in 2035		New in 2040	
			GW	% Growth	GW	% Growth	GW	% Growth
Delta – Texas	0.00	Mod/Mod					22.2	
		Mod/High					48.3	
		High/High					106.7	
Mountain – Plains	0.92	Mod/Mod	0.36	39.1%	0.94	102%	1.40	152%
		Mod/High	0.79	85.4%	2.64	287%	11.9	1290%
		High/High	6.10	663%	19.3	2100%	29.2	3170%
Plains – Southwest	0.40	Mod/Mod	0.69	172%	1.16	290%	1.48	370%
		Mod/High	2.53	631%	3.66	914%	13.1	3280%
		High/High	5.54	1380%	13.0	3240%	14.4	3600%
Plains – Texas	0.82	Mod/Mod	0.02	3.0%	0.49	60.0%	0.91	111%
		Mod/High	1.15	140%	9.84	1200%	14.6	1780%
		High/High	14.3	1750%	28.9	3520%	34.9	4260%
Delta – Midwest	3.00	Mod/Mod	0.00	0.0%	0.00	0.0%	0.00	0.0%
		Mod/High	0.00	0.0%	0.00	0.0%	0.00	0.0%
		High/High	0.10	3.2%	0.91	30.4%	1.32	44.2%
Delta – Plains	4.76	Mod/Mod	0.00	0.0%	0.35	7.4%	0.73	15.3%
		Mod/High	4.89	103%	19.7	414%	0.00	0.0%
		High/High	20.7	434%	48.5	1020%	55.3	1160%

Region	2020 GW	Scenario Group	New in 2030		New in 2035		New in 2040	
			GW	% Growth	GW	% Growth	GW	% Growth
Mid-Atlantic – Midwest	21.7	Mod/Mod	1.10	5.1%	2.39	11.0%	2.65	12.2%
		Mod/High	9.87	45.5%	33.8	156%	21.9	101%
		High/High	42.4	196%	103	475%	119	550%
Mid-Atlantic – New York	2.00	Mod/Mod	0.00	0.0%	0.29	14.7%	0.81	40.6%
		Mod/High	0.00	0.0%	2.43	122%	14.8	742%
		High/High	2.03	102%	8.24	412%	12.7	634%
Mid-Atlantic – Southeast	7.07	Mod/Mod	0.19	2.6%	0.51	7.3%	1.50	21.3%
		Mod/High	2.78	39.3%	6.86	97.1%	12.5	177%
		High/High	4.36	61.7%	9.88	140%	12.2	173%
Midwest – Plains	12.1	Mod/Mod	1.35	11.2%	3.14	26.0%	3.62	30.1%
		Mod/High	7.99	66.3%	21.1	175%	23.0	191%
		High/High	24.6	204%	88.0	731%	98.7	819%
Midwest – Southeast	8.27	Mod/Mod	0.00	0.0%	0.00	0.0%	0.00	0.0%
		Mod/High	1.28	15.4%	4.46	53.9%	6.23	75.3%
		High/High	10.3	125%	34.4	416%	39.9	483%
Delta – Southeast	5.92	Mod/Mod	0.00	0.0%	0.00	0.0%	0.00	0.0%
		Mod/High	0.92	15.6%	5.10	86.2%	10.7	181%
		High/High	10.1	171%	33.9	572%	37.7	637%

Source: DOE National Transmission Needs Study, Draft February 2023, Table VI-4, p. 96
https://www.energy.gov/sites/default/files/2023-02/022423-DRAFTNeedsStudyforPublicComment.pdf

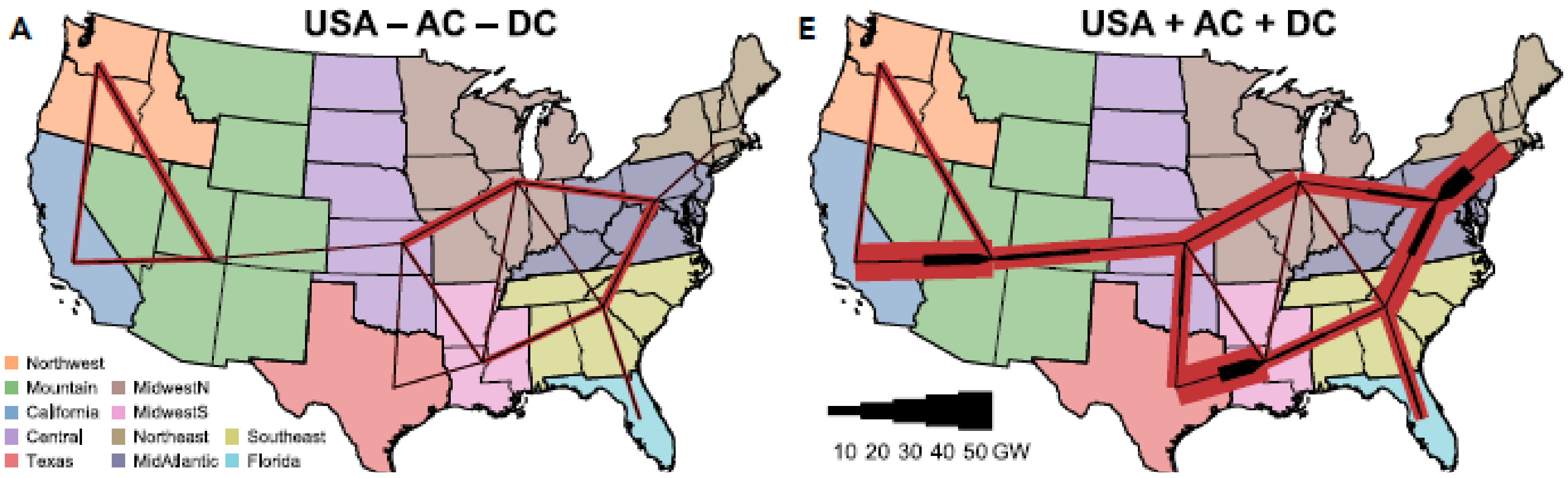
MIT Study: Cost Reductions Enabled by Interregional Transmission





Key Result: A more robust national grid would reduce the total cost of decarbonizing the grid … but (higher-cost) regional and more local solutions may also be feasible

**Optimal Transmission Build:
With and Without National Transmission Coordination**



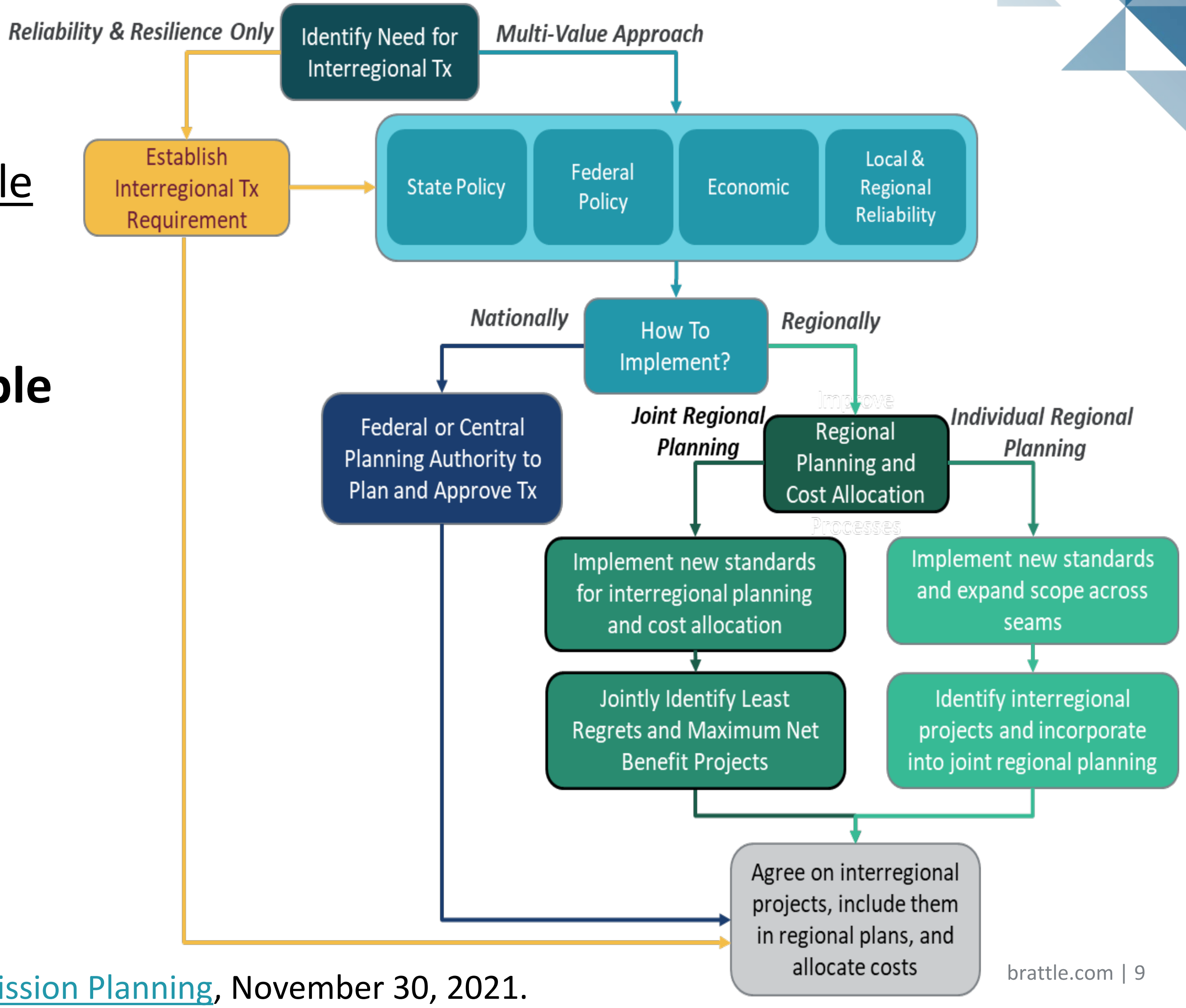
P. R. Brown and A. Botterud, *The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System*, Joule, December 11, 2020.

Options for Improving Interregional Planning Processes

While national studies show there are benefits of interregional transmission, these studies do not create an actionable "need" for approving projects

Four paths can be pursued simultaneously, identifying actionable transmission needs through:

1. New Interregional Tx requirements?
2. New Federal planning?
3. Improve joint RTO planning
4. Expand planning by individual RTOs



Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Value Consideration for Interregional Transmission

To be able to plan interregional transmission that reduces costs and improves reliability compared to regional or local solutions requires that we:

- Fully and efficiently utilize interregional transmission in energy markets and for resource adequacy
- Improve planning models:
  - Improve representation of neighboring regions in model footprint to capture diversity
  - Capture impacts of challenging conditions and extreme events, such as heat waves or cold snaps
    - Simultaneous spikes in loads, fuel prices, generation and transmission outages, resilience challenges
    - LBNL study: 40-80% of annual transmission value is concentrated in top 5% of all hours
  - Integrate/combine all benefit metrics of neighboring regions in economic analyses
  - Recognize the full resource adequacy value of interregional transfer capability (even if non-firm or not committed to capacity imports) to reflect load and resource diversity
- Proactively evaluate (including in regional planning processes) if interregional solutions exist that are more effective than regional or local solutions
  - Recognize regional/interregional benefits, including avoided cost of regional/local solutions

First Step: More Efficiently Utilize Interregional Transmission

The time is ripe to consider "intertie optimization" to reduce seam-related inefficiencies & barriers to interregional transmission development, including for merchant lines that provide regional market benefits without regulated cost recovery from all customers

- NYISO, ISO-NE, and Potomac Economics have called for intertie optimization in 2010-2011 to address seam-related inefficiencies, but only "coordinated transaction scheduling"(CTS) was implemented at the time
- A decade later, market monitors continue to document seams-related inefficiencies, noting that CTS has not been effective, and recommending intertie optimization
- The Western energy imbalance markets and European "market coupling" experiences have shown that intertie optimization between BAAs offers substantial benefits, reducing costs, improving reliability and renewable integration—dramatically improving efficient utilization of interregional transmission
  - The Extended Day-Ahead Market (EDAM) and Markets+ will further enhance the value of intertie optimization across BAA seams in the West
- CAISO's new "Subscriber PTO" proposal integrates available capacity on merchant transmission projects into the regional and interregional energy market optimization

ESIG Webinar (Monday, Oct 2): The Need for Intertie Optimization – Reducing Customer Costs, Improving Grid Resilience, and Encouraging Interregional Transmission

Thank You!

Comments and Questions?

Additional Slides

About the Speaker

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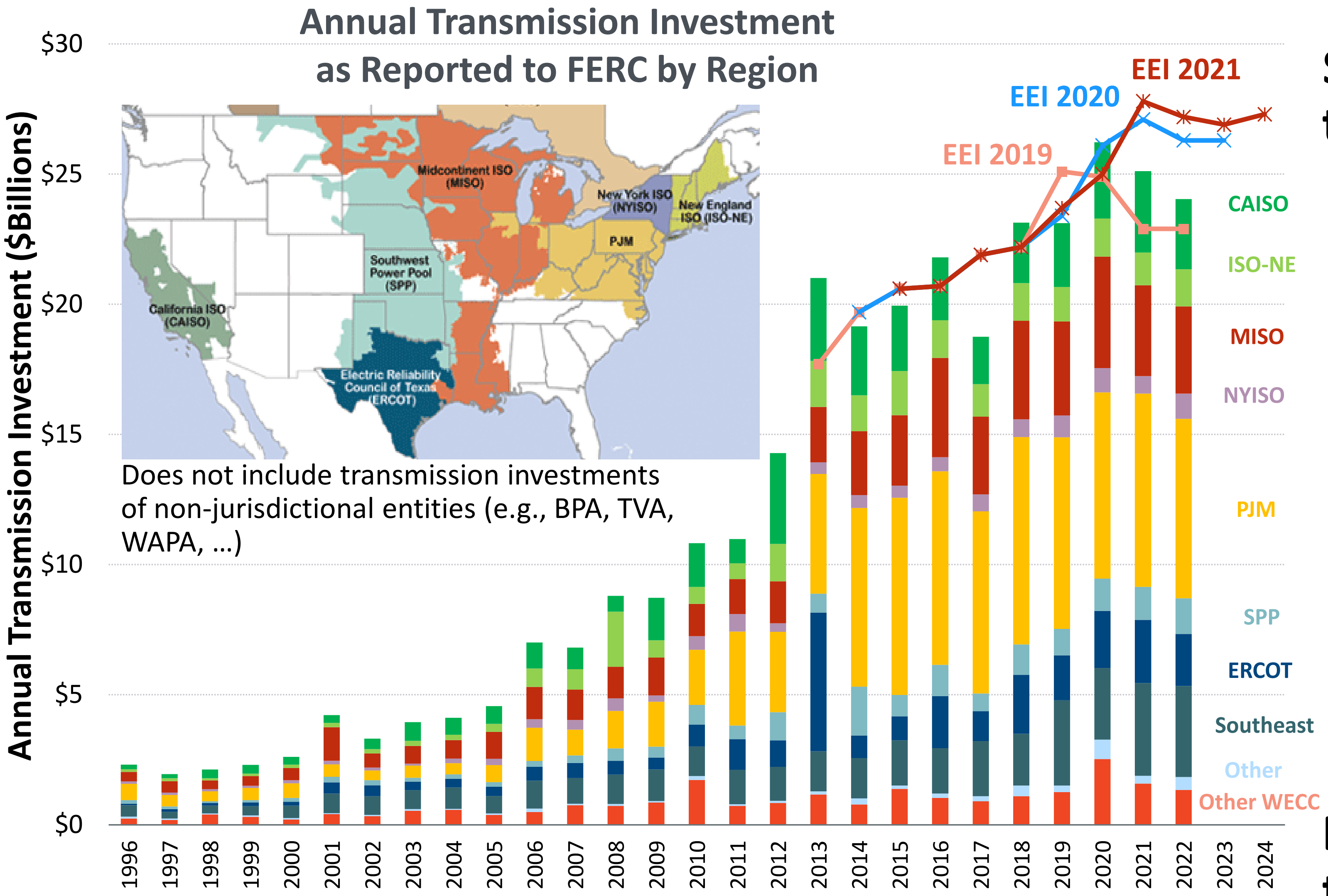
Johannes (Hannes) Pfeifenberger, a Principal at The Brattle Group, is an economist with a background in electrical engineering and over twenty-five years of experience in wholesale power market design, renewable energy, electricity storage, and transmission. He also is a Visiting Scholar at MIT's Center for Energy and Environmental Policy Research (CEEPR), a Senior Fellow at Boston University's Institute of Sustainable Energy (BU-ISE), a IEEE Senior Member, and currently serves as an advisor to research initiatives by the U.S. Department of Energy, the National Labs, and the Energy Systems Integration Group (ESIG).

Hannes specializes in wholesale power markets and transmission. He has analyzed transmission needs, transmission benefits and costs, transmission cost allocations, and renewable generation interconnection challenges for independent system operators, transmission companies, generation developers, public power companies, industry groups, and regulatory agencies across North America. He has worked on transmission matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, and Canada and has analyzed offshore-wind transmission challenges in New York, New England, and New Jersey.

He received an M.A. in Economics and Finance from Brandeis University's International Business School and an M.S. and B.S. ("Diplom Ingenieur") in Power Engineering and Energy Economics from the University of Technology in Vienna, Austria.

Transmission Investments is at Historically High Levels



Sources: The Brattle Group analysis of FERC Form 1 Data; EEI "Historical and Projected Transmission Investment" most recent accessed here: https://www.eei.org/resourcesandmedia/Documents/Historical%20and%20Projected%20Transmission%20Investment.pdf

$20-25 billion in annual U.S. transmission investment, but:

- More than 90% of it justified solely based on reliability needs without benefit-cost analysis
  - About 50% solely based on “local” utility criteria (without going through regional planning processes)
  - The rest justified by regional reliability and generation interconnection needs
- While significant experience with transmission benefit-cost analyses exists, very few projects are justified based on economics to yield overall cost savings

Essentially no interregional transmission!

Examples of Brattle Reports on Regional and Interregional Transmission Planning and Benefit-Cost Analyses

Well-Planned Electric Transmission Saves Customer Costs:
Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future

PREPARED FOR
WIRES

Link: Well-Planned Transmission

PREPARED BY
Judy W. Chang
Johannes P. Pfeifenberger

May 2016

THE Brattle GROUP

Toward More Effective Transmission Planning:
Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid

PREPARED FOR
WIRES

Link: Effective Transmission Planning

PREPARED BY
Johannes P. Pfeifenberger
Judy W. Chang
Akarsh Sheilendranath

April 2015

The Brattle Group

Link: Transmission Benefits

The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments

July 2013

Judy W. Chang
Johannes P. Pfeifenberger
J. Michael Hagerty

Link: Diversity Value

BU
Boston University Institute for Sustainable Energy

The Value of Diversifying Uncertain Renewable Generation through the Transmission System

September • 2020

A Roadmap to Improved Interregional Transmission Planning

Link: Interregional Roadmap

PREPARED BY
Johannes P. Pfeifenberger
Kasparas Spokas
J. Michael Hagerty
John Tsoukalis

November 30, 2021

Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs

Link: Brattle Grid Strategies

PREPARED BY

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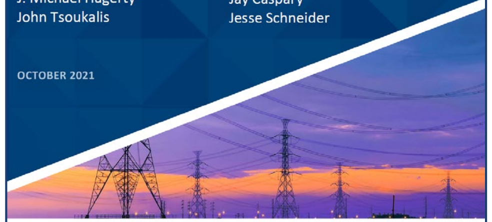
OCTOBER 2021



Brattle
GRID STRATEGIES LLC

Summarizes proven approaches to quantifying various benefits

The Need for and Value Proposition of Interregional Transmission

Existing studies highlight how interregional transmission can provide significant benefits as the grid transitions to clean resources

- **The value proposition (increased reliability, reduced costs, risk mitigation) of interregional transmission defines the "need" for the approval these projects**
- In the last ten years, numerous studies have looked at a wide range of grid transition scenarios—including a "continuation of recent trend" view in which coal is gradually being replaced by renewables to reduce emissions
  - In all instances, **building new interregional transmission reduces overall system costs and reduces emissions** while reducing risk and helping to maintain or increase reliability
- The **need for interregional transmission has evolved** as renewable costs have declined and state clean-energy and decarbonization policies have become more ambitious. It has shifted from transporting (mostly) low-cost wind to load centers to include a broader set of benefits: **interregional transmission improves reliability and protects customers from high-cost outcomes**
- While there is some substitutability between solar, storage, and transmission, the **declining cost of solar and storage has not changed the conclusion that interregional transmission reduces costs**
- The development of **interregional transmission and lower electricity rates also create jobs**; potentially more than many local-only renewables policies
- Particularly as shares of weather-correlated renewable generation increases, **robust interregional transmission** is needed to ensure that the geographic scale of the grid exceeds **the size of typical weather systems**

National Studies Show Large Benefit of Interregional Transmission

Study	Region	Findings
NREL North American Renewable Integration Study (2021)	U.S., Canada, Mexico	• Increasing trade between countries can provide $10-30 billion in net benefits • **Interregional transmission expansion achieves up to $180 billion in net benefits**
MIT Value of Interregional Coordination (2021)	Nation-Wide	• National coordination of **reduces the cost of decarbonizing by almost 50% compared to no coordination between states** • The lowest-cost scenario builds almost 400 TW-km of transmission; including **roughly 100 TW-km of DC capacity between the interconnections** and over 200 TW-km of interregional AC capacity • **No individual state is better off implementing decarbonization alone** compared to national coordination of generation and transmission investment • Low storage and solar costs still result in significant cost effective interregional transmission
Princeton Net Zero America Study (2021)	Nation-Wide	• Achieving net-zero emissions by 2050 requires **700-1,400 TW-km of new transmission** • Investment in transmission needed ranges **$2-4 trillion dollars by 2050**
U.C. Berkeley 90% by 2035 (2020)	Nation-Wide	• The only national study that suggest relatively little interregional transmission would be needed to achieve 90% clean electricity. However, the study's simulation approach does not utilize more granular and well-established methods to properly value interregional transmission.
Vibrant Clean Energy Interconnection Study (2020)	Eastern Interconnect	• **40 to 90 TW-km of transmission is built by 2050** to meet climate goals • Transmission development can create **1-2 million jobs in the coming decades**, more than wind, storage, or distributed solar development • Transmission **reduces electricity bills by $60-90 per MWh**
Wind Energy Foundation Study (2018)	ERCOT, MISO, PJM, and SPP	• Transmission planners are not incorporating this rising tide of voluntary corporate renewable energy demand into plans to build new transmission
NREL Seams Study (2017)	Eastern and Western Interconnects	• Major new ties between interconnections **saves $4.5-$29 billion** over a 35 year period

Source: A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Limitations of National Studies

Although existing studies demonstrate the benefits of interregional transmission, they have not been successful in motivating improved interregional planning or actual transmission project developments. The reasons include some or all of the following:

- Many studies **tend to analyze aspirational clean energy targets (e.g., 90% by 2035 or 100% by 2050)** not the actual policies and mandates applicable for the next 10-15 years
  - By not modeling actual state or federal policies, clean-energy mandates, and renewable technology preferences, the studies cannot demonstrate a compelling "need" to policy makers, regulators, and permitting agencies
- The studies are **not transmission planning studies** that produce specific transmission projects that can be developed to deliver the identified benefits and they **do not support an actionable need for specific projects**
  - The results of these studies do not connect with RTO planning processes and needs identification
- Studies **do not to identify how benefits and costs are distributed** across utility service areas, states, or RTO/ISO under different scenarios, as would be necessary to gain support and develop feasible cost recovery options
  - The studies typically do not consider or propose how to recover ("allocate") transmission costs
- There has not been **an analysis of the state-by-state economic impact and job creation** from interregional transmission development, reduced electricity prices, and shifts in the locations of clean-energy investment
- Most studies do not **propose actionable solutions** to address the many barriers to planning processes and to the development of new interregional transmission projects

National Studies are Not a Substitute for Transmission Planning

While national studies indicate the economic benefits of new regional and interregional transmission, they do not analyze the transmission grid in sufficient detail to yield actionable interregional transmission plans (and cannot substitute for interregional transmission planning)

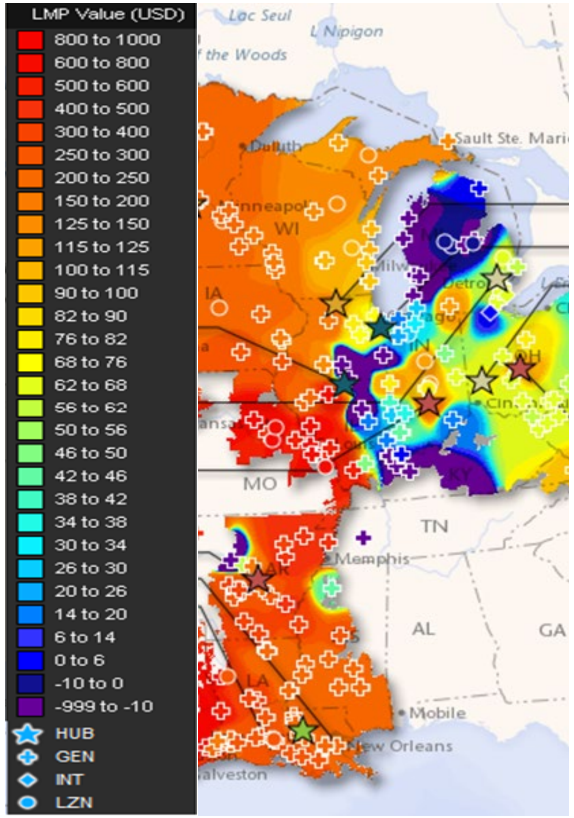
- Various "macro grid" studies show how much transmission capacity might be cost effective between certain regions, but they fail to:
  - Consider existing **transmission planning criteria** (e.g., reliability, stability, size of largest contingencies)
  - Pinpoint **specific locations on the power system** where transmission projects could interconnect to achieve cost reductions (studies typically only indicate which regions would benefit from more transfer capacity)
  - **Identify a list of actionable individual transmission projects (or manageable portfolios of projects)** and quantify project-specific benefits needed by regional planning authorities and transmission developers to obtain approvals for individual projects
  - **"Connect" to RTO/ISO and TO planning processes** that can approve actual projects for development
  - **Consider actual project costs and cost allocations** (including the costs of necessary local upgrades)

Detailed interregional transmission studies that include RTOs/ISOs are needed to identify specific projects that meet all planning criteria and are cost-effective overall and to the individual regions

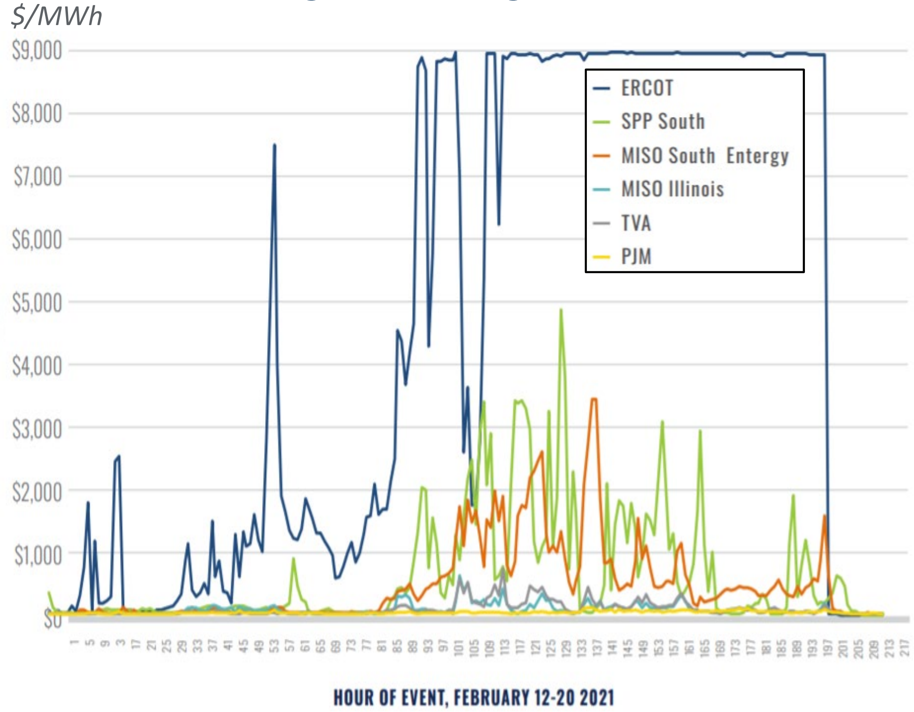
Case Study: Winter Storm Uri

Transmission constraints led to substantial price separations. Anadditional GW of transmission into Texas would have fully paid for itself over the course of the four-day event (Goggin, 2021).

LMPs on Feb 15th, 2021 at 7:45-7:55



Electricity Price Differences Between Regions During Uri



Savings per GW of Additional Interregional Transmission Capability
($ millions)

ERCOT – TVA	$993
SPP South – PJM	$129
SPP South – MISO IL	$122
SPP South – TVA	$120
SPP S – MISO S (Entergy Texas)	$110
MISO S-N (Entergy Texas - IL)	$85
MISO S (Entergy Texas) – TVA	$82

Framework for More Proactive Transmission Planning*

FERC NOPR efforts and available experience point to proven planning practices that can reduce total system costs and risks, but are rarely used today:

1. **Proactively and holistically plan for future generation and load** by incorporating realistic projections of all needs: the anticipated generation mix, public policy mandates, load levels, and load profiles over the lifespan of the transmission investments. Avoid siloed, incremental planning processes.
2. **Account for the full range of transmission needs** and **use multi-value planning** to comprehensively identify investments that cost-effectively address all categories of needs and benefits
3. **Address uncertainties and high-stress grid conditions explicitly through scenario-based planning** that takes into account all transmission needs for a broad range of plausible long-term futures as well as real-world system conditions, including challenging and extreme events
4. **Use comprehensive transmission network portfolios** to address system needs and **cost allocation** more efficiently and less contentiously than a project-by-project approach
5. **Jointly plan inter-regionally across neighboring systems** to recognize regional interdependence, increase system resilience, and take full advantage of interregional scale economics and geographic diversification benefits

* Brattle & Grid Strategies Report: Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, October 2021.

Intertie Optimization: The poor utilization of interregional transmission interties has long been documented

Potomac Economics has documented inefficient utilization of interregional transmission interties since 2003.

- David Patton, Coordinated Interchange Recommendations, March 13, 2003 (Presentation to New England RTO Working Group).

In 2010, Potomac Economics estimated that optimizing interties between MISO, PJM, NYISO, ISO-NE, and Canadian system operators would conservatively yield between $160-300 million in annual cost savings.

- See Analysis of the Broader Regional Markets Initiatives, pp. 10-13

In 2011, NYISO and ISO-NE proposed to address these seams-related inefficiencies through intertie optimization

- See Interregional Interchange Scheduling (IRIS) Analysis and Options

Yet, little has changed and interregional interties continue to be utilized poorly (see next slides)

The 2011 Intertie Optimization proposal by NYISO and ISO-NE

In 2011, NYISO and ISO-NE proposed to implement intertie optimization to address the inefficiencies from poor utilization of interregional transmission.

- ISOs agreed with concerns raised by its Market Monitor since 2003
- The ISOs' analysis showed that "too little power is flowing in the correct direction more than 4000 hours per year." "Nearly half of the time that New England has higher-cost generation on the margin than New York, the net scheduled flow is westbound into New York"
- "The price difference exceeds $5 per MWh (in absolute value) more than half of the year, and exceeds $10 per MWh (in absolute value) nearly one-third of the year [when] there is transmission capacity available to schedule additional transfers across the interface." "[T]otal energy expenditures would be on the order of one to two hundred million dollars lower annually—or perhaps half a million dollars per day lower—if the real-time inter-regional interchange system produced efficient tie schedules."
- The three root causes are:
  - **1. Latency Delay**. The time delay between when the tie is scheduled and when power flows, during which time system conditions and LMPs may change.
  - **2. Non-economic Clearing**. The ISOs make decisions about which tie schedule requests to accept without economic coordination, producing inefficient schedules.
  - **3. Transaction Costs**. The fees and charges levied by each ISO on external transactions serve as a disincentive to engage in trade, impeding price convergence and raising total system costs

NYISO/ISO-NE Recommended Intertie Optimization, but CTS was implemented instead

NYISO and ISO-NE offered designs for two possible solutions:

- Intertie Optimization: similar to the least-cost economic dispatch system used internally for each ISO's energy market, it relies on the bid-based supply offers from generators and demand resources to determine real-time LMPs and transmission flows within and between the two ISOs' networks.
- Coordinated Transaction Scheduling (CTS): facilities bilateral trading in real time through a simplified bid format (called an interface bid) and coordinated acceptance of interface bids by the ISOs (using an improved clearing rule).

The ISOs recommended the Intertie Optimization because:

- Intertie optimization is the more efficient solution
- The CTS system was not expected to produce as complete a price convergence between regions

Only CTS was implemented between NYISO and ISO-NE (and later PJM and MISO):

- Concerns were raised that intertie optimization may unnecessarily displace bilateral trading
- It was hoped that CTS might be almost as efficient as intertie optimization

MISO and NYISO Market Monitor: CTS has not been successful in reducing seams-related inefficiencies

The Potomac Economics (the NYISO and MISO Independent Market Monitor) has documented the ineffectiveness of CTS:

- For example, in the MISO 2021 State of the Market Report, the IMM notes that CTS between MISO and PJM: "*has produced very little of the sizable savings it could generate*" and that "*more than 40 percent of the current CTS transactions are ultimately unprofitable*" (at xx and 90, emphasis added).

To address these continued inefficiency the IMM recommends to modify CTS so it can better approximate intertie optimization:

- "we recommend the RTOs consider modifying the CTS to clear transactions every five minutes through [the Unit Dispatch System, UDS] based on the most recent five-minute prices in the neighboring RTO area."
- Doing so was estimated to offer cost savings of $23m for transactions with PJM and $44m for transactions with SPP

Table 14: CTS with Five-Minute Clearing Versus Current CTS
2021

	Percent of Intervals Adjusted	Production Cost Savings	Profits	Percent Unprofitable
PJM				
Current CTS	9.7%	$7,203,734	$199,456	39.4%
5-Minute CTS	77.5%	$23,207,329	$11,765,360	13.8%
SPP				
5-Minute CTS*	89.6%	$44,089,866	$25,984,814	22.1%

* Results omit Feb. 13-19 when SPP experienced very high prices from the Arctic Event.

Source: MISO 2021 STATE OF THE MARKET REPORT (potomaceconomics.com)

PJM Market Monitor: has been recommending intertie optimization because CTS has not been effective

The PJM Market Monitor has recommended to reconsider intertie optimization since 2014:

- In the 2022 PJM State of the Market Report (at 105), the PJM Market Monitoring Unit (MMU) repeats the recommendation it has made since 2014: "The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that would remove the need for market participants to schedule physical transactions across seams. Such a solution would include an optimized, but limited, joint dispatch approach that uses supply curves and treats seams between balancing authorities as constraints, similar to other constraints within an LMP market."

The recommendation is supported by a finding of inefficient intertie schedules that are inconsistent with seams-related price differences during almost half of all trading periods:

Table 9-27 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and MISO: 2022

Price Difference Range (Greater Than or Equal To)	Inconsistent Hours	Percent of Inconsistent Hours	Consistent Hours	Percent of Consistent Hours
$0.00	4,176	100.0%	4,584	100.0%
$1.00	3,773	90.3%	4,190	91.4%
$5.00	2,517	60.3%	2,737	59.7%
$10.00	1,570	37.6%	1,612	35.2%
$15.00	989	23.7%	1,056	23.0%
$20.00	673	16.1%	700	15.3%
$25.00	490	11.7%	531	11.6%
$50.00	150	3.6%	243	5.3%
$75.00	65	1.6%	137	3.0%
$100.00	38	0.9%	94	2.1%
$200.00	26	0.6%	34	0.7%
$300.00	19	0.5%	15	0.3%
$400.00	17	0.4%	8	0.2%
$500.00	15	0.4%	6	0.1%

Table 9-29 Distribution of hourly flows that are consistent and inconsistent with price differences between PJM and NYISO: 2022

Price Difference Range (Greater Than or Equal To)	Inconsistent Hours	Percent of Inconsistent Hours	Consistent Hours	Percent of Consistent Hours
$0.00	3,463	100.0%	5,297	100.0%
$1.00	3,193	92.2%	5,021	94.8%
$5.00	2,327	67.2%	3,834	72.4%
$10.00	1,667	48.1%	2,511	47.4%
$15.00	1,206	34.8%	1,664	31.4%
$20.00	912	26.3%	1,173	22.1%
$25.00	709	20.5%	881	16.6%
$50.00	360	10.4%	360	6.8%
$75.00	220	6.4%	209	3.9%
$100.00	143	4.1%	133	2.5%
$200.00	49	1.4%	54	1.0%
$300.00	22	0.6%	28	0.5%
$400.00	14	0.4%	24	0.5%
$500.00	9	0.3%	20	0.4%

Source: 2022 State of the Market Report for PJM (monitoringanalytics.com)

CAISO's Subscriber-PTO (SPTO) Proposal: designed to optimizing available capacity on interregional merchant transmission projects

CAISO developed a SPTO framework to integrate unutilized capacity on merchant transmission lines into regional and interregional day-ahead and real-time energy markets

- Applies to interregional merchant transmission lines (such as TransWest Express, an HVDC line from Wyoming to Utah and Southern California) whose costs are recovered from "subscribers" … rather than from native load customers through CAISO regulated transmission rates
- The SPTO proposal recognizes that fully integrating interregional merchant lines into DA and RT energy markets (and compensating the holders of the transmission rights for market-based use) offers substantial benefits to CAISO, its customers, and the larger western power market

Summary of the SPTO design (filed at FERC last week)**:**

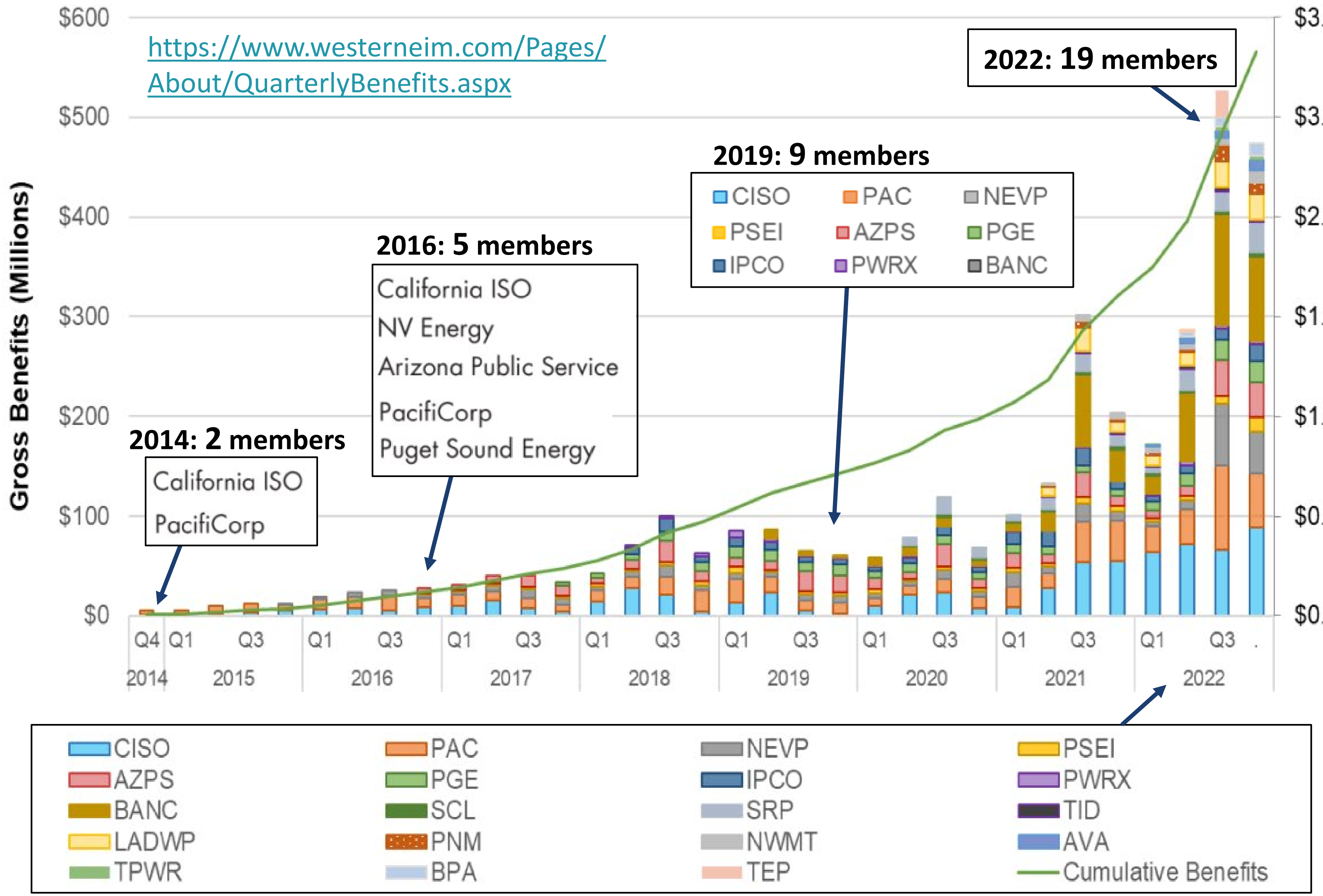
- The merchant SPTO facility is put under CAISO operational control
- Priority rights for subscriber schedules have priority (perfect congestion hedge)
- Unscheduled merchant transmission capacity (held by subscriber or project owner) is made available for regional and interregional market utilization in both day-ahead and real-time
- CAISO will optimize the SPTO capacity made available in its markets, including inter-regionally in EIM and EDAM
- CAISO will pay a "Non-subscriber Usage Charge" to compensate the merchant facility for market transactions
  - Paid from CAISO's transmission access charge to avoid rate pancaking

Experience with Intertie Optimization: Western EIM and EIS

The Western EIM and Western EIS have been created to optimize in real-time the available transmission across the interregional seams of multiple Balancing Areas in the WECC

- They represents the most relevant examples of the significant cost savings that intertie optimization between BAs can offer … along with reliability, resilience, and renewable integration benefits
- WEIM and WEIS transactions are incremental to a baseline of bilateral trades
- WEIM and WEIS transactions are scheduled on a 15-minute/ 5-minute basis after all bilateral trading closes (approximately 20 minutes before each real-time operating period)
- The available experience shows that real-time energy transactions optimized by neighboring system operators **offers significant value beyond what can be achieved through bilateral trades**.
- For example, as shown on next slide, WEIM has achieved:
  - **Between $170 million and $530 million in savings during each quarter of 2022,**
  - **Cumulative savings of $3.5 billion since its inception**
- In response to WEIM and WEIM success, market operators are now developing the Extended Day Ahead Market (EDAM) and Markets+ to optimize interregional transmission on a day-ahead basis as well
  - Market-based congestion/transfer revenues accrue to entity contributing the transmission rights/capability

WEIM Benefits: the value of transmission optimization within and across multiple Balancing Areas in RT energy markets



2022

Additional Reading on Transmission

Pfeifenberger, Plet, et al., The Operational and Market Benefits of HVDC to System Operators, for GridLab, ACORE, Clean Grid Alliance, Grid United, Pattern Energy, and Allete, September 2023.

Pfeifenberger, DeLosa, et al., The Benefit and Urgency of Planned Offshore Transmission, for ACORE, ACP, CATF, GridLab, and NRDC, January 24, 2023.

Brattle and ICC Staff, Illinois Renewable Energy Access Plan: Enabling an Equitable, Reliable, and Affordable Transition to 100% Clean Electricity for Illinois, December 2022.

Pfeifenberger et al., New Jersey State Agreement Approach for Offshore Wind Transmission: Evaluation Report, October 26, 2022.

Pfeifenberger, DeLosa III, Transmission Planning for a Changing Generation Mix, OPSI 2022 Annual Meeting, October 18, 2022.

Pfeifenberger, Promoting Efficient Investment in Offshore Wind Transmission, DOE-BOEM Atlantic Offshore Wind Transmission Economics & Policy Workshop, August 16, 2022.

Pfeifenberger, Generation Interconnection and Transmission Planning, ESIG Joint Generation Interconnection Workshop, August 9, 2022.

Pfeifenberger and DeLosa, Proactive, Scenario-Based, Multi-Value Transmission Planning, Presented at PJM Long-Term Transmission Planning Workshop, June 7, 2022.

Pfeifenberger, Planning for Generation Interconnection, Presented at ESIG Special Topic Webinar: Interconnection Study Criteria, May 31, 2022.

RENEW Northeast, A Transmission Blueprint for New England, Prepared with Borea and The Brattle Group, May 25, 2022.

Pfeifenberger, New York State and Regional Transmission Planning for Offshore Wind Generation, NYSERDA Offshore Wind Webinar, March 30, 2022.

Pfeifenberger, The Benefits of Interregional Transmission: Grid Planning for the 21st Century, US DOE National Transmission Planning Study Webinar, March 15, 2022.

Pfeifenberger, 21st Century Transmission Planning: Benefits Quantification and Cost Allocation, for NARUC members of the Joint Federal-State Task Force on Electric Transmission, January 19, 2022.

Pfeifenberger, Spokas, Hagerty, Tsoukalis, A Roadmap to Improved Interregional Transmission Planning, November 30, 2021.

Pfeifenberger, Tsoukalis, Newell, "The Benefit and Cost of Preserving the Option to Create a Meshed Offshore Grid for New York," Prepared for NYSERDA with Siemens and Hatch, November 9, 2022.

Pfeifenberger, Transmission–The Great Enabler: Recognizing Multiple Benefits in Transmission Planning, ESIG, October 28, 2021.

Pfeifenberger et al., Transmission Planning for the 21st Century: Proven Practices that Increase Value and Reduce Costs, Brattle-Grid Strategies, October 2021.

Pfeifenberger et al., Initial Report on the New York Power Grid Study, prepared for NYPSC, January 19, 2021.

Van Horn, Pfeifenberger, Ruiz, "The Value of Diversifying Uncertain Renewable Generation through the Transmission System," BU-ISE, October 14, 2020.

Pfeifenberger, Newell, Graf and Spokas, "Offshore Wind Transmission: An Analysis of Options for New York", prepared for Anbaric, August 2020.

Pfeifenberger, Newell, and Graf, "Offshore Transmission in New England: The Benefits of a Better-Planned Grid," prepared for Anbaric, May 2020.

Tsuchida and Ruiz, "Innovation in Transmission Operation with Advanced Technologies," T&D World, December 19, 2019.

Pfeifenberger, "Cost Savings Offered by Competition in Electric Transmission," Power Markets Today Webinar, December 11, 2019.

Chang, Pfeifenberger, Sheilendranath, Hagerty, Levin, and Jiang, "Cost Savings Offered by Competition in Electric Transmission: Experience to Date and the Potential for Additional Customer Value," April 2019 and "Response to Concentric Energy Advisors' Report on Competitive Transmission," August 2019.

Ruiz, "Transmission Topology Optimization: Application in Operations, Markets, and Planning Decision Making," May 2019.

Chang, Pfeifenberger, "Well-Planned Electric Transmission Saves Customer Costs: Improved Transmission Planning is Key to the Transition to a Carbon-Constrained Future," WIRES&Brattle, June 2016.

Newell et al. "Benefit-Cost Analysis of Proposed New York AC Transmission Upgrades," on behalf of NYISO and DPS Staff, September 15, 2015.

Pfeifenberger, Chang, and Sheilendranath, "Toward More Effective Transmission Planning: Addressing the Costs and Risks of an Insufficiently Flexible Electricity Grid," WIRES and Brattle, April 2015.

Chang, Pfeifenberger, Hagerty, "The Benefits of Electric Transmission: Identifying and Analyzing the Value of Investments," on behalf of WIRES, July 2013.

Chang, Pfeifenberger, Newell, Tsuchida, Hagerty, "Recommendations for Enhancing ERCOT's Long-Term Transmission Planning Process," October 2013.

Pfeifenberger and Hou, "Seams Cost Allocation: A Flexible Framework to Support Interregional Transmission Planning," on behalf of SPP, April 2012.

Pfeifenberger, Hou, "Employment and Economic Benefits of Transmission Infrastructure Investment in the U.S. and Canada," on behalf of WIRES, May 2011.

Brattle Group Practices and Industries

ENERGY & UTILITIES

- Competition & Market Manipulation
- Distributed Energy Resources
- Electric Transmission
- Electricity Market Modeling & Resource Planning
- Electrification & Growth Opportunities
- Energy Litigation
- Energy Storage
- Environmental Policy, Planning and Compliance
- Finance and Ratemaking
- Gas/Electric Coordination
- Market Design
- Natural Gas & Petroleum
- Nuclear
- Renewable & Alternative Energy

LITIGATION

- Accounting
- Analysis of Market Manipulation
- Antitrust/Competition
- Bankruptcy & Restructuring
- Big Data & Document Analytics
- Commercial Damages
- Environmental Litigation & Regulation
- Intellectual Property
- International Arbitration
- International Trade
- Labor & Employment
- Mergers & Acquisitions Litigation
- Product Liability
- Securities & Finance
- Tax Controversy & Transfer Pricing
- Valuation
- White Collar Investigations & Litigation

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