Interregional Transmission: Opportunities to Improve Market Seams

PRESENTED BY

Johannes Pfeifenberger

PRESENTED AT

MGA-OMS 16th Annual Transmission Summit

July 8, 2026

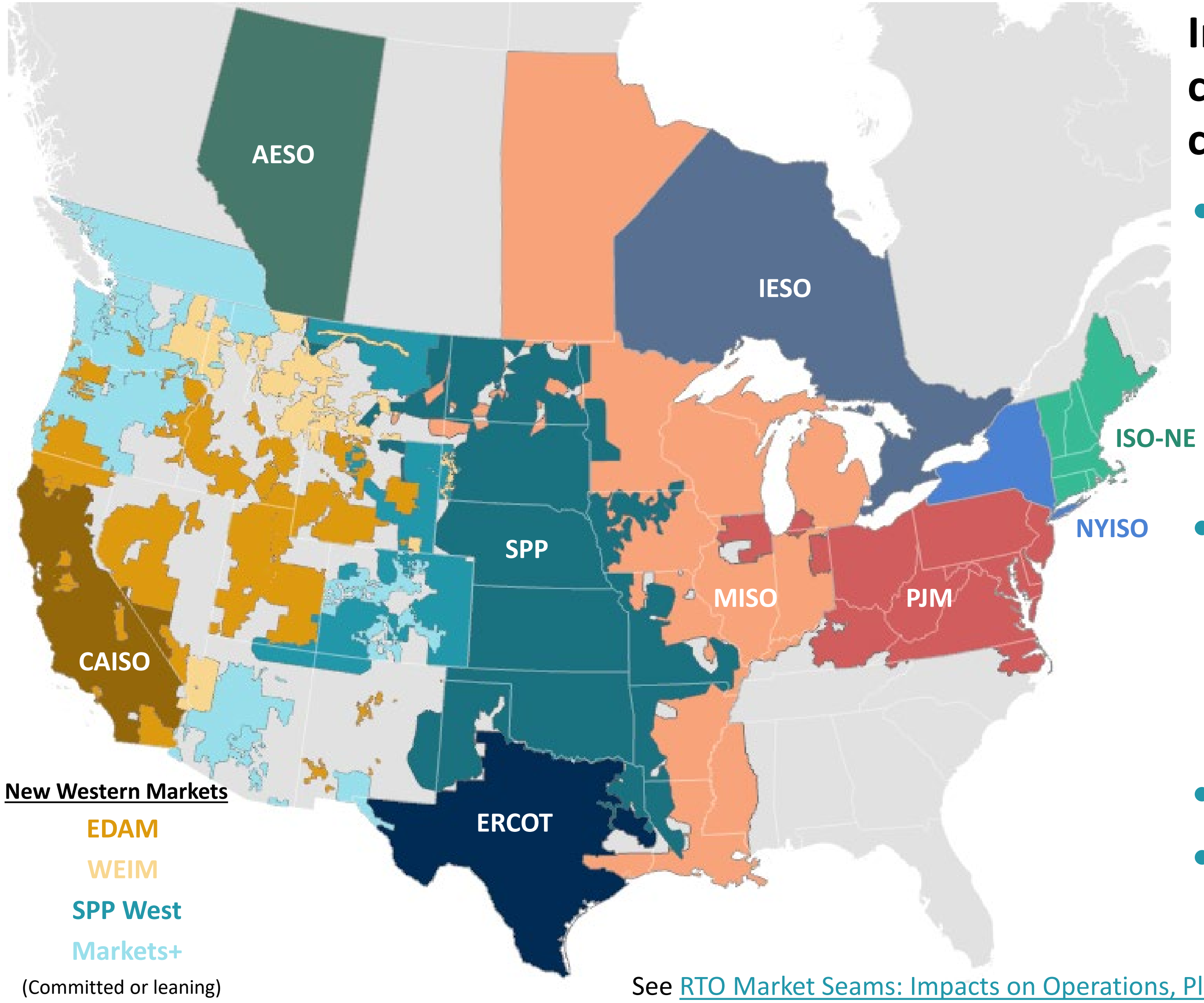
Brattle

MGA

America's Smartland

Midwestern Governors Association

North American RTOs/ISOs and their intertwined seams



Intertwined seams of US regional grid operators create complex operational, market, and planning challenges

- **Challenge first arose in late 1990s/early 2000 when MISO was formed and some midwestern utilities (such as ComEd and AEP) chose to join PJM**
  - To address inefficiencies, FERC required MISO and PJM to "depancake" their seam and address planning and congestion management challenges
- **Entergy joining MISO in 2013 (to create MISO-South) created additional seams challenges**
  - MISO loop flows over SPP and TVA highlighted the limitations of seams-management tools developed by MISO and PJM
- **Significant seams inefficiencies remain!**
- **Market expansion into the WECC can take advantage of and advance beyond existing experience in the East!**

See RTO Market Seams: Impacts on Operations, Planning, and Pricing, April 16, 2026.

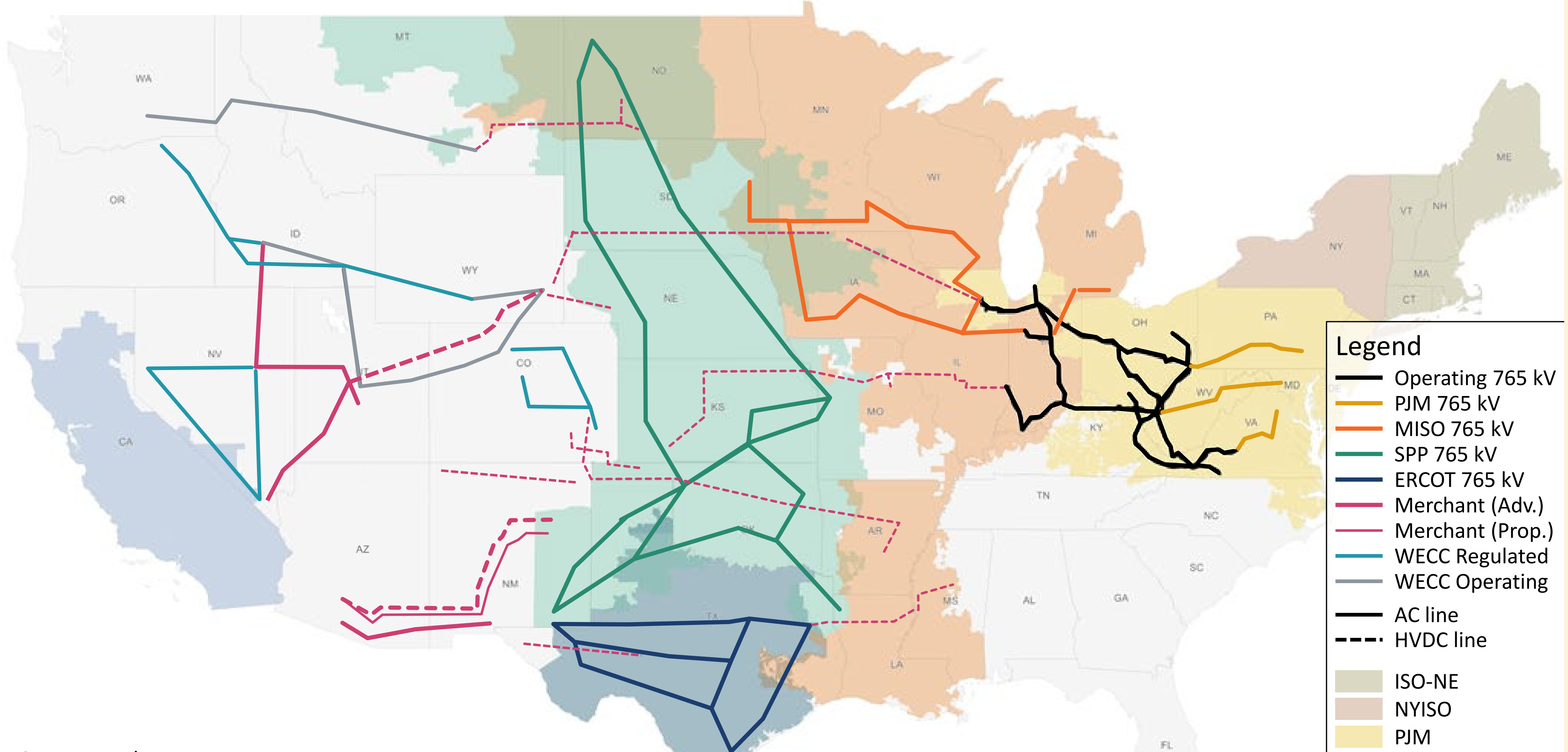
Five sources of inefficiencies created by market seams

Seams between RTOs will generally be more efficient than seams between non-market regions that rely entirely on bilateral trades!

Nevertheless, significant seams-related inefficiencies exist between RTO markets:

1. **Interregional transmission planning** is generally ineffective (mostly pursued by merchant developers)
2. **Generator interconnection** delays and cost uncertainty created by affected system impact studies (and effectiveness coordination through means such as the SPP-MISO JTIQ, reducing costs by 50%)
3. **Loop flow management** through market-to-market coordinated flowgates (with shares of firm flow entitlements) under the existing JOAs is necessary (but still plagued by design inefficiencies)
4. **Inefficient trading** across contract-path market seams
   - **Intertie bidding** to improve energy trading (particularly in day-ahead)
   - **Intertie optimization** for real-time optimization (after all bilateral trading is closed)
5. **Resource adequacy** value of interties (often not considered in RTO's resource adequacy evaluations) and barriers to capacity trades (often created by RTOs' restrictive capacity import requirements and incompatible resource accreditations)

Interregional **planning** is needed to fill in gaps between EHV systems



Sources and Notes:
The Brattle Group, S&P Global Market Intelligence.
SPP 765kV overlay includes anticipated ITP 2026 solutions.
Compare to "765kV Super Highway" proposed by AEP in 2006.

MISO and SPP can plan across multiple interregional transmission seams:

- MISO-SPP
- MISO-PJM
- MISO/SPP-ERCOT
- SPP-WECC
- MISO/SPP-Canada
- Highest value: Bridging the seams to ERCOT and WECC

Significant barriers to planning new interregional transmission

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 (often too contentious or overly formulaic)
C. Regulatory Constraints	10. Overly-prescriptive tariffs and joint operating agreements 11. State need certification, permitting, and siting

Source: The Brattle Group. 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.

MISO-SPP JTIQ: Lower-cost **generator interconnection** solutions

MISO's and SPP's Joint Targeted Interconnection Queue (JTIQ) Study shows that proactively studying a larger interregional set of generator interconnection requests offers substantial cost savings

- Goal: Identify more comprehensive, cost-effective and efficient interregional network upgrades than could be found through the RTO's individual sequential interconnection queue and affected system coordination processes
  - Pooled GI requests for 5 (and 10) years in both regions near seam
- Result: Seven projects, **$1.65 billion JTIQ Portfolio** expected to fully address the transmission needs along the MISO-SPP seam previously identified in MISO and SPP individual generation interconnection studies
  - Able to quickly allow for 9 GW of existing generator interconnection requests and enable an additional 20 GW of projects near the SPP-MISO seam
  - Additionally yields estimated $1 billion in production cost savings ($724 million in MISO and $247 million in SPP) due to congestion relief
- Lower JTIQ generator interconnection costs: **$58/kW** with 100% participant funding; and **$28/kW** if production cost savings to regional loads are netted
  - **Less than half of SPP's and MISO's individual GI costs of $100-130/kW!**

See MISO-SPP Joint Targeted Interconnection Queue Study, March 2022.
Tsuchida, Proactive Planning for Generation Interconnection A Case Study of SPP and MISO (August 17, 2022) at 9

High seams-related **trading** inefficiencies

NLR's 2024 Interregional Transmission Barriers Report documents and analyzes seams-related inefficiencies

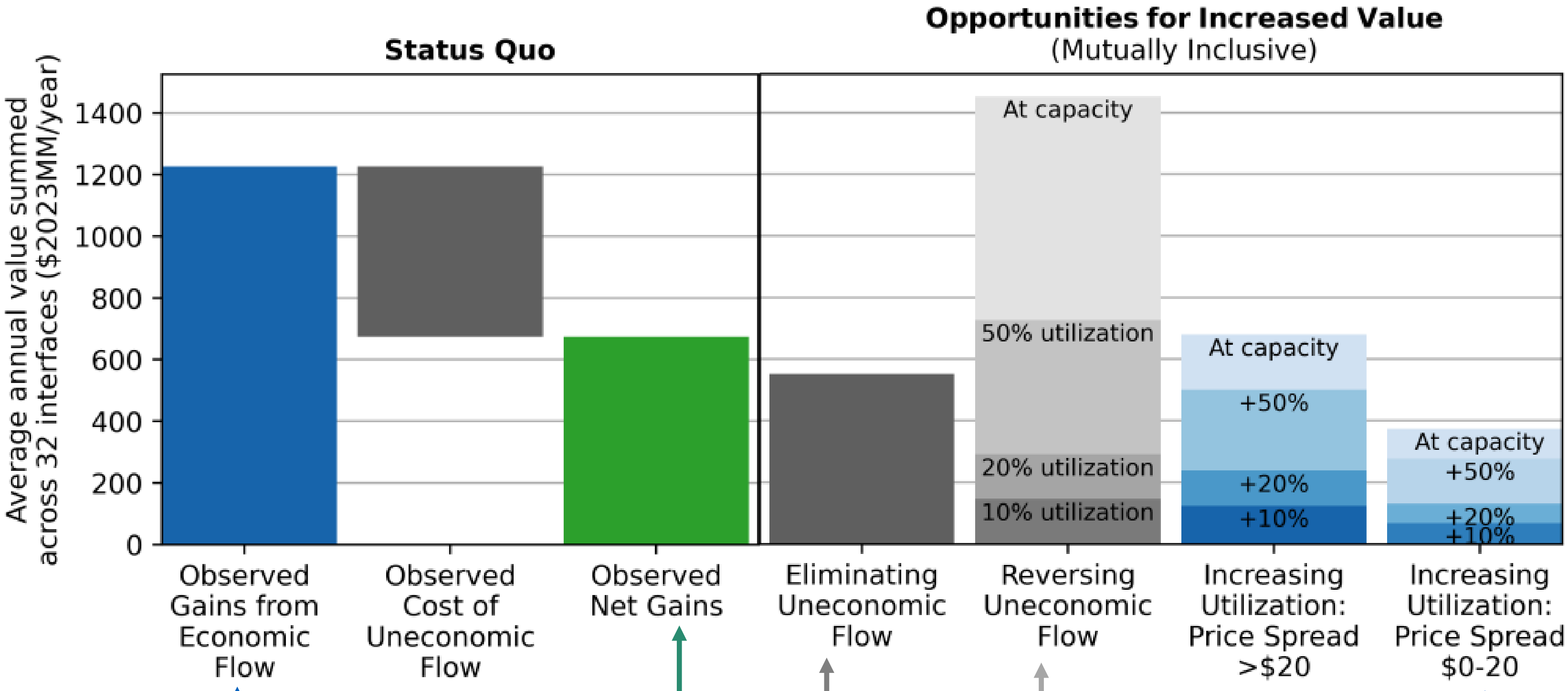
- Uneconomic Flows: Power flows from higher-priced to lower-priced areas 40-50% of the time!
- High Price Differentials: Significant spreads in power prices between regions when transmission is not constrained
- Underutilized Transmission Capacity: in combination with persistent price differences, available transmission assets are not used efficiently to bring lower-priced power to higher-priced regions.
- Lack of Transparency on Inefficiencies**:** lack of transparency in interchange transactions is an obstacle to identifying inefficiencies—and opaqueness is more likely to occur in areas without regional organized markets (e.g., lack of market monitoring)

Seams-related inefficiencies also relate to loop flows imposed by one region's market-dispatch on its neighboring regions, causing both reliability concerns and congestion management challenges

Estimated seams trading inefficiencies and potential savings

LBNL Paper: Interregional Electricity Transmission in the United States: Realized Savings and Opportunities for Increased Value, 2014-2023 (April 2025)

– Analyzed the benefits & efficiency of energy trades across 32 interties between US market areas for last decade



Intertie optimization could yield up to $3b/year in additional interregional benefits using the existing interties (before adjusting for price convergence, but not counting intra-hour benefits)

More fully utilize available capacity (in prevailing direction): up to $1b/yr added

$1.2b in annual value

Offset by over $500m in uneconomic trades

Yields close to $700m in annual net benefits

Reverse flow when beneficial: up to $1.4b/yr in added value

Eliminate uneconomic trades: Over $500m/yr in added value

Intertie Optimization: Efficiently utilize transmission between markets

A decade of experience shows that "Intertie Optimization" will be necessary to reduce seam-related trading inefficiencies in real-time markets!

- NYISO, ISO-NE, and Potomac Economics have called for intertie optimization in 2010-2011 to address seam-related inefficiencies
- Only "coordinated transaction scheduling"(CTS) has been implemented between ISO-NE, NYISO, PJM, and MISO. Yet, a decade later, market monitors continue to document seams-related inefficiencies, noting that CTS has not been effective, recommending intertie optimization
- The Western energy imbalance markets and European "market coupling" experiences have shown that optimizing interties between BAAs offers substantial benefits—reducing costs, improving reliability and renewable integration
- For the seams between SPP, MISO, and PJM we estimated that, without intertie optimization, approximately 20-30% of the total transmission value ($50-60 million per 1000 MW of intertie capacity) is lost because bilateral trades cannot respond quickly enough to frequently-changing real-time prices

Intertie optimization (now explored by SPP in WECC) is needed to fully capture the value of existing and new interregional transmission

See: Intertie Optimization Report and FAQs, IEEE PES Intertie Optimization slides.

Intertie Optimization: Avoids the ineffectiveness of CTS

Coordinated Transaction Scheduling (CTS)

- 75+min prescheduled 15-min transactions, based on forecasts, which often results in uneconomic trades
- Based on CTS bids by traders, who need to reserve transmission (at a cost)
- Transmission charges reduce CTS efficiency
- If transmission charges are eliminated, traders capture value of transactions (free rides)
- Experience:
  - Low transaction volume due to costs and risk of inefficient trades;
  - Has not been able to improve inefficient use of interregional transmission

Intertie Optimization

- Optimized in real time every 5 min, greatly reducing the frequency of uneconomic trades
- Optimized by RTOs using transmission that remains available after bilateral markets have closed
- Hurdle-free optimization increases market efficiency
- Value of transactions shared by RTOs (i.e., their transmission owners and, ultimately, customers)
- Experience:
  - High transaction volume with substantial benefits to participating BAAs (e.g., Western EIM)
  - Can greatly reduce inefficient use of interregional transmission (e.g., European “market coupling”)

Bottom Line:

- CTS has never been working – not for Traders, not for RTOs, not for TOs, and not for Customers
- When FERC approved CTS, it expected replacing it with intertie optimization (should CTS not work)

See IEEE PES Intertie Optimization, April 2025 and Frequently Asked Questions

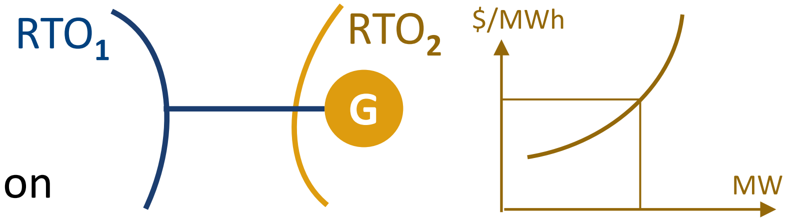
Intertie Optimization: Implementation options

How would RTOs/ISOs determine and schedule optimal intertie transactions?

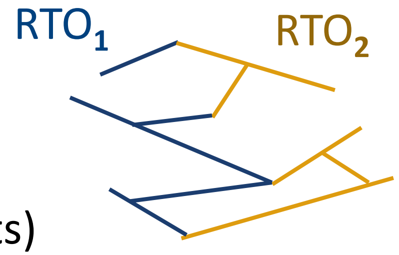
The RTOs would use their existing market optimization SCED engines to optimize intertie schedules subject to available intertie capabilities <u>after all bilateral transactions have closed</u>

- As the PJM IMM explains, this 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" (2023 SOM Report at 478)

1. **<u>Contract-path</u> option**: treat the contract path across the interface like a single line with a generator (representing the neighboring region) dispatched through SCED.
   - The neighboring region would provide generation supply curve (incremental/decremental cost of importing more or less) for RT intervals
   - Simplest, will increase efficiency, but not optimally use full physical transmission



2. **<u>Flow-based</u> option:** represent interface physically with limiting flow gates
   - The neighboring region provides binding flow gates and marginal generators with shift factors on these flow gates (ISO-NE's 2014 IEEE "Marginal Equivalent" proposal)
   - Will use full physical capability (ISO-NE simulations achieved 99% of full optimization)



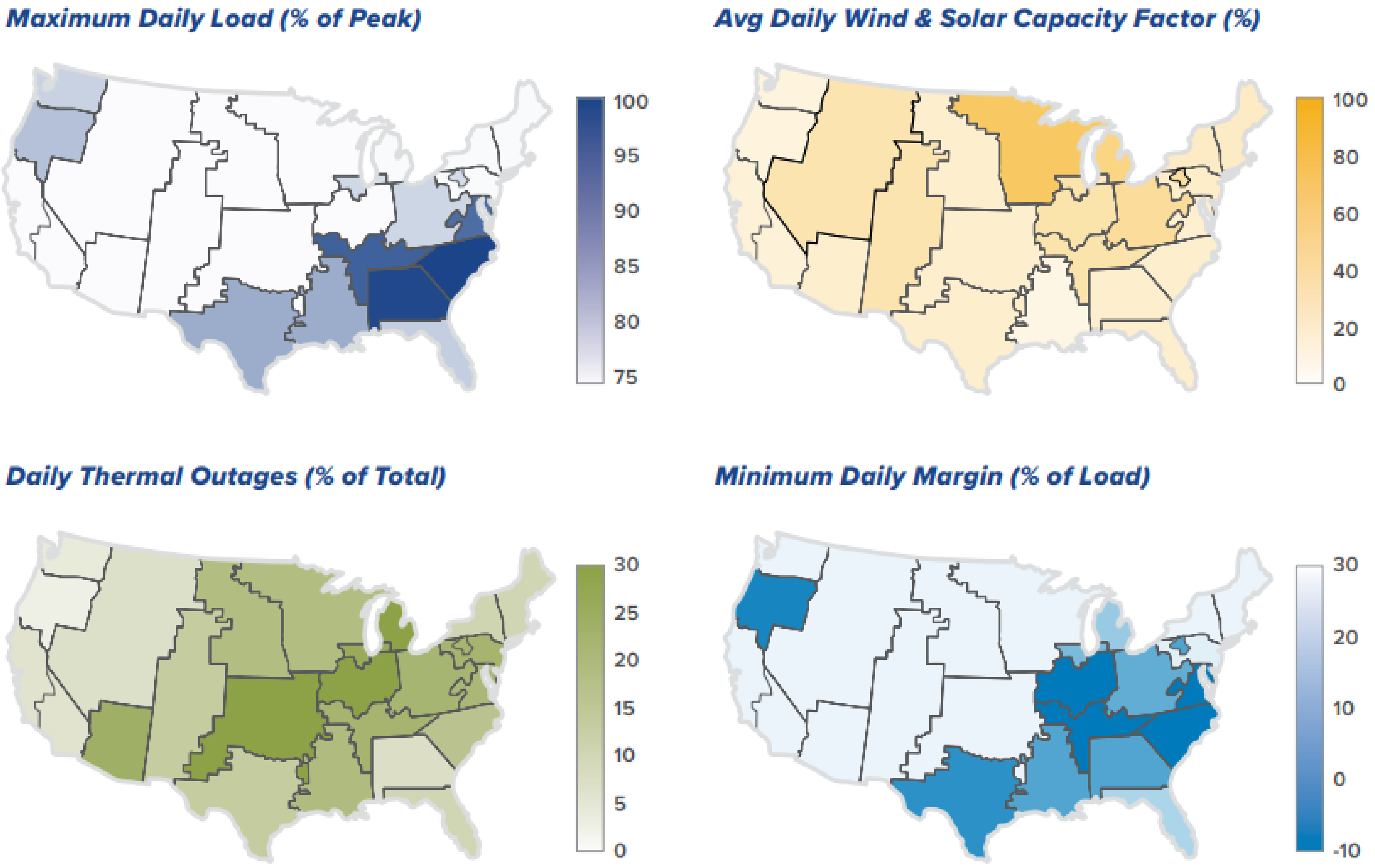
3. **<u>Combined SCED</u> option:** used full, multi-regional SCED (similar to Western imbalance markets)
   - Assures full optimization but likely impractical for existing market-based regions

See also: Frequently Asked Questions

High **resource adequacy** value of interregional transmission

Concept: if a robust grid is larger than most weather systems, individual regions can rely on (non-firm) imports from others' generating reserves, reducing everyone's resource adequacy risks, costs, and reserve margins

Example: Load and resource diversity of neighboring regions on **December 22, 2022 (during Winter Storm Elliot)**



Source: Brooks et al., Resource Adequacy Value of Interregional Transmission, (2025)

Conclusion: Significant opportunities exist to address market seams

The experience with seams mitigation efforts highlights that significant inefficiencies remain due to the RTOs' market seams

These inefficiencies can and should be addressed:

1. Interregional <u>planning</u> requires new approaches and federal/state involvement
2. Coordinated inter-regional <u>generator interconnection</u> processes (e.g., through JTIQ) can reduce costs and interconnection delays
3. Neighboring regions need to improve managing the operational, congestion, and market impacts of the <u>loop flows</u> they impose on each other
4. Large existing <u>trading inefficiencies</u> across market seams can be addressed through intertie optimization
5. The <u>resource-adequacy</u> and resilience benefit of (even uncommitted, non-firm) interregional transmission needs to be recognized in installed capacity requirements and transmission planning

Thank You!

Comments and Questions?

(Additional Slides)

About the Speaker

Johannes P. Pfeifenberger

PRINCIPAL
THE BRATTLE GROUP, BOSTON

Hannes.pfeifenberger@brattle.com

+1.617.234.5624

(webbio and publications)

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 former Senior Fellow at Boston University's Institute of Sustainable Energy (BU-ISE), an IEEE Senior Member, and 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 market and transmission matters in SPP, MISO, PJM, New York, New England, ERCOT, CAISO, WECC, Alberta, Ontario, and Quebec.

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.

The need for intertie optimization

The Need for Intertie Optimization, prepared for ACORE, Advanced Power Alliance, Grid United, Invenergy, MAREC, and NRDC, October 2023

Intertie Optimization FAQs and Implementation Principles, February 2024

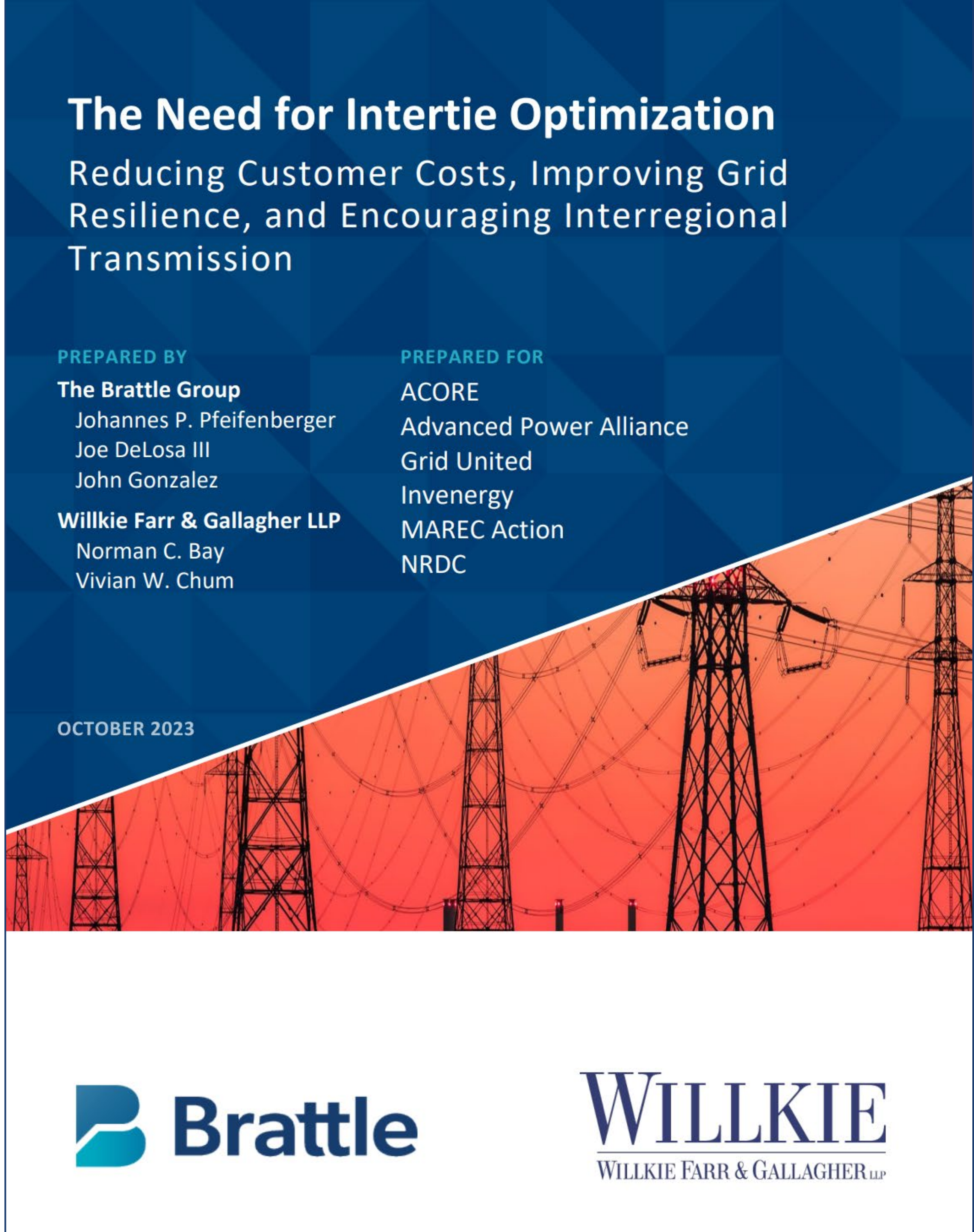
Intertie Optimization: Efficient Use of Interregional Transmission (Update), presented to OPSI, April 12, 2024

Market Benefits and Seams: Options and Implications, presented to CREPC-WIRAB, April 24, 2024.

Intertie Optimization: Achieving Efficient Use of Interregional Transmission, IEEE PES, Energy Policy Forum, April 16, 2025.

RTO market seams

RTO Market Seams: Impacts on Operations, Planning, and Pricing, WPUI, April 16, 2026.



NARUC Study: Collaborative Enhancements to Unlock Interregional Transmission (June 2024)

Recommends reforms improve planning, permitting, and operational utilization of interregional transmission, including intertie optimization:

NARUC
National Association of Regulatory Utility Commissioners

	Solutions				Areas of State and Federal Engagement	
Planning	Coordinated Interregional Planning	Planning Methods Harmonization	Model and Data Harmonization		Involvement in Planning; Encourage Interregional Collaboration	Issue Guidelines for Interreg. Planning; Funding/Support, Potential Federal Planning Authority
Permitting	State Transmission Authorities	Host Community Benefits	Planning Need Determination Acceptance for Permitting	Multi-State Evidentiary Record	Communicate Tx Needs to Developers/ Planners; Streamline Permitting	Funding/Training for State Staff; Federal Backstop Authority
Operations	Reduce Transaction Charge Impacts	Reduce Advanced-Time Scheduling Requirements	Develop Optimized Interregional Scheduling Mechanism	Improve Preparation for Resiliency	Engage with System Operators to Encourage Improvements in Tx Utilization	Analytical Guidance; Technical Forums to Improve Tx Utilization

Source: https://pubs.naruc.org/pub/BACDBB9D-02BF-0090-0109-B51B36B74439

Recommendations from Barriers and Opportunities to Realize the System Value of Interregional Transmission (June 2024)

NREL

The *National Laboratory of the Rockies* recommends similar reforms to "significantly enhance the value of interregional transmission and deliver additional within-region

Common Actions

- Develop a framework for resource adequacy sharing among regions
- Support joint studies to identify transfer needs during extreme events and develop operational procedures to mitigate issues
- Evaluate internal transmission system ability to accommodate large power transfers as the underlying generation mix changes

Nonmarket and Hybrid Actions

- Implement coordinated scheduling and operations platforms or consolidation
- Pursue joint congestion management programs and reevaluate qualified paths for congestion management
- Develop consistent methods to calculate available transfer capacity
- Update processes to prioritize system reliability in scheduling market and wheeling transactions

Market Actions

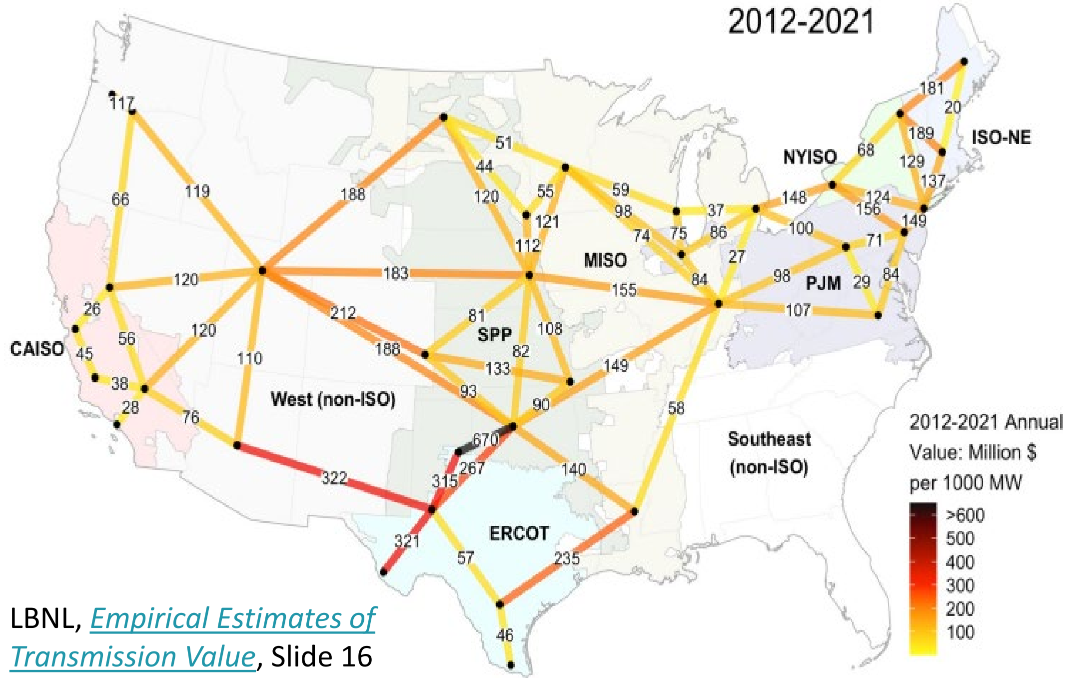
- Eliminate fees and improve price forecasting for coordinated transaction scheduling or move toward intertie optimization
- Update corridor flow limits, automate procedures, and align assumptions for congestion management programs
- Revise interface pricing methods and validate interregional transactions
- Integrate operational control of merchant HVDC lines with regional market operations

Transformative Actions

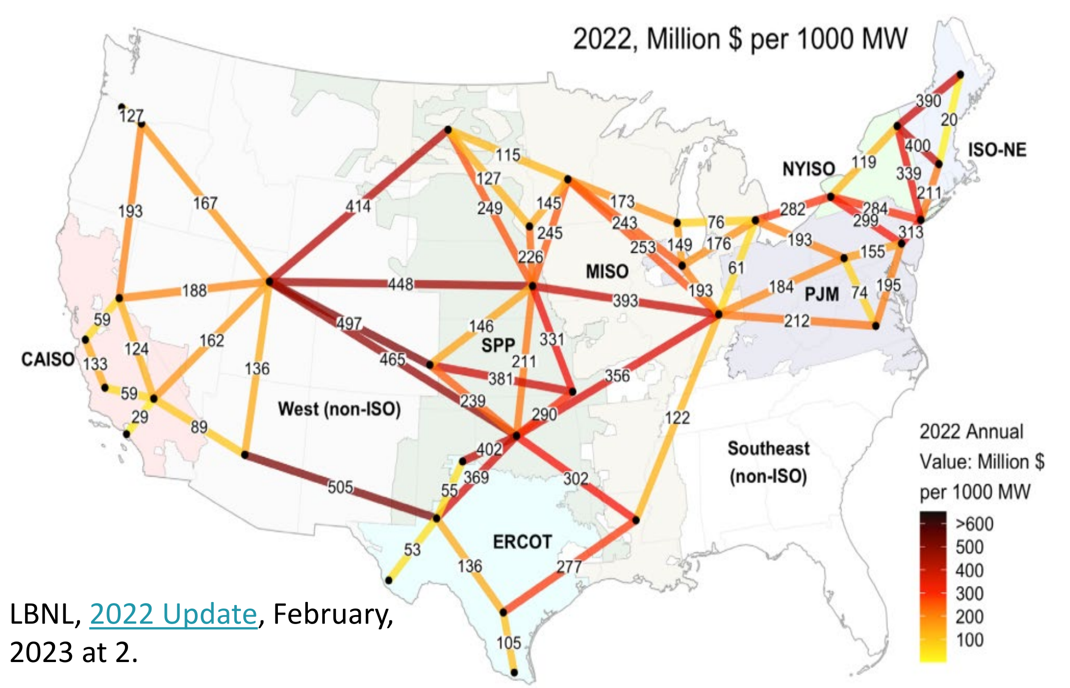
- Conduct long-range, nationwide interregional transmission planning
- Implement interconnection-wide intertie optimization
- Establish a national system operator and planner to coordinate national network planning, scheduling, and resource adequacy functions

- **Recognize resource-adequacy and resilience value of interregional transmission**
- **Improved coordination and joint congestion management**
- **Depancaking**
- **Improved intertie pricing**
- **Move toward intertie optimization**
- **Interregional planning**
- **Interconnection-wide optimization**

LBNL Empirical Estimates: Total value of interregional transmission



LBNL, [Empirical Estimates of Transmission Value](), Slide 16



LBNL, [2022 Update](), February, 2023 at 2.

Sources: [LBNL, Empirical Estimates of Tx. Value]() (Aug 2022), Slide 16; [The Latest Market Data Show that the Potential Savings of New Electric Transmission was Higher Last Year than at Any Point in the Last Decade](), Fact Sheet, LBNL (Feb 2023) at 2.

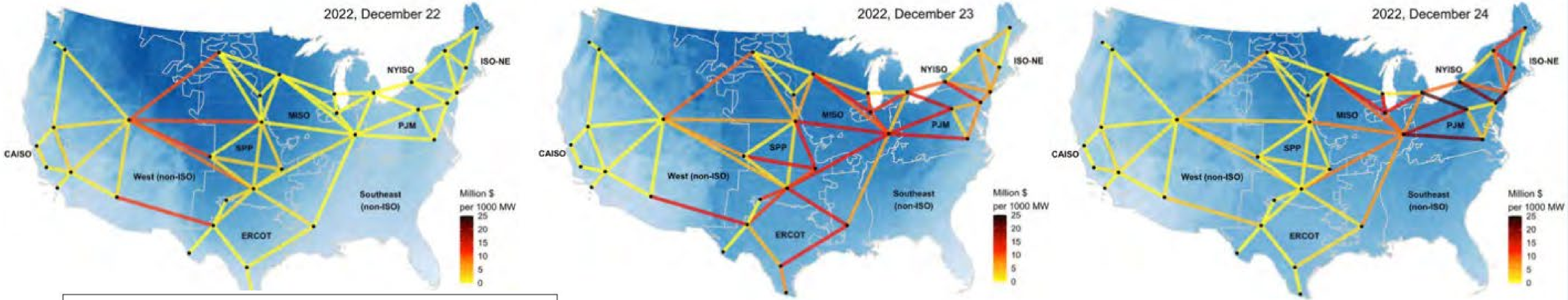
Methodology: Transmission value based on historical real-time price difference between regional nodes

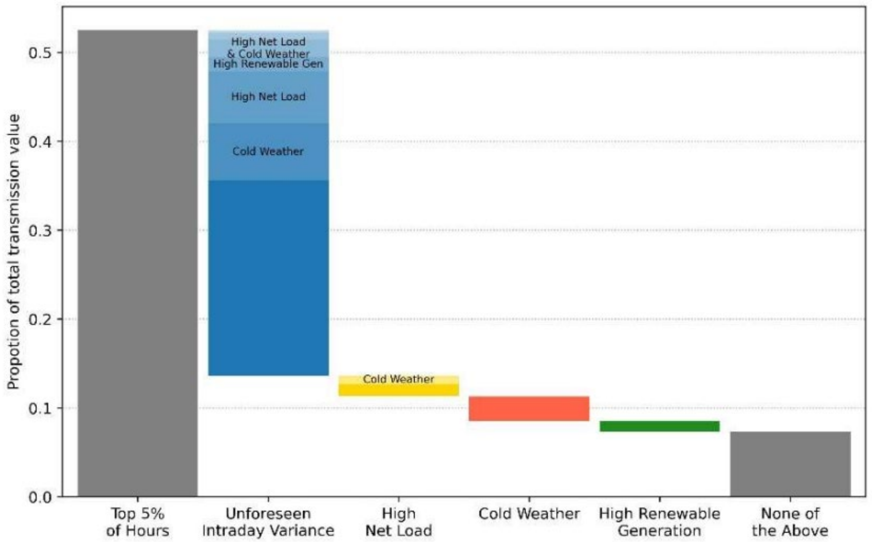
Study Findings:

- Interregional links have greater value than regional links
- **40-80% of transmission's congestion value is from 5% of hours due to extreme conditions,** <u>20-30% from top 1% of hours</u> reflecting the high impact of challenging system conditions
- The value in some of the recent years (e.g., 2021, 2022) is double the 10-year average

Value of transmission is concentrated in few unpredictable hours

Highest transmission congestion is concentrated in relatively few hours of the year and during extreme events. Example: Winterstorm Elliot (2022)





Findings:

- Real-time values (reflecting actual conditions) are higher than DA values
- On average, about half of the value is concentrated in top 5% of all hours
- Most of that value is due to real-time market conditions that are not foreseeable on a day-ahead basis

Sources: LBNL, [Transmission Value Manuscript NatureEnergy] (March 29, 2024); [Department of Energy’s 2023 National Transmission Needs Study] (Oct 2023)

The resource adequacy and resilience value of interregional transmission

In its ITCS, NERC found that existing interregional transmission has substantial resilience value. It further concluded that adding another 35 GW would be “prudent” solely for resilience value (before considering additional economic values)

Increasing Energy Deficiency Hours

Table ES.1: Recommended Prudent Additions Detail

Transmission Planning Region	Weather Years (WY) / Events	Resource Deficiency Hours	Maximum Deficiency (MW)	Additional Transfer Capability (MW)	Interface Additions (MW)
ERCOT	Winter Storm Uri (WY2021) and nine other events	135	18,926	14,100	Front Range (5,700) MISO-S (4,300) SPP-S (4,100)
MISO-E	WY2020 Heat Wave and two other events	58	5,715	3,000	MISO-W (2,000) PJM-W (1,000)
New York	WY2023 Heat Wave and seven other events	52	3,729	3,700	PJM-E (1,800) Québec (1,900)
SPP-S	Winter Storm Uri (WY2021)	34	4,137	3,700	Front Range (1,200) ERCOT (800) MISO-W (1,700)
PJM-S	Winter Storm Elliott (WY2022)	20	4,147	2,800	PJM-E (2,800)
California North	WY2022 Heat Wave	17	3,211	1,100	Wasatch Front (1,100)
SERC-E	Winter Storm Elliott (WY2022)	9	5,849	4,100	SERC-C (300) SERC-SE (2,200) PJM-W (1,600)
SERC-Florida	Summer WY2009 and Winter WY2010	6	1,152	1,200	SERC-SE (1,200)
New England	WY2012 Heat Wave and two other events	5	984	700	Québec (400) Maritimes (300)
MISO-S	WY2009 and WY2011 summer events	4	629	600	ERCOT (300) SERC-SE (300)
TOTAL				**35,000**	

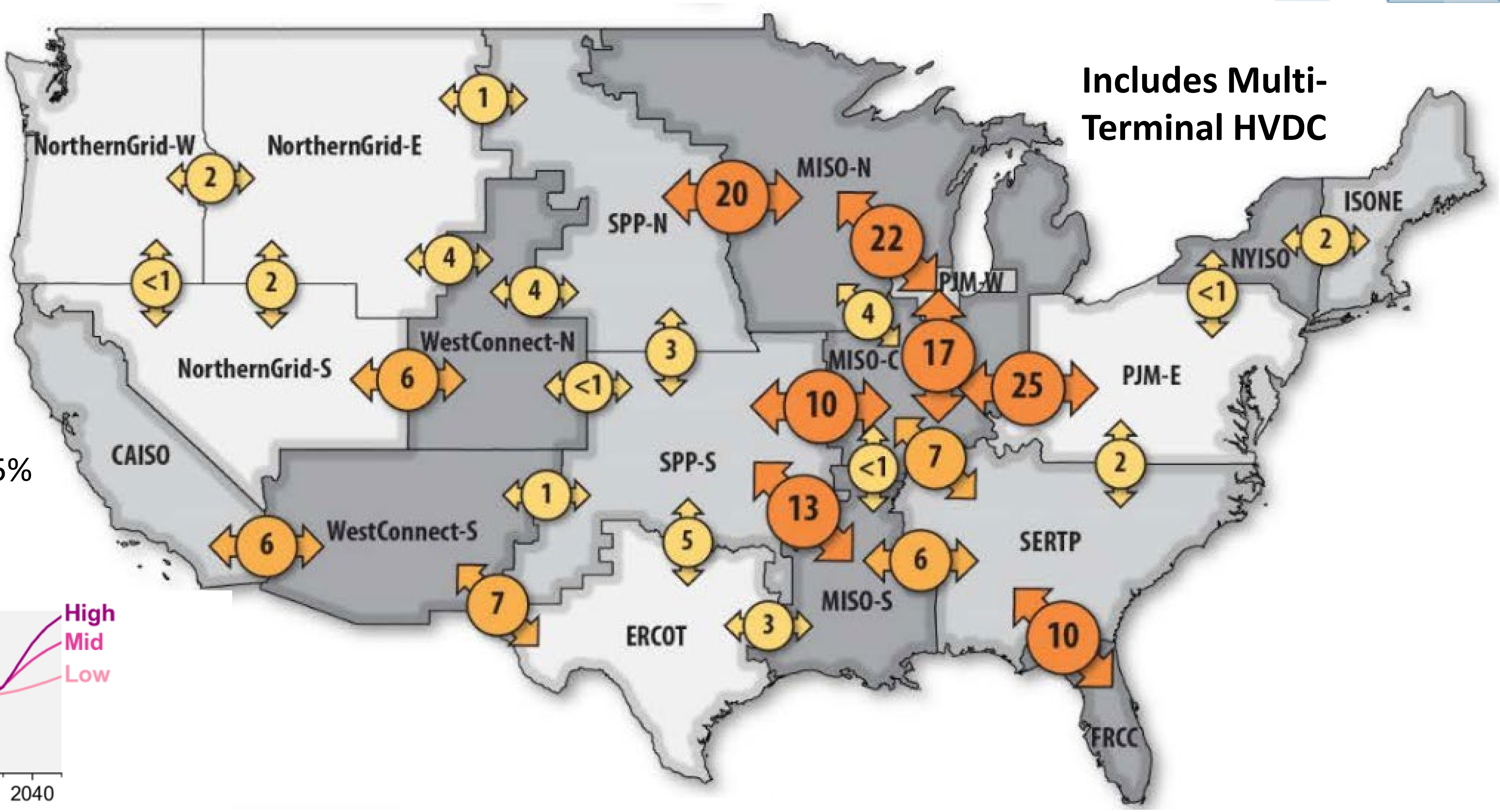
- This resource adequacy and resilience value of even “uncommitted” interregional transmission is recognized only by some RTOs/ISOs (e.g., NYISO and ISO-NE)
- Some RTOs (such as PJM) attribute very little resource adequacy value to existing interregional transmission and zero value to new interregional transmission
- None of the RTOs compensate the resource adequacy and resilience value of uncommitted interregional transmission provided by merchant lines (i.e., not paid through regulated transmission rates)
- Significant barriers also exist for capacity imports, where reserving firm transmission is no longer sufficient for capacity imports (such as in PJM)

Source: NERC Interregional Transfer Capability Study (ITCS), Parts 2 and 3 Report (2024)

DOE's 2024 National Transmission Planning Study (NTPS)

GW of "High-opportunity" interregional transmission expansion, beneficial by 2035

(Based on "central" case; beneficial in 75% of all scenarios evaluated)



Includes Multi-Terminal HVDC

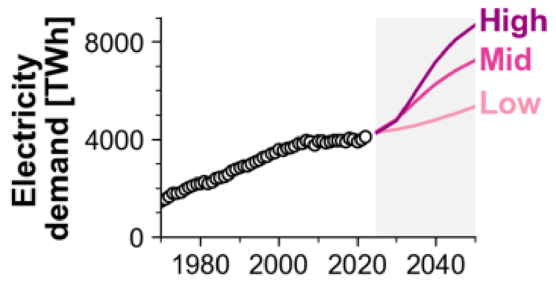


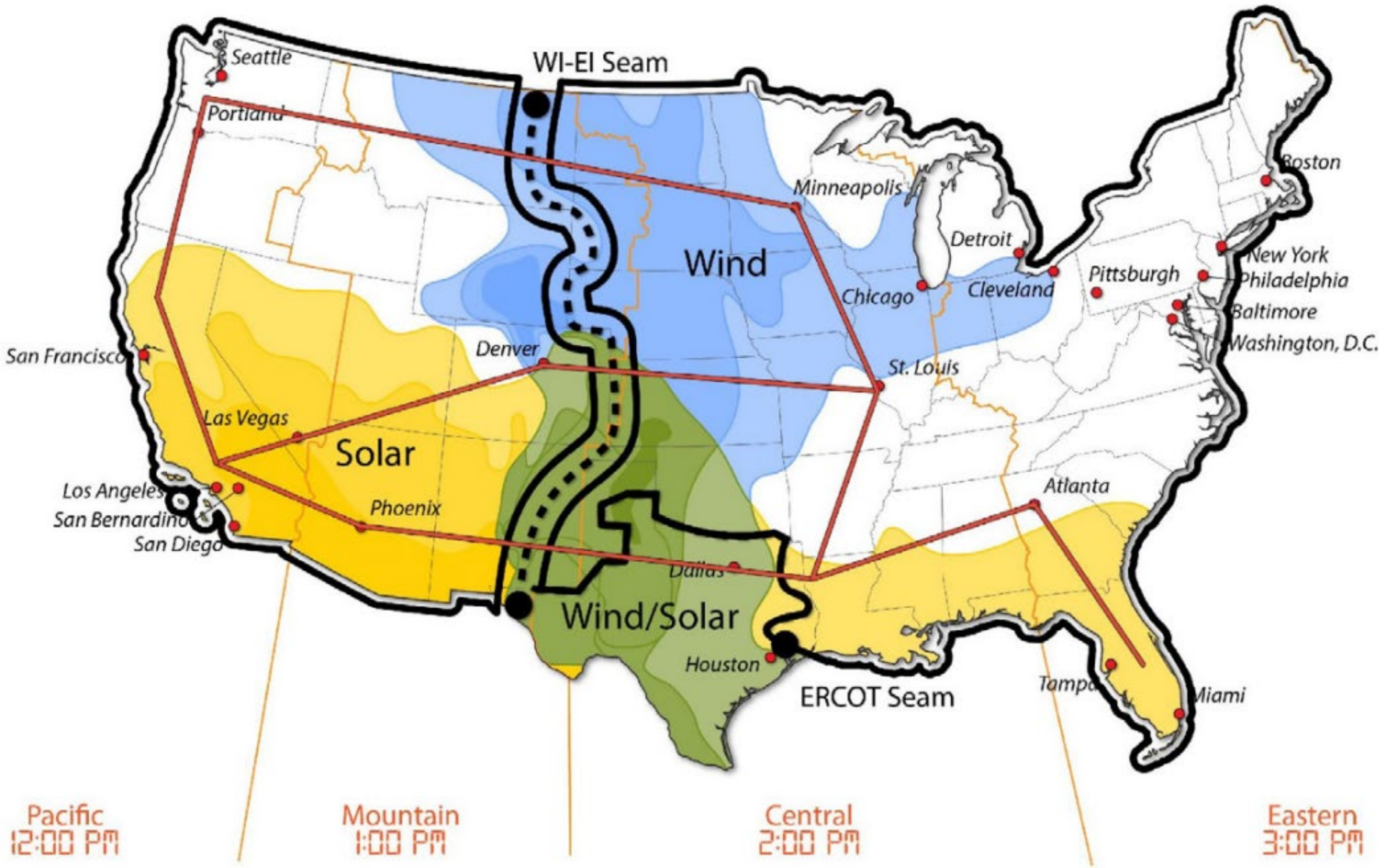
Figure 5. Annual demand assumptions for the contiguous United States

Historical demand shown is electricity sales to ultimate customers from EIA (2024b).

Source: DOE National Transmission Planning Study (Chapter 2, p. 47)

NREL's 2020 Interconnections Seams Study

Example: Macro Grid to Connect WECC, ERCOT and the Eastern Interconnection



Result: substantial net benefits for increasing the transfer capability between the interconnections

- Four different "designs" studied:
  1. Only upgrade AC systems (not across seam)
  2a. Upgrades to DC ties plus AC lines
  2b. Point-to-point HVDC transmission lines
  3. Macro Grid (shown)
- Depending on scenario and design, estimated benefit-cost ratios range from 1.4 to 2.9
- Study did not consider certain benefits, such as resilience to extreme events

Source: NREL, Interconnections Seams Study, October 2020.

DOE's 2023 Transmission Needs Study

Example: Cost-effective interregional transmission capacity between Northern WECC, SPP, MISO-N, and PJM:

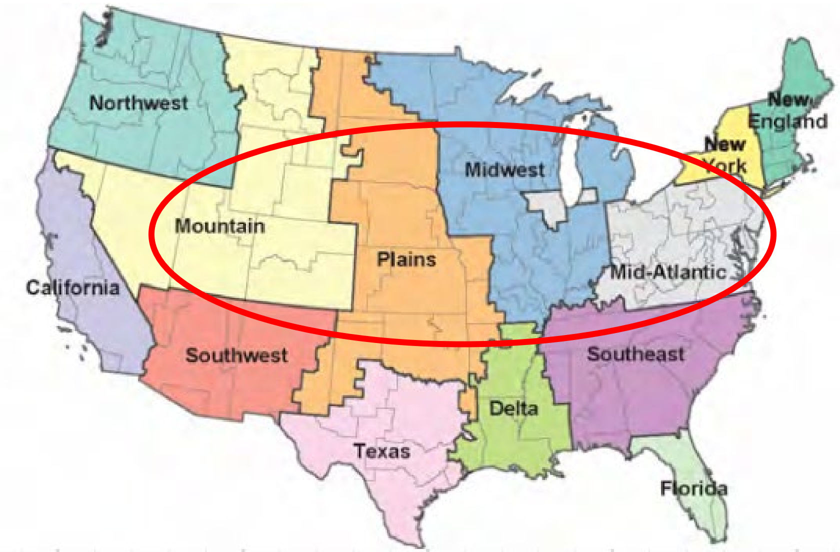


Table VI-4. Median regional transfer capacity results for each scenario group in 2030, 2035, and 2040. Both new transfer capacity in GW and percent growth from 2020 system are shown.

Regional Pair	2020 GW	Scenario Group	New in 2030		New in 2035		New in 2040	
			GW	% Growth	GW	% Growth	GW	% Growth
Mountain – Plains	0.92	Mod/Mod	0.36	39.1%	0.94	102%	1.40	152%
Mountain – Plains	0.92	Mod/High	0.79	85.4%	2.64	287%	11.9	1,290%
Mountain – Plains	0.92	High/High	6.10	663%	19.3	2100%	29.2	3,170%
Midwest – Plains	12.1	Mod/Mod	1.35	11.2%	3.14	26.0%	3.62	30.1%
Midwest – Plains	12.1	Mod/High	7.99	66.3%	21.1	175%	23.0	191%
Midwest – Plains	12.1	High/High	24.6	204%	88.0	731%	98.7	819%
Mid-Atlantic – Midwest	21.7	Mod/Mod	1.10	5.1%	2.39	11.0%	2.65	12.2%
Mid-Atlantic – Midwest	21.7	Mod/High	9.87	45.5%	33.8	156%	21.9	101%
Mid-Atlantic – Midwest	21.7	High/High	42.4	196%	103	475%	119	550%

Source: DOE, National Transmission Needs Study, October 2023, Table VI-4, p. 131-133

Limitations of national studies

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

- Some studies **analyze aspirational targets or scenarios that do not reflect the actual policies and mandates** applicable for the next 10-15 years
  - This makes it difficult demonstrate a compelling "need" to policy makers, regulators, and permitting agencies
- The studies are **not transmission planning studies**: they often do not identify specific transmission projects and 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 broad support and develop feasible cost allocations
  - 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, reduction in electricity prices, and shifts in the locations of clean-energy investment
- Most studies do not address the many barriers to planning processes and to the permitting/development of specific interregional transmission projects

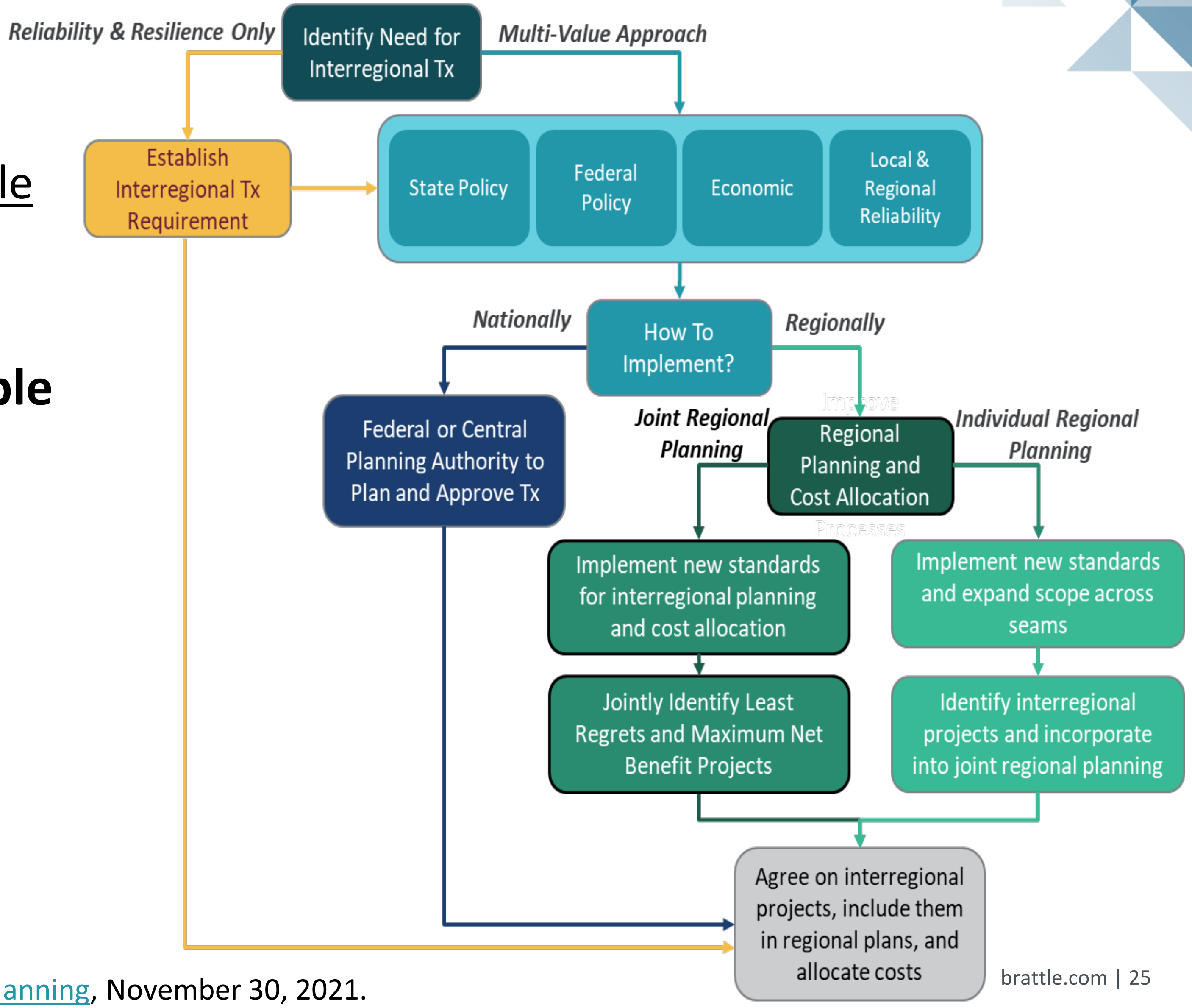
At the same time, RTOs' existing interregional planning processes has been mostly ineffective, yielding only a few small "economic efficiency" projects (other than JTIQ, discussed later)

Options for improving interregional planning processes

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

Four paths can be pursued simultaneously, identifying actionable <u>transmission needs</u> 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.

Order 1920's enhances "Interregional Transmission Coordination"

As FERC's Explainer states: "Order No. 1920 requires transmission providers in neighboring transmission planning regions to modify their existing **interregional transmission coordination procedures** to align with long-term regional transmission planning reforms. Order No. 1920 established the following requirements to adapt existing procedures with this requirement.

1. Require transmission providers to share information regarding long-term transmission needs and **identify and jointly evaluate interregional transmission facilities** to address those needs
2. **Allow entities to propose** interregional transmission facilities as more efficient or cost-effective solutions to long-term transmission needs

Transmission providers are mandated to make the following information publicly available through their website or e-mail list to **enhance transparency and information sharing**.

1. Long-term transmission needs discussed in interregional transmission coordination meetings
2. Interregional transmission facilities proposed or identified as part of long-term regional transmission planning
3. Details such as voltage level, estimated cost, and estimated in-service date of proposed interregional transmission facilities
4. Results of cost-benefit evaluations for such interregional transmission facilities, including overall benefits and region-specific benefits
5. Selection of interregional transmission facilities to meet long-term transmission needs, if any

These reforms aim to ensure that identified long-term transmission needs are considered in interregional coordination and cost allocation processes, thereby promoting fair rates."

Considerations for planning new 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 to more fully capture benefits:
  - 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

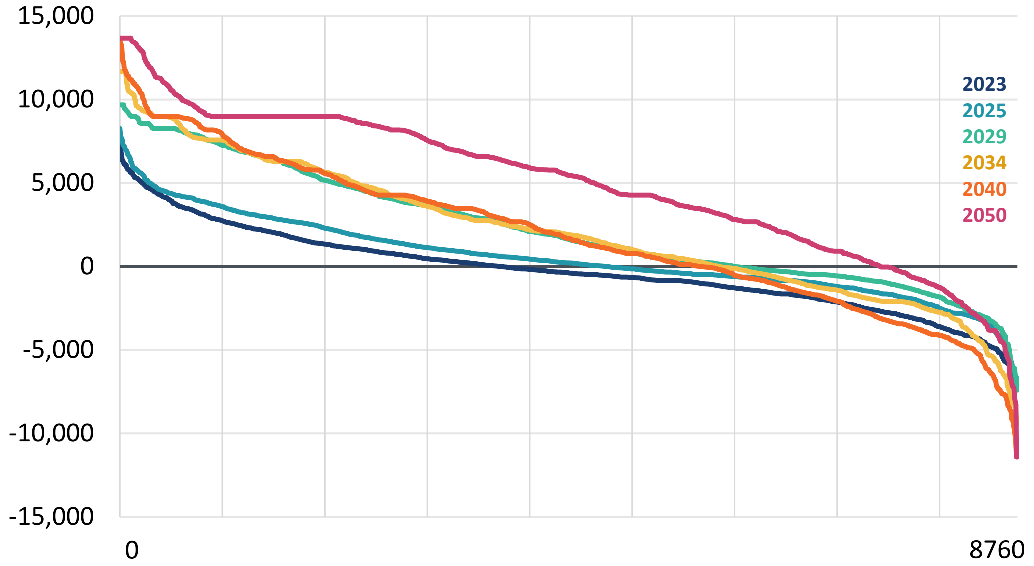
SPP FERNS: RA value of non-firm trade with neighboring regions

Simulations from SPP FERNS report show that SPP will increasingly trade with neighboring regions through interties with MISO, ERCOT, and the West

- Although interties with neighboring regions are not assumed to contribute to SPP resource adequacy requirements, SPP can often import energy to serve load during scarcity periods
- We quantified the implied resource adequacy ("proxy ELCC") value based on the (non-firm) energy imports into SPP over external interfaces during the 100 highest resource adequacy risk hours

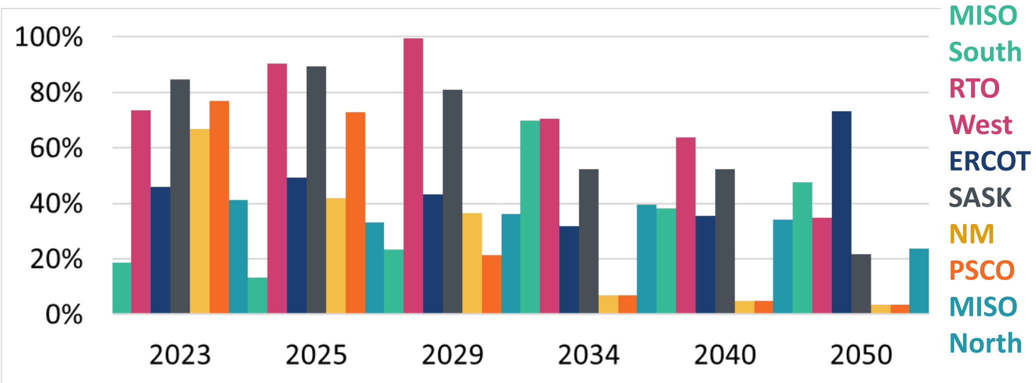
Note: Charts show results for "Scenario B2" reflecting high renewable generation shares (reaching 90% by 2050, up from 46% today) at moderate load growth

SPP Net Imports and Exports across all interties (MW)
(Positive = net flow out of SPP; Negative = net flow into SPP)



Note: Net imports shown across interfaces between SPP and all neighboring regions

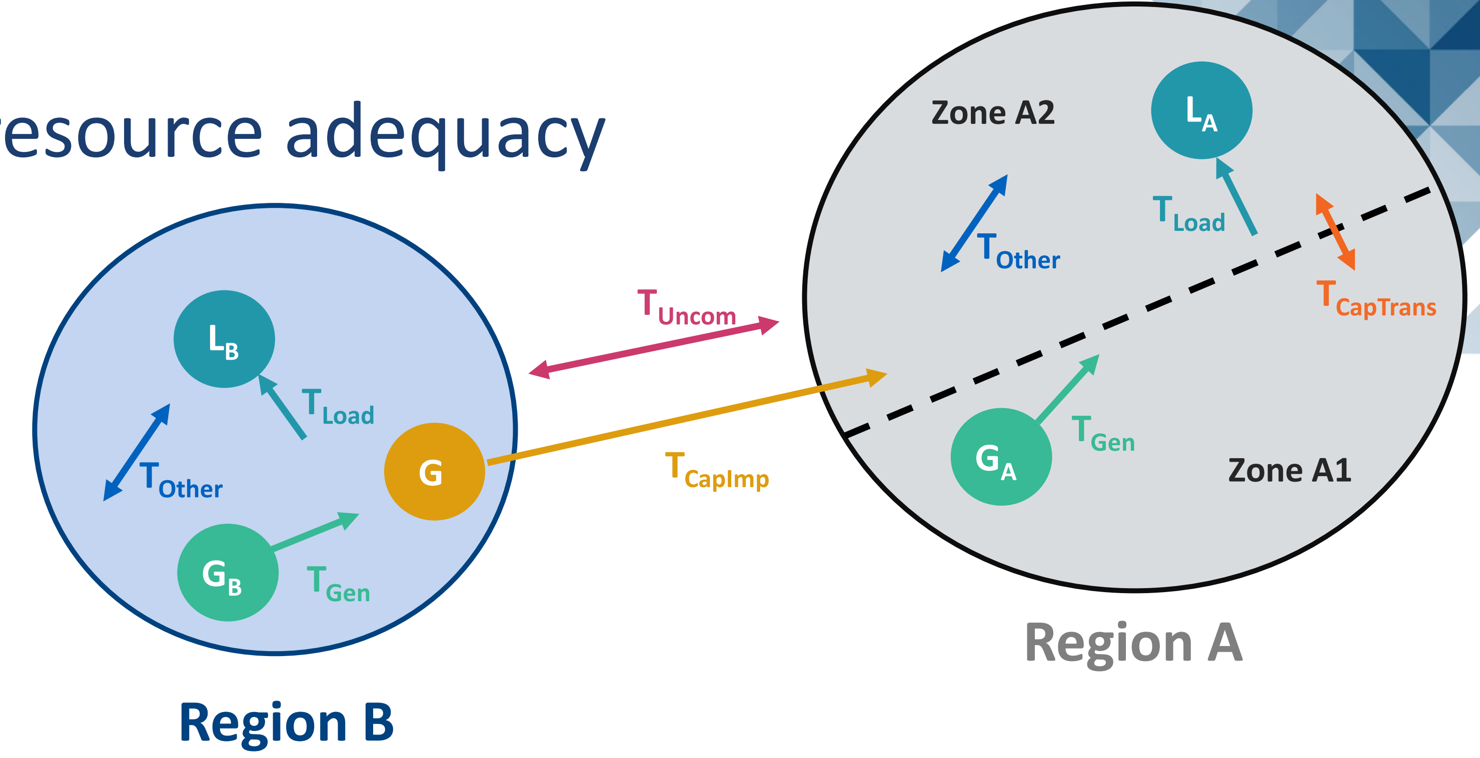
Implied "Proxy ELCCs" of Non-firm Energy Imports over Interties with Neighboring Regions (Scenario B2)



The role of transmission in resource adequacy

Transmission plays a major role in supporting resource adequacy:

- Allows generation to reach load
- Allows taking advantage of regional/interregional diversity to reduce the total amount of generation needed



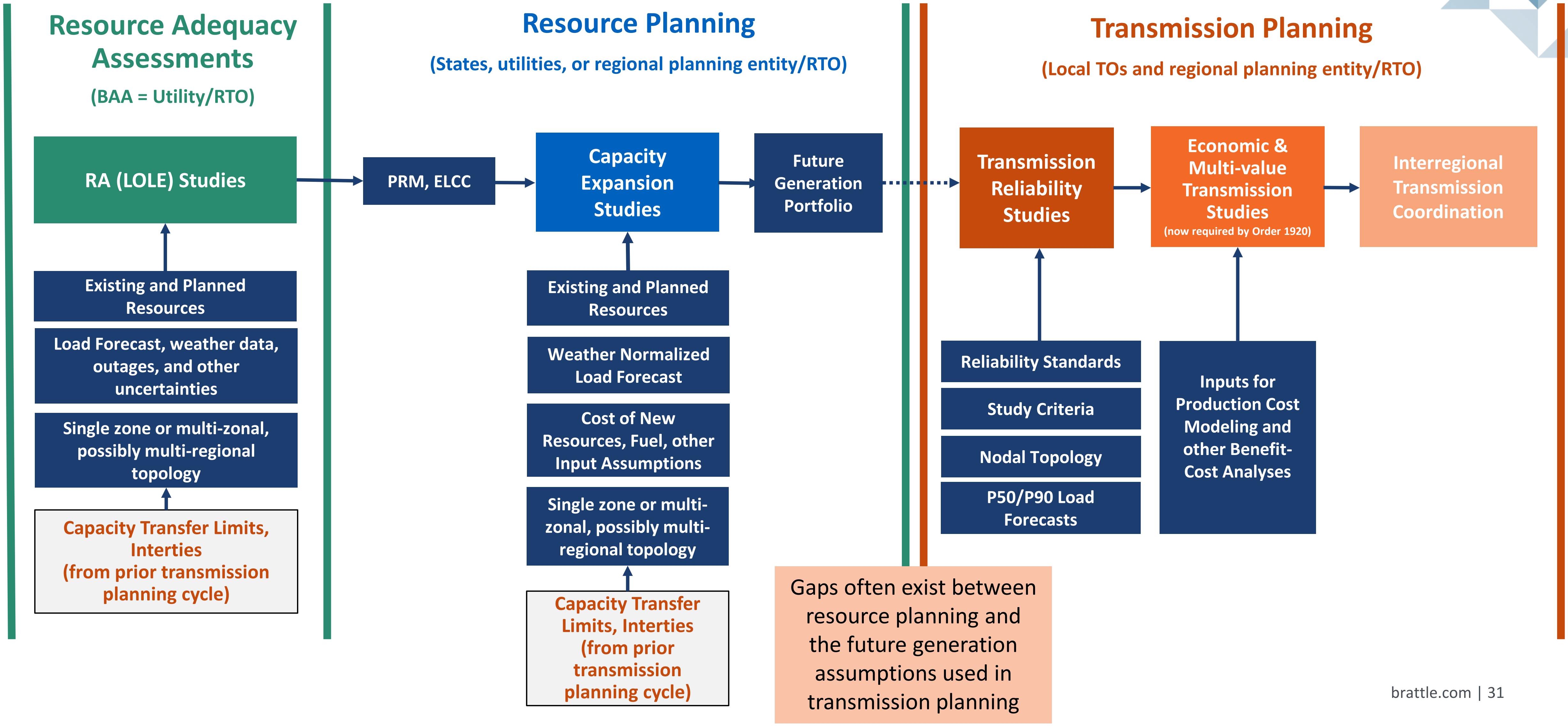
	Type of transmission	Resource Adequacy Value of this Type of Transmission
Local & Regional	T_{Load}	Connects loads that create RA requirements
	T_{Gen}	Connects new generation needed **to meet zonal/regional RA requirements**
	$T_{CapTrans}$	Enables cross-zonal capacity transfers within region, **reducing RA requirement and costs**
	T_{Other}	Other transmission needed to reliably (and efficiently) deliver generation to serve load
Interregional	T_{CapImp}	Enables resource-specific **capacity imports** from neighboring regions to meet RA requirements
	T_{Uncom}	Non-firm imports over uncommitted capacity **reduce regional RA requirements** due to interregional load and resource diversity

Siloed transmission planning processes do not fully value RA

	Considered in / Type of transmission	Local Reliability Planning	Generator Interconnection Queue	Transmission Service Requests	Regional Reliability Planning	Regional Economic & Public Policy Planning	Interregional Coordination
Local & Regional	T_{Load}	✓			✓		
Local & Regional	T_{Gen}	◐	✓		◐		✓
Local & Regional	$T_{CapTrans}$		◐			◐	
Local & Regional	T_{Other}	✓		✓	✓	✓	◐
Interregional	T_{CapImp}			✓	◐		✓
Interregional	T_{Uncom}						◐
	Effectiveness of planning processes for addressing resource adequacy needs	Not focused on RA (RA benefits incidental)	**Effective but slow**; causes significant delays in achieving RA requirements	**Effective but often slow**; only for unit-specific capacity imports	Not focused on RA (RA benefits incidental)	**Potentially effective but often slow** (if transmission is focused on RA)	**Ineffective**; diversity value often not fully considered in planning

Is Transmission Type Considered in Process?	✓ Explicitly Considered	◐ May Be Considered	
How often is the Process used for Transmission Approvals?	Commonly Used	Sometimes Used	Rarely Used

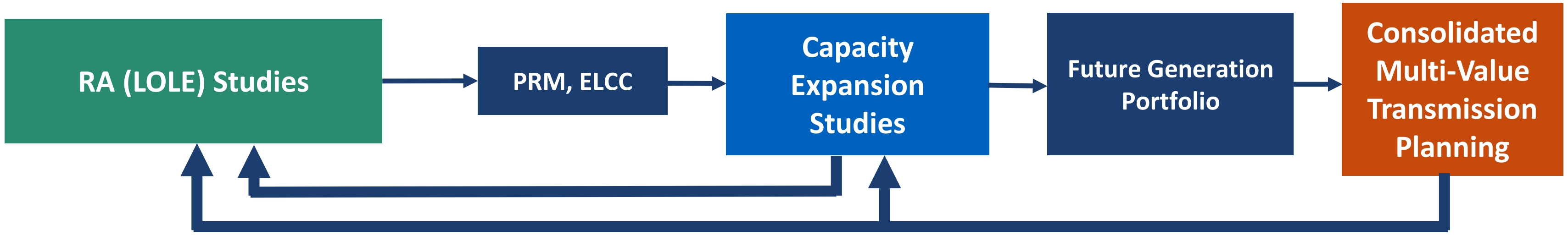
A gap in planning models contributes to seams inefficiencies



Solution: Better integration of RA, generation, and transmission planning

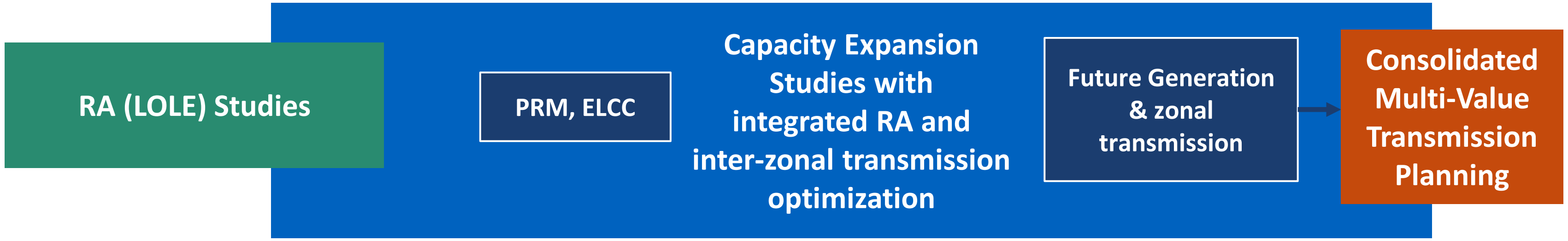
Option 1: Iterative RA, capacity expansion, and multi-value transmission planning

- RA value of transmission explicitly quantified in multi-value transmission planning (e.g., MISO LRTP)
- Iterative either within same planning cycle or (at least) across subsequent planning cycles
- Example: CPUC-CEC-CAISO coordinated (and iterative) planning process



Option 2: Capacity expansion modeling co-optimized with RA and zonal transmission

- Capacity expansion models with integrated RA and zonal transmission co-optimization
- Offers more optimal starting point for detailed transmission planning, endogenously capturing RA value
- Requires expansion model with calibrated/verified RA and transmission expansion representation
- Example: SPP Future Energy and Resource Needs Study (FERNS)



Brattle Group Publications on Transmission

Pfeifenberger, Transmission Benefits and Opportunities for Improved Planning under Order 1920, ESIG Webinar, March 23, 2026.

Pfeifenberger, Better Transmission Planning: Proactive, Holistic, Scenario-based, Least-Regrets, with Portfolio-based Cost Allocations, CREPC, Oct 22, 2025.

Pfeifenberger, Integrated System Planning under Uncertainty, LSI Electric Power Conference, September 23, 2025.

Pfeifenberger, et al., Optimizing Grid Infrastructure and Proactive Planning to Support Load Growth and Public Policy Goals, prepared for Clean Air Task Force, July 2025.

Tsuchida, et al., Incorporating GETs and HPCs into Transmission Planning Under FERC Order 1920, prepared for ACORE, April 2025.

Pfeifenberger, et al., Proposal to Develop Optimal Transmission Planning in Alberta, prepared for AESO, April 2025.

Pfeifenberger, "Intertie Optimization: Achieving Efficient Use of Interregional Transmission," IEEE PES Energy and Policy Forum, April 2025.

DeLosa, et al., Strategic Action Plan, prepared for the Northeast States Collaborative on Interregional Transmission, April 2025.

Pfeifenberger, Transmission Cost Allocation for Order 1920 Compliance, NARUC-NASEO-DOE Webinar, Dec 6, 2024.

Pfeifenberger, Order 1920 Compliance: An Opportunity to Improve Transmission Planning beyond Mandates, ESIG, Oct 22, 2024.

Gramlich, Hagerty, et al., Unlocking America's Energy: How to Efficiently Connect New Generation to the Grid, Grid Strategy and Brattle, August 2024.

Pfeifenberger, Ensuring Cost-Effective Transmission in Support of a Clean Energy Transmission, NESCOE, Aug 9, 2024.

DeLosa, Pfeifenberger, Joskow, Regulation of Access, Pricing, and Planning of High Voltage Transmission in the US, MIT-CEEPR working paper, March 7, 2024.

Pfeifenberger, How Resources Can Be Added More Quickly and Effectively to PJM's Grid, OPSI Annual Meeting, October 17, 2023.

Pfeifenberger, Bay, et al., The Need for Intertie Optimization: Reducing Customer Costs, Improving Grid Resilience, and Encourage Interregional Transmission, Oct 2023.

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, Dec 2022.

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

Brattle Group Publications on Transmission (cont'd)

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 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.

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.

Clarity in the face of complexity

The Power of Economics™

Brattle