Intertie Optimization: Achieving Efficient Use of Interregional Transmission

PRESENTED BY

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Note

This presentation is in part based on:

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

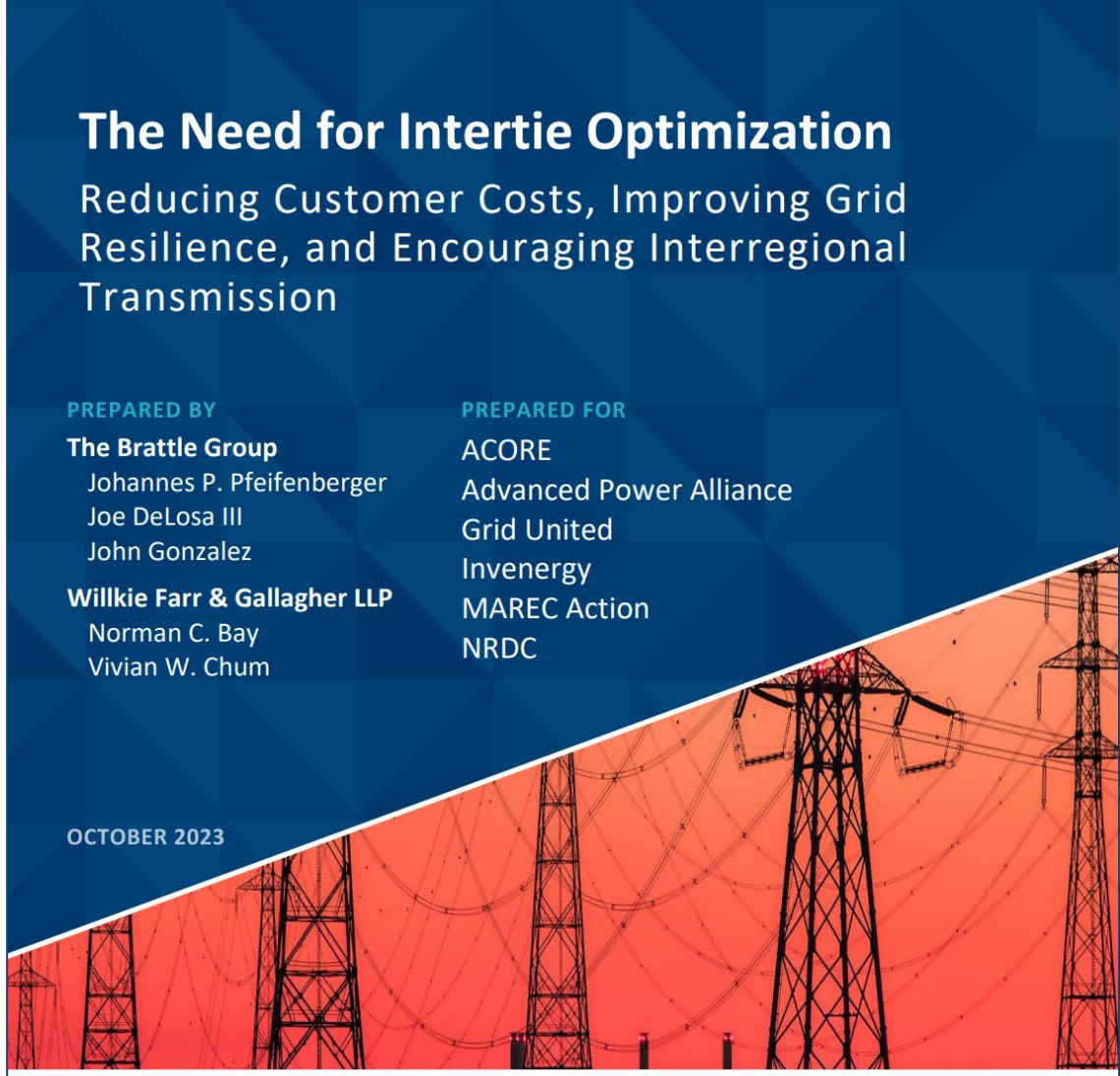
Intertie Optimization FAQs and Implementation Principles, February 2024

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.

Various State of Market, LBNL, and NREL reports
(as cited in the slides)

The presentation reflects the analyses and opinions of the authors and does not necessarily reflect those of The Brattle Group's or Willkie Farr & Gallagher LLP's clients.



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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 ineffective (as discussed in the appendix slides)
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** inefficiencies through market-to-market coordinated flowgates (with shares of firm flow entitlements) under the existing JOAs
4. **Inefficient trading** across contract-path market seams and the need for intertie optimization
   - **This is the main focus of today's presentation**
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 Transmission is Poorly Utilized by Bilateral Trades

2023 PJM State of the Market Report: power flows the wrong way 40-50% of the year!

- Price differences across the MISO-PJM seam exceeded $5/MWh during 3,331 hours; yet during 1,519 (43%) of these hours, market flows were inconsistent with those price differences, exporting power from the higher-priced market to the lower-priced market
- On PJM-NYISO interties, price differences exceeded $5/MWh during 4,218 hours, with inconsistent market flows during 1,641 (50%) of these hours

Potomac Economics previously observed similar intertie inefficiencies:

- On MISO's seams: "more than 40 percent of … transactions are ultimately unprofitable"
- Between NYISO and ISO-NE: the efficiency of real-time trades has been deteriorating, achieving "optimal" RT transactions during only 11% of all trading periods in 2022, down from 23% in 2018

This inefficiency is particularly pronounced and consequential in real-time markets, for which intertie optimization offers the only effective solution

- **Day-ahead**: average (absolute) value of 2023 PJM-NYISO price difference of $4.62/MWh with price differences changing signs 2.9 times per day. With absolute PJM-MISO difference = $3.72/MWh, changing sign 3.8 times/day
- **Real-time**: average (absolute) PJM-NYISO price difference of $11.04/MWh with sign changing sign 49 times each day. With absolute PJM-MISO difference = $10.21/MWh, changing sign 61 times each day

Intertie Optimization: More Efficiently Trade Across Market Seams

The time is ripe to consider "intertie optimization" to reduce seam-related trading inefficiencies!

- NYISO, ISO-NE, and Potomac Economics 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
  - PJM's IMM has recommended intertie optimization in every year since 2014; NREL and NARUC reports recommend intertie optimization as well
- 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—
  - Has dramatically improved efficient utilization of interregional transmission
  - Does not require "cost allocation" for new transmission
  - Provides value of optimized transactions directly to transmission owners and their customers
  - Widely embraced; FERC approved; WEIM reduced costs by over $5 billion since inception

Intertie Optimization: Avoids the Inefficiencies 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 is not working – not for Traders, not for RTOs, not for TOs, and not for Customers

See also: Frequently Asked Questions

Experience with Intertie Optimization: WECC and Europe

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

- Depancaked WEIM and WEIS transactions are scheduled on a 15-minute/ 5-minute basis after all bilateral trading has closed (approximately 20 minutes before each real-time operating period), using transmission that remains available and otherwise would go unutilized
- $5 billion in savings accrued through 2023 to the neighboring BAAs and other entities that contribute available transmission
- Real-time optimization of interregional transmission now expanded to day-ahead markets (EDAM)
- CAISO's Subscriber PTO framework: integrate unutilized capacity on merchant transmission lines into regional and interregional DA and RT energy markets

Flow-based "Market Coupling" in central and western Europe (for transmission left available after bilateral day-ahead and intra-day trading closes) is currently expanded to Scandinavia

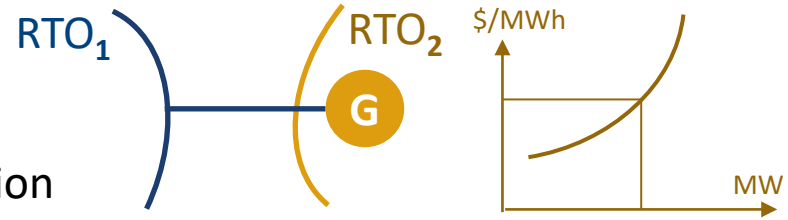
Intertie Optimization: Implementation Options

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

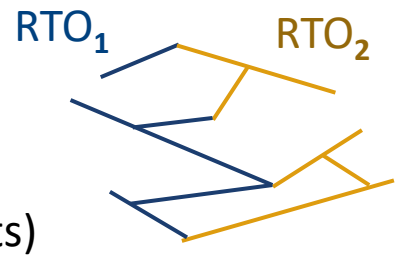
The RTOs would use their existing market optimization SCED engines to optimize intertie schedules subject to available intertie capabilities after all bilateral transactions are closed

- 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. **Contract-path 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. **Flow-based 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 achieve 99% of full optimization)



3. **Combined SCED 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

Promising Initiative: SPP's Inter-Market Optimization Framework

- SPP staff has been exploring an Inter-Market Optimization Framework to improve the efficiency of transfers between SPP and its neighbors, resulting in increased economic benefits for SPP's market participants
- On October 16, 2024, SPP's Strategic Planning Committee (SPC) endorsed that staff's work on this concept be prioritized within the "Optimized Seams" objectives of SPP's strategic planning roadmap
- SPP's proposed next steps:
  - Further evaluate potential value of adding this feature to the market design
  - Prioritize inter-market optimization within the Optimized Seams strategic opportunity
  - Develop policy proposals to address challenges identified

Source: SPP Documents & Filings – SPC Meeting Materials, Oct 8, 2024

FERC Has the Authority to Implement Intertie Optimization

- FERC has long recognized the inefficiencies of market seams. *See* Order No. 888 & Order No. 2000
- FERC's authority to address seams issues is clear given its duty to ensure just and reasonable rates
- There is well established precedent for FERC to address market seams:
  - Coordinated Transaction Scheduling (ISO-NE-NYISO; NYISO-PJM; and PJM-MISO)
  - Western EIM and EIS
  - FERC precedent with respect to CTS: recognizing the value of "Tie Optimization" and leaving the door open. *See NYISO*, 139 FERC ¶ 61,048 (2012) (recognizing the possibility of replacing CTS with a "different methodology for scheduling external transactions (i.e., Tie Optimization or a superior alternative), if it is determined that such changes could result in greater cost savings")
- If the RTOs/ISOs propose intertie optimization, FERC has the clear authority to accept the filing under section 205. FERC would also be able to require intertie optimization under FPA section 206

The Bottom Line

The time is ripe for RTOs to pursue "intertie optimization" to reduce seam-related inefficiencies:

- NYISO, ISO-NE, and Potomac Economics have called for intertie optimization in 2010-2011 to address seam-related inefficiencies, but only CTS was implemented
- 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 and markets offers substantial benefits
- FERC has the authority to approve/implement intertie optimization under either section 205 or 206 of the FPA

In addition to intertie optimization, seams related initiatives should also include encouraging the full recognition of the resource adequacy and resilience value of (even uncommitted) interregional transmission capacity

THANK YOU

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See also: Frequently-asked Questions
Additional Slides

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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 former 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.

NREL Report: Barriers and Opportunities to Realize the System Value of Interregional Transmission (June 2024)

NREL recommends reforms to "significantly enhance the value of interregional transmission and deliver additional within-region benefits":

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

→ **Recognize resource-adequacy and resilience value of interregional transmission**

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

- Improved coordination and joint congestion management

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

- Depancaking
- Improved intertie pricing
- → **Move toward intertie optimization**

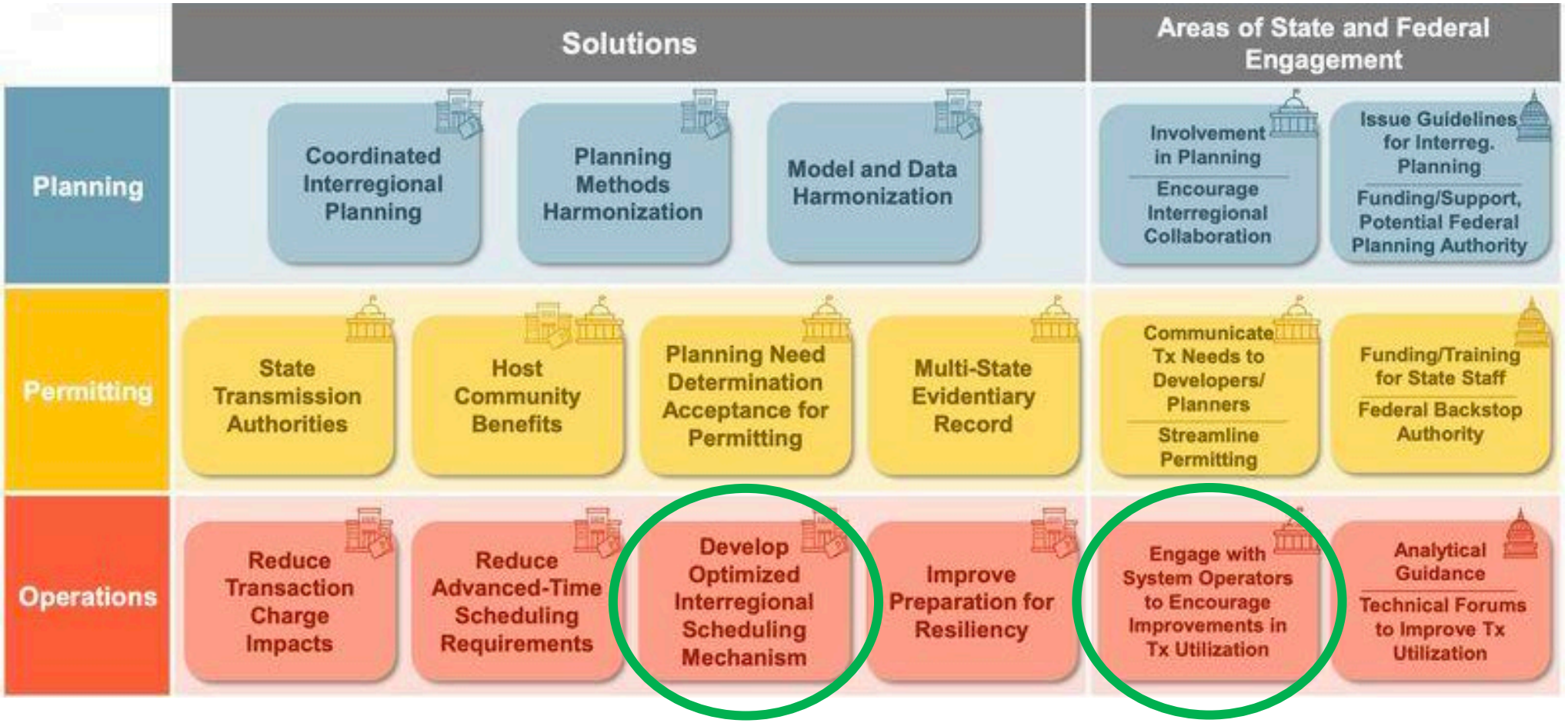
Transformative Actions

- 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

- Interregional planning
- Interconnection-wide optimization

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

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



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

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)
- Other 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 on a merchant basis (i.e., not paid for through regulated transmission rates)
- Significant barriers exist even for capacity imports, where firm transmission is no longer sufficient in some RTOs (such as PJM)

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

History of Intertie Optimization and CTS

In 2011 NYISO & ISO-NE offered fully-specified design for intertie optimization:

- Intertie Optimization: similar to the least-cost economic dispatch system used internally for each ISO's energy market, it relies on "market-based offers to determine the real-time schedule of energy interchange between their interconnected transmission networks" (see updated 2014 optimization framework*)

The ISOs recommended the Intertie Optimization as their preferred solution because:

- Intertie optimization "is the more efficient solution" (and consistent with existing ISO roles of independent LMP-based market and settlement administrators)

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

- It was hoped that CTS, as the less complex solution, might be almost as efficient
- Yet, years of experience now show that CTS is not effective

PJM IMM recommended intertie optimization in every SOM Report since 2014:

- "The MMU recommends that PJM explore an interchange optimization solution with its neighboring balancing authorities that … 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" (e.g, 2023 SOM Report at 478)

* Zhao, Litvinov, and Zheng, "A Marginal Equivalent Decomposition Method and Its Application to Multi-Area Optimal Power Flow Problems," IEEE Transactions on Power Systems, Volume 29, Issue 1 (2014). (Successfully tested large-scale simulations of a "marginal equivalence" approach that works for both RTO and non-RTO seams)

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 (a factor magnified in impact by the increasing volatility of real-time market conditions)
  - **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

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

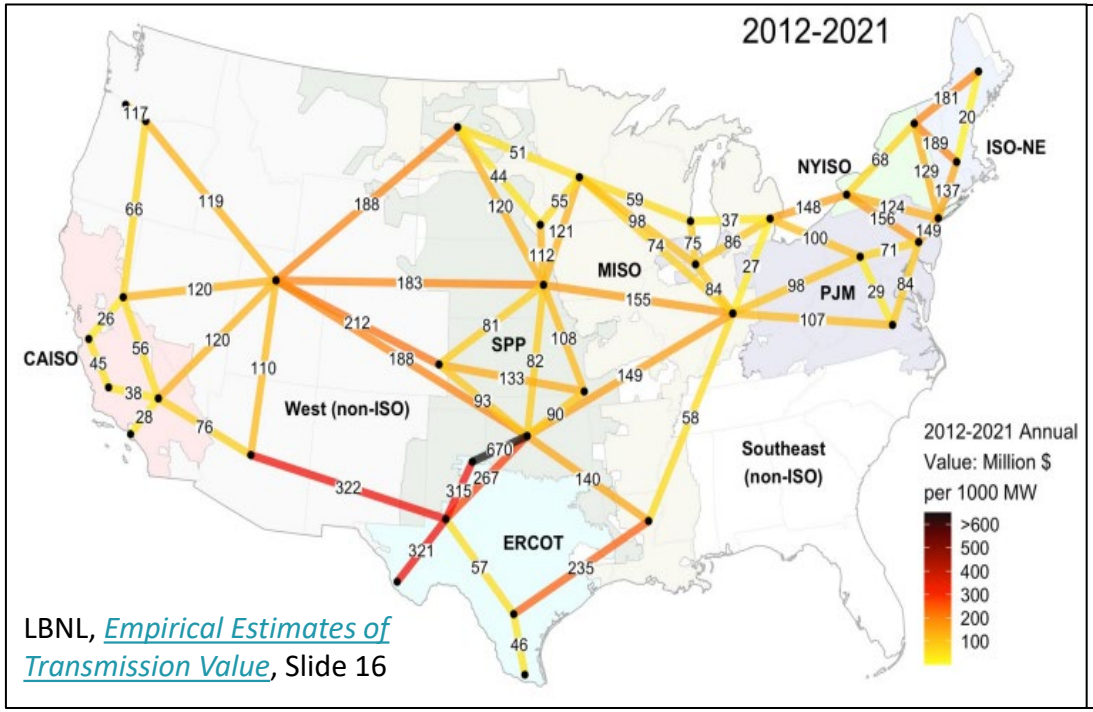
CAISO developed the SPTO framework to integrate unutilized capacity on merchant transmission lines into regional and interregional DA and RT energy markets

- 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

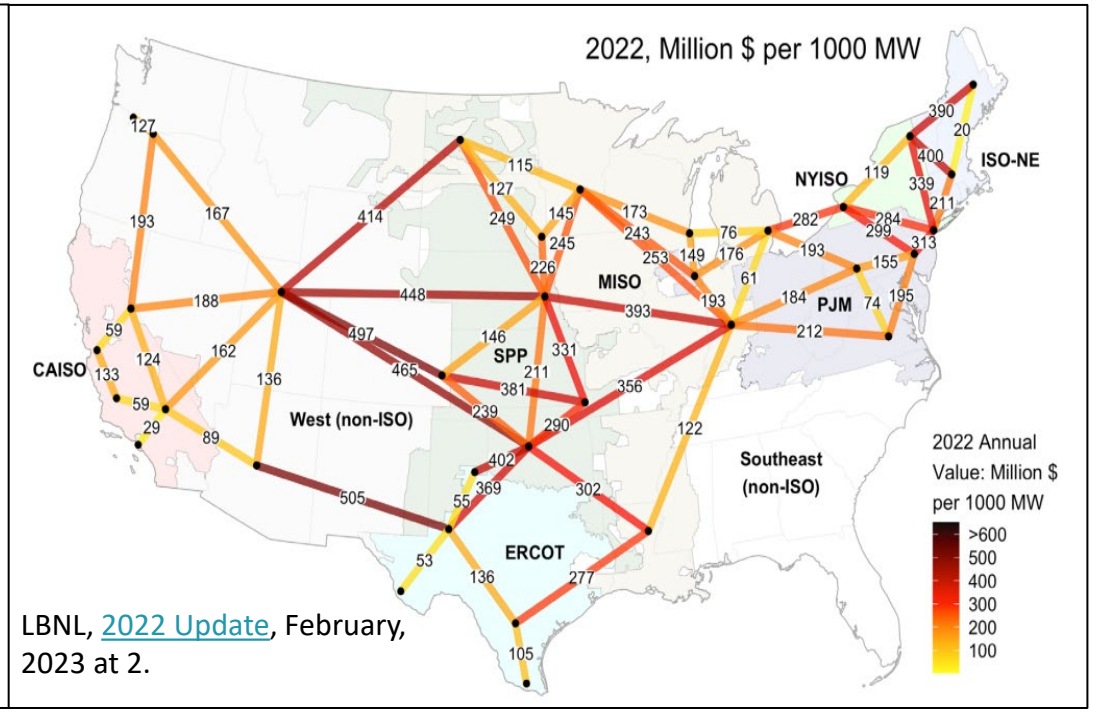
Summary of the SPTO design (filed 9-22-23 in FERC Docket ER23-2917)

- The merchant SPTO facility is put under CAISO operational control
- Priority rights for subscriber schedules (perfect congestion hedge)
- Unscheduled merchant transmission capacity (held by subscriber or project owner) is made available for regional and interregional "market use" in both day-ahead and real-time
- CAISO will optimize SPTO capacity made available, 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 (and capped at) CAISO's transmission access charge to avoid rate pancaking

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.

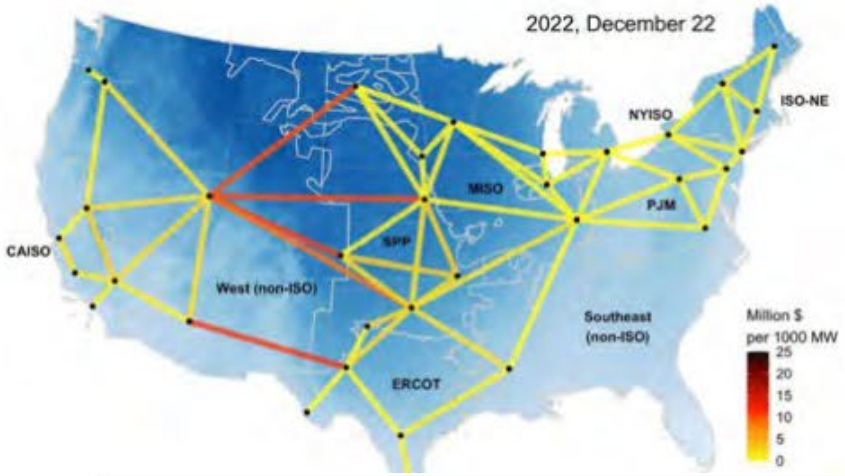
Methodology: Transmission value based on historical real-time price difference between regional nodes

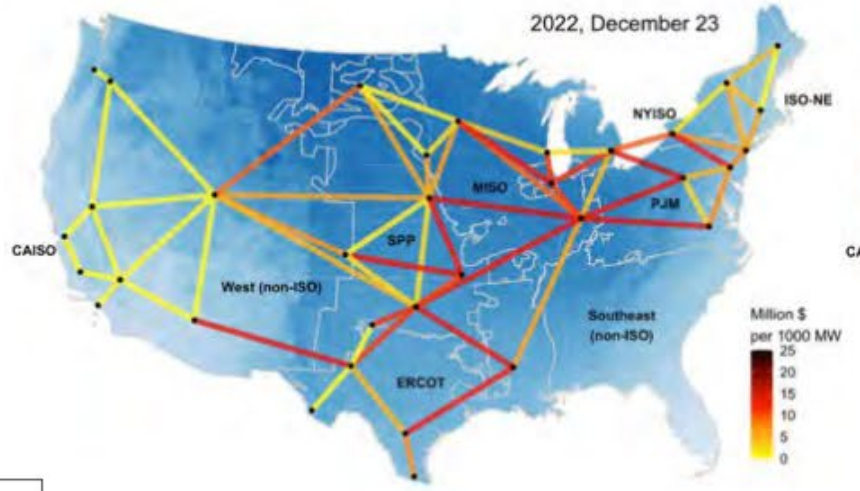
Study Findings:

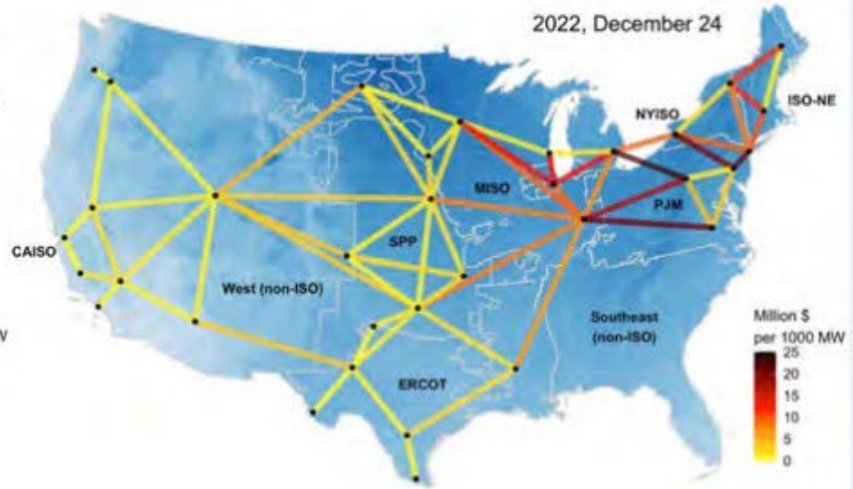
- Interregional links have greater value than regional links
- **40-80% of transmission's congestion value is from 5% of hours due to extreme conditions,** 20-30% from top 1% of hours reflecting the high impact of challenging system conditions
- The value in some of the recent years (e.g., 2021, 2022)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

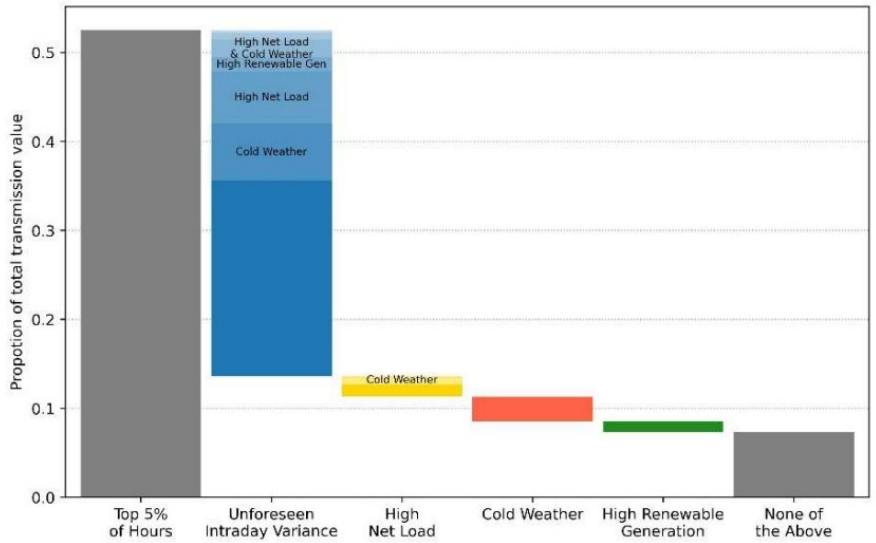
Value of Transmission is Concentrated in Few Unpredictable Hours

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









Findings:

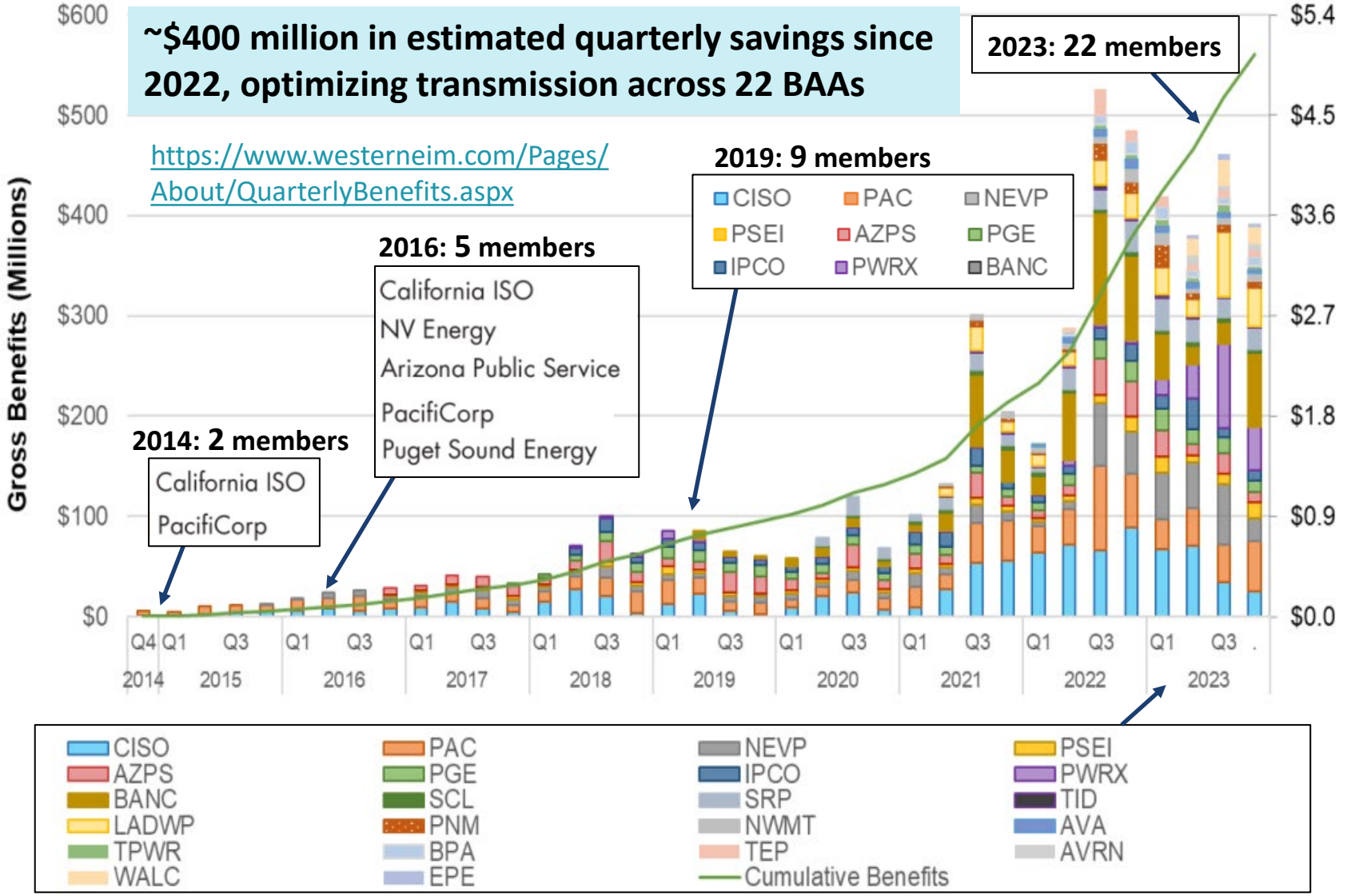
- Real-time values (reflecting actual conditions) are higher than DA values
- On average, about half of the value is concentrated in top 5% of all hours
- Most of that value is due to real-time market conditions that are not foreseeable on a day-ahead basis
- Estimated benefits exceed estimated costs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

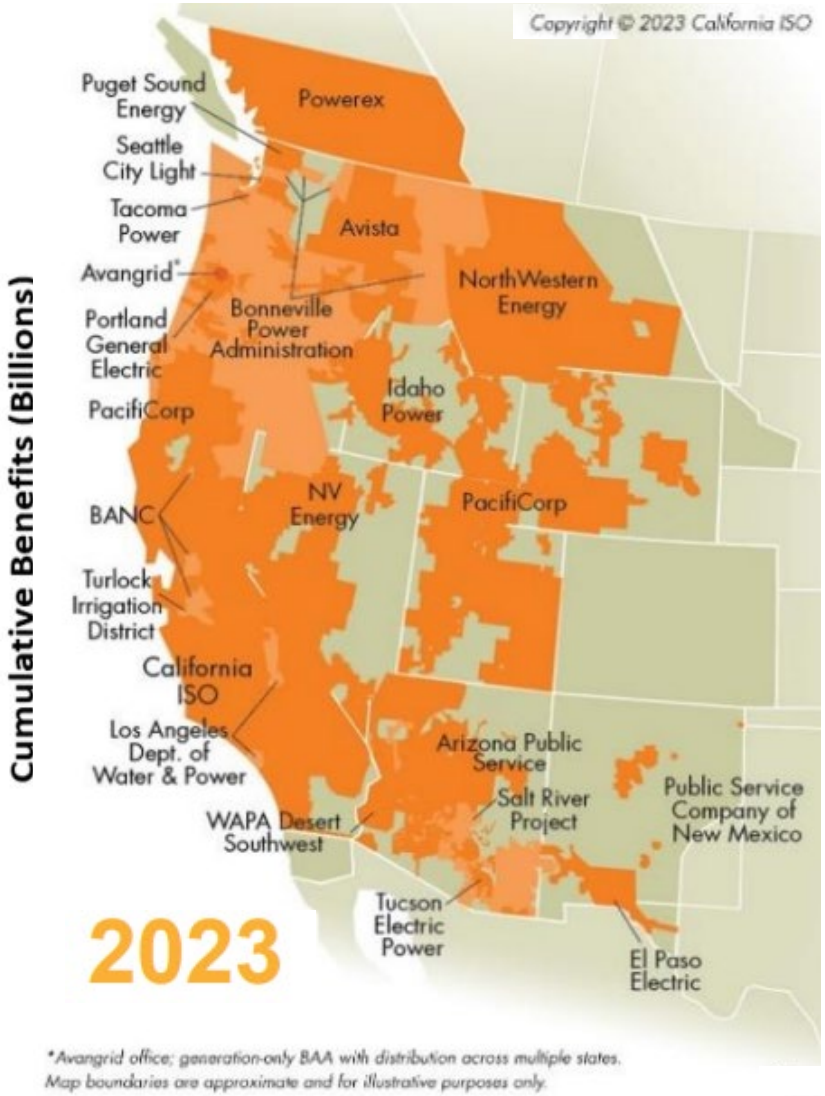
Sources: LBNL, Transmission Value Manuscript NatureEnergy (March 29, 2024); Department of Energy's 2023 National Transmission Needs Study (Oct 2023)

By 2023, WEIM already achieved $5 billion savings from transmission optimization across multiple BAs in RT energy markets

~$400 million in estimated quarterly savings since 2022, optimizing transmission across 22 BAAs

https://www.westerneim.com/Pages/About/QuarterlyBenefits.aspx





Estimated Value of Intertie Optimization: SPP, MISO and PJM

Volatility of price differences between SPP, MISO, and PJM shows that intertie optimization is needed to capture 20-30% of the total real-time transmission value

- Our analysis 2020-2022 price differences point to a high "book-end" value if interregional transfer capacity could be used more optimally for RT energy market transactions
  - **Bilateral trades** that respond to observed RT price differences with a 1-2 hour delay would typically **capture only 70-80%** of the total energy value of interties, including during reliability events
  - The value that cannot be captured by through bilateral trades consequently is roughly **20-30% of the total real-time value** (assuming a 1-2 hour delay of trades in response to observed prices)

This represents an average value of approx. $50-60 million/year for every 1,000 MW of intertie capacity

  - It can only be captured by system operators through automated operational means, such as intertie optimization or an interregional energy imbalance market (similar to the Western EIM or EIS)

For merchant transmission lines, intertie optimization revenues would need to accrue to either the transmission owner or its subscribers

  - See CAISO Subscriber PTO proposal

Estimated Value of Intertie Optimization (detailed results)

Approach (based on LBNL framework): Value of 1000 MW of trade based on differences in hourly real-time energy prices for nodes in western SPP, central MISO, and western PJM

		SPP > MISO	MISO > SPP	MISO > PJM	PJM > MISO	SPP > PJM	PJM > SPP
Value with No Trading Delay ($ million)	[1]						
2020		$91	$27	$26	$23	$93	$26
2021		$189	$136	$69	$44	$222	$143
2022		$338	$53	$144	$58	$410	$39
Value with 1 Hour Delay ($ million)	[3]						
2020		$76	$10	$13	$11	$79	$10
2021		$165	$108	$46	$22	$198	$117
2022		$307	$23	$104	$20	$384	$14
Value with 2 Hour Delay ($ million)	[4]						
2020		$71	$7	$11	$9	$75	$7
2021		$150	$95	$39	$17	$185	$107
2022		$290	$8	$91	$7	$372	$3
Value of Intertie Optimization ($ million)	[1] - [3]						
1 Hour Delay: 2020		$15	$17	$13	$12	$14	$16
2021		$24	$28	$24	$21	$24	$26
2022		$31	$30	$40	$39	$26	$25
	[1] - [4]						
2 Hour Delay: 2020		$20	$20	$16	$13	$18	$19
2021		$39	$41	$30	$26	$37	$37
2022		$48	$46	$53	$51	$38	$35

Bidirectional Intertie		SPP-MISO	MISO-PJM	SPP-PJM
Annual Average Value with No Trading Delay ($ million)	[1]	$278	$122	$311
Annual Average Value with 1 Hour Delay ($ million)	[3]	$230	$72	$267
% Value Lost Due to Delay	1 - ([3]/[1])	17%	41%	14%
Annual Average Value with 2 Hour Delay ($ million)	[4]	$206	$58	$250
% Value Lost Due to Delay	1 - ([4]/[1])	26%	52%	20%
Annual Average Value of Intertie Optimization ($ million)				
One hour	[1] - [3]	$48	$50	$43
Two hour	[1] - [4]	$71	$63	$61

Approx. $50-60 million/yr per 1000 MW

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