The Need for Intertie Optimization:

Reducing Customer Costs, Improving Grid Resilience, and Encouraging Interregional Transmission

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Note: This presentation is based on the whitepaper of the same title posted here (with responses to frequently asked questions). All results and any errors are the responsibility of the authors.

Executive Summary

1. NYISO, ISO-NE, and Potomac Economics recommended intertie optimization in 2011 to address seam-related inefficiencies, but only "Coordinated Transaction Scheduling"(CTS) was implemented at the time
2. A decade later, the Market Monitors continue to document seams-related inefficiencies, noting that CTS has not been effective
3. Western energy imbalance markets and European "market coupling" have shown that intertie optimization offers substantial economic, reliability, and renewable integration benefits
4. CAISO's SPTO proposal: full DA+RT optimization of interregional merchant transmission
5. **The time is ripe to consider intertie optimization more broadly to reduce seam-related inefficiencies and barriers to interregional transmission development**
6. Our analysis of historical real-time price differences between SPP, MISO, and PJM show that the lack of intertie optimization may mean 20-30% of total RT energy value is lost. Intertie optimization could save $50-60 million/year for every 1000 MW of interregional transmission
7. **FERC has the authority to approve intertie optimization under section 205 and would also be able to implement intertie optimization under section 206 of the FPA**

The case for intertie optimization between regions

Interregional transmission is poorly utilized

For example, in the 2022 PJM State of the Market Report, the Market Monitor notes:

- Price differences across the MISO-PJM seam exceeded $10/MWh during 3,182 hours; yet during 1,570 (49%) 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 $10/MWh during 4,178 hours, with inconsistent market flows during 1,667 (40%) of these hours

Potomac Economics similarly observes 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 forecasting price differences for the next 1-2 hours is becoming increasingly more difficult

- **Day-ahead**: average (absolute) value of 2022 PJM-NYISO price difference of $12.94/MWh with price differences changing signs 3.1 times per day. With absolute PJM-MISO difference = $9/MWh, changing sign 4.1 times/day
- **Real-time**: average (absolute) PJM-NYISO price difference of $115.36/MWh with sign changing sign 47.9 times each day. With absolute PJM-MISO difference = $99.86/MWh, changing sign 62.9 times/day

The poor utilization of interregional transmission 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

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

NYISO & ISO-NE Recommended Intertie Optimization in 2011, but CTS was implemented instead

NYISO & ISO-NE offered fully-specified, implementable 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 "market-based offers to determine the real-time schedule of energy interchange between their interconnected transmission networks" (see updated optimization framework*)
- Coordinated Transaction Scheduling: 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 and forecasts of real-time prices)

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)
- 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, as the less complex solution, might be almost as efficient

* 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)

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 been documenting 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)

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 between 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
- 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
  - Value of transactions accrues to the neighboring BAAs and other entities that contribute available transmission
- 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**
- In response to WEIM and WEIM success, market operators are now developing the Extended Day Ahead Market (EDAM) and Markets+ to fully optimize interregional transmission on a day-ahead basis as well

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

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)

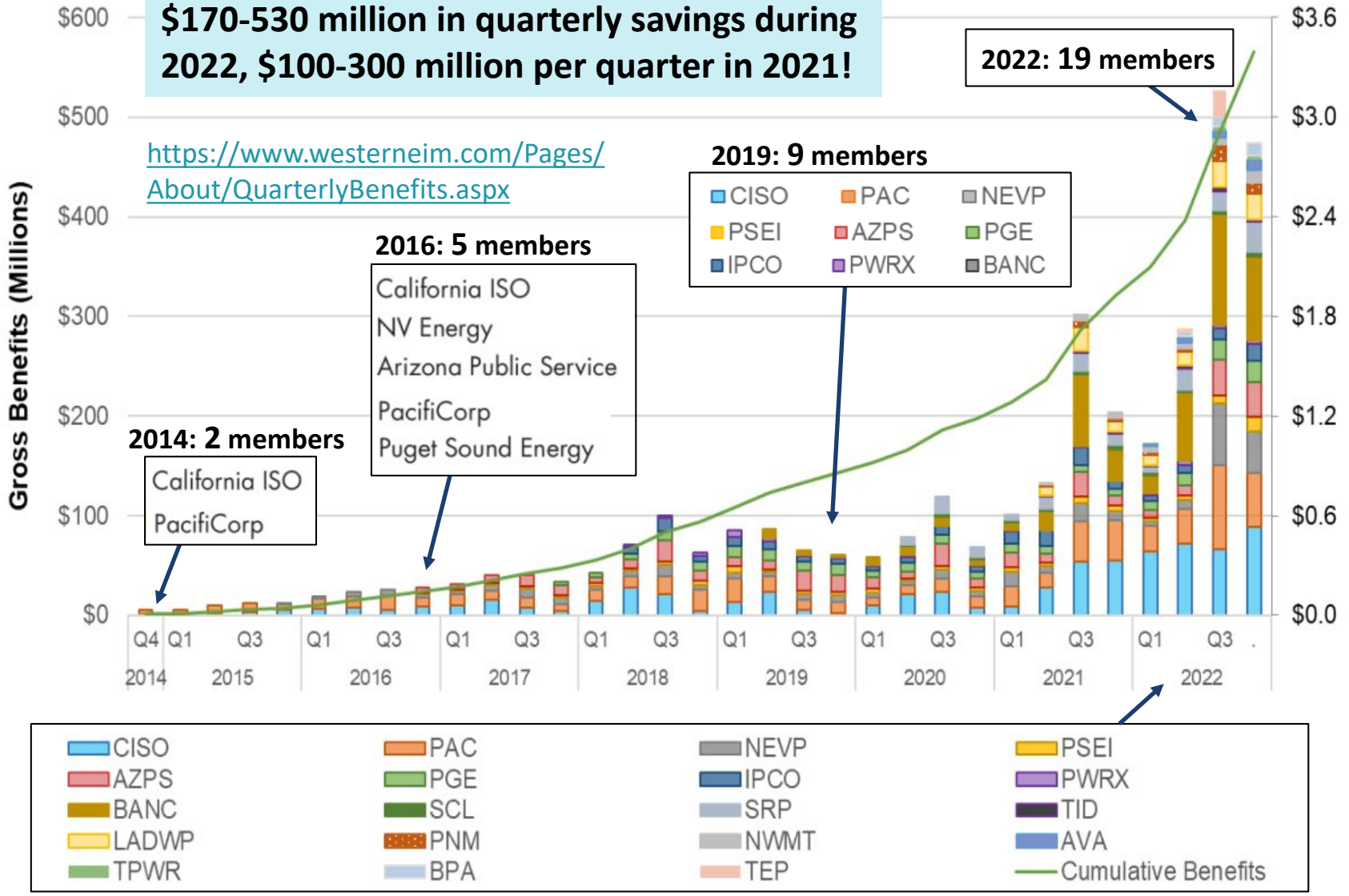
- The merchant SPTO facility is put under CAISO operational control
- Priority rights for subscriber schedules (perfect congestion hedge)
- Unscheduled merchant transmission capacity (held by subscriber or project owner) is made available for regional and interregional "market use" in both day-ahead 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

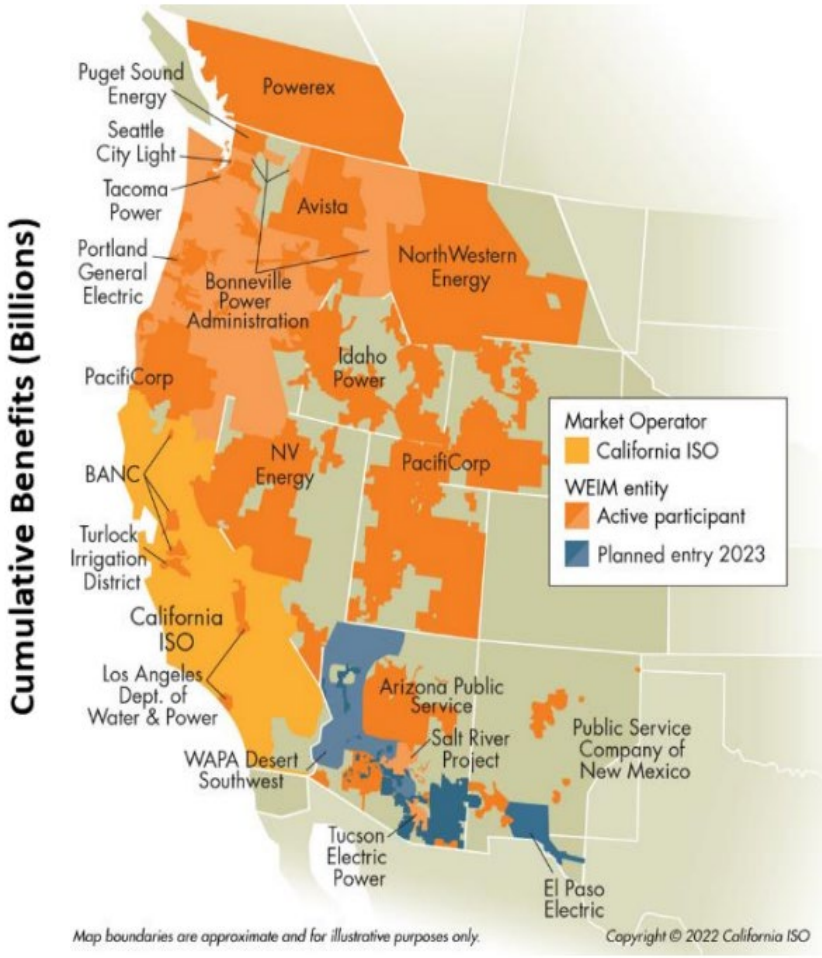
The potential value of intertie optimization

WEIM Example: $4 billion savings from transmission optimization across multiple BAs in RT energy markets (through 2Q 2023)

$170-530 million in quarterly savings during 2022, $100-300 million per quarter in 2021!

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



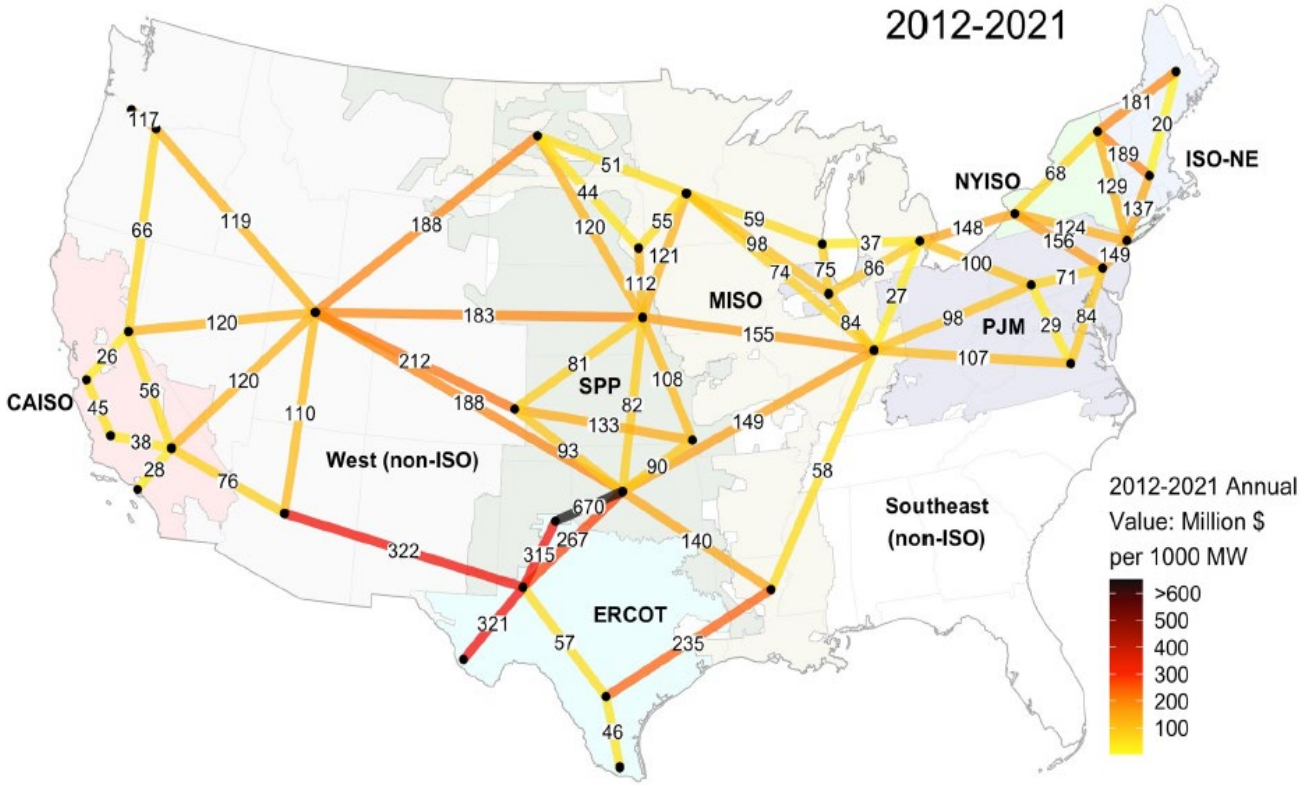


Empirical estimates of transmission value using Locational Marginal Prices (Berkeley Labs, August 2022)

Study Purpose: Quantify congestion value of increased transmission to provide insight on economic benefits beyond reliability

Study Methodology: Identify high/low priced locations using 2017-2020 LMP data. Link locations and calculate congestion relief

Marginal Value of Relieving Transmission Congestion



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

Implications for Intertie Optimization:

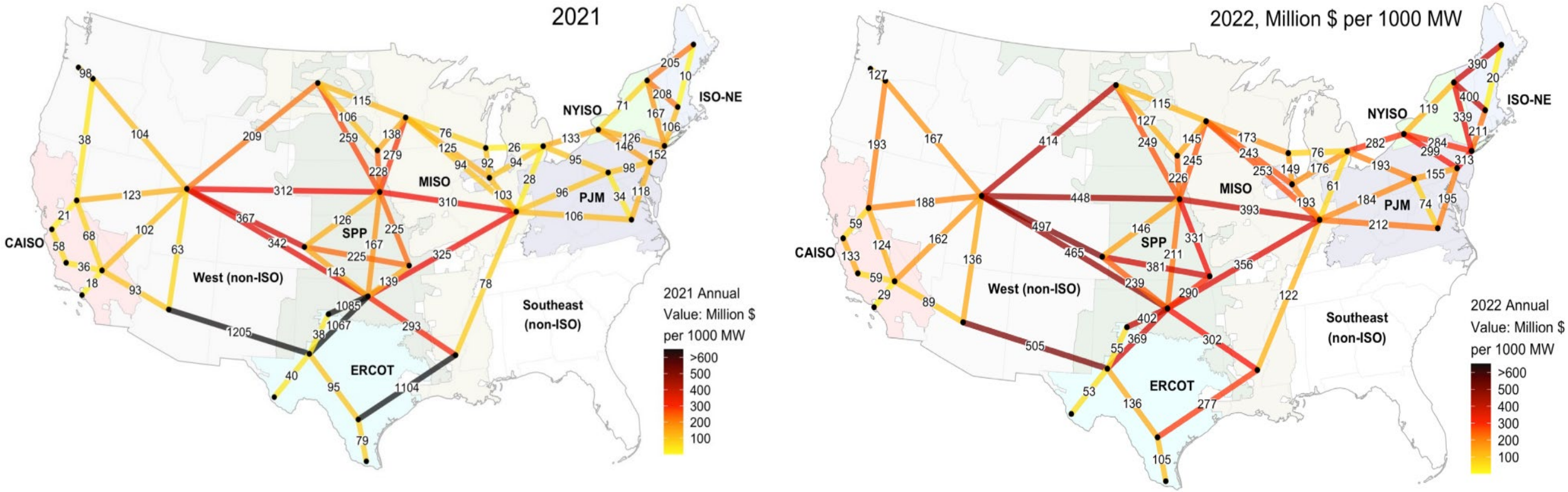
- Intertie optimization would immediately create benefits by increasing real-time transactions over the existing (but inefficiently used) transmission links between regions
- It would also increase the value that can be realized by new transmission links, which is critical for merchant transmission lines (not paid for through regulated transmission rates)

Source: LBNL, Empirical Estimates of Tx. Value (Aug 2022), Slide 16

LBNL annual results of empirical transmission value: 2022 and 2023 Update

2021 and 2022 intertie values significantly exceeded the prior decade's average, reflecting major storms, higher gas prices, and higher geographic-diversity value

Marginal Value of Relieving Transmission Congestion



Source: LBNL, Empirical Estimates of Tx. Value (August 2022), slide 18; D. Millstein, R. Wiser, et al., 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 (February, 2023) at 2.

Estimated value of intertie optimization

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

The regulatory case for intertie optimization

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

FERC Can Accept Intertie Optimization Under FPA Section 205

- If the RTOs/ISOs propose intertie optimization, FERC has the clear authority to accept the filing
- Legal standard under section 205
- Here, accepting Intertie Optimization would be just and reasonable
- 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")

What Happens if There Is No RTO/ISO Filing?

- FERC can require intertie optimization under FPA section 206
- FERC's section 206 authority and its requirements
- How to show that Coordinated Transaction Scheduling is unjust and unreasonable?
- What replacement rate would be just and reasonable, and how would it be implemented?

The bottom line

The time is ripe to consider "intertie optimization" to reduce seam-related inefficiencies and 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 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 offers substantial benefits: reducing costs, improving reliability and renewable integration—dramatically improving utilization of interregional transmission
  - 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 for optimization in the regional and interregional energy markets
- FERC has the authority to approve/implement intertie optimization under either section 205 or 206 of the FPA

Thank You!

Comments and Questions?

About the Speakers

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Hannes Pfeifenberger is a Principal of The Brattle Group where he leads the firm's Electricity Wholesale Markets and Planning Group. He is an economist with a background in electrical engineering and over 25 years of experience in the areas of electricity markets, regulation, and finance. Hannes specializes in wholesale electricity market and transmission, helping clients explore the benefits of improved power market designs and grid investments, the integration of renewable generation and storage resources, and the impact of regulatory and legislative actions in the context of evolving market conditions. He 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), and an IEEE Senior Member. Hannes frequently serves as an advisor to research initiatives by the Energy Systems Integration Group (ESIG) and the US Department of Energy's National Labs.