Intertie Optimization FAQs and Implementation Principles

Q1. At a high level, what is intertie optimization and how does it work?

A1. Intertie optimization is the process of efficiently utilizing any interregional transmission capability between neighboring RTOs/ISOs that remains unused after all bilateral trades have been arranged. Intertie optimization (also referred to as "tie optimization") was first proposed by ISO-NE and NYISO in 2011 as follows:

> The core concept of Tie Optimization is for the ISOs to optimize their external transmission links in the same way, or as closely as possible [to how] the ISOs optimize transmission internally. … The concept that underlies Tie Optimization is not new. It is the same bid-based, security-constrained least cost dispatch logic that underlies the wholesale energy market administered by each ISO. This competitive market design applies to all internal nodes and internal transmission facilities today. Tie Optimization simply extends this standard market design to cover the … transmission facilities that interconnect the two ISOs. Operationally, Tie Optimization coordinates real-time energy dispatch across both ISOs' control areas through the exchange of load and offer data for every [dispatch interval].[1]

The PJM market monitor has explained it in similar terms:

> [intertie optimization] 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.[2]

Intertie optimization is discussed more fully in the whitepaper "The Need for Intertie Optimization: Reducing Customer Costs, Improving Grid Resilience, and Encourage Interregional Transmission" (October 2023).

Q2. What are the expected benefits of intertie optimization?

A2. As ISO-NE and NYISO have explained in 2011, applying intertie optimization across the interregional seams between neighboring markets "achieves the lowest possible production cost and efficiently uses the existing transmission infrastructure."

Intertie optimization achieves these production costs savings and associated customer benefits by avoiding the inefficiencies encountered under the existing interregional scheduling processes. As is well documented, these intertie scheduling processes leave interregional transmission underutilized and inefficiently used today. Intertie optimization thus avoids two well documented inefficiencies: (1) when interties are under-utilized, energy flows in the right direction but at insufficient amounts that do not fully utilize the tie and maximize delivery of lower-cost generation; and (2) when energy

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1 See NYISO, ISO New England, Inter-Regional Interchange Scheduling (IRIS) Analysis and Options (January 5, 2011) at iv.

2 Monitoring Analytics, 2022 State of the Market Report for PJM (March 9, 2023) at 105.

flows in the wrong direction, from the higher-priced region to the lower-priced region, displacing more-efficient region-internal generation with less-efficient external generation.

For example, 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.[3] Similarly, optimal levels of real-time transactions between ISO-NE and NYISO have been achieved during only 11% of all trading periods in 2022, down from 23% in 2018.[4] Intertie optimization will avoid these inefficiencies.

Q3. What is the position of the Market Monitors on intertie optimization?

A3. As summarized in the Intertie Optimization Whitepaper, market monitors have long stressed the inefficiency of the existing seams-management approaches. Potomac Economics (the Independent Market Monitor for NYISO, ISO New England, and MISO) first pointed out the need for more efficient management for energy transactions across regional seams in 2003,[5] with similar conclusions reached by other independent market monitors and internal market monitoring units at the time. Yet, despite efforts to improve seams management over the last decade through "coordinated transactions scheduling" (CTS), the recent market monitoring reports demonstrate that CTS has not been effective. For example, in 2023, the PJM IMM has repeated yet again the recommendation it has made every year 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.[6]

Similarly, Potomac Economics continues to recommend that market operators address these seam-related inefficiencies—suggesting that CTS could be improved by clearing "transactions every five minutes through [the Unit Dispatch System] based on the most recent five-minute prices in the neighboring RTO area."[7]

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3 Monitoring Analytics, 2022 State of the Market Report for PJM (March 9, 2023) at Table 9-27.

4 ISO New England Internal Market Monitor, 2022 Annual Markets Report (June 5, 2023) at 160, Figure 5-6. We refer to "optimal" trades as those where the total transmission capability is used in the appropriate (i.e., low-to-high priced) direction.

5 D. Patton, 2003 State of the Market Report – New York Electricity Markets, Potomac Economics (April 2004) at 98-104.

6 Monitoring Analytics, 2022 State of the Market Report for PJM (March 9, 2023) at 105.

7 Potomac Economics, 2021 State of the Market Report for the MISO Electricity Markets (June, 2022) at 89, 120.

Q4. Is there any precedent for the use of intertie optimization that demonstrates its value?

A4. Yes, the Western energy imbalance markets have been created to optimize transactions within and across transmission seams between multiple Balancing Authority Areas (BAA). As discussed in Section III of the Intertie Optimization Whitepaper, the Western energy imbalance markets have been very successful, generating cost savings that now exceed $4 billion. While intertie optimization in the eastern interconnection would be between large RTOs (i.e., not small BAAs like in the WECC), RTOs in the eastern interconnection of the U.S. have previously estimated that the cost savings from intertie optimization would be significant.[8]

Similarly, "market coupling" was implementated between European energy markets in 2006 and enhanced over time, also creating significant cost savings.[9,10]

Q5. How expensive would it be to implement intertie optimization? Does it involve just a market design plus an algorithm (software) or does it also require steel in the ground?

A5. Intertie optimization would only require an algorithm (software) along with very modest changes to how intertie transactions are already scheduled and financially settled by neighboring system operators using their existing settlement systems. No physical hardware or new transmission facilities would be necessary.

As the PJM market monitor notes, the intertie optimization would simply use the RTOs/ISOs' existing market engines and treat "seams between balancing authorities as constraints, similar to other constraints within an LMP market."[11] The RTOs/ISOs existing LMP- and congestion-revenue-based settlement processes would then be applied to capture the value of intertie optimization for their market participants.

Q6. To what market time frames would intertie optimization apply?

A6. The optimization should (most urgently) be applied to the existing 5-minute real-time markets (since interregional transmission utilization is most inefficient in real time and real-time markets are increasingly volatile). But similar to European market coupling, it could also be applied to day-ahead markets.

Q7. At what point during regional market operations would intertie optimization be activated?

A7. Intertie optimization would be activated after all bilateral market transactions between the neighboring regions have been made and are "locked in," which is generally the case 20 minutes

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8 For example, see NYISO, ISO New England, Inter-Regional Interchange Scheduling (IRIS) Analysis and Options (January 5, 2011) at v, II-13, identifying $77 million in production cost savings and $784 million in reduced load expenditures from intertie optimization between New York and New England for the five year study period from 2006 through 2010.

9 Belplex, Trilateral Market Coupling, Energy Exchanges and Transmission System Operators working together towards European Market Integration, (January 12, 2006).

10 See Launch of Flow-Based Market Coupling in the Core Region Enhances Energy Transition, Press Release (June 8, 2022).

11 Monitoring Analytics, 2022 State of the Market Report for PJM (March 9, 2023) at 105.

before real-time. Intertie transactions would then be scheduled on a 5 minute basis (e.g., by the RTOs/ISOs' market engines or a third-party market seams optimization) subject to available interregional transfer limits similar to how generation resources within the markets are scheduled subject to transmission constraints today.

Q8. How would RTO/ISO market engines determine and schedule optimal intertie transactions? Would this require a major modification of RTO/ISO market software?

A8. There are a number of options, none of which would require modifications of RTO/ISO market software beyond integrating additional information about neighboring systems. The neighboring RTOs/ISOs would exchange (every 5 minutes) real-time information on interregional transfer limits and the dispatchable marginal generation resources on their side of the seam. This information can then be used by (one or both of) the existing market engines to determine the optimal schedule of the flows on the intertie along with the dispatch of their region-internal resources.

In its simplest form, the intertie and available import/export schedules could be represented as (1) a gen-tie that reflects the contract path limit of their interface; and (2) a proxy unit that reflect the available marginal generation on the other side of the intertie in the neighboring region. Dynamic intertie schedules (similar to the "pseudo tie" schedules already utilized by RTOs/ISOs today) would then be used to "flow" the market-optimized intertie transactions between the neighboring regions.

As ISO-NE staff have tested through simulations and published in a 2014 IEEE paper,[12] more sophisticated algorithms are available that recognize that an interface between two regions often is not a single transmission line with a static transfer capability, but consists of a number of individual constraints that can be managed more optimally through the dispatch of marginal generation units based on their shift factors on the relevant constraints. In this case, the information exchanged between the RTOs/ISOs would be expanded to account for the information of marginal generation units and binding constraints between the RTOs/ISOs. Implementing such a flow-based intertie optimization algorithm would allow the neighboring regions to transfer more power between them (and do so more optimally) than what is possible under the contract-path interface model.

Finally, intertie transactions could be determined through a full multi-regional market optimization "overlay" similar to what has been achieved by the two Western energy imbalance markets (EIM

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[12] ISO-NE staff developed and successfully tested through large-scale simulations a "marginal equivalence" approach to intertie optimization under which neighboring system operators exchange every 5 minutes information on marginal generation costs and relevant transmission constraints so that the information can be incorporated into the other RTO/ISO's real-time dispatch. As the authors note, this approach can be applied between two RTO/ISO regions as well as between RTOs/ISOs and non-market regions.

See 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).

The article also includes a bibliography of the extensive prior research that had been done in this area.

and WEIS), in which one RTO/ISO uses its real-time market engine to optimize transactions across BAAs in the larger interregional footprint. Such a full multi-regional optimization would, of course, require the exchange of more substantial amounts of data. However, as the 2014 IEEE paper by ISO-NE staff shows, even a more limited exchange of flowgate and marginal generation data can achieve intertie schedules that are very close to those achievable from an integrated multi-regional optimization.

Q9. What transmission capacity would be used for intertie optimization?

A9. Intertie optimization would use any interregional transmission capacity that remains unused after all bilateral trading has concluded. This includes the ability to schedule market-based intertie transactions that "counter flow" the schedules resulting from bilateral trades.

Q10. Should intertie optimization frameworks cover both regulated and merchant transmission?

A10. Yes. Because some of the existing and many of the proposed interregional transmission facilities are merchant lines, it is critical that intertie optimization frameworks cover merchant transmission lines. The owners and/or subscribers of merchant lines would make available for intertie optimization (along with regulated transmission) any transmission capacity that remains unused after bilateral trading closes.

Q11. Would intertie optimization include a fixed "transactions charge" (hurdle rate) that is recovered from every MWh of power transferred by the optimization?

A11. No. Traditional wheeling charges would not apply in this instance because their application would create a hurdle that would discourage many efficient transactions on the otherwise-unused transmission from taking place at all. There is really no wheeling revenue loss in this case because wheeling revenues would not have been collected on any of the transmission that would otherwise remains unused after all bilateral market transactions have been scheduled (e.g., 20 minutes before real-time operations).

Importantly, the transmission owners providing the transfer capability used for intertie optimization will still receive revenue for the use of their facilities, just in a different form. Transmission owners will be compensated with transfer revenues that reflect the difference in LMPs on the intertie—as has already been implemented for the Western energy imbalance markets. For example, if the intertie LMP of the exporting RTO/ISO were $30/MWh and the intertie LMP of the importing RTO/ISO were $50/MWh, the "transfer revenue" from the $20/MWh price difference would be credited back to the transmission providers (e.g., split equally between the transmission owners of the exporting and importing regions).

As noted in the Intertie Optimization Whitepaper, avoiding the imposition of wheeling charges on intertie optimization transactions that do not reflect the true marginal cost of transmission is important—particularly since the interregional transmission capacity would otherwise remain

unused (such as in real-time, after all bilateral trades have been scheduled). This concept of "hurdle free" transactions (but collecting charges based on LMP differences) is also central to the design of the RTO/ISO energy markets, the interregional energy imbalance markets in the Western U.S., as well as the European "market coupling" frameworks.

Q12. If intertie optimization is based on hurdle-free transactions, does that mean RTOs/ISOs will have to de-pancake OATT transmission rates between them for all transactions?

A12. No. While depancaking transmission rates would have efficiency benefits for all transactions, OATT-based wheeling charges could still be applied to all bilateral trades (as long as they are allowed by FERC). But no such wheeling charges would be imposed on intertie-optimization-based transactions (i.e., transactions that would not even exist in the absence of intertie optimization.) As noted earlier, this is consistent with the approach taken by the Western energy imbalance markets.

Q13. How do RTO/ISO transmission customers, who are paying for the transmission facilities used by intertie optimization, benefit from intertie optimization if no wheeling charges are applied?

A13. The RTO/ISO customers who are paying for the transmission facilities utilized by intertie optimization would benefit from (1) receiving the market value of the associated intertie transactions (based on the LMP-based intertie transaction settlements credited to transmission providers as discussed earlier); and, generally, (2) the more efficient generation dispatch and convergence of market prices.

For example, as is already the case in the Western EIM and proposed EDAM, the value of the intertie transactions (i.e., the real-time or day-ahead congestion revenues associated with an intertie's LMP difference) would be allocated to those who make the transmission available for intertie optimization. These transfer-related revenues would be credited to the entities providing the transmission utilized, which may mean the revenue is split 50/50 between the neighboring RTOs/ISOs (and their transmission owners) for regulated transmission.[13] If the transmission capacity has been made available by the holders of long-term transmission rights or merchant transmission providers, these congestion revenues would be paid to those who made the rights available.

Q14. Does the payment of congestion revenues to the provider of transmission capacity mean that Financial Transmission Rights (FTRs) or Congestion Revenue Rights (CRRs) need to be issued to the holders of the physical transmission rights?

A14. No. The transmission utilized by intertie optimization is "as available" non-firm transmission. No FTRs/CRRs would thus be associated with intertie optimization. This is similar to the fact that FTRs/CRRs are not available for any interregional and real-time market transactions either.

[13] Under transmission owners' formula rates, these revenue credits would typically be used (like wheeling revenues) to reduce the transmission rates charged to native-load and other transmission customers.

Rather, the transfer (e.g., congestion) revenues associated with LMP difference across the interties would be credited allocated to the entities who make the transmission available for intertie optimization.

Q15. Is exempting transactions associated with intertie optimization from wheeling charges consistent with open access principles?

A15. Yes. The approach is consistent with how all organized regional power markets and energy-imbalance markets work. No transmission charges are imposed on individual transactions within RTO/ISO markets and no transmission charges are imposed on any transactions associated with Western energy imbalance markets either. Intertie optimization is utilizing on a non-firm basis only transmission that otherwise would remain unused.

It is also consistent with the fact that transmission providers already have the discretion to "discount" non-firm transmission based on market conditions. Allocating intertie transfer revenues to those who made the transmission available, while not imposing any wheeling charges, reflects the discounted non-firm nature of this transmission that reflects actual market conditions and the marginal value of the available (but otherwise unused) transmission capability.

Q16. Does intertie optimization require that RTOs/ISOs take on a financial position through market transactions?

A16. No. The creation of interregional market transaction through intertie optimization does not change the role RTOs/ISOs already have in their regional markets.

As NYISO and ISO-NE have pointed out in their 2011 report, even with intertie optimization the RTOs/ISOs do not directly participate in the markets and do not buy or sell power. They simply continue to act as independent settlement administrators for the payments to and from market participants. All energy flows between regions scheduled through intertie optimization are priced at the LMPs, just like market-internal transactions. This also facilitates market transparency and correctly prices congestion.

Q17. Does intertie optimization require that neighboring regions are integrated into a single security-constrained economic dispatch (SCED) optimization?

A17. No. While the "single-SCED approach" is being used by the Western energy imbalance markets, more disaggregated intertie optimization frameworks are available as well. These frameworks partition the optimization problem into subproblems and coordinate their solutions by exchanging necessary market information. This type of coordination will drive each RTO/ISO's dispatch towards the optimal solution for the interregional dispatch problem, thus achieving improvements in overall economic efficiency.

For example, ISO-NE staff developed and successfully tested through large-scale simulations a "marginal equivalence" approach to intertie optimization under which neighboring system

operators exchange information on marginal generation costs and relevant transmission constraints every 5 minutes so that the information can be incorporated into the other RTO/ISO's real-time dispatch. This approach could be applied between two RTO/ISO regions or between RTOs/ISOs and non-market regions. (See 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)).

Q18. How would intertie transactions actually be scheduled between BAAs during 5-minute real-time periods?

A19. Just as is already the case in the Western energy imbalance markets, the intertie-optimization schedules would be integrated in each BAA's balancing function on a 5-minute real-time basis. These 5-minute transfer schedules, similar to how dynamic transmission schedule or pseudo tie schedules between BAAs are already used today, can be implemented consistent with how the operators of the western energy imbalance markets have implemented their BAA-to-BAA transfers.

Q19. Would improving the existing Coordinated Transaction Scheduling (CTS) frameworks be an alternative to intertie optimization?

A19. While it is theoretically possible to modify the CTS frameworks, it is not a feasible way forward for at least three reasons.

First, CTS relies on the neighboring RTOs/ISOs' **forecasts of real-time prices on interties** made approximately one hour prior to each real-time period. These forecasts are highly and increasingly inaccurate. As PJM's Market Monitor has explained, "the large differences between forecast and actual LMPs in the intervals closest to real-time could cause CTS transactions to be approved that would contribute to transactions being scheduled counter to real-time economic signals, and contribute to inefficient scheduling."[14] The increasing difficulty to accurately forecast real-time market conditions has reduced the effectiveness of CTS even between markets that have depancaked their transmission charges, such as between ISO-NE and NYISO. As ISO-NE's Market Monitoring Unit has shown in its 2022 State of the Market Report, the performance of CTS is deteriorating, with the number of optimal CTS trades declining from 23% in 2018 to just 11% in 2022.[15] Avoiding the forecast-related inefficiencies of CTS would require changing the CTS framework to rely on real-time market prices (rather than forecasts). Intertie optimization would not need to rely on RTO/ISO forecasts, but utilize real-time information exchanged by the

[14] Monitoring Analytics, 2022 State of the Market Report for PJM (March 9, 2023) at 526.

[15] ISO New England Internal Market Monitor, 2022 Annual Markets Report (June 5, 2023) at 160, Figure 5-6. We refer to "optimal" trades as those where the total transmission capability is used in the appropriate (i.e., low-to-high priced) direction.

neighboring RTOs/ISOs on a 5-minute basis—as is also the case for the Western energy imbalance markets.

Second, CTS transactions of many RTOs/ISOs would be subject to **pancaked transmission charges**. The application of pancaked transmission charges to CTS transaction has been identified by market monitors as one of the barriers to efficient utilization of interregional transmission. As part of a recent study of CTS and potential intertie optimization for SPP and MISO, for example, Potomac and the SPP market monitor explained that "prices rarely diverge enough to cover both fees and historical risk premiums," discouraging market participants from participating in CTS and reducing available benefits.[16] While depancaking the transmission charges between RTOs will be necessary (but not sufficient) to improve the effectiveness of CTS, doing so is exceptionally challenging. It is perhaps unreasonable to ask transmission owners to voluntarily give up the substantial wheeling revenues associated with bilateral trading (which reduce the net cost of transmission to native load customers) in order to provide CTS transmission for free while allow third-party traders to benefit from CTS trades. Intertie optimization avoids this misalignment of incentives by (1) only utilizing transmission that remains available after all bilateral trades have been scheduled; and (2) crediting to those who made the interregional transmission capacity available for intertie optimization the value (transfer revenues) associated with LMP-based settlements of intertie optimization transactions.

Third, CTS transactions rely on **transmission reservations** that need to be pre-scheduled by the trading companies who submit CTS schedules. This is inefficient since when the transmission has to be reserved it is not certain that a CTS transaction will actually happen. At the same time, reserving the transmission is associated with transactions costs, wheeling charges (where these charges have not been depancaked), and other OATT-related charges (such as scheduling charges). As the SPP market monitoring unit noted, when transmission charges are applied, and these charges are applied even to CTS schedules that eventually do not clear and do not flow any power, this creates additional risk for market participants and reduces the effectiveness of CTS.[17] In contrast, intertie optimization would not require the reservation of transmission capability; rather, it would utilize the transfer capability left available after all bilateral trades and associated

[16] Coordinated Transaction Scheduling Study, SPP Market Monitoring Unit (May 8, 2020) at 9, 11.

[17] Coordinated Transaction Scheduling Study, SPP Market Monitoring Unit (May 8, 2020) at n.4.

transmission schedules have been finalized—as is, again, the case for the Western energy imbalance markets.

Q20. Does this mean intertie optimization offers a number of important advantages over CTS?

A20. Yes. Intertie optimization will be the more efficient solution, which is why NYISO and ISO-NE have recommended it over CTS in 2011. As the two ISOs had noted in the context of their recommendation to implement "tie optimization":

> The CTS system is not expected to produce as complete a price convergence between regions as Tie Optimization. The profit margin that market participants require to accept real-time price risk between regions when trading power will result in a price difference between New York and New England. That difference means the CTS system will tend to produce less efficient schedules, and higher production costs, than Tie Optimization. [18]

In addition to yielding a more efficient outcome, intertie optimization offers a number or additional (though related) advantages:

- It is a fully automated process that runs after all bilateral trades are made; it does not require any bids submitted from traders.
- There is no need to forecast real-time prices for each side of interties. Intertie optimization simply uses the real-time market engines of the neighboring ISOs to schedule intertie transactions on a 5 minute basis.
- Intertie optimization does not require any transmission reservations or schedules tied to individual traders' bids; rather, it fully and efficiently utilizes transmission capacity that remains unused in real-time (after all bilateral trades are scheduled).
- Intertie optimization fully and automatically compensates the transmission providers for the value of the transactions enabled by their transmission (and it does so, equivalent to discounting non-firm wheeling rates to market conditions, for each 5-minute real-time interval).

[18] See NYISO, ISO New England, Inter-Regional Interchange Scheduling (IRIS) Analysis and Options (January 5, 2011) at viii.