Managing Seams: Market Coordination in Western Wholesale Energy Markets

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Purpose & Value Proposition

- Western Interconnection - experiencing a seismic shift in energy markets
- Transition away – gradual but surely – from bilateral to wholesale organized energy transfers…
- WRA philosophy - Ideally, one west-wide market! And strive for:
  - ✓ grid reliability and situational awareness,
  - ✓ cost-efficient rules for energy trades (intra and inter-market)
  - ✓ transparent clear price signals to incentivize clean energy intake and storage/DR adoption
- Multiple wholesale markets will cause seams – this assessment is “not picking winners/losers” – but lay the groundwork for mitigating practices
- Recruited an independent team to provide a balanced perspective for future!

Methodology

- This study and resulting recommendations are based on extensive analysis of wholesale electricity markets across the U.S. and of the unique structure and history of the West, including:
  - Evaluation of Eastern markets and market seams impacts
  - Evaluation of Western context:
    - Design and operation of existing and proposed markets
    - Coordination mechanisms (operations, resource adequacy, operating reserve sharing)
    - Transmission and generation ownership and contractual arrangements
    - Transmission planning
    - Historical trading and power flow patterns
  - Outreach to industry participants and stakeholders

Industry Outreach

- Outreach included a broad cross-section of the industry to assure input reflected regional, company type, and industry function perspectives:
  - Integrated Utilities
  - Public Power
  - Federal Power Agencies
  - Market Operators
  - Transmission Planners
  - IPPs/Power Marketers

Introduction

- The fragmentation of current real-time markets in the West into multiple subregional markets will introduce barriers to regional energy transfers in the form of increased cost and risk to schedules between markets.
- The effects of market seams will be far reaching and impact nearly all aspects of the industry.

Operational • Less efficient dispatch • Reduced system reliability • Higher congestion costs	**Commercial** • Disrupted bilateral trading • Reserve sharing challenges • Capacity market barriers
Economic • Higher consumer prices • Reduced trading volumes • Cost shifts between systems	**Planning** • Resource adequacy impacts • Transmission planning gaps • Higher GHG reduction costs

Market Seams Defined

Market seams are boundaries between organized wholesale energy markets that create barriers to energy transfers.

How Markets Facilitate Trade:

- ✓ Greater transparency of prices and availability
- ✓ Reduced transaction costs through centralized clearing
- ✓ Lower administrative barriers (no need to preschedule transmission within market)
- ✓ Real-time bid-based dispatch ensuring all profitable transactions occur

How Market Seams Create Barriers:

- × Decreased transparency of external market conditions
- × Increased costs (transmission fees, congestion charges)
- × Administrative burdens (scheduling, transmission procurement)
- × Price risk and delivery uncertainty

Maritime Transport Analogy

- The Suez Canal is a seam in the global oil transport
- The Panama Canal is a seam in global goods transport
- Each canal has a vessel width and draft limitation
- The amount of container goods, measured in twenty-foot equivalent units (TEU), carried by a vessel has been standardized by the Panama Canal capability limits

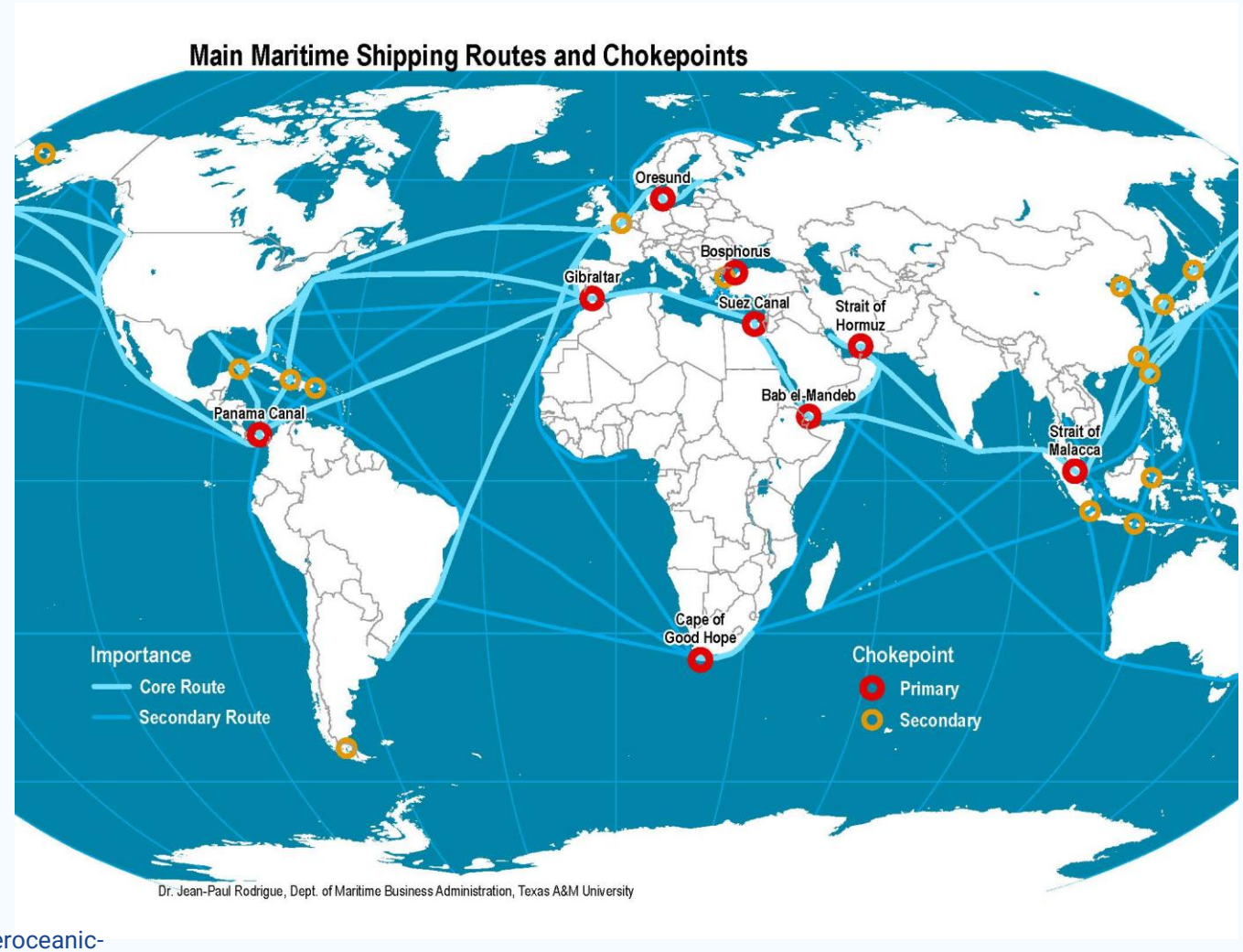

Image source – https://porteconomicsmanagement.org/pemp/contents/part1/interoceanic-passages/main-maritime-shipping-routes/

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Analogy Continued
Panama Canal

The Panama Canal was widened and deepened to allow a 50 ft./15.24 m draft in 2016

Current drought limits vessels to 43.5 ft/13.3m draft

However, the canal vessel is more limited than the open ocean water vessel

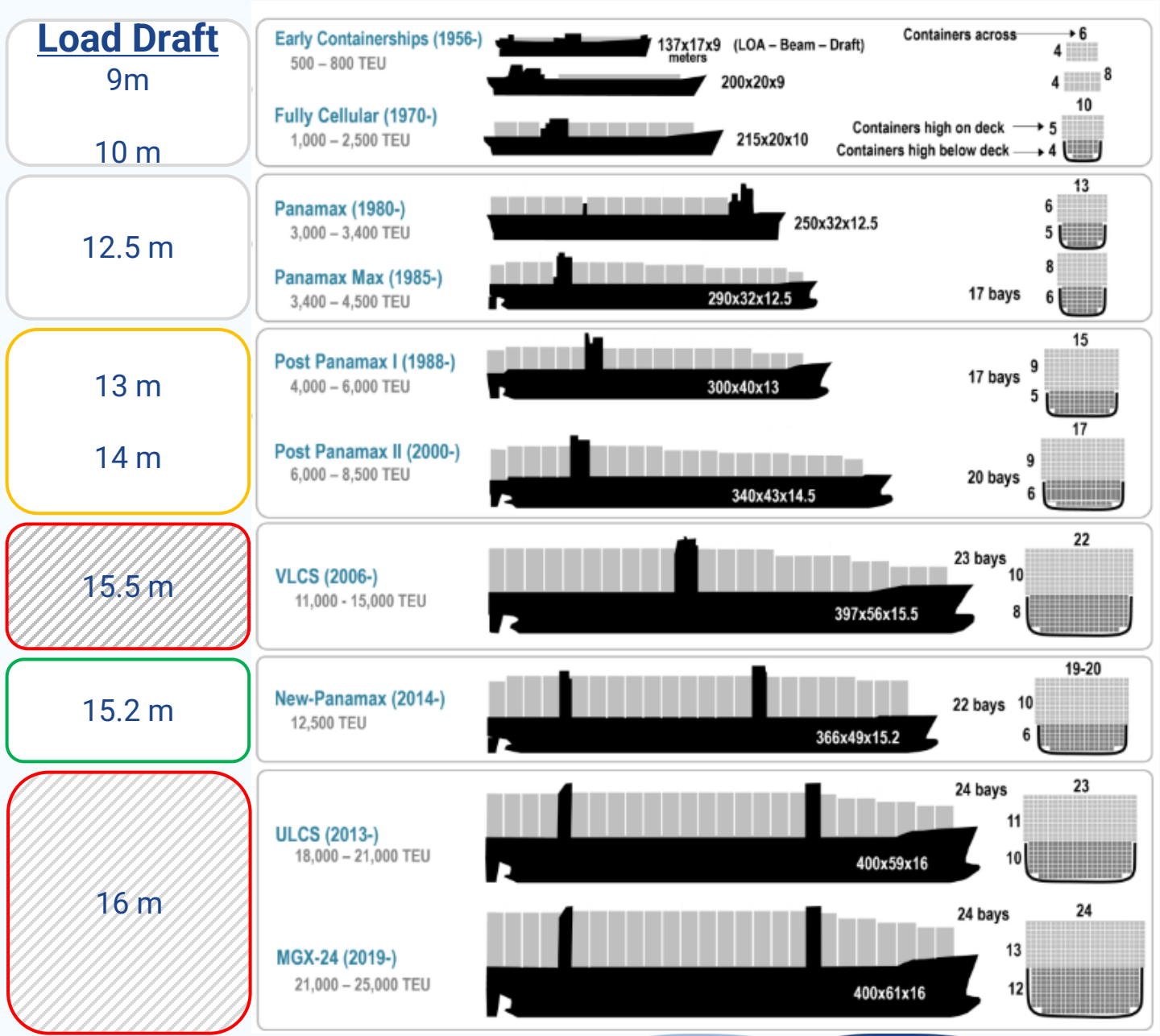

Image source – https://transportgeography.org/contents/chapter5/maritime-transportation/evolution-containerships-classes/

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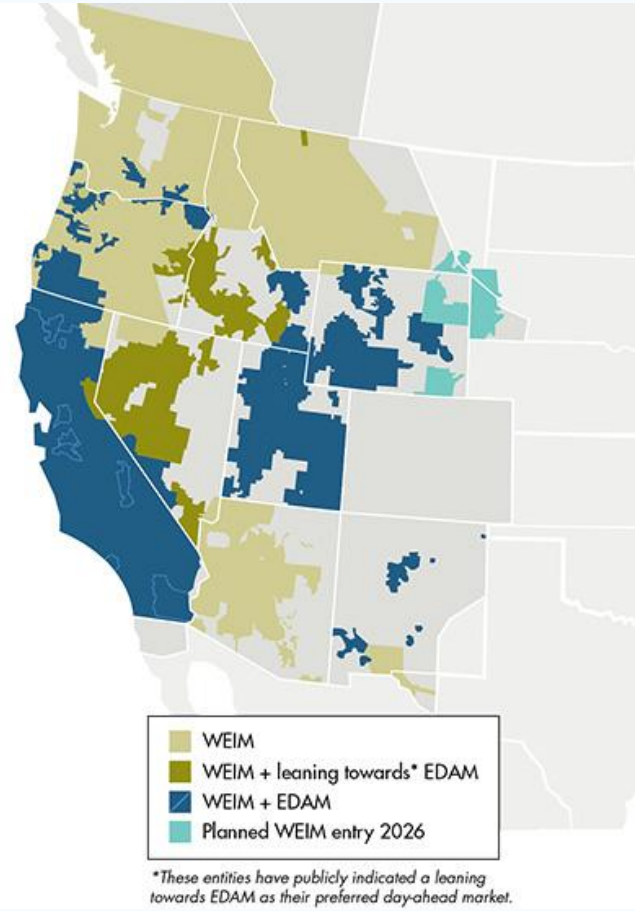
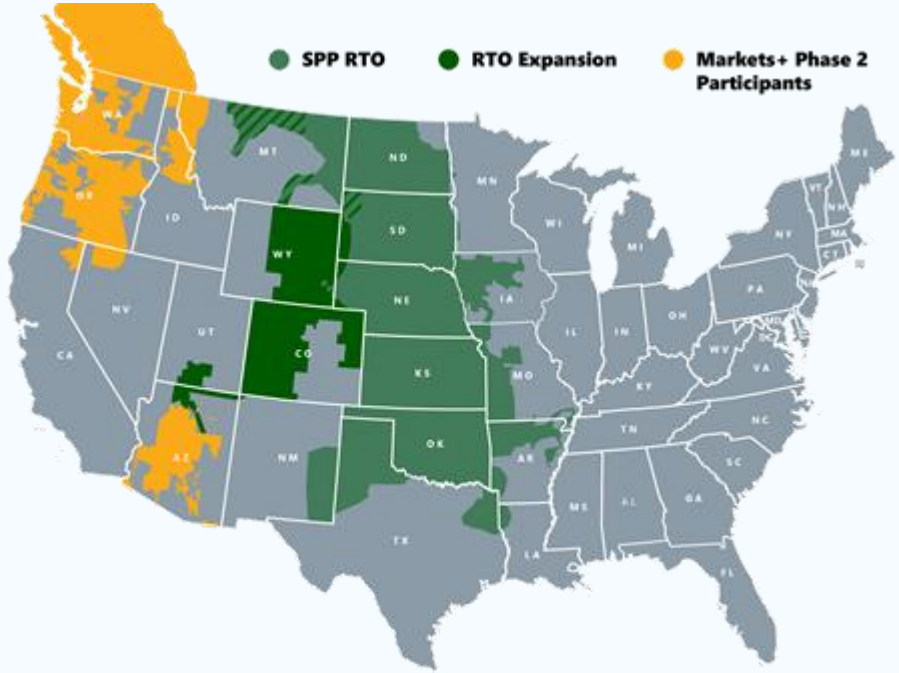
Market Seams Will Severely Limit Inter-Regional Flows



- EDAM and Markets+ footprints are fragmented.
- Transfers between markets:
  - Require reserved transmission service
  - Must be self-scheduled
  - Are subject to imbalance, congestion and losses charges.
- Markets+ is non-contiguous and will essentially operate as two independent markets.
  - Transfers between Markets+ South and North will require transmission service and scheduling through CAISO/EDAM.



Time is of the Essence

- A fragmented operating and trading environment will require new coordination mechanisms and adaption of existing mechanisms and commercial arrangements.
- Negotiating and implementing agreements will be complicated by the overlay of multiple:
  - Transmission Service Providers (TSPs) with individual OATTs
  - Balancing Authorities (BAs)
  - Reliability Coordinators (RCs)
  - Market Operators
- The West's fragmented structure requires coordination among dozens of separate entities and will require substantial effort and time.

Western Context

Eastern Interconnection Evolution

- Markets evolved from pre-existing power pools (1990s-2000s)
- Aligned with NERC regional boundaries
- Eight separate NERC regions consolidated to four RTOs
- Resource pooling, centralized dispatch, reserve sharing often existed pre-market
- Markets solidified and expanded existing coordination

Western Interconnection Path

- Limited power pool functions
- Single NERC region: Western Electric Coordinating Council (WECC)
- State-led initiative launched CAISO markets (1998)
- Markets expanded via WEIM and WEIS
- Decade of increasing coordination and benefits
- Now facing fragmentation and unwinding of existing forms of coordination

Existing West-Wide Coordination

Existing West-Wide Coordination

WECC: Single NERC region

- Western Power Pool (WPP):
  - Operating reserve sharing program
  - Western Resource Adequacy Program (WRAP)
  - WestTEC: region-wide transmission planning coalition
- Wholesale energy markets CAISO, WEIM, WEIS

Critical Difference from the East

- In the East, market boundaries align with other coordination mechanisms. In the West, market seams will cut across and disrupt existing coordination structures.

The Risk

- Unlike Eastern RTOs where markets enabled broader coordination, Western market fragmentation threatens to undermine beneficial region-wide coordination just when it is needed most.

Seams Focus Areas

Operating Timeframe Impacts:

- ***Congestion Management***: No West-wide process exists; WIUFMP inadequate (6 utilities, 4 paths)
- ***Reliability Coordination***: Multiple RC-RC, BA-BA agreements need updating; emergency procedures critical
- ***Reserve Sharing***: NWPP program spans markets; unpredictable financial exposure when deploying reserves across seams

Longer Timeframe Impacts:

- ***Resource Adequacy*** (WRAP): Interoperability concerns with day-ahead markets; energy deployment across seams creates financial risk
- ***Transmission Planning***: Models must reflect market barriers or risk overestimating flows and benefits

Congestion Management: Loop Flow

Problem: Unscheduled energy transfers flowing through external systems due to grid physics, not following contract paths.

- Market Impact: Day-ahead markets significantly change regional flows through centralized, least-cost dispatch. Market flows are not tagged—origins masked from external operators.
- Consequences:
  - Transmission congestion on external systems
  - Cost shifts between transmission users
  - Reliability challenges requiring emergency actions

Current State: Path-Based Complexity.

- West relies on contract path-based processes that don't accurately reflect physical flow, making congestion management less effective.

Solution Path

- TSPs convert to flowgate methodology
- Complete and implement Enhanced Curtailment Calculator (ECC) standard
- Implement economic market-to-market redispatch

Reliability & Emergency Coordination

Complex Coordination Requirements

- Multiple BAs Within Each Market: EDAM and Markets+ include multiple Balancing Authorities
- Example: CAISO-BPA Coordinated Transmission Agreement manages EIM flows and must be updated for EDAM and Markets+ coordination

Reliability Coordination Updates Needed

- RC West (CAISO) provides RC for EDAM footprint
- SPP RC provides RC for Markets+ and SPP RTO expansion
- Current joint RC agreement needs updating
- New RC-RC agreements may be needed (BC Hydro ↔ SPP RC, Alberta ESO ↔ SPP RC)

Emergency Operating Procedures Critical

- Market seams eliminate dynamic real-time trading between markets. Expect more frequent emergency procedures during extreme weather.
- MISO 2018 Lesson: *"Lack of common emergency procedures and lack of understanding of each other's systems increased the challenges faced during that event"*

Operating Reserve Sharing and WRAP

Western Resource Adequacy Program (WRAP)

- Status: Voluntary program (mandatory for Markets+ members), independent of markets but participants in both.
- Interoperability Issues:
  - WRAP resources cleared/scheduled in day-ahead markets
  - Energy deployment across seams creates financial settlement uncertainty
  - Potential conflicts between WRAP obligations and market operations
- Solution: WPP task force evaluating (completion end 2025).
- Several EDAM participants have withdrawn.

NWPP Reserve Sharing Program

- Challenge: Program spans multiple markets and non-contiguous subregions. When reserves deployed across seam:
  - Constitutes energy sale settling at market clearing prices (unknown at deployment)
  - Prices move independently on either side of seam
  - Congestion costs unpredictable → financial exposure
- Action Required: Evaluate performance obligations and financial risks; may need restructuring.

Transmission Planning

- Transmission investment benefits are measured by production cost reductions. Transmission planning processes must reflect both commercial and physical limits to accurately identify and value potential transmission upgrades.
- Seams introduce two critical planning risks:

Overestimating Economic Flows:

- Failure to reflect market seams barriers in models overestimates economic flows between markets and overstates production cost benefits of potential transmission expansion.

Underestimating Transmission Value:

- New transmission within a market may enable energy transfers previously constrained by market seams, not physical limits.
- Commercial barriers rather than physical constraints inhibit otherwise economic flows.
- Such transmission may be undervalued in traditional analysis.

Market Design Enhancement to Minimize Impacts

- Managing Congestion – the easiest but requires tools not yet available in the West.
- Protecting Existing Usage Rights – essential to preserve equity among system users.
- Maximizing Transmission Utilization – requires market-to-market redispatch coordination.
- Ensuring Efficient Market Interface Prices – complex and West has unique gaming risks.
- Reducing Barriers to Trade – has not been successful in other markets.
- Internalizing Interchange Optimization – unproven, complicated in the West.

Managing Congestion

Market-to-Non-Market: Flow Limits

- Define mutually agreed external transmission flow limits. Market operators constrain flows in market clearing process.
- Pros: Maintains reliability, enables loop flow tracking, assigns congestion relief obligations.
- Cons: Underutilizes grid when unconstrained, restricts flows below efficient levels.

Eastern RTO Challenge: $119 million in excess congestion costs at MISO-SPP seam (2022) due to:

- Administratively complex despite automation
- Inaccurate modeling and software limitations
- Operator disagreements on when to invoke

Market-to-Market: Enhanced Coordination

- Approach: Allow equal access to full combined transmission capability. When congestion occurs, coordinate least-cost redispatch.
- Benefits: Higher transmission utilization, greater efficiency, economic dispatch between markets.
- Complexity: Requires flow entitlements, settlement rules, system integration, tariff changes, engagement of all TSPs/operators/BAs.

Protecting Rights & Maximizing Use

Firm Flow Entitlements

- Fixed entitlements reflecting historical system usage ensure continued availability of existing rights and fair cost allocation.
- Three Historical Usage Types:
  - Network Resources delivery to network load
  - Firm point-to-point transfers
  - Reasonable loop flows from external systems

Eastern RTO Challenge: Based on 2004 usage. SPP/MISO/PJM have worked without success to agree on update baseline — flows have changed dramatically.

Western-Specific Considerations

- Joint transmission ownership (e.g., AC Pacific Intertie)
- Unique contract provisions for scheduling/usage
- Jointly owned generation delivery rights (e.g., Palo Verde)
- Non-standard transmission usage rights
- Some agreements may need modification or supplementation

Reducing Trade Barriers

The Problem: Trading at market seams is highly inefficient

- PJM Market Monitor (2024): Real-time flows consistent with price differentials only 55.2% at PJM/MISO, 62.7% at NYISO/PJM.
- Despite 20+ years of refinement, participants unable to reliably arbitrage price differences.

Barrier Categories

- Within Market Operator Control: Inflexible trading mechanisms, inefficient interface pricing, misaligned timelines.
- Less Controllable: Price transparency, transaction costs, volatility, hedging availability, path-based transmission limits.

Reducing Trade Barriers – Interface Pricing

Interface Pricing Challenge

- No Industry Standard: Different markets use different approaches; all working to address issues.
- Markets+ Problem: Non-contiguous footprint complicates pricing. Import to WA ≠ import to AZ. Single price would be inaccurate; multiple prices risk gaming.

Solution

- Develop accurate interface pricing methodology + schedule source/sink validation procedures to prevent "sham" scheduling.

Reducing Trade Barriers

Intertie Bidding

- Allow non-source-specific "spot market" energy offers in day-ahead (not just individual generators). Encourages financial transactions.
- Status: CAISO offers this; WEIM entities must enable. Neither PacifiCorp nor Portland General Electric proposed enabling in EDAM filings. Markets+ evaluating.
- Recommendation: Enable in both EDAM and Markets+

Real-Time Dispatchable Transactions

- CTS (Coordinated Transaction Scheduling): Used at NYISO/PJM seam and MISO/PJM. Poor performance—only 30 MW average in MISO (2023). MISO Monitor simulation shows improvements could increase profitability from $237K to $41M.
- RTDT (Real-Time Dispatchable Transactions): SPP proposal—most promising. 5-minute clearing vs. hourly. Markets+ considering; EDAM does not include.

Reducing Trade Barriers: Advanced Solutions

Interchange Optimization

- Add interchange optimization to market clearing objective function. Market operators coordinate flows to maximize economic transfers.
- Brattle Group Study: 20-30% of inter-regional transmission value in SPP/MISO/PJM lost due to inability to trade efficiently.
- Growing Interest: NREL endorsed, Northeast States Collaborative pursuing, SPP evaluating for MISO seam, PJM Monitor recommended, ISO-NE/NYISO developed proposal.
- Status: Not yet operational in any market. Technically complex. Needs more research for West.

Recommendation Summary

Entity	Critical Actions
NAESB / Reliability Coordinators	Complete ECC standard; lead implementation
Market Operators	Congestion protocols; interface prices; source/sink validation; intertie bidding; evaluate CTS, RTDT/interchange optimization
Reliability Coordinators / Balancing Authorities	Update RC-RC and BA-BA agreements; emergency procedures
Transmission Service Providers	Convert to flowgate methodology (MOD 030)
Western Power Pool	Evaluate NWPP Reserve Sharing and WRAP programs
Transmission Planners	Model market barriers accurately in benefits analysis
Transmission Customers	Update resource planning assumptions; evaluate contracts

Appendix

Recommendations

Responsible Entity	ID	Requirement Description
Balancing Authorities (BA)	BA 1	Evaluate, revise, or negotiate new BA-BA, BA-Market Operator coordination agreements to ensure compatibility with new markets and address new seams
	BA 2	Evaluate performance and financial implications of market seams for reserve sharing arrangements.
Reliability Coordinators (RC)	RC 1	Complete development and lead implementation of NAESB ECC standard for congestion management in the West. Ideally, this will be done prior to the need for market-to-market congestion management.
	RC 2	Evaluate and revise RC-RC coordination agreements to ensure compatibility with new markets and address new seams. New agreements may be needed, for example, between BC Hydro and SPP RC or between the Alberta Electric System Operator RC and SPP RC.
	RC 3	Coordinate with Balancing Authorities and Market Operators to evaluate and update emergency operating procedures.

Recommendations

Responsible Entity	ID	Requirement Description
Market Operators (MO)	MO 1	Establish interface prices.
	MO 2	Develop rules and procedures for interchange source/sink monitoring and Validation.
	MO 3	Develop congestion management protocols and incorporate them into day- ahead and real-time markets. Pending completion of Enhanced Curtailment Calculator (ECC) effort, simplified methods should be considered leveraging existing congestion management mechanisms: a. Market-to-non-market to limit flows on external non-market systems. b. Market-to-market for market-based congestion management with external markets.
	MO 4	Evaluate and consider implementing: a. Intertie bidding in day-ahead to enable non-point-specific supply offers or demand bids. b. Enhanced real-time dispatchable trading options, including Coordinated Transaction Scheduling and Real-Time Dispatchable Transactions as proposed for SPP RTO. c. Interchange optimization.

Recommendations

Responsible Entity	ID	Requirement Description
North American Energy Standards Board (NAESB)	NAESB 1	Promulgate comprehensive congestion management standard for the Western Interconnection (Western Interconnection Loading Relief Business Practice Standard).
Transmission Service Customers (TSC)	TSC 1	Evaluate existing contractual arrangements to identify potential changes to comply with new market scheduling requirements or to address financial exposure if contract requires energy delivery across a market seam.
	TSC 2	Update resource planning processes and tools to reflect realistic assumptions about availability and cost of imports.
	TSC 3	Evaluate performance and financial implications of market seams for Western Resource Adequacy Program (WRAP) energy deployments.

Recommendations

Responsible Entity	ID	Requirement Description
Transmission Planners (TP)	TSP 1	Evaluate existing contractual arrangements to identify potential changes to comply with new market scheduling requirements or to address financial exposure if contract requires energy delivery across a market seam.
Transmission Owner/Service Providers (TSP)	TSP 1	Convert from Rated System Path Methodology (NERC MOD 029) to Flowgate Methodology (NERC MOD 030) for determining available transmission and posting Available Flowgate Capabilities.
Western Power Pool (WPP)	WPP 1	Evaluate NWPP Reserve Sharing Program performance obligations and financial settlements in light of recently approved tariffs for EDAM and Markets+.
	WPP 2	Evaluate WRAP terms and performance obligations in light of EDAM and Markets+ tariffs. When developing operating protocols, consider the financial implications of scheduling resources across market seams.

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