TOPOLOGY OPTIMIZATION FOR RELIABLE AND EFFICIENT CONGESTION MANAGEMENT

Introduction and Considerations for Implementation

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Presented by:
Pablo A. Ruiz, Ph.D.
CEO and *CTO*, NewGrid
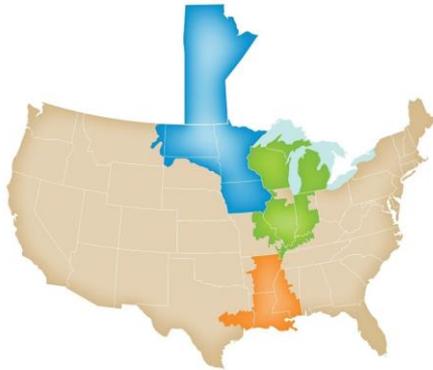*Senior Consultant*, The Brattle Group

TRANSMISSION CONGESTION MANAGEMENT

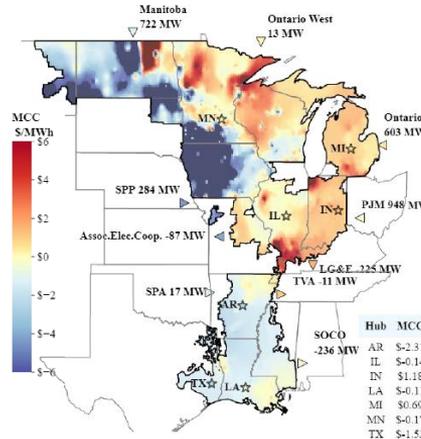Traditional congestion management treats the transmission grid as fixed

- Congestion management approach is to redispatch, i.e., "**increase the tolls!**"
- Congestion costs spiked in 2022 (estimated costs in the U.S. were $20.7 billion[1])
- Frequent overloads (emergency rating exceedance), customer outages during extreme events [2]

## Midcontinent ISO (MISO) 2024 Congestion Costs: $1.73 billion [3]

Fall 2024

[1] [Transmission Congestion Costs Rise Again in U.S. RTOs](), Richard Doying, Michael Goggin and Abby Sherman, Grid Strategies Report, July 2023.

[2] For example, transmission congestion led to customer outages in SPP during the Arctic Blast, see [Bitter cold overwhelms grid, leaves millions in dark](), Edward Klump, Peter Behr and Mike Lee, Energywire, February 16, 2021.

[3] Calculated from the four seasonal Potomac Economics [MISO IMM Quarterly Reports 2024]().

Source: [FERC]().

Source: Potomac Economics [MISO IMM Quarterly Report Fall 2024]().

TOPOLOGY OPTIMIZATION ENABLES FLEXIBLE GRID OPERATION

NewGrid topology optimization software quickly *finds, evaluates* reliable reconfigurations to reroute flow around congestion ("***Google Maps for the transmission grid***").

- Reconfigurations implemented by opening or closing circuit breakers.

  - Analogous to temporarily diverting traffic away from congested roads to make traffic flow smoother.

- Technology supports transmission decision making processes.

  - Utilities already reconfigure the transmission system, based on staff experience, on ad hoc basis.

  - Fast search time: seconds to minutes

- Reconfigurations are **reliable** under all specified contingencies and do not radialize load beyond a user-specified value.


6 minutes faster
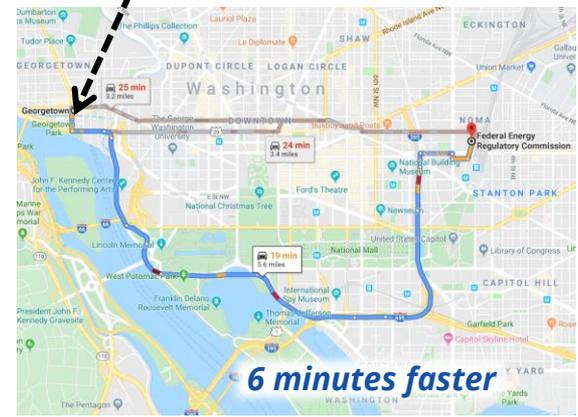
THERE ARE DIFFERENT RECONFIGURATION TYPES

Optimization routines search reconfigurations to relieve **one or more simultaneous constraints**, and identify **preventive or corrective solutions**. Reconfiguration types vary depending on system topology, system conditions and congestion problem characteristics.

Open/close branch

Branch types:
- Lines
- Transformers
- Bus tie breakers
- Reactor by-pass breakers

line

bus tie breaker
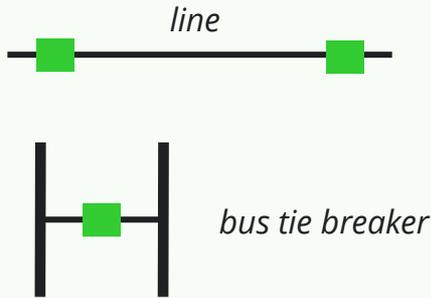
Bus split/merge

Some substation arrangements allow bus splits:
- Ring bus
- Double bus double breaker
- Breaker and a half

A

D   B

C

split ring bus
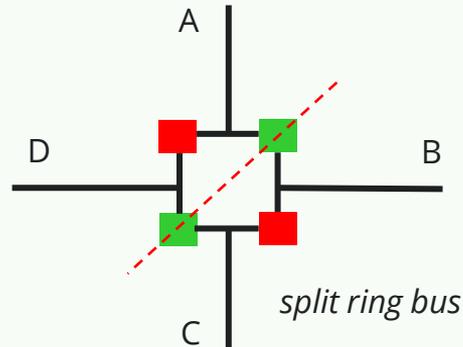
Contingency-change

Substation reconfigurations
- Bus normally connected
- Split bus or disconnected element under specific contingency conditions

A

D   B

C

open ring bus
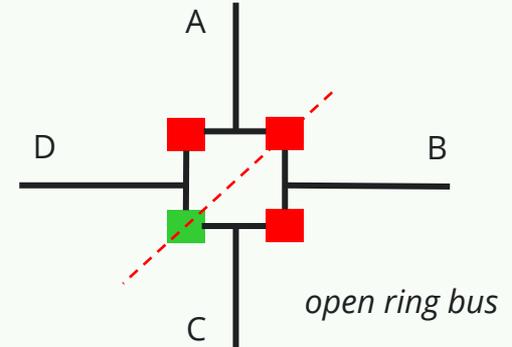
🟥 Closed Circuit Breaker   🟩 Open Circuit Breaker

TECHNOLOGY APPLICATIONS AND SYSTEM INTEGRATION

	Processes	Technology User	Applications	System Integration	Timeframe
Simplest	**Reconfiguration Request Process**	**Market Participants** (RTOs, RCs and TOPs have the software needed to evaluate requests)	mitigation of major expected constraints	none	days / weeks / months ahead
	Planning and Operations Planning Support	**RTO, RC, TOP**	operating/mitigation plan development, outage scheduling support, optimize transmission expansion	none to minimal (offline advisory tool)	days / weeks / months ahead
Highest benefits	**Real-Time Operations Support**	**RTO, RC, TOP**	reconfigurations tailored to address real-time conditions: mitigate overloads, release stranded generation	Energy Management System (EMS)	days ahead to real time
	Market Clearing w/ Optimized Topology	**RTO**	continuous optimization of topology as conditions evolve to mitigate cost of congestion management	EMS and Market Management System (MMS)	days ahead to real time

PRACTICAL CONSIDERATIONS

- How to analyze a candidate reconfiguration for reliability impacts and implementability?
  - Reconfigurations are equivalent to *reversible* planned transmission outages.
  - Reconfiguration analysis should be consistent with planned outage analysis.
  - Many outages are processed in practice (e.g., over 15,000 tickets in MISO annually).

- How to analyze a candidate reconfiguration for economic benefits/convenience?
  - Analyze a few credible scenarios with challenging congestion for the implementation period.
  - Do not over analyze: the reconfiguration is reversible, the cost of not implementing is high.
  - Contingency-change reconfigurations – if the changed contingencies do not result in congested constraints with the same dispatch, reconfiguration is beneficial.

- When to implement a reconfiguration?
  - Two options: ahead of congestion when it's expected to occur, or when it starts to materialize.
  - For outage-driven reconfigurations, implementation can be tied to the outage.

- When to revert a reconfiguration?
  - Two book end options: maximize number of closed breakers, minimize switching operations.
  - Simplest: topology optimization software (integrated w/ EMS) identifies when to revert.
  - Manual approach (legacy) is workable but only for a few temporary reconfigurations.
  - Some reconfigurations can be permanent (open ring bus to trip unit with a contingency).

EDFR Perspectives on Reconfigurations

- **EDFR continues to be a proponent of reconfigurations due to their ability to improve market efficiency / address congestion**
  - Based on studies commissioned by EDFR and in the industry
  - Reconfigurations can be implemented for binding constraints in operations and short-term planning
    - Reconfigurations can mitigate impact of grid outages
    - Traditional grid planning processes usually target solutions for constraints only when such constraints bind materially (resulting in delayed identification of upgrades)
  - Reconfigurations can be a bridge solution, pending traditional grid upgrades
  - Reconfigurations can be used in combination with traditional upgrades

- **EDFR has been advocating for new processes at RTO level to enable reconfigurations to be evaluated in the interconnection, planning and operational processes**
  - Recent progress has been achieved in MISO, SPP and ERCOT for reconfiguration solutions in operations

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MISO Reconfiguration Process

- **On June 30 2023, MISO announced a new "MISO Cost Reconfiguration Process" which allows market participants to request grid reconfigurations to reduce regional congestion**

  - MISO is the first RTO to create such formal process for receipt and approval of economic reconfiguration requests

  - This was a collaborative effort with process initially requested by a number of market participants
    - MISO TOPs showed strong interest in creating a formal process to ensure evaluations are done in a consistent, transparent and reliable manner

  - Process lays out a path for third parties to submit reconfiguration requests that meet specific criteria
    - 21 requests submitted in 2024, 6 approved and 2 additional ones implemented for reliability
    - MISO reported $21 million in savings in 2024

01 IDENTIFY PATTERN	02 OPTIMIZE TOPOLOGY	03 ASSESS IMPACT	04 EVALUATE OPTIONS	05 IMPLEMENT SOLUTIONS
STEP 1: A Market Participant identifies a congestion pattern of interest	STEP 2: The Market Participant identifies reconfiguration solutions, analyzes them and submits requests to MISO and the Transmission Owners/Operators	Step 3: MISO and the Transmission Owners/Operators assess reliability and economic impacts; Generation Operators that are directly affected evaluate their risk exposure	Step 4: MISO and TO/TOP approves or denies the solution	Step 5: MISO and the Transmission Owners/Operators implement the solution if real-time conditions allow

Exit
If an economic reconfigure is no longer effective or reliable due to changes in system conditions, or fails one of the initial screening criteria, MISO and the TO/TOP will exit the congestion cost reconfiguration.

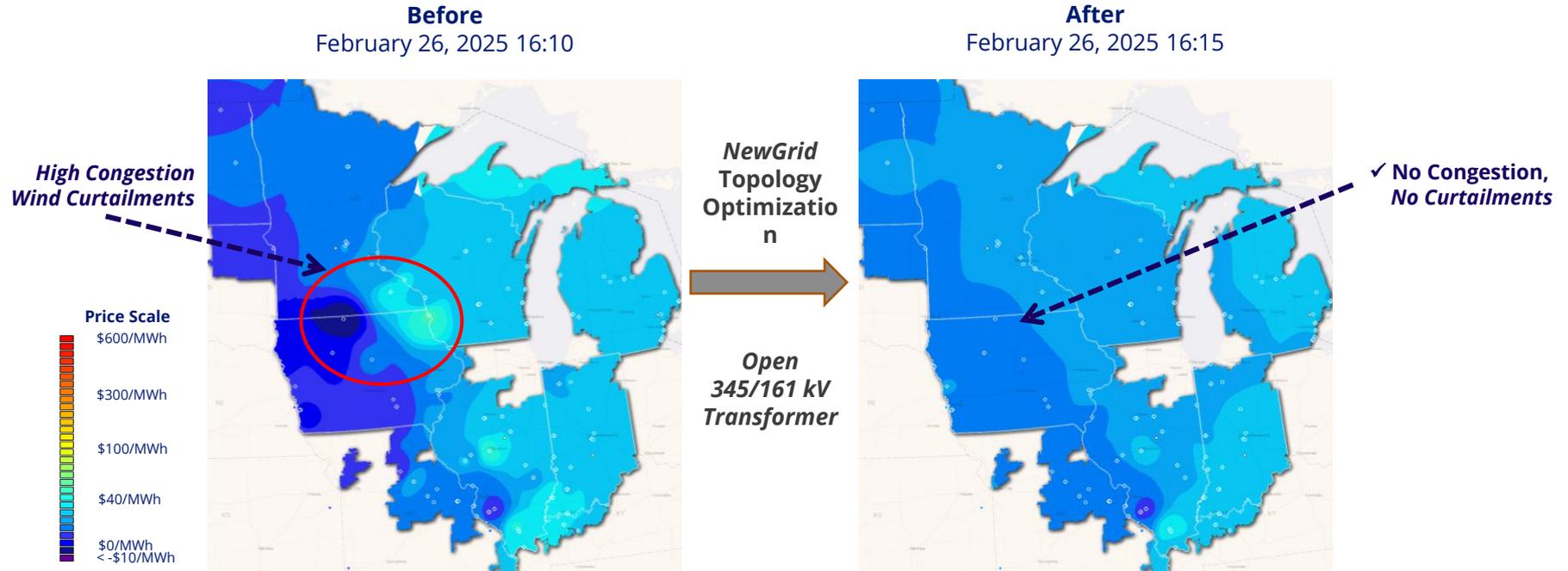Source: MISO Process to Support Congestion Cost Reconfigurations in the MISO footprint

- Requests will be submitted as cases through the MISO Help Center at: https://help.misoenergy.org

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MISO Reconfiguration Example

Reconfiguration solution developed by NewGrid rerouted about 10% flow around the target constraint, fully mitigating congestion on it for the rest of the day.

Before
February 26, 2025 16:10

After
February 26, 2025 16:15

High Congestion Wind Curtailments

Price Scale
$600/MWh

$300/MWh

$100/MWh

$40/MWh

$0/MWh
< -$10/MWh

NewGrid Topology Optimization

Open 345/161 kV Transformer

✓ **No Congestion, No Curtailments**

Source: MISO Real Time LMP Contour Map.

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ERCOT Reconfiguration Process

- **Previously, reconfigurations could only be applied for reliability reasons as the protocol language disallowed reconfigurations for congestion management if a SCED solution (market redispatch with curtailment or high congestion costs) exists**

- The Independent Market Monitor (IMM) had identified reconfigurations as top recommendation for improved congestion management:

  "We recommend that ERCOT accept a limited number of proposals and independently identify options to reconfigure transmission elements in the network operations model when they are physically feasible and economically beneficial. A process can be established to identify which limited number of reconfiguration options have the biggest benefits."

  Source: http://www.energychoicematters.com/stories/20230530b.html ; IMM 2022 State of the Market Report

- **A coalition of stakeholders worked with ERCOT staff to develop feasible language changes and filed revision requests to allow a new category of reconfigurations to be economically justified**

  (NPRR1198, NOGRR258, and ERCOT sponsored PGRR113)
  - Introduced a new type of Congestion Management Plan: Extended Action Plan (EAP)
  - Stakeholder process took approximately a year to find a mutually acceptable and transparent solution
  - Revision Requests were approved in summer of 2024
  - Implementation of system changes are expected during 2025

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ERCOT EAPs – Qualifications & Process

- **Criteria for approval of an EAP by ERCOT include:**
  - **Does not result in radial Load**
  - **Does not negatively impact current or scheduled Transmission Facility Outages**
  - **Does not create new binding thermal constraints or voltage violations, or increase flow on any existing binding constraint by more than 2% for 69 kV and 1% for 115 kV and above**
  - **Does not negatively impact any Generic Transmission Constraints (GTCs),decrease Generic Transmission Limits (GTLs), or create new instability situations**
  - **Provides more than $1 million savings to total production cost or total congestion cost with the EAP action in place compared to generation re-Dispatch alone.**
  - **Limits the action to changing the normal status of circuit breakers at up to three substations**

- **Submission and timelines include:**
  - **EAPs submitted by a Market Participant will be posted on the Market Information System (MIS) Secure Area by ERCOT within five Business Days of receipt of a complete submission.**
  - **ERCOT will provide a 30-day comment period from the date the proposed EAP is posted to the MIS Secure Area by ERCOT, unless notice of a shorter comment period is provided by ERCOT.**
  - **ERCOT shall consider all comments received within the 30-day comment period on the proposed EAP, along with its own evaluation and those of the Transmission Facility owners, and either approve, modify, or reject the proposed EAP within 15 days, unless extended by ERCOT.**
  - **When a proposed EAP is approved, modified or rejected, ERCOT shall post an explanation, or a description of the modification within five Business Days. If the EAP is approved, the posting shall include the start date and end date or associated Transmission Facility change that will determine the end date of the EAP.**

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ERCOT EAPs – Considerations and Guardrails

- **Proposed new EAPs must be submitted to ERCOT for review and approval.**

- **ERCOT shall seek input from TSPs and Resource Entities that own Transmission Facilities included in the EAPs** and shall approve proposed new, EAPs and proposed changes to EAPs in accordance with the process outlined in the Operating Guides.

- **EAPs may be proposed by any Market Participant or developed by ERCOT and can be utilized for reliability or economic reasons.**

- EAPs proposed for reliability reasons may have thermal constraints that do not have a Security-Constrained Economic Dispatch (SCED) solution.

- **EAPs proposed for economic reasons may have thermal constraints that are resolvable by SCED but result in high congestion costs. If an EAP is proposed primarily for economic reasons, the avoidable congestion must have resulted in:**
    - (a) Over $2 million of congestion cost in a given month within the past 36 months; or
    - (b) $5 million of congestion cost over any three months within the past 36 months.

- **ERCOT may limit the quantity of EAPs that are used.**

- **ERCOT may reject proposals that fail to practicably assess impact to operations and reliability.**

- **The implementation of an approved EAP may be temporarily suspended** by the TO or by ERCOT for reliability reasons, or for the duration of a Transmission Facility Outage if the EAP interferes with a TO's ability to take the outage. The existence of an EAP shall not, in and of itself, prevent a requested Transmission Facility Outage from being approved by ERCOT.

- **ERCOT shall conduct a review of each existing EAP annually or as required by changes in system conditions to ensure its continued effectiveness.** Each review shall proceed according to a process and timetable documented in ERCOT procedures.

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SPP Reconfiguration Process

A similar 3rd party process is under development in SPP – Economic Topology Optimization (SIR73)

- Currently in Phase 2 of effort to develop economic transmission reconfiguration request process
- Next steps – review with MOPC in April 2025

Step 1: Market Participant (MP) or designee submits request to SPP and TOP

Step 2: SPP analyzes request for reliability and economics

Step 3: SPP communicates results to TOP

Step 4: TOP analyzes request and implements reconfiguration as appropriate

Step 5: SPP reviews on an ongoing basis

Source: SPP SIR73 Economic Topology Optimization

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Increasing access to Reconfigurations

With multiple markets adding processes allowing for economically justified reconfigurations, the benefits include:

- Reduction in congestion and curtailment
- More access to generation
- Better utilization of transmission investments
- Reduce congestion costs
- Reduce system wide production costs
- Allow Transmission Operators to more efficiently operate equipment