SPP Transmission Topology Optimization Pilot

EFFICIENT CONGESTION MANAGEMENT AND OVERLOAD MITIGATION THROUGH SYSTEM RECONFIGURATIONS

PRESENTED BY

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THE Brattle GROUP newgrid SPP Southwest Power Pool

Topology Optimization

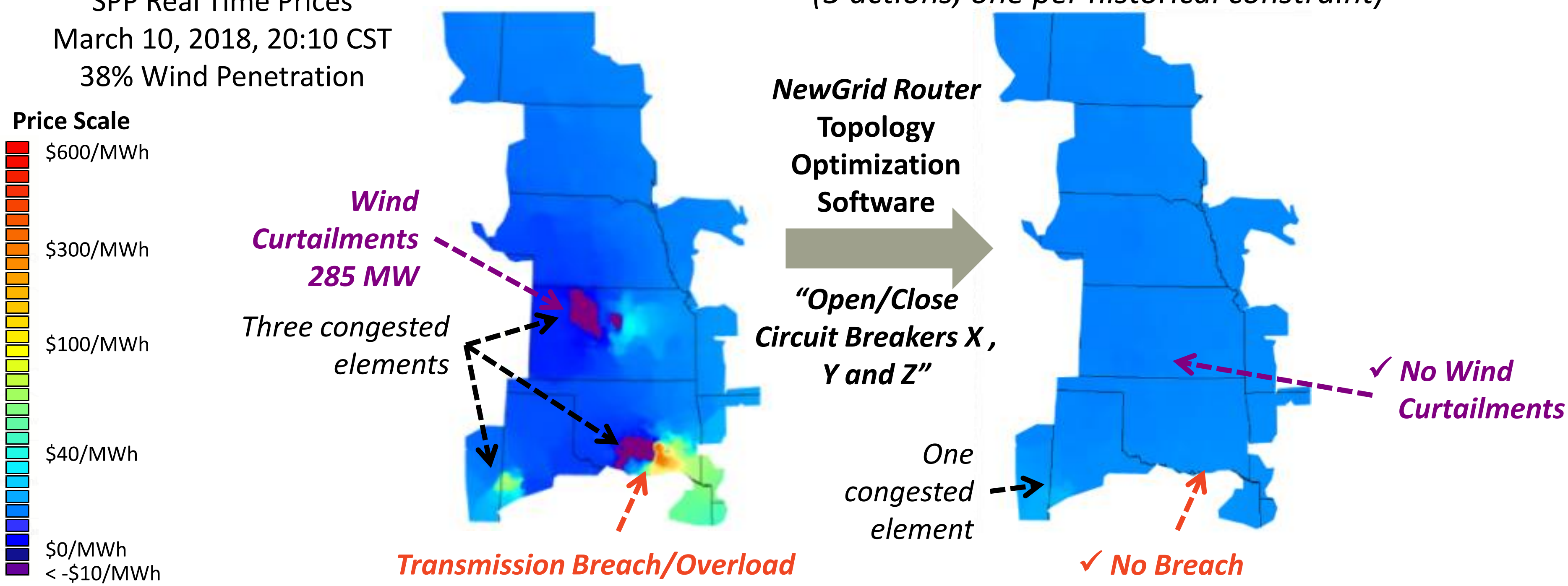
Topology optimization complements resource-based congestion management by automatically finding reconfigurations to route flow around congested elements (“Waze for the transmission grid”).

Example:

SPP Real Time Prices
March 10, 2018, 20:10 CST
38% Wind Penetration

Historical Case

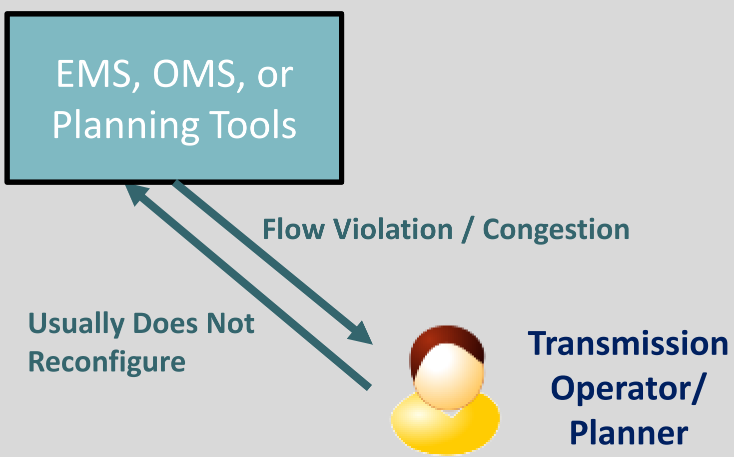
With Reconfigurations
(3 actions, one per historical constraint)



Reconfiguration Practice

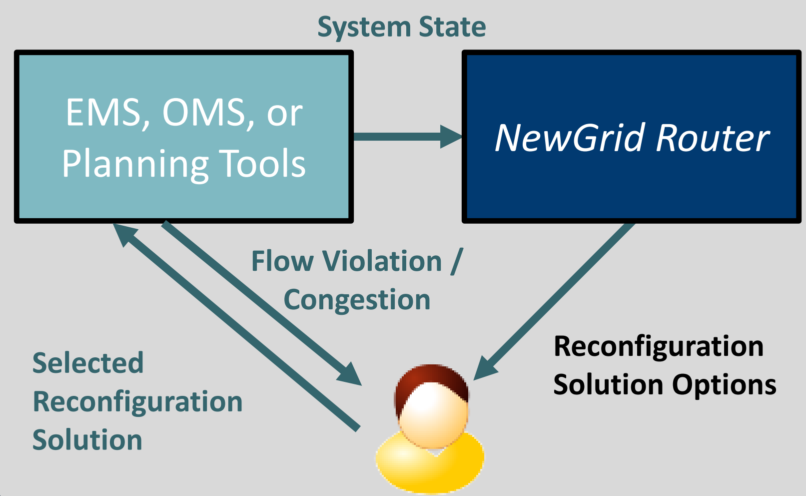
Traditional/Today

- Reconfigurations are employed on an ad-hoc basis
- Reconfigurations are identified based on staff experience (time-consuming process)
- The transmission grid flexibility is underutilized



With Topology Optimization

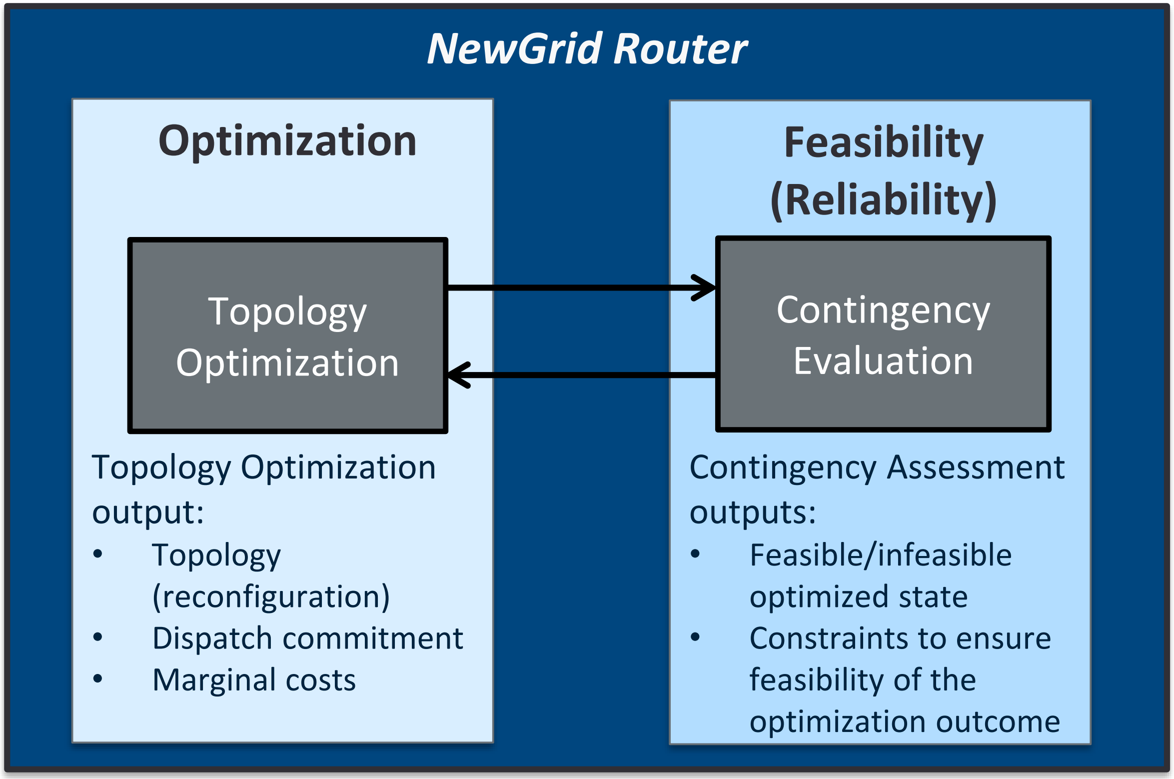
- Software identifies reconfiguration solution *options* to select
- Fast identification: 10 sec – 2 min
- Facilitate training of new operators
- Take full advantage of grid flexibility
- Achieve better outcomes



Reconfigurations Meet Reliability Criteria

NewGrid Router runs contingency analysis to ensure that the new configurations are feasible (*e.g.*, do not cause new contingency violations).

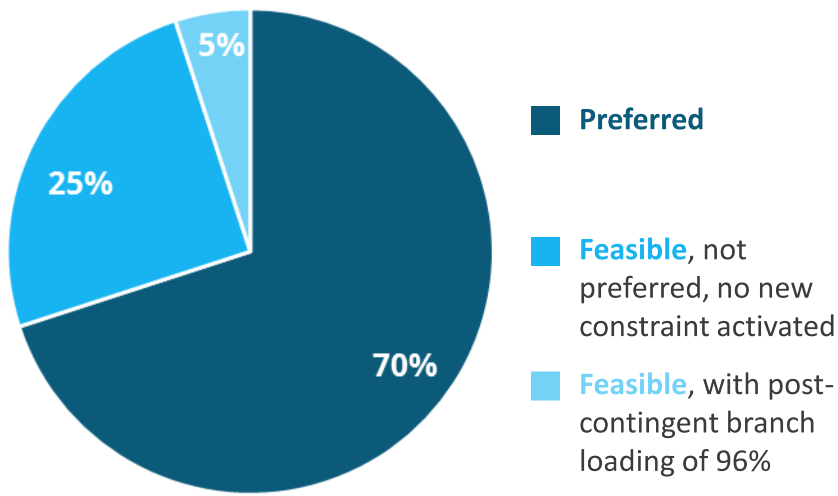
- Preventive solutions: reconfigure in base case
- Corrective solutions: reconfigure if contingency occurs



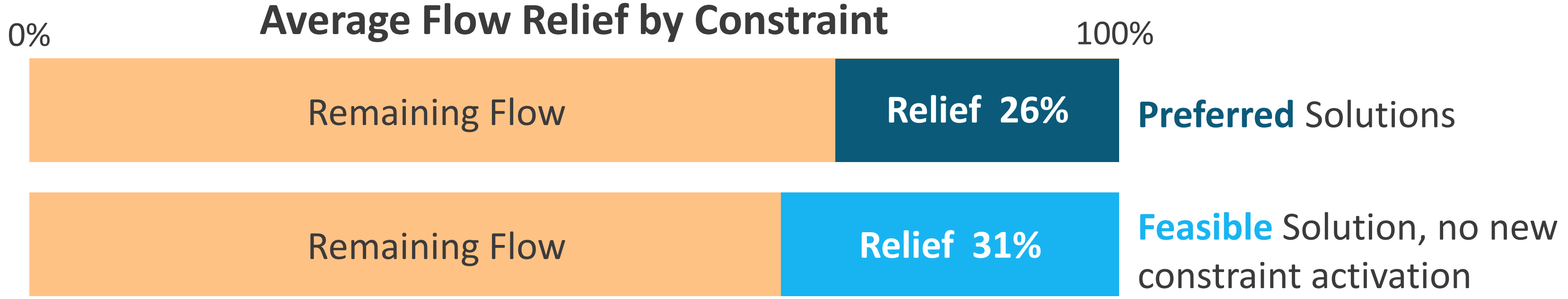
SPP Study: Constraint Flow Relief Effectiveness

- SPP selected 20 real-time snapshots with congestion/overloads on focus constraints.
- Brattle identified reconfiguration options using *NewGrid Router*, SPP validated them on the EMS.
- **Feasible** Solution: meets pre- and post-contingency criteria, validated in the EMS
- **Preferred** Solution by SPP, in addition:
  - Loading on any new constraints below 95%
  - Comprises a single action below 345 kV
  - Radializes less than 30 MW of load
  - Provides at least 10% relief

Best Solution by Constraint



Average Flow Relief by Constraint



Now Let's Discuss Field Results from SPP…

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Transmission Topology Optimization Pilot with SPP Operations – Results

ESIG 2019 Spring Technical Workshop
Session 4: Preparing for Future Energy Systems

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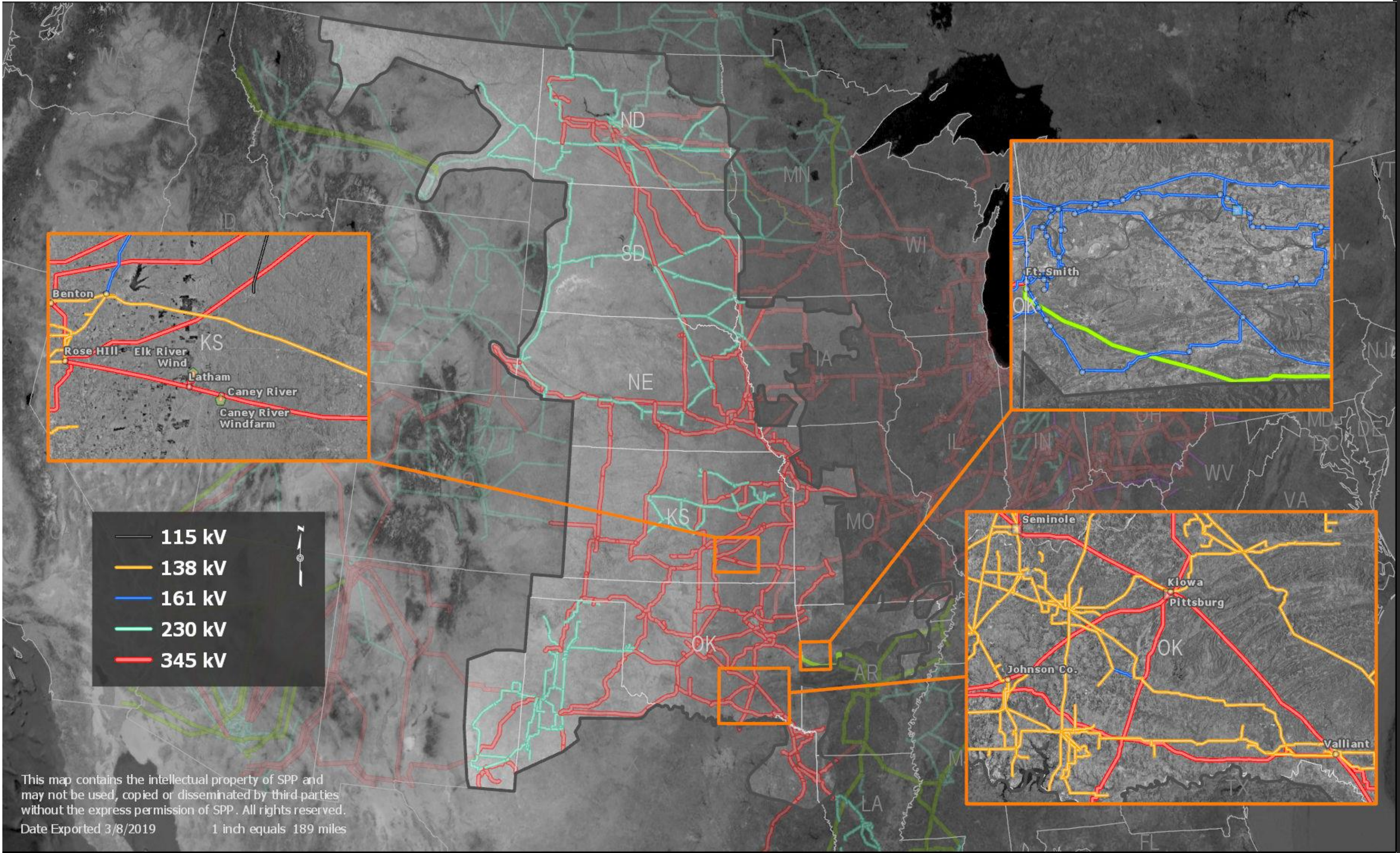
Southwest Power Pool
HELPING OUR MEMBERS WORK TOGETHER
TO KEEP THE LIGHTS ON... TODAY AND IN THE FUTURE.

Topology Optimization Pilot Overview

- SPP Operations conducted a pilot with the NewGrid Router topology optimization tool (Q3 2018 – Q4 2018)
- Operations Analysis & Planning (Reliability focus)
  - Focus was on finding 'preferred' solutions:
    - At least 5% N-1 loading reduction
    - Up-to 30 MW newly radialized load
    - Single switching action
    - 230 kV or below only (230 kV XFR low side)
    - No resultant constraint loading over 95% post-contingent
  - Evaluated 100 flowgates with congestion during real-time operations
  - Found 'preferred' solutions to 55 flowgates
- Some reconfigurations were used in real-time operations:
  - Johnson County – Russet Op Guide
  - Mitigation of the DARCLAANOFTS permanent flowgate

SPP Topology Optimization Pilot Example Locations



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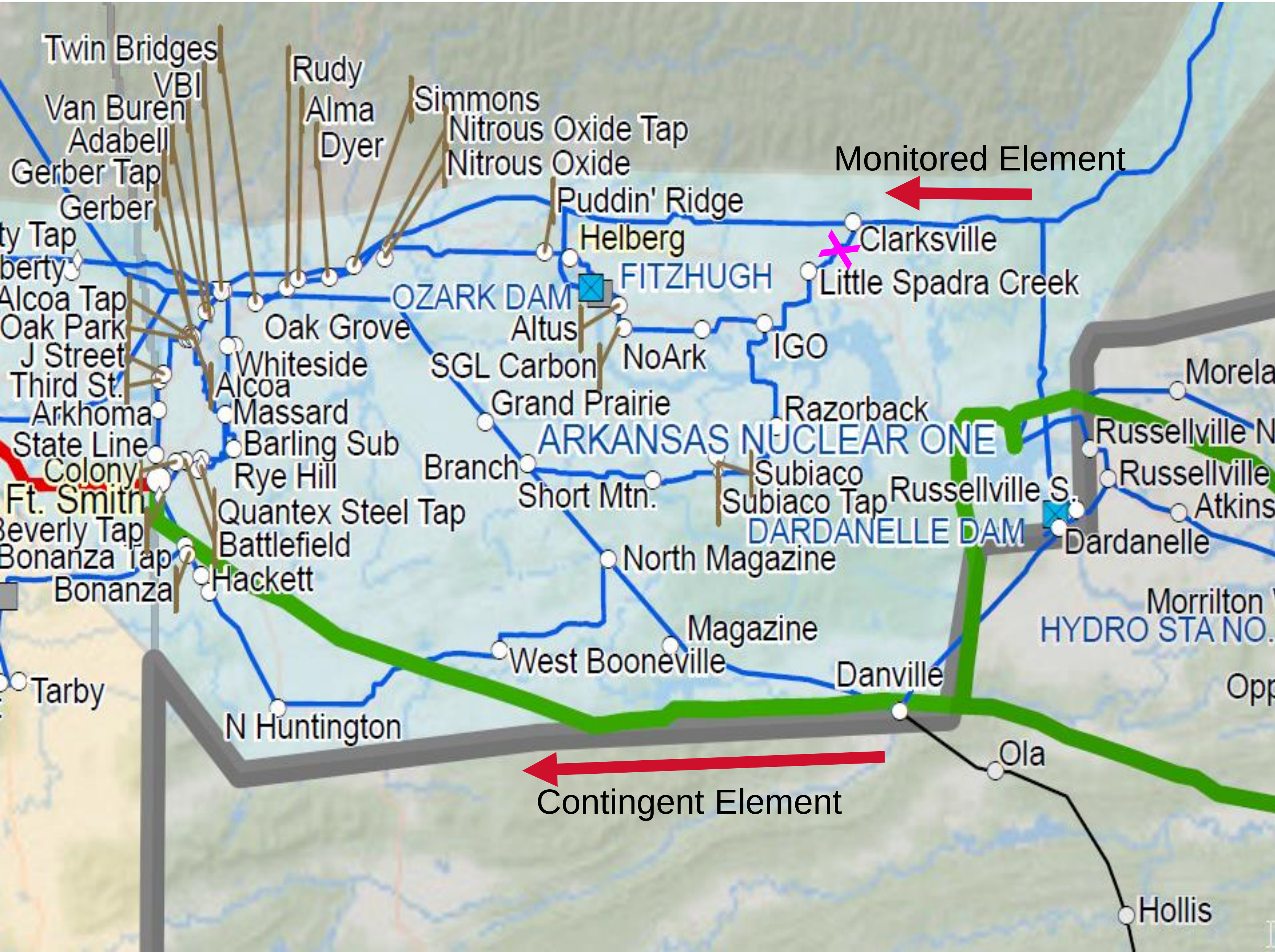
Real-time Solution Example

- In August 9, 2018 SPP Operations was experiencing a post-contingent overload on the DARCLAANOFTS permanent flowgate
- This constraint can be challenging to control due to significant external parallel flow impacts
- Real-time staff requested Operations Support to perform a Topology Control assessment of this constraint
- Operations Support was able to quickly identify a pre-contingent mitigation plan which reduced the constraint flow by over 20% and eliminated the post-contingent overload

Router Mitigation: Open the Clarksville – Little Spadra 161 kV line pre-contingent



Confirmation of existing mitigation plans

- SPP also found Router useful as a means to ensure that existing mitigation plans are the most effective and efficient
- Example existing plan check:
  - Constraint: Butler – Altoona 138 kV (flo) Caney River – Neosho 345 kV
  - Existing Mitigation: Open Butler – Midian 138 kV
  - Router quickly found the same mitigation solution!

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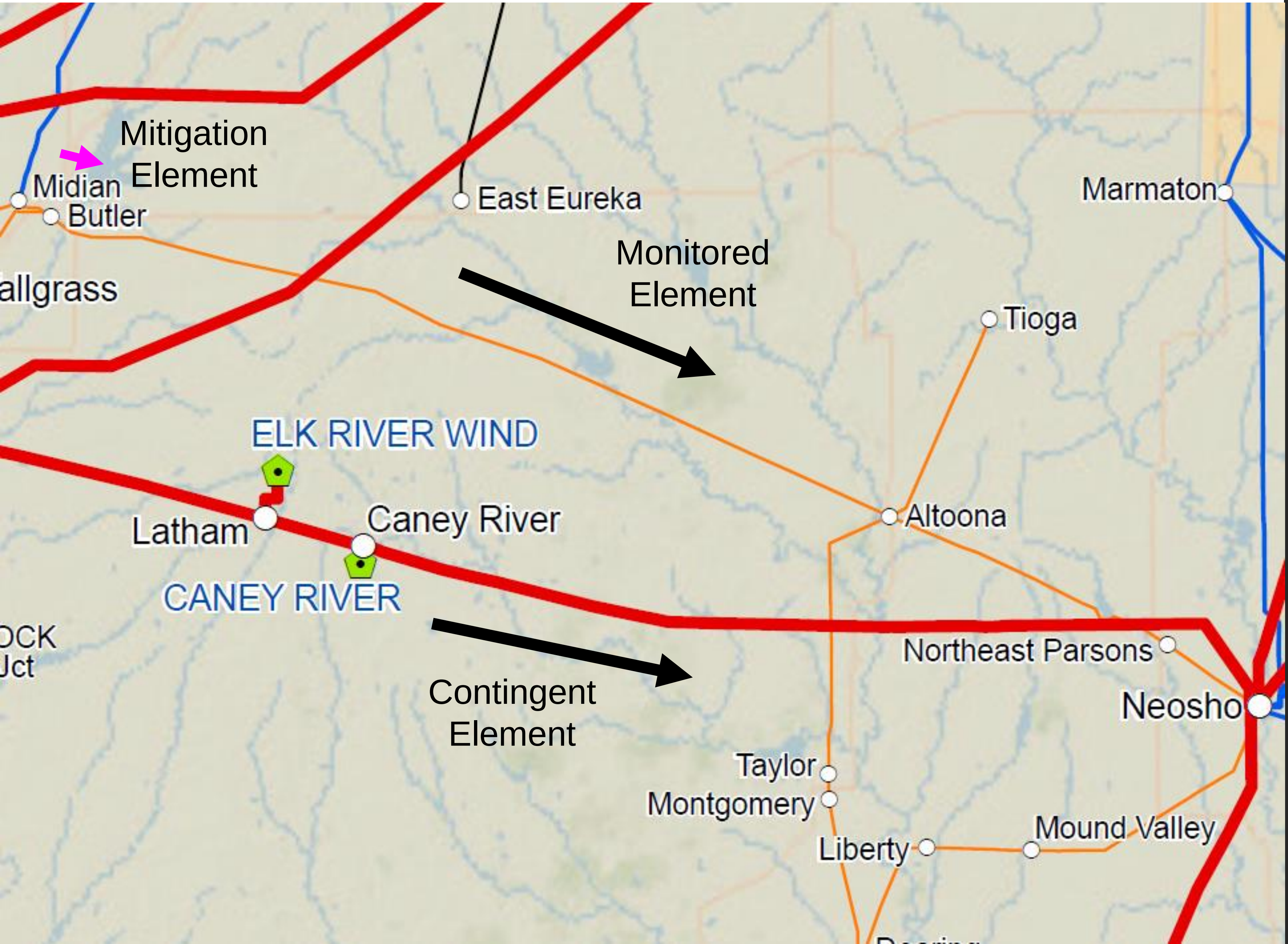
Router Mitigation: Open Butler - Midian138 kV line



Congestion during High Wind Penetration Intervals

- SPP transmission can be exposed to heavy transfers of wind generation during high wind & low load conditions
- These transfers typically flow from West to East across SPP
- Constraints exposed to these system transfers and located far away from generation can be difficult to control, as generation shift factors are too low for the market to effectively redispatch resources
- Example high wind transfer constraint:
  - Constraint: Stonewall – Tupelo 138 kV (flo) Pittsburg – Valliant 345 kV
  - Router Solution: Open Civit – Stratford 138 kV for 24% relief
  - Newly radialized load < 10 MW
- Topology Optimization made it possible to quickly find a solution while minimizing the amount of load radialized

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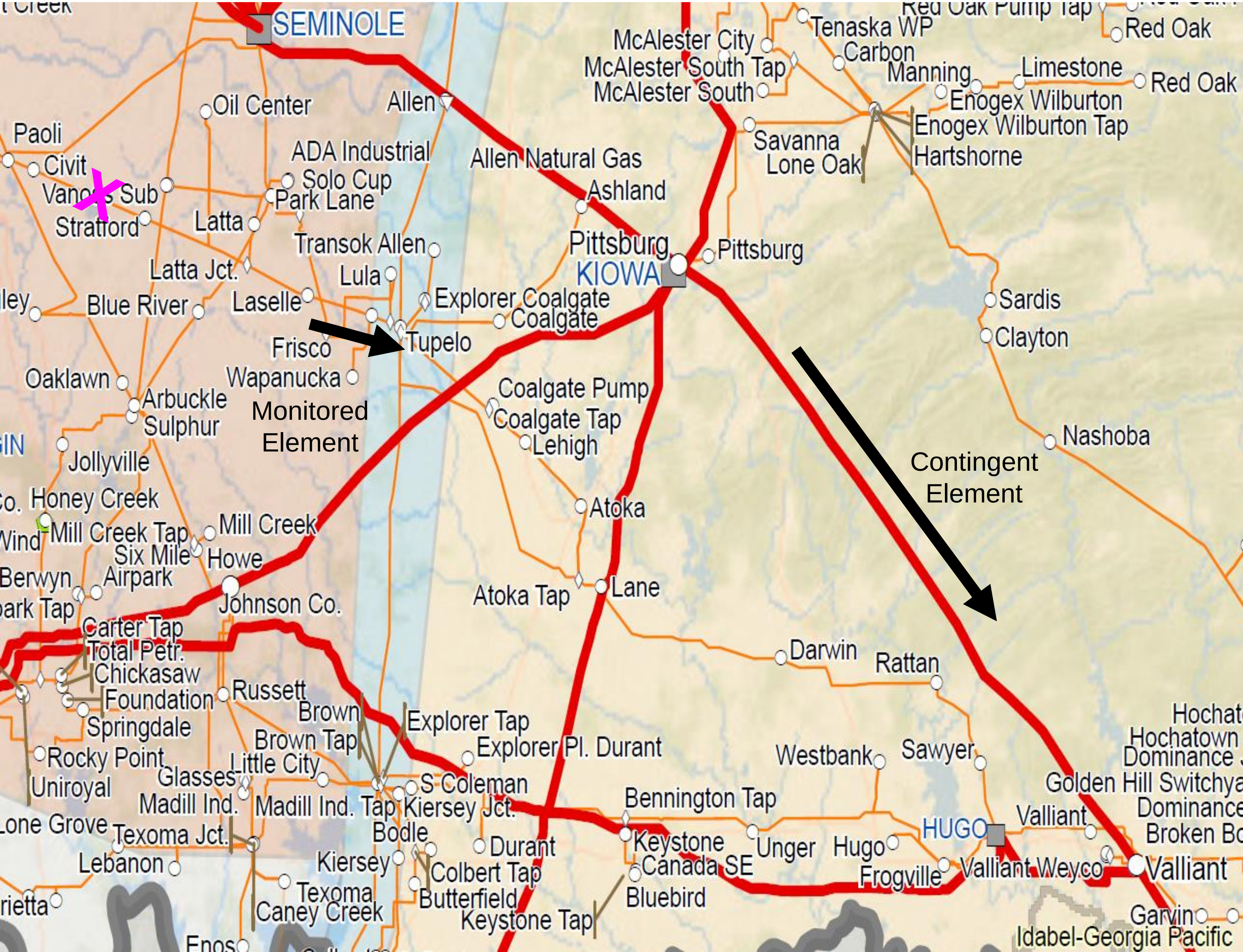
Router Mitigation: Open the Civit – Stratford 138 kV line



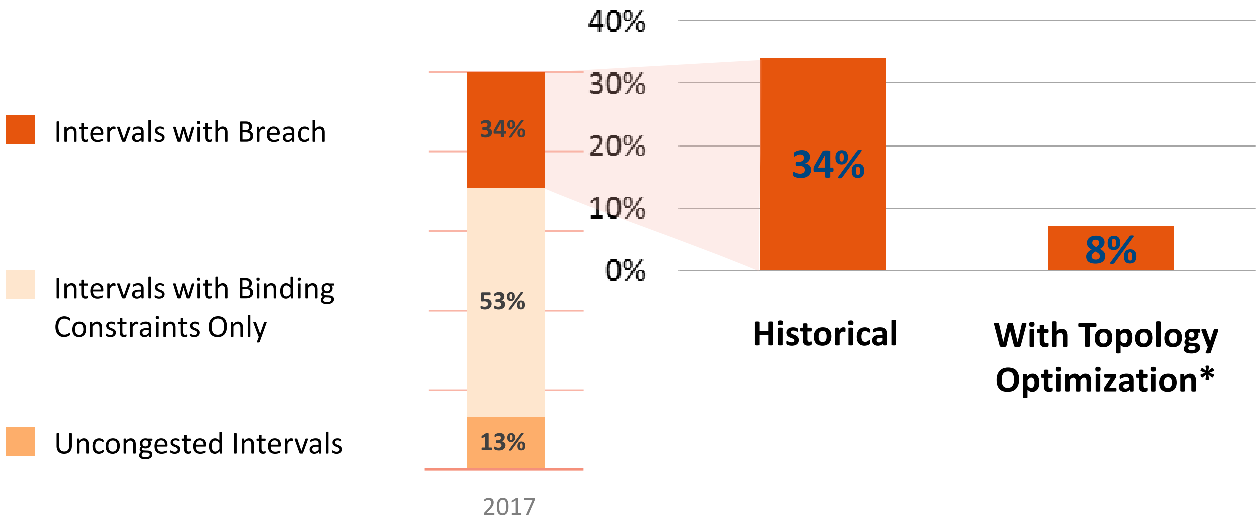
Appendix Contents

Reliability Benefits – Breached Constraint Relief

Topology optimization can significantly reduce the frequency of breached constraints in the markets without incurring additional costs.

- Real-time system conditions differ from those planned day-ahead.
- Operators have limited means to manage some constraints in real time.

Frequency of Breached Real Time Intervals (2017)



Sources:
Historical: SPP State of the Market Report 2017.

* *We conservatively assume that the use of topology optimization in RT Operations could provide breach constraint relief in 75% of the observed breached constraints; in the study of the 20 selected historical constraints, 95% of them were relieved to well below their limit.*

Market Simulation Methodology

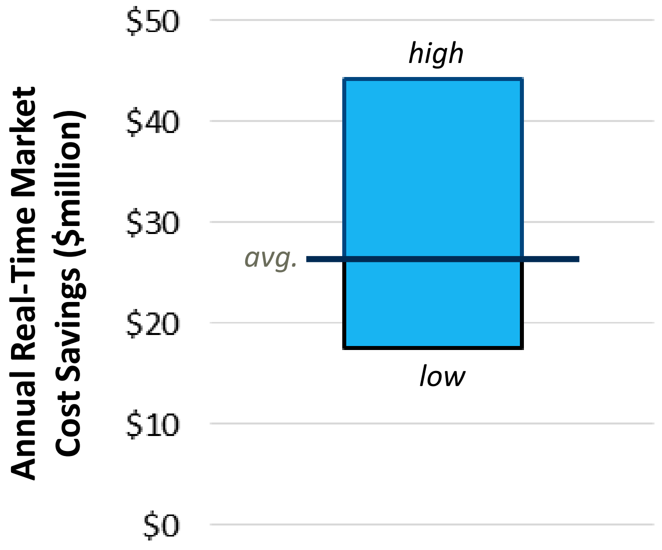
Constraint relief in the previous slides were based on the historical dispatch. We assessed real-time markets savings for four out of the twenty cases selected by SPP.

- We simulated the real-time market for four cases and evaluated the reduced congestion costs of applying reconfigurations to relieve constraints in those cases.
- Base case market results benchmarked against the historical market dispatch and shadow prices.
- Conservative assumptions:
  - We fixed the dispatch of 25-85 units (out of 200-250 market-dispatchable units) to the historical dispatch level so as to achieve market simulation results that meet the benchmark.
  - Because we removed many units as decision variables from the market, we are most likely underestimating the savings achievable by relieving bindings constraints.

Market Efficiency Benefits

Topology optimization would provide **annual Real Time Market savings of over $18-44 million** when used in market optimization.

- Based on the cases simulated, the real-time market cost savings provided by topology optimization is about 3% (+2%/-1%) of the initial *congestion rent* of the constraints relieved.
- We extrapolated the market savings based on the historical Real Time Market congestion rent ($1.2 billion in 2017), conservatively assuming that topology optimization can effectively provide relief for 75% of the constraints.*



* *In the study of the 20 selected historical constraints, 95% of them were relieved with topology optimization.*

Appendix 2

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Appendix 2

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