Visualization Methods for Quickly Understanding the Evolution of Power Flow Constraints under AC Contingency Analysis

CIGRE NGN Paper Competition | October 10th, 2023

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Motivation

- Vast tables of results generated by AC contingency analysis tools
- Challenge to comprehend the findings and identify effective mitigations

Present data clearly and emphasize power system analysis links through visualization tools.

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Method application

Analysis of the power system in the State of Michigan



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Michigan's power system unique location







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Michigan transfer capability







PowerGEM Power Grid Engineering & Markets

• PowerGEM's Transmission and Reliability Analysis (TARA)

2025 MISO cases modified

- Retirements planned for 2025, but decommissioned in 2022
- New generation added
- Solar, Wind, Battery and Hybrid
- MISO Queue 12/31/2024
- Dispatch levels for Summer and Shoulder

Transmission system projects

• Long Range Transmission Planning: Tranche 1 (LRTP Tranche 1)





- Transfer capability is done by lowering generation in the sink region and raising it in the source region
- Several interfaces monitored:
 - American Electric Power AEP (PJM)
 - American Transmission Systems
 - Incorporated ATSI (PJM)
 - Northern Indiana Public Services NIPS (MISO)
 - Ontario (IESO)
- Net generation and load determined across different areas
- Many sensitivities considered

Contingency Analysis Visualization

Easily define the relation of the element, the contingency that caused the violation, and its severity level

X-axis: contingencies

Y-axis: elements impacted

(A) Visualizing Thermal Violations (MW Overloads of Lines & Transformers)



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Thermal Violation Analysis

- At 9000 MW transfer level, the system is at its limits
- The inclusion of Tranche 1 reduces:
 - the number of contingencies that cause violations from over 300 to 244
 - number of elements impacted from 34 to 21
 - severity of the worst violations by up to 15%

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Voltage Violation Analysis





Results and Conclusions



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- The visualization approach applied enables:
 - more efficient analysis of massive amounts of data
 - faster identification of relationships among the data
- The heat maps allowed the contingency analysis results to be visualized at a system level
 - The impact of thermal violations on the power import level was well identified, and the problem elements were easily targeted.
- As the future becomes more uncertain, understanding multiple scenarios quickly is essential for planning.

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Thank you!

Questions?

