

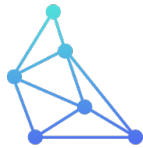
Stability Screening Methods

A Hitchhiker's Guide

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ESIG Spring Technical Workshop, March 2026

GridLAB



T E L O S E N E R G Y



HickoryLedge

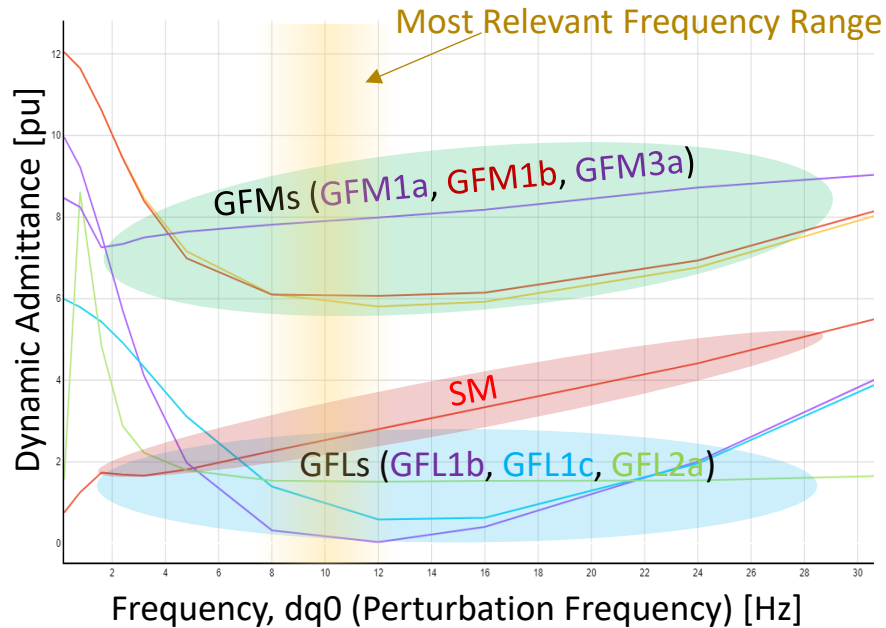
Brief Overview of the Dynamic Impedance Method

Core Finding: Quality of voltage regulation is critical to voltage stability

1. Resources

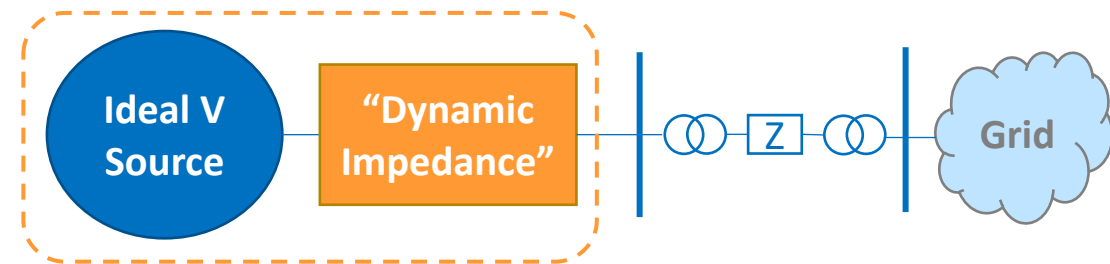


2. Impedance Analysis using EMT Models



Our work on the Dynamic Impedance Method (DZM) was published in 2023 and shared in: [ESIG](#), [NERC IRPS](#), [WSIS/IEEE White Paper](#)

3. Admittance of the resource at 10Hz is applied as an impedance behind the terminals



Analysis Framework

Data Inputs...

Network
Topology

Scenarios &
Resource Mixes

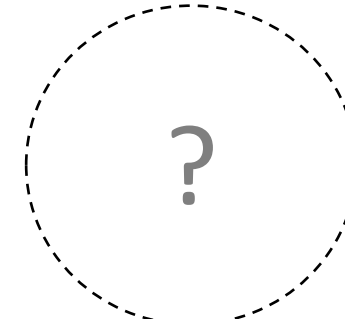
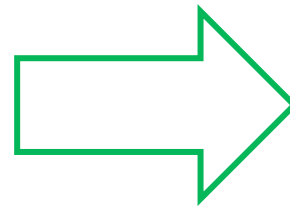
Contingency List

Detailed (EMT)
Resource
Models

Case Preparation with DZM...

Case with DZM
Representation
of Resources

Dynamic
Impedance
Analysis



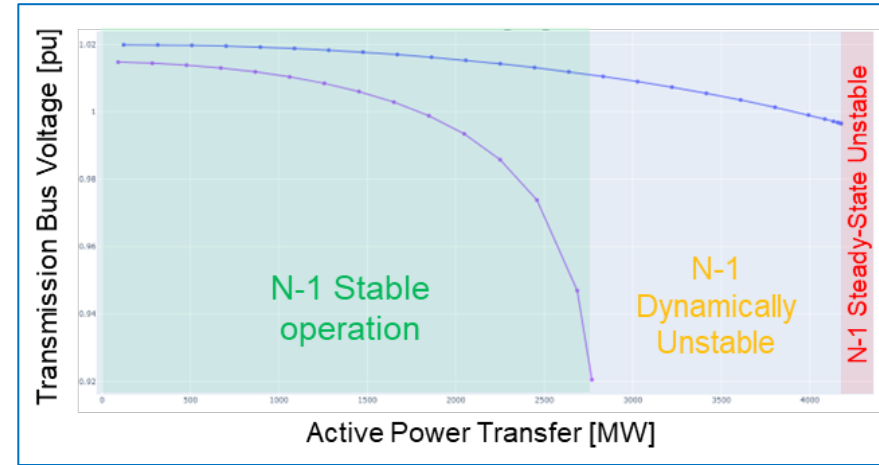
A case with DZM representation of all resources
– IBR, SM, STATCOM, etc. –
forms a foundation for other methods of analysis

With this foundation, let's consider some analytical methods to build on top...



P-V Analysis

Using DZM



Attribute	P-V Analysis	P-V Analysis Comments
Ease of Use	✗	Need to define sources & sinks, multiple dispatch cases
Resource Type Represented	✓	DZM used to represent resources
Proximity to other IBR Represented	✓	No IBR aggregation assumptions required, DZM considers it
Transmission Stress Represented	✓	Sensitive to power flow pattern
Metric Calibration Not Required	✓	MW transfer limits identified directly

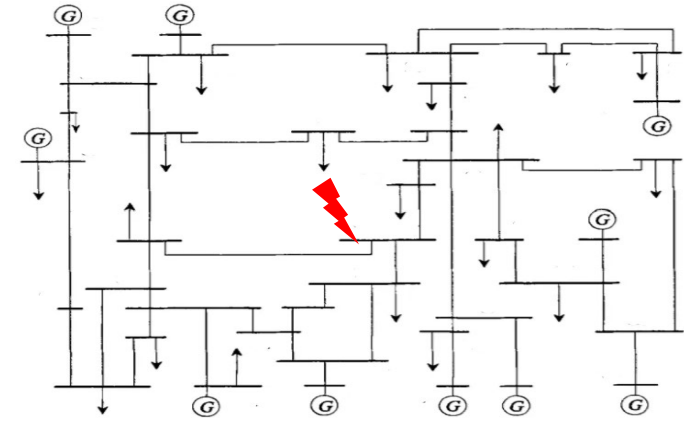
Can we reduce the complexity of defining sources & sinks and incremental power transfer cases?



Short-Circuit Based Analysis

Equivalent Short Circuit Ratio (EqSCR) using DZM

- There are many variations of short-circuit (driving-point impedance) analysis
- An enhanced version (EqSCR using DZM is considered here)



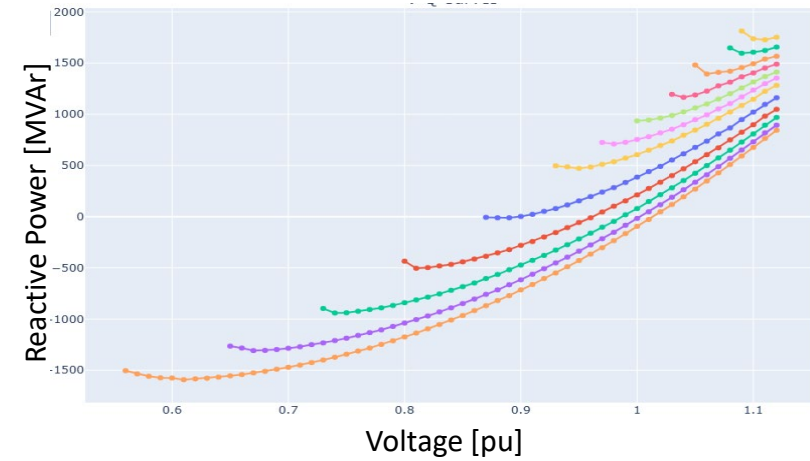
Attribute	P-V	SC Analysis	SC Based Analysis Comments
Ease of Use	✗	✓	Works on a single powerflow case
Resource Type Represented	✓	✓	Captured if DZM is used to represent resources
Proximity to other IBR Represented	✓	✓	Captured if EqSCR and DZM are used
Transmission Stress Represented	✓	✗	Blind to power flow pattern & system dispatch
Metric Calibration Not Required	✓	✗	Metric is relative; calibration required

Trade-off of simplicity for accuracy – Is there another compromise?



Q-V Analysis

Using DZM



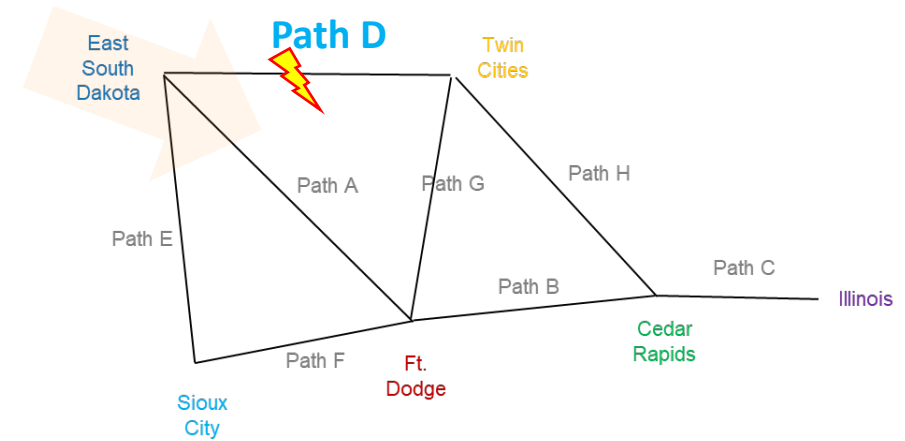
Attribute	P-V	EqSCR	Q-V	Q-V Analysis Comments
Ease of Use	✗	✓	✓	Works on a single powerflow dispatch
Resource Type Represented	✓	✓	✓	DZM used to represent resources
Proximity to other IBR Represented	✓	✓	✓	DZM with network captures proximity
Transmission Stress Represented	✓	✗	✓	Sensitive to power flow pattern
Metric Calibration Not Required	✓	✗	✓	MVAR margin reported; not quite MW

- Q-V provide results **even for very stressed cases** where there is non-convergence post-contingency
- This allows for a **quick ranking** of the most severe contingencies **accounting for a real system dispatch**

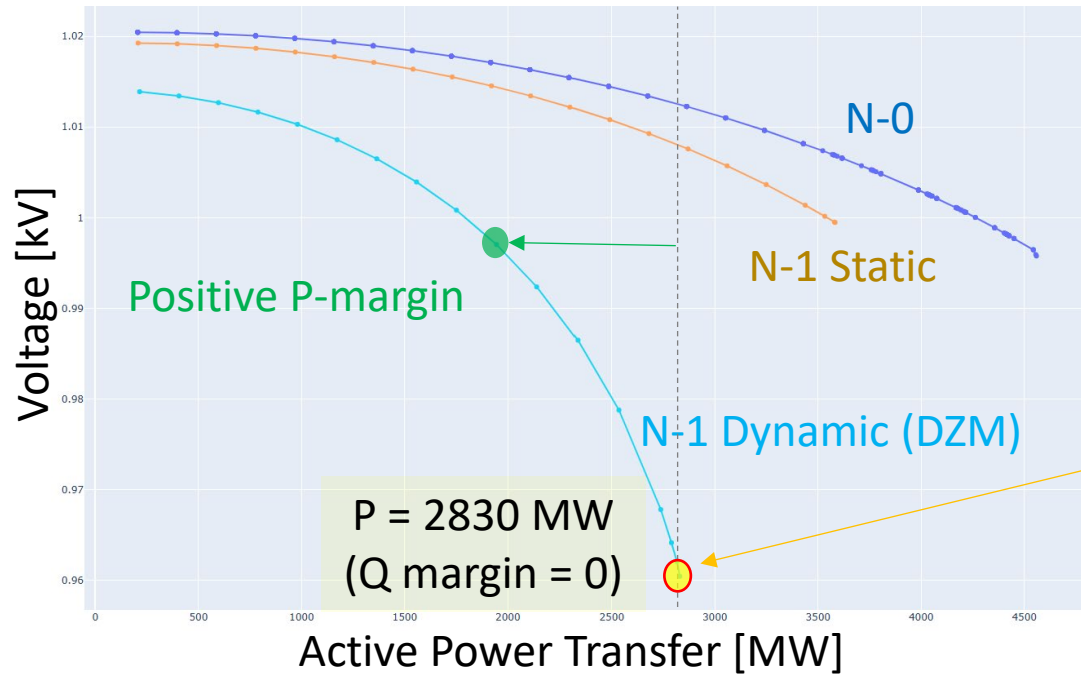


Q-V Analysis in Practice

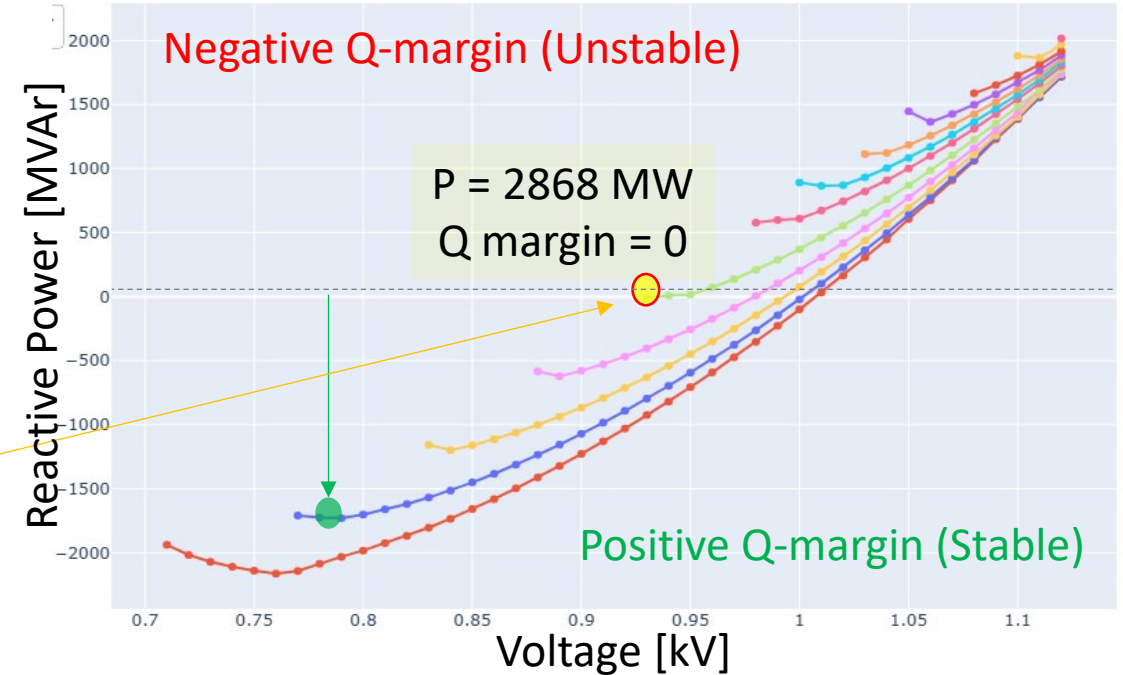
Curves for Path D, 2 Circuit Contingency



P-V Curves

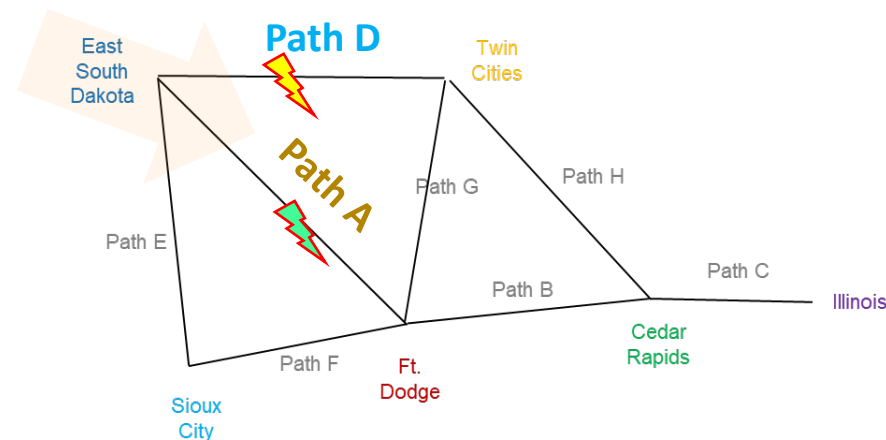


Q-V Curves for the N-1 Dynamic (DZM)

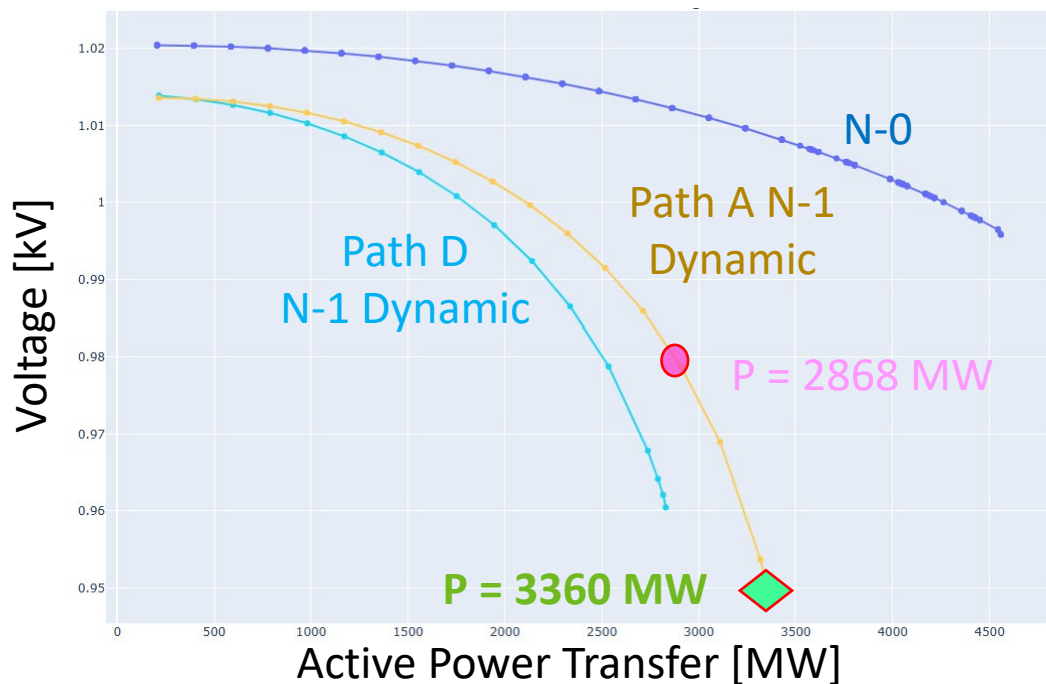


Q-V, Different Contingencies

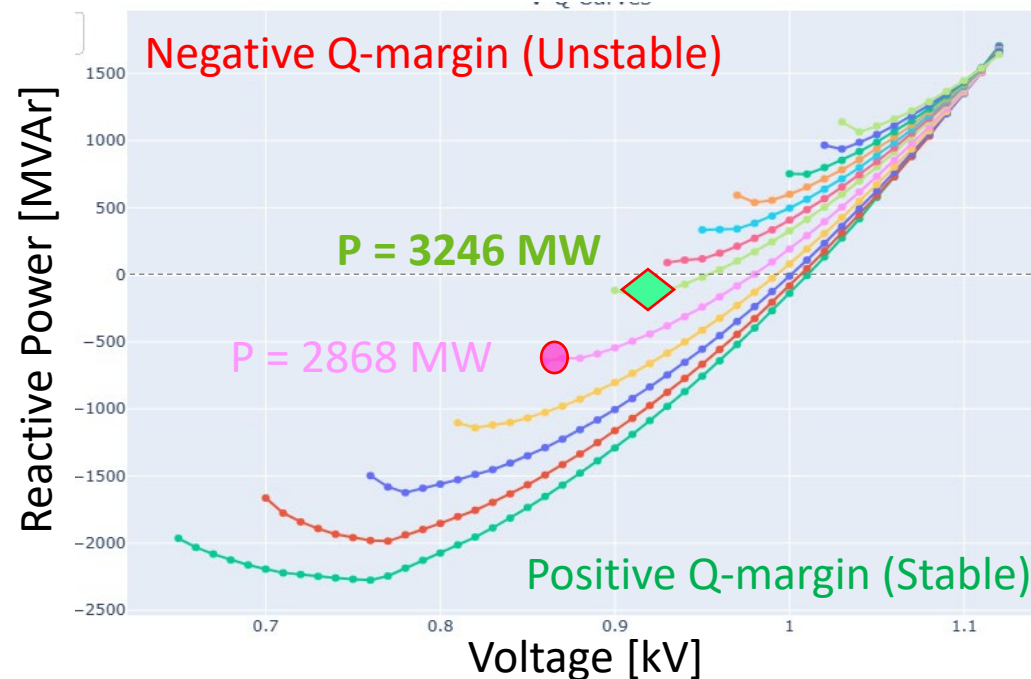
Curves for **Path D** & **Path A**, 2 Circuit Contingencies



P-V Curves



Q-V Curves for the Path A N-1 Dynamic (DZM)

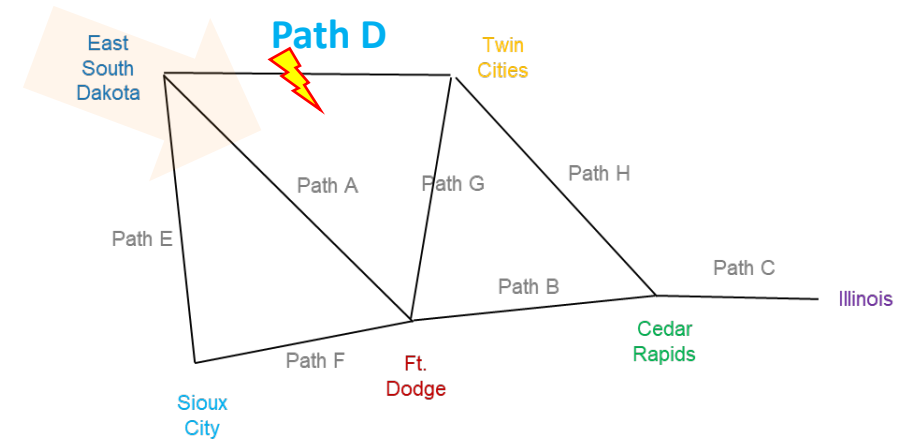


The SCMVA of Path A and Path D Contingencies are the same – **but dispatch & transmission stress matters!**

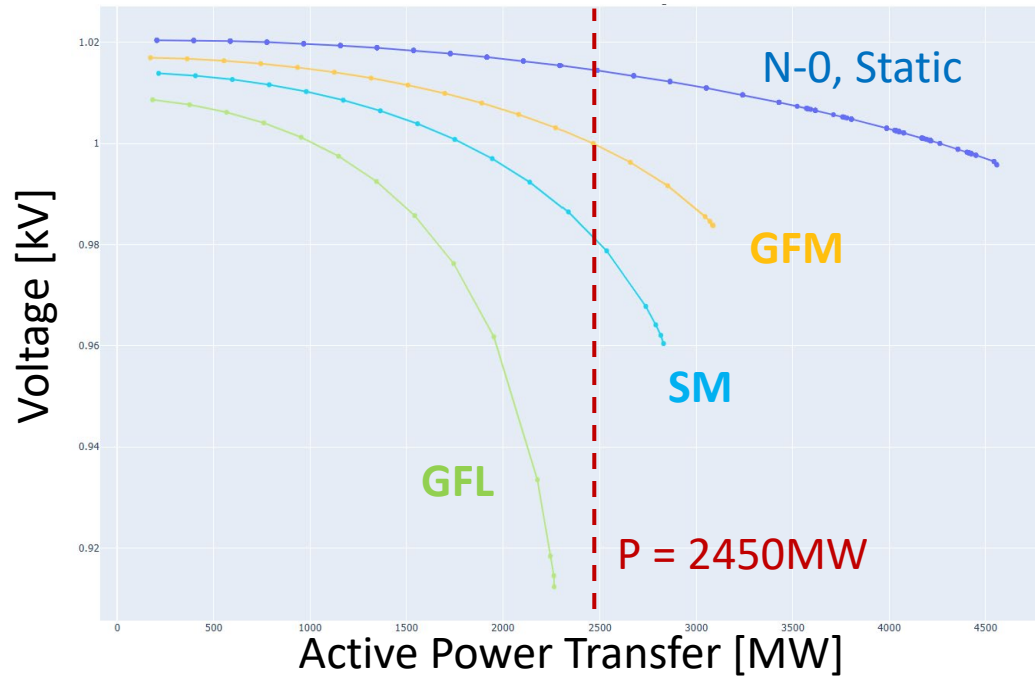


Q-V, Different Resources

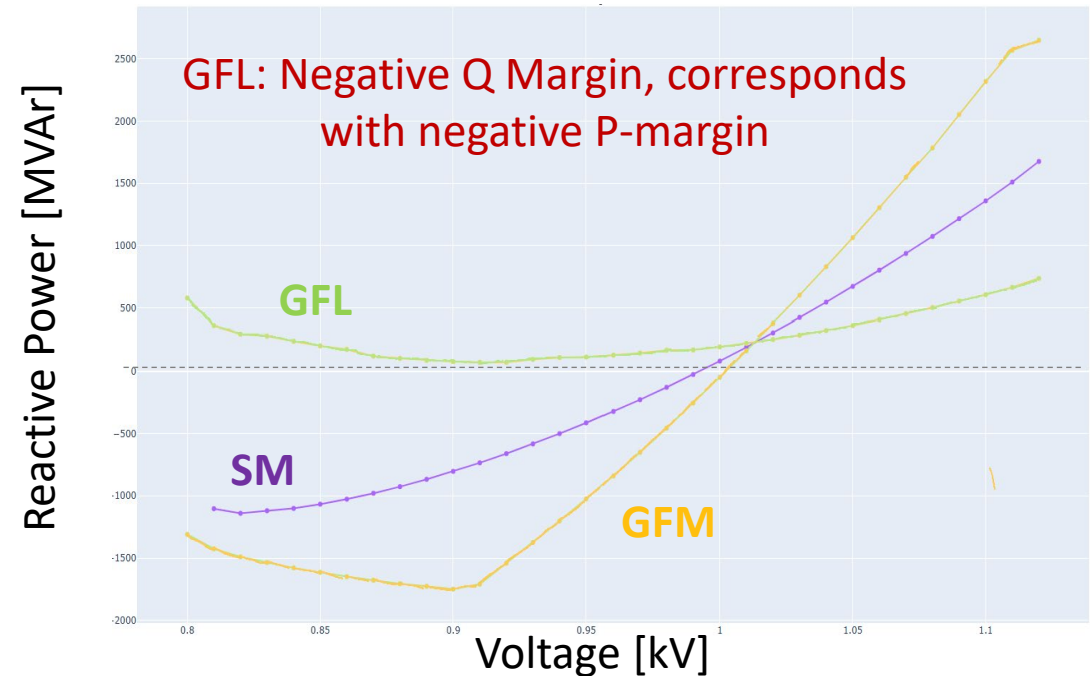
Curves for **Path D** Contingency, SM v. GFM IBR



P-V Curves



Q-V Curves, evaluated at 2450MW (DZM)



Connecting Q-margin to P-margin

Why?

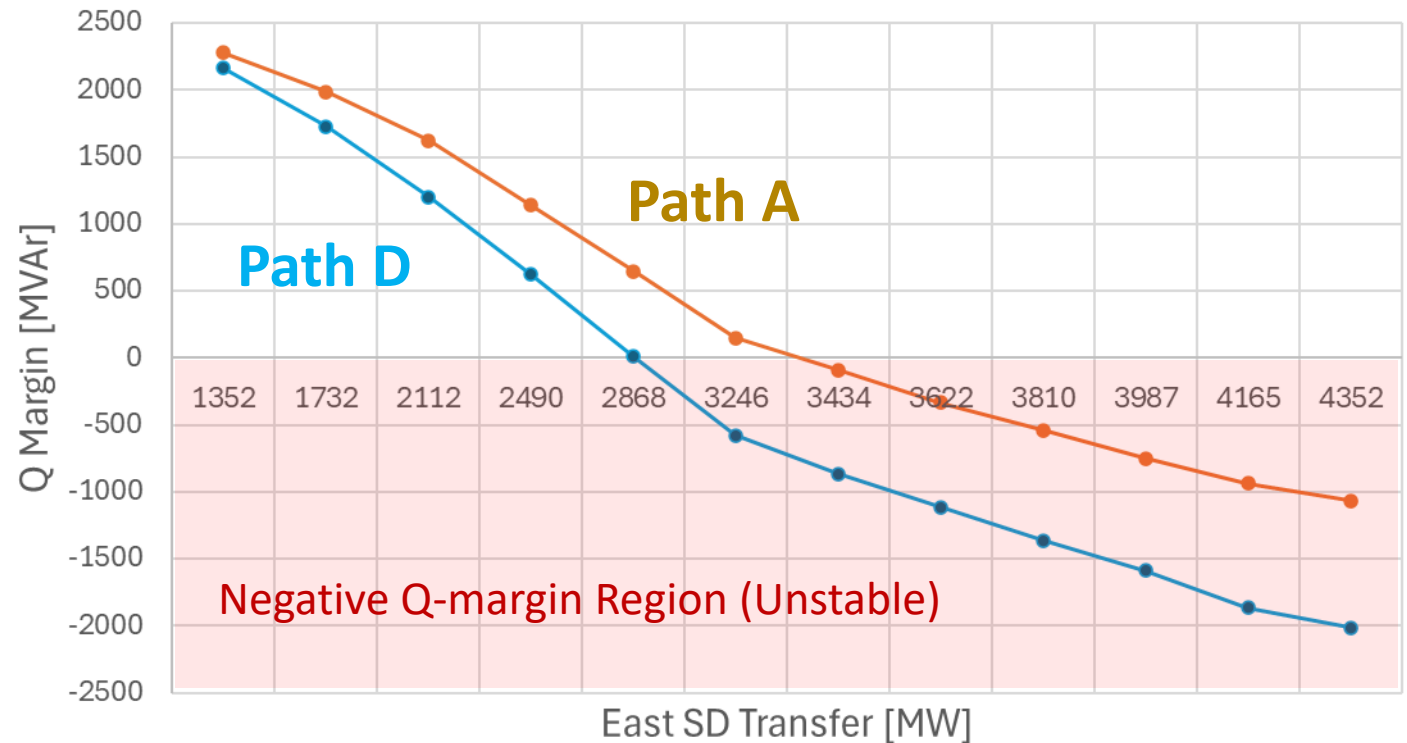
- Power transfer is closely tied to economics
- Q-V is easier to apply than P-V

The next challenge:

- Finding a relationship between Q-margin and P-margin that enables Q-V analysis to estimate power transfer limits...

...more to come!

Q-margin vs MW Transfer at East SD for Path A & D, 2 Ckt Contingencies



Summary: Comparison of Methods

Screening Methods

Attribute	P-V	EqSCR	Q-V	SCR
Ease of Use	✗	✓	✓	✓
Resource Type Represented	✓	✓	✓	✗
Proximity to other IBR Represented	✓	✓	✓	💩
Transmission Stress Represented	✓	✗	✓	✗
Metric Calibration Not Required	✓	✗	✓	✗

Using DZM Simple SCR (no DZM)

Simulation Methods

PD	EMT
🕒	💀
✓	🏆
✓	✓
✓	✓
✓	✓

- Analysis is not one-size-fits-all; each approach offers different trade-offs
- Choose carefully based on your application; know what you're getting (and what you're not getting)

Thank You! Questions?

Special thanks to the support provided by GridLAB!



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