Project Overview

AC Stability Concepts in Support of LTRP

March 29, 2023 | ESIG Spring Workshop

MISO

TELOS ENERGY

HickoryLedge

GridLAB

An Emerging Challenge

Long Range Planning (expansive scenario set) with a high inverter future

+

Practical challenges to modeling inverters

+

Quickly evolving technology

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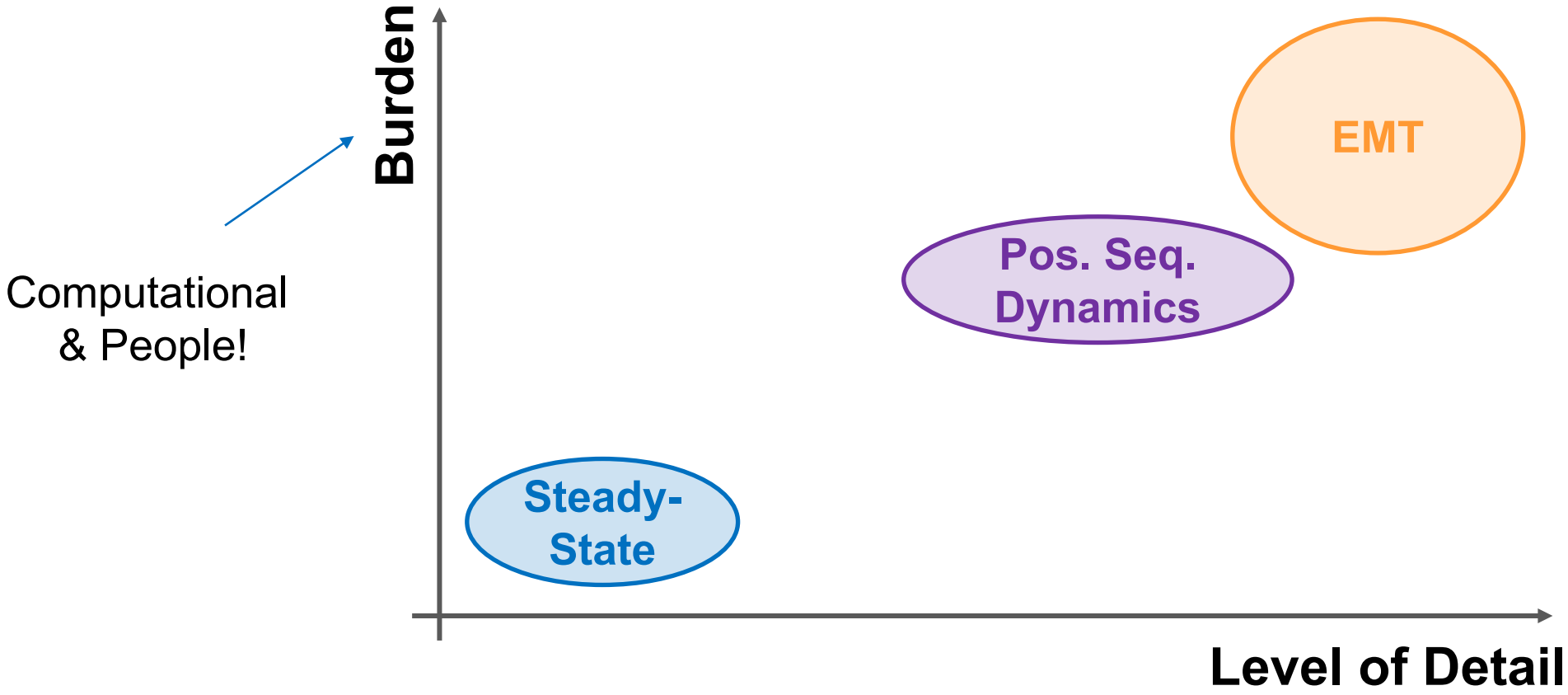
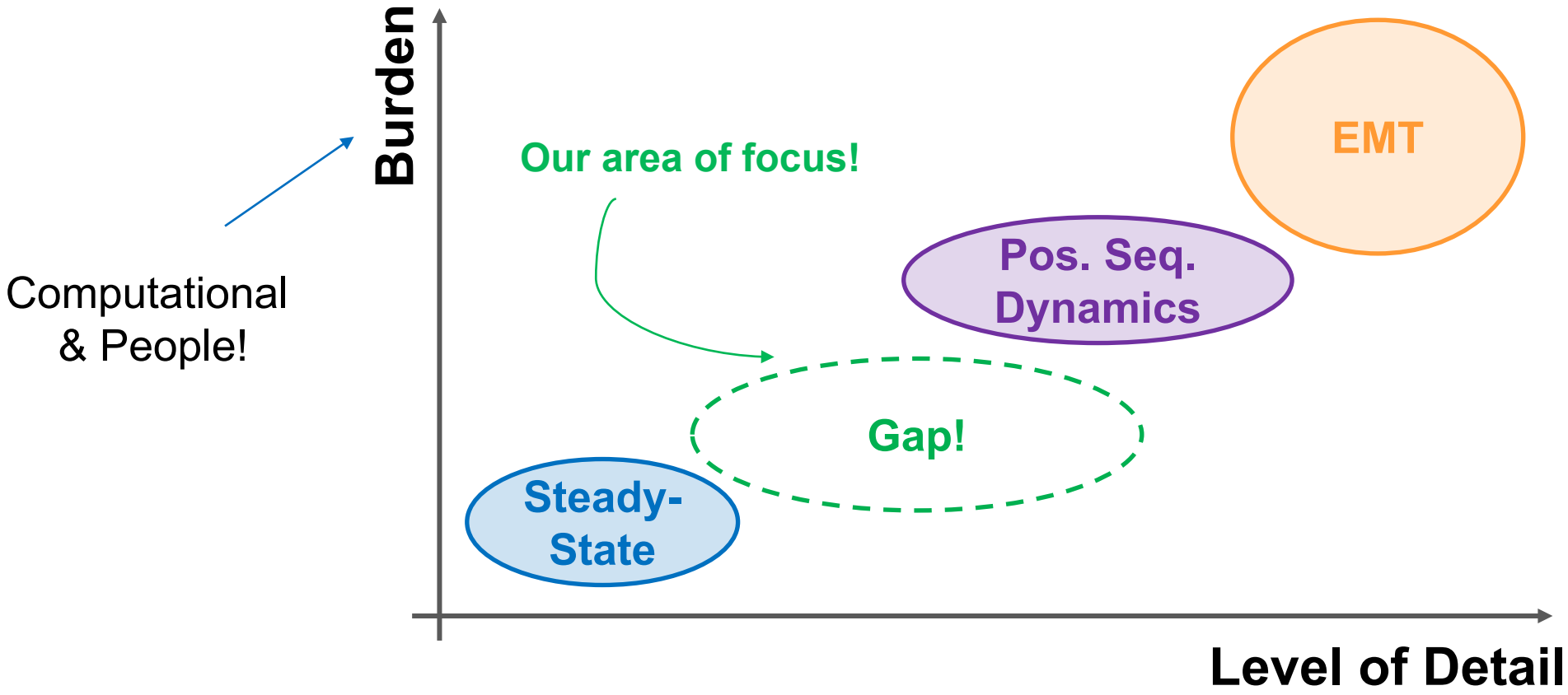
The Big Picture of Stability Studies



The Big Picture of Stability Studies



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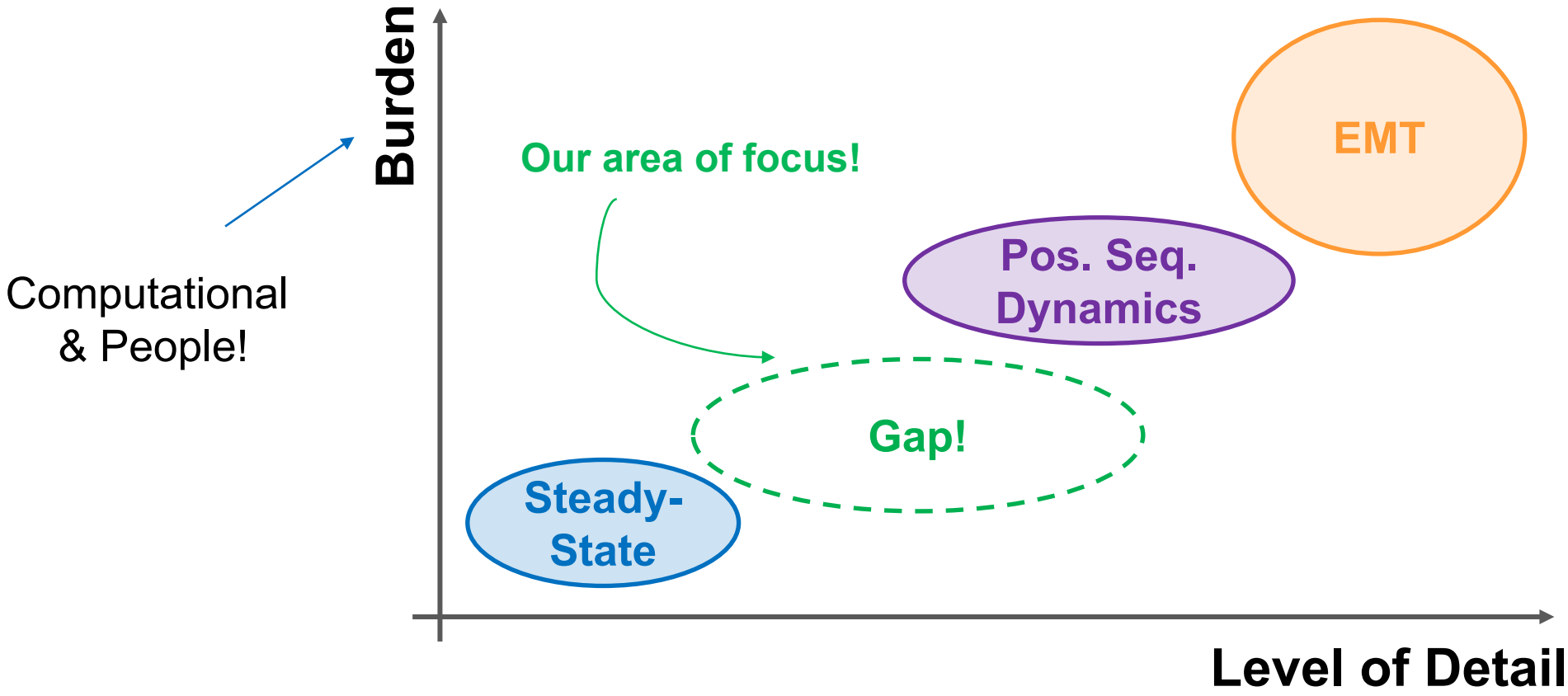


EMT Studies…

…ain't easy, but it's necessary…

…sometimes. When & where are important!

Voltage Stability & Grid Strength

Transmission Systems, Historically

Voltage Stability & Grid Strength

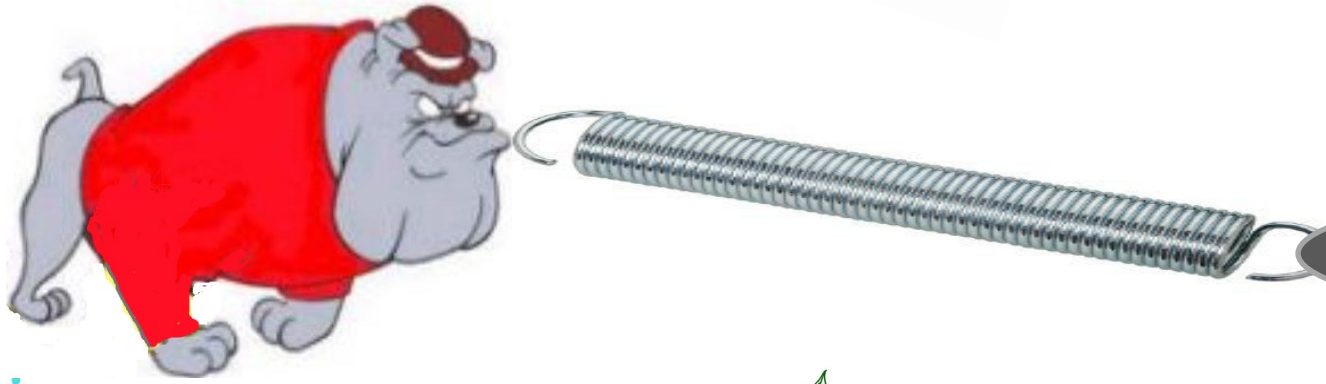
Transmission Systems, Historically

Weakening Grids

Voltage Stability, Extending the Analogy to Resources

Strong Grid
Big Resource, Big Transmission Line

Weak Grid
Small Resource, Big Transmission Line

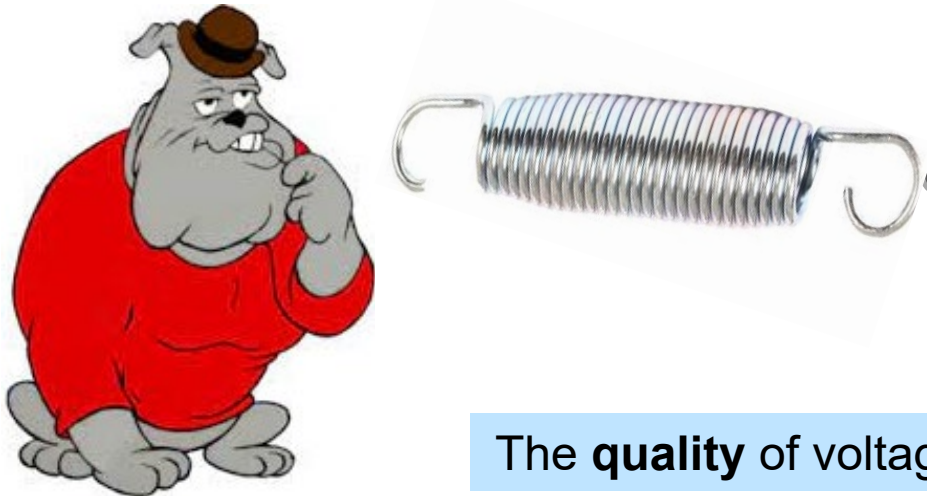


Weak Grid
Big Resource, Long Transmission Line

Voltage Stability, Extending the Analogy to Controls

Strong Grid
Big Resource, Big Transmission Line,
Immediate Response

Like: Synchronous Machines, Grid-Forming Inverters



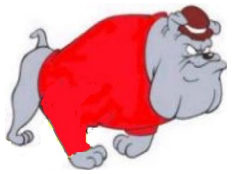
Weak Grid
Big Resource, Big Transmission Line,
Delayed or Small Response

Like: Grid-Following Inverters

The **quality** of voltage regulation matters for voltage stability!

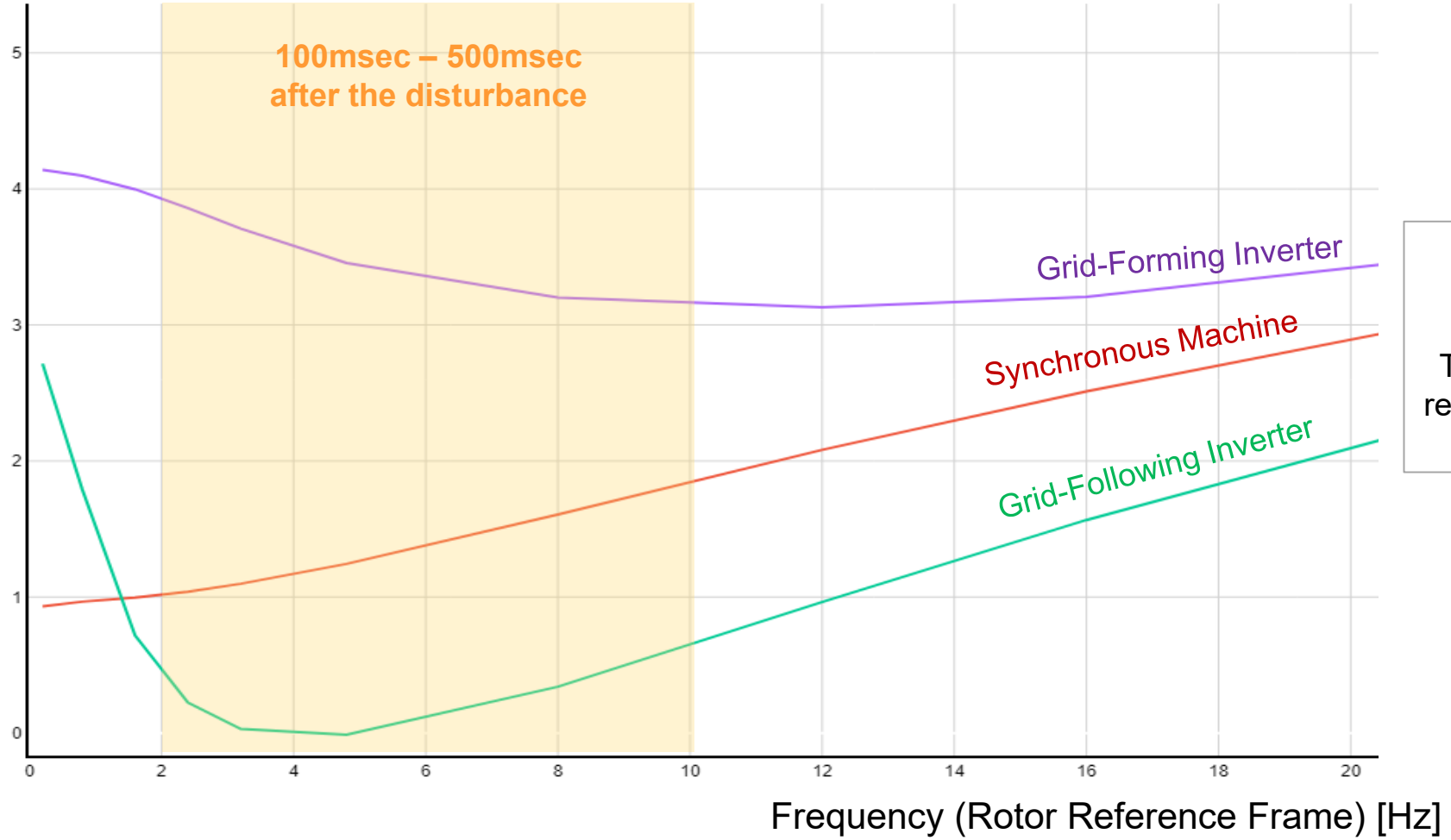
Quality…
- How much?
- How quickly?
- How damped?

Resource Characterization, Quantified



Grid Strengthening

(Resource's Internal Admittance [pu])



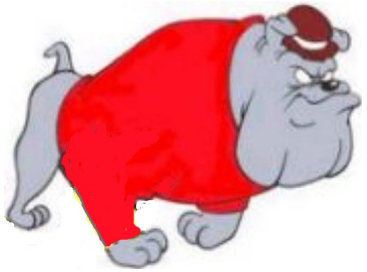
Many steps are not shown here, but…

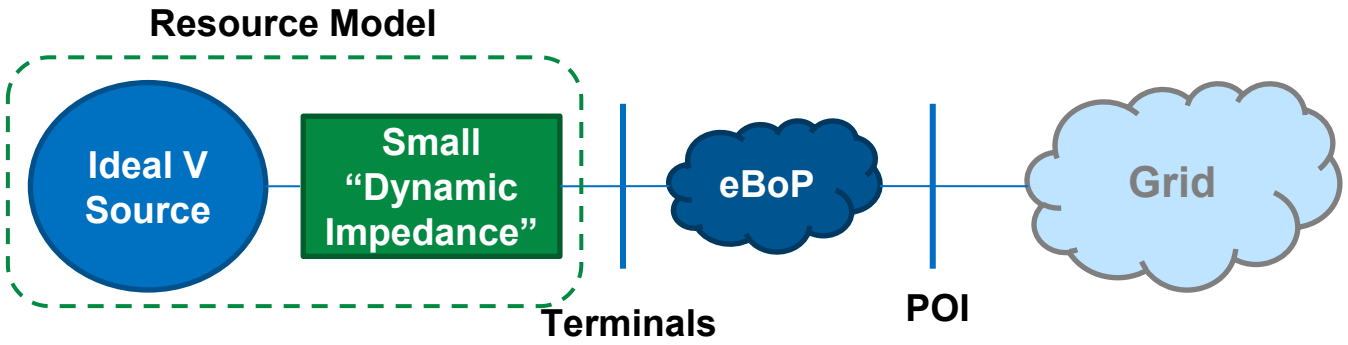
These curves are the results of EMT analysis of detailed models

Introducing a Dynamic Impedance

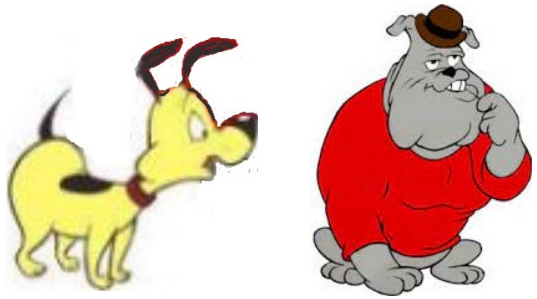
A Familiar Thevenin Equivalent

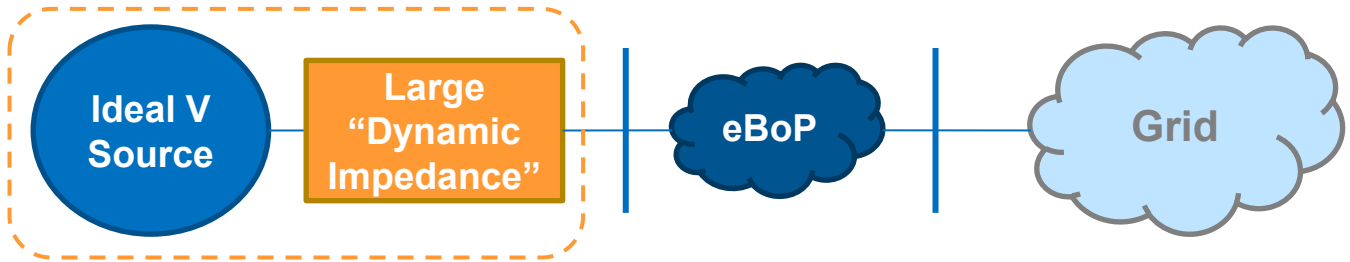
Grid Strengthening
High-Admittance aka
Low-Impedance
Resource





Poor Grid Strengthening
Low-Admittance aka
High-Impedance
Resources

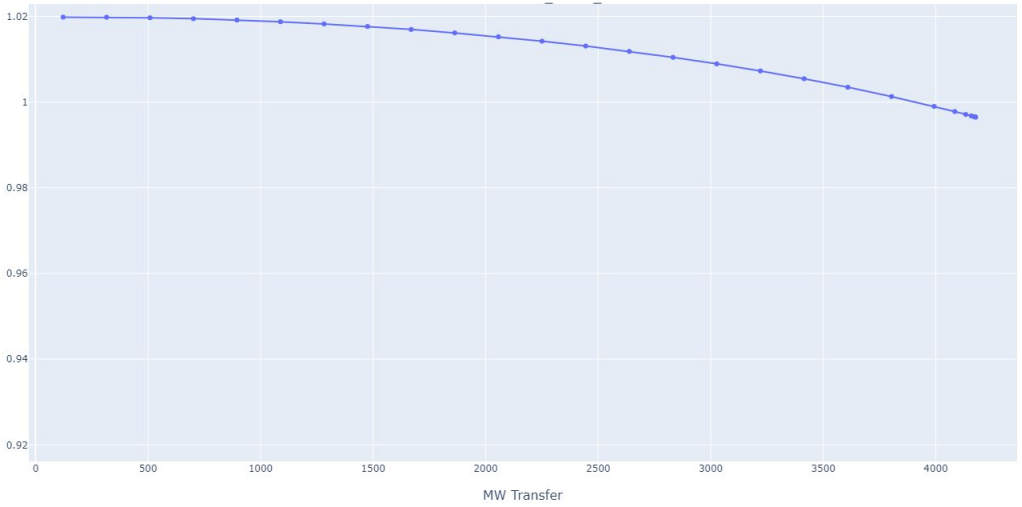


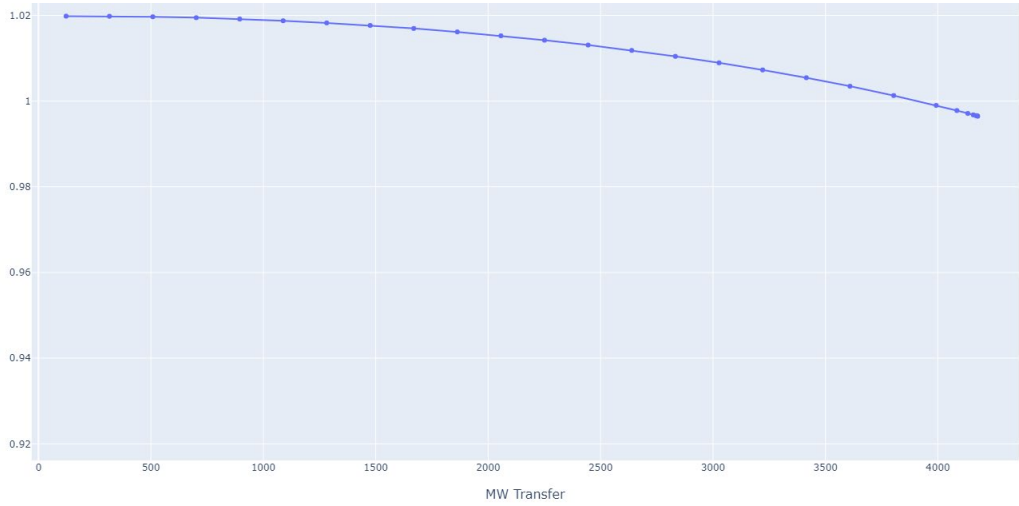


A Dynamic Stability Metric for Large Systems

Consider a Steady-State Voltage Stability Analysis (P-V Curve)

P-V Curve for a N-1 Contingency Event (No dynamic impedance utilized)





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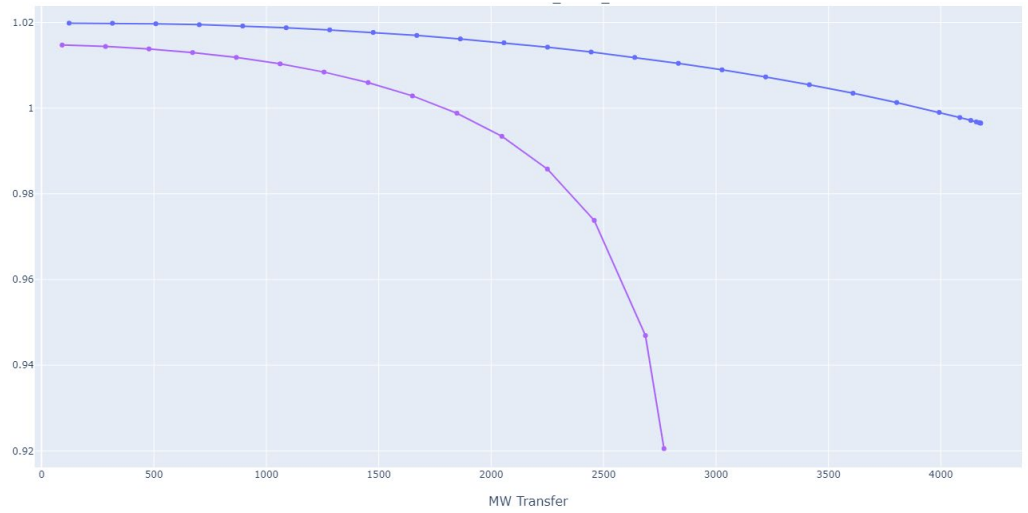
GFL-like resource at sending-end



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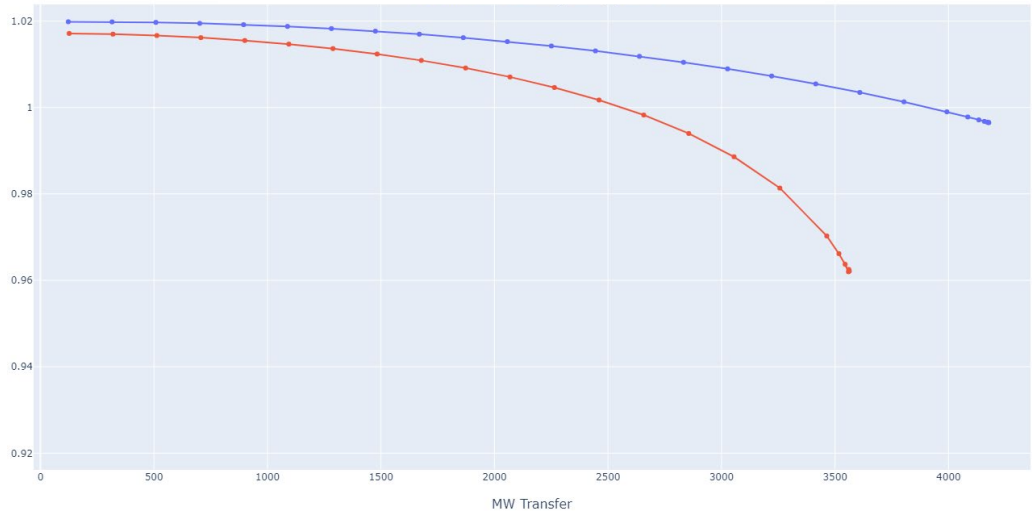

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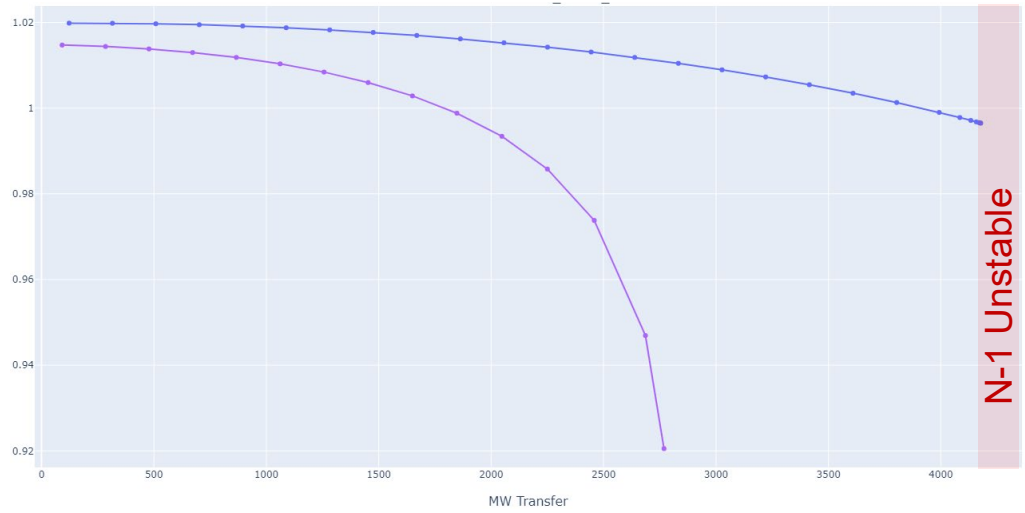

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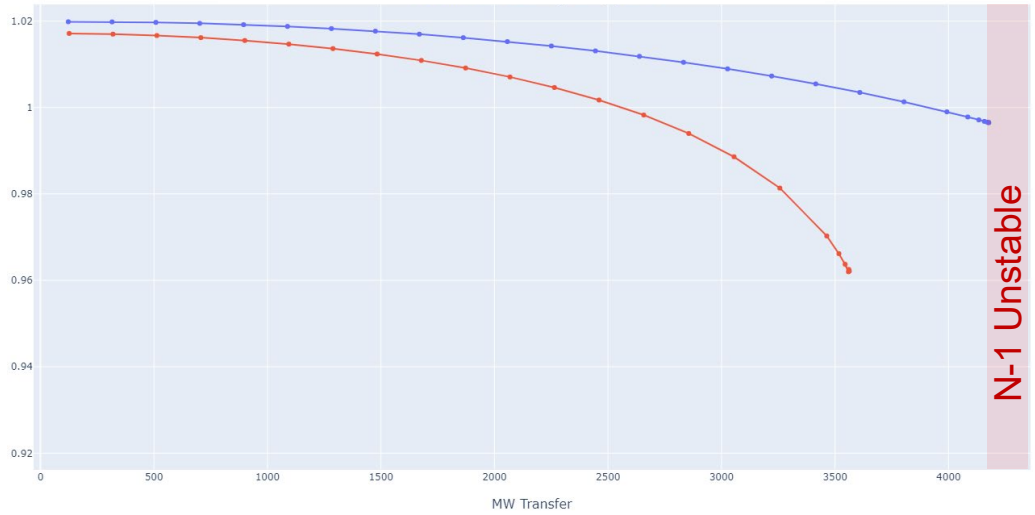

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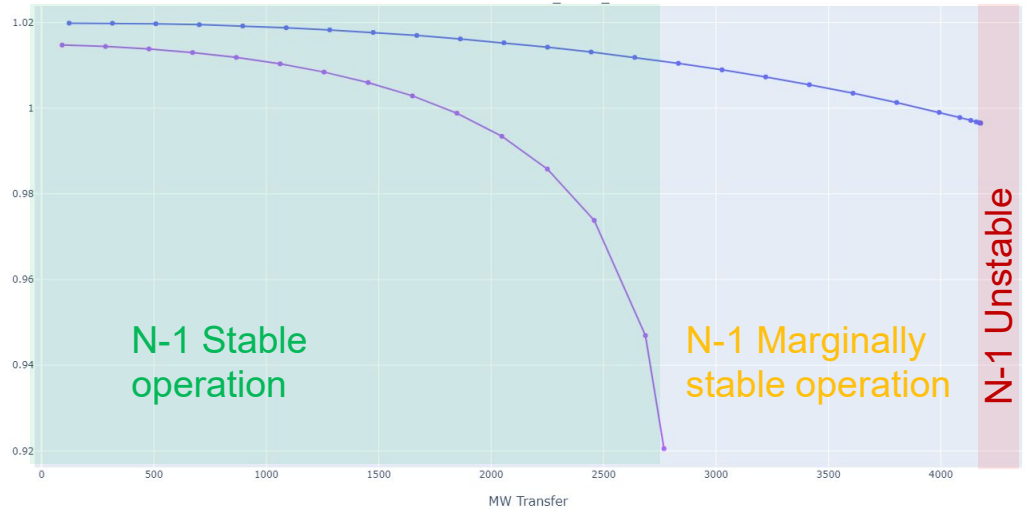

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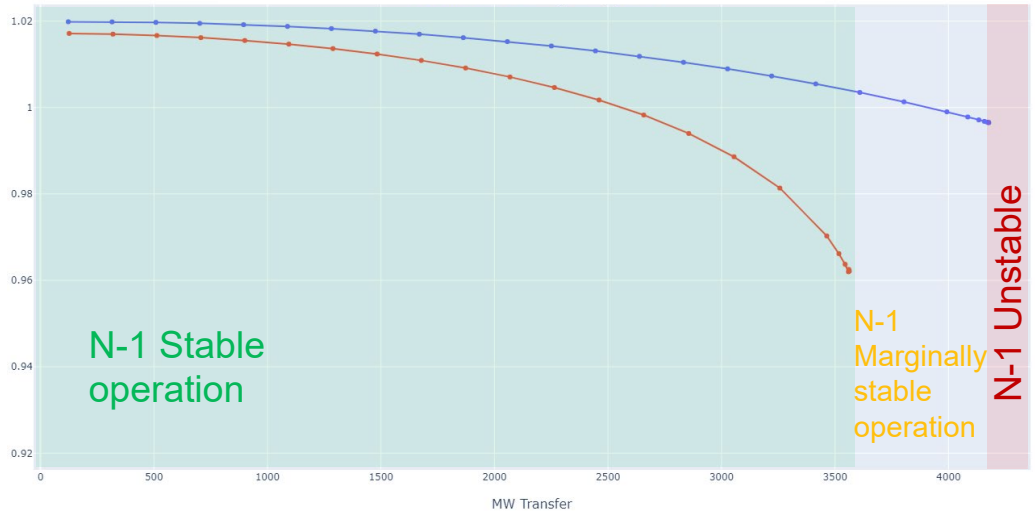

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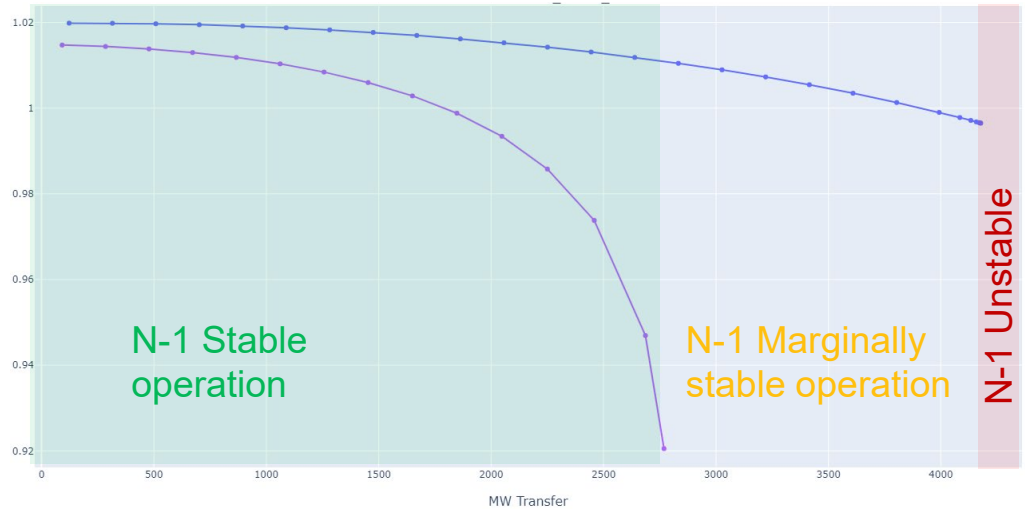

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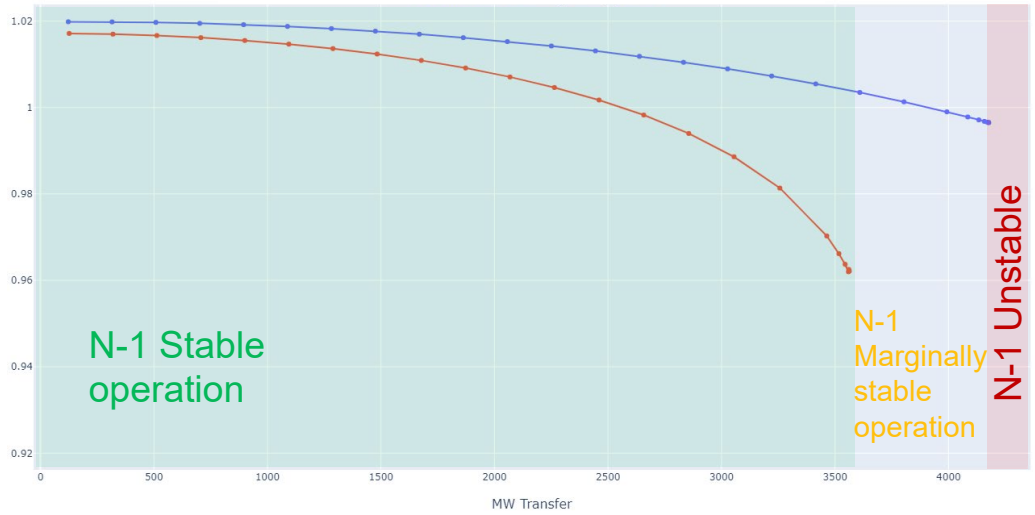
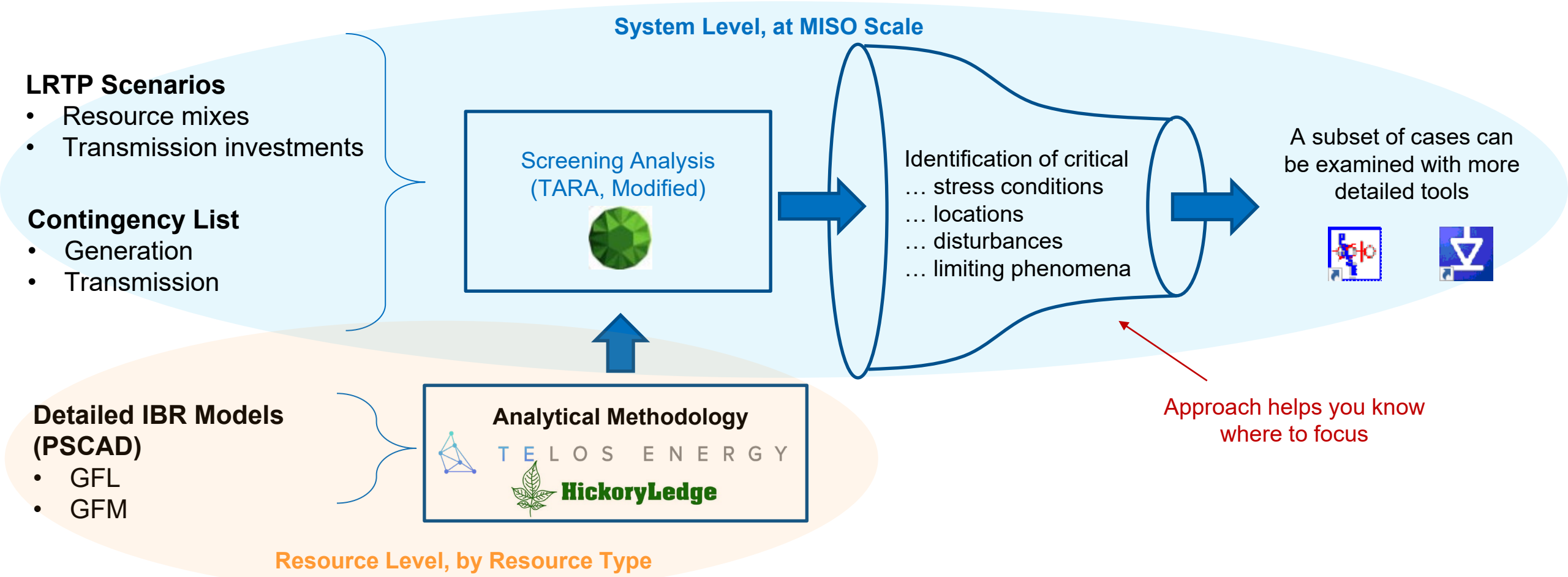


The IBR type assumed can make a large different in power transfer capability, considering dynamic stability limits!

Integration with MISO LRTP

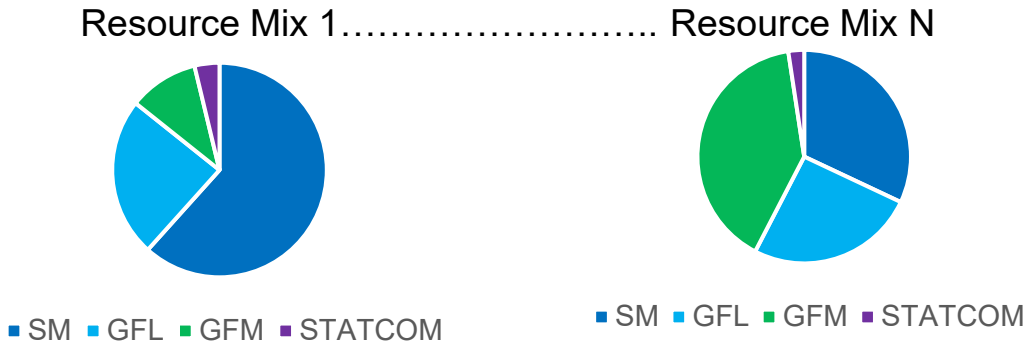


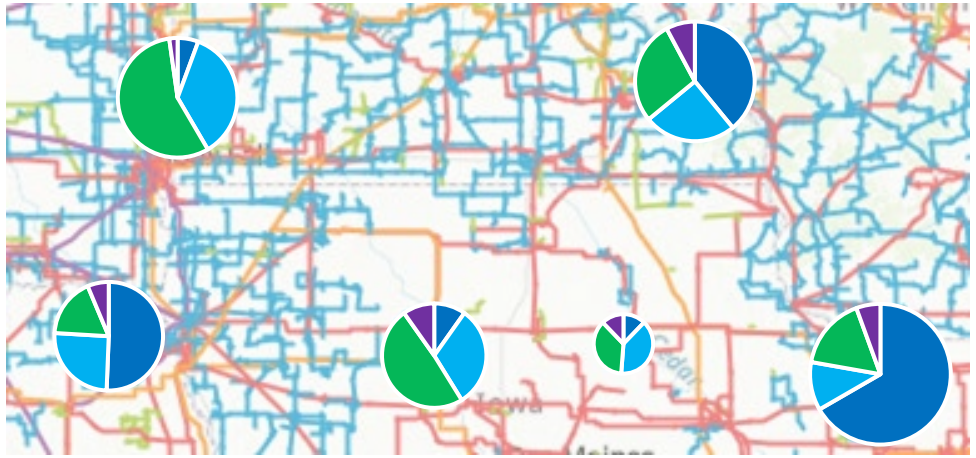
Fast method that will include representation of IBR Types → Enables evaluation of a large set of scenarios with varied resource technologies

A New Knob for Planning: Resource Type

Represent the **key stability characteristics** of **different resource mixes** in the **existing tools**

At each region / location, a resource mix…





Potential to automate this for existing (steady-state) tools and contingency analysis databases

Thank You!

Matt Richwine
Matthew.Richwine@telos.energy

Andrew Siler
Andrew.Siler@telos.energy

Nick Miller
Nicholas@hickoryledge.com