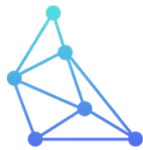


Project Overview

AC Stability Concepts in Support of LTRP

March 29, 2023 | ESIG Spring Workshop



T E L O S E N E R G Y



HickoryLedge

GridLAB

An Emerging Challenge

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

+

Practical challenges to modeling inverters

+

Quickly evolving technology



An Emerging Challenge

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

+

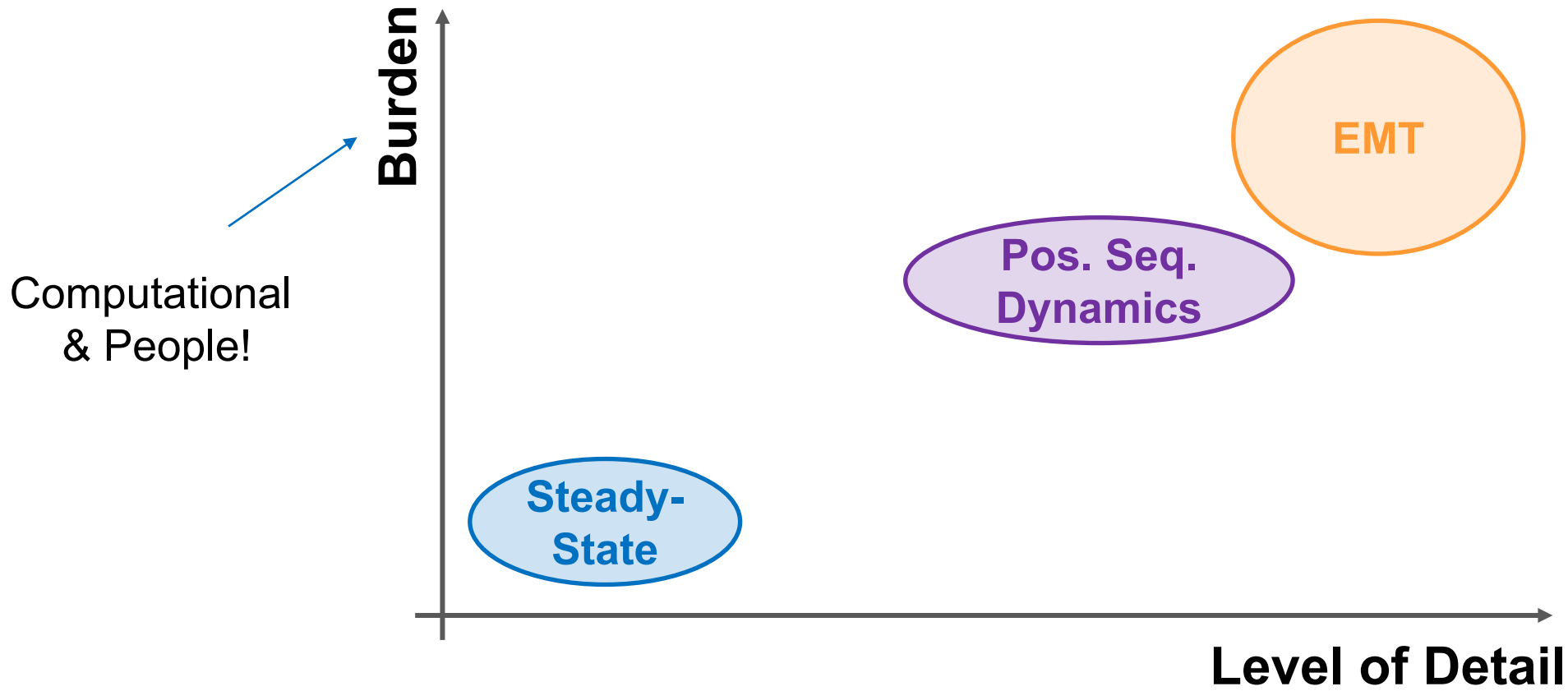
Practical challenges to modeling inverters

+

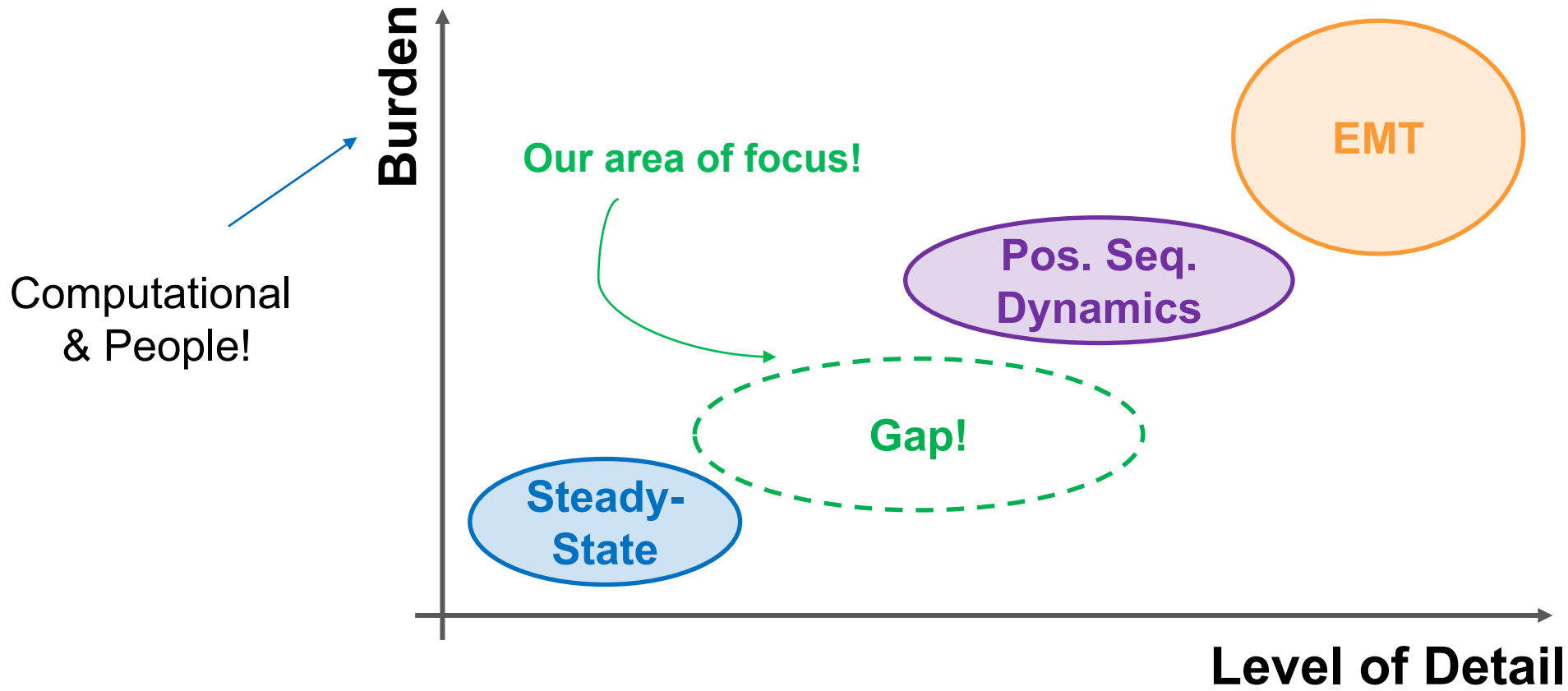
Quickly evolving technology



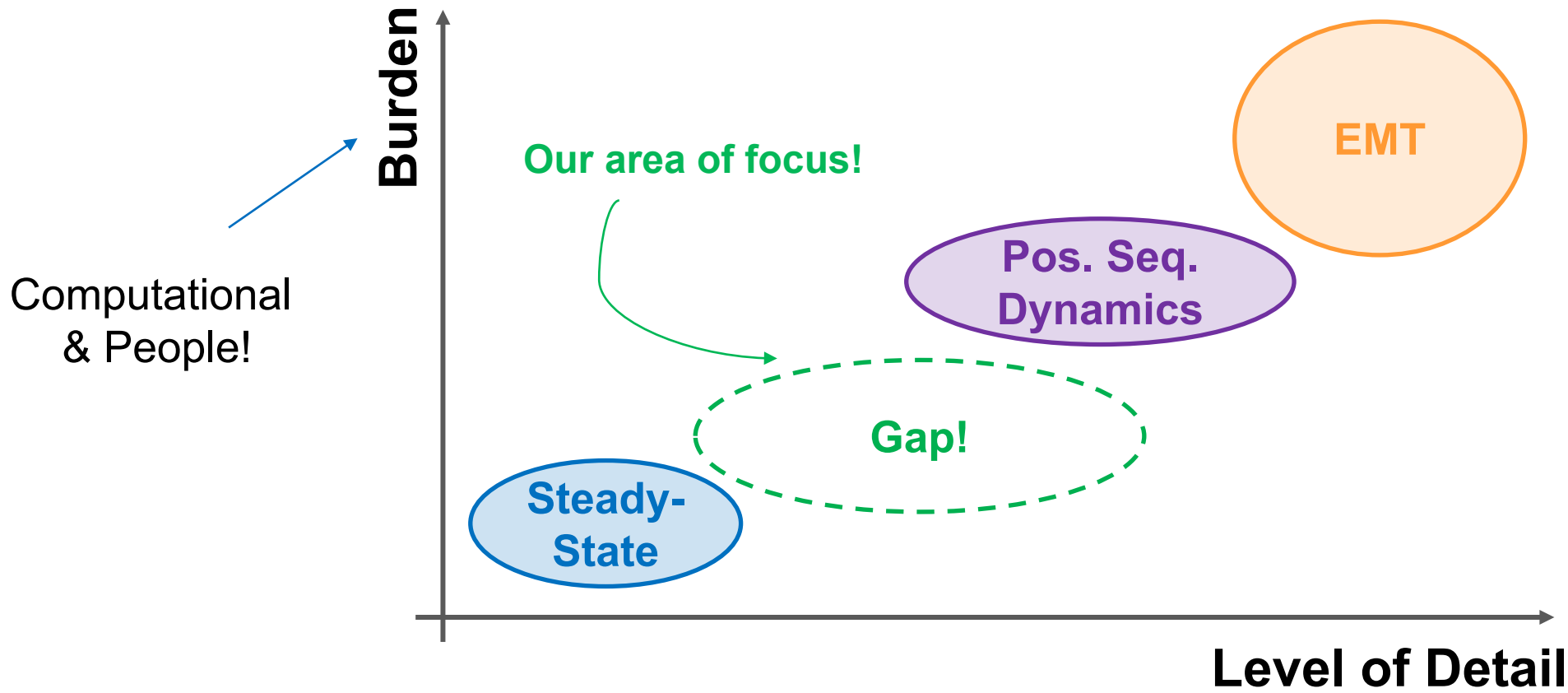
The Big Picture of Stability Studies



The Big Picture of Stability Studies



The Big Picture of Stability Studies



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



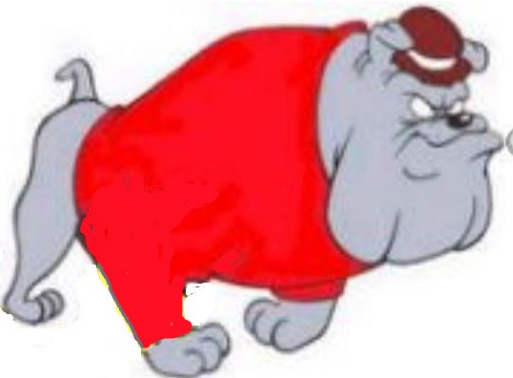
Strong Grid

Big Resource, Big Transmission Line



Weak Grid

Small Resource, Big Transmission Line

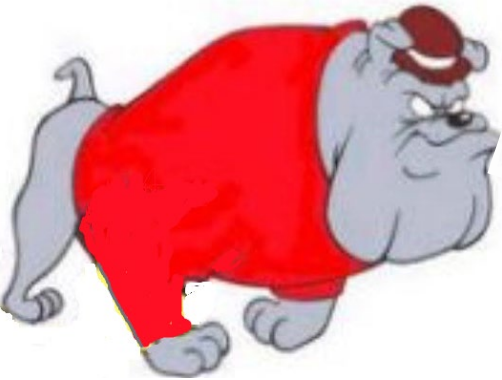


Weak Grid

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?

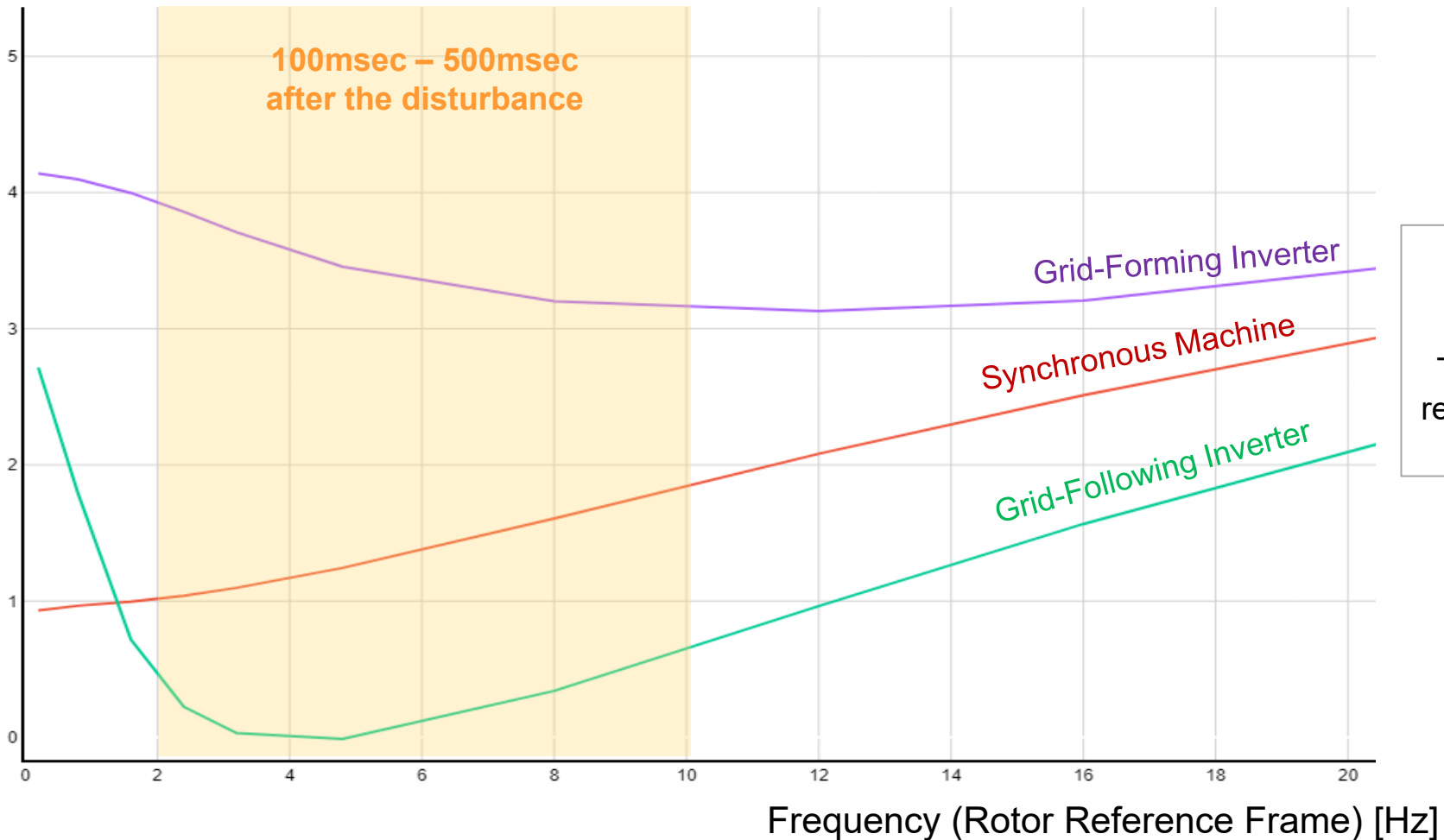


Resource Characterization, Quantified



Grid
Strengthening

(Resource's Internal
Admittance [pu])



Many steps are not
shown here, but...

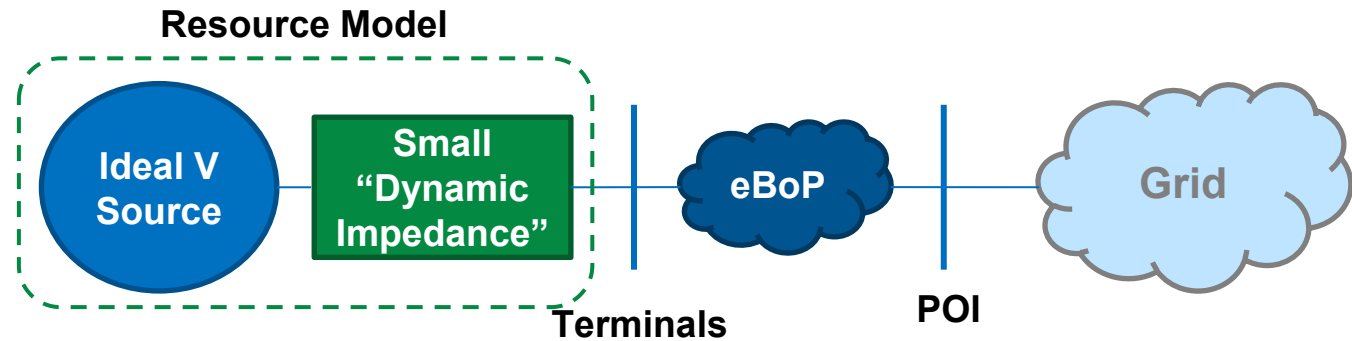
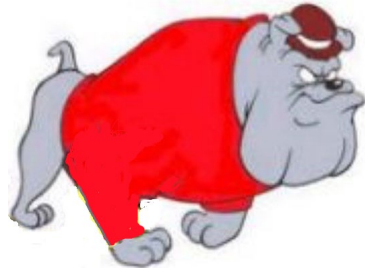
These curves are the
results of EMT analysis
of detailed models



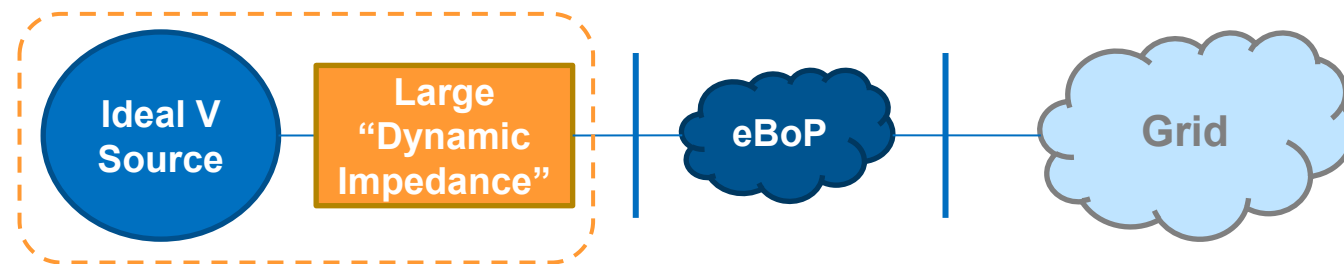
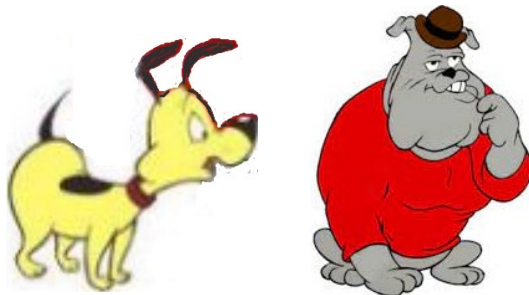
Introducing a Dynamic Impedance

A Familiar Thevenin Equivalent

Grid Strengthening
High-Admittance aka
Low-Impedance
Resource



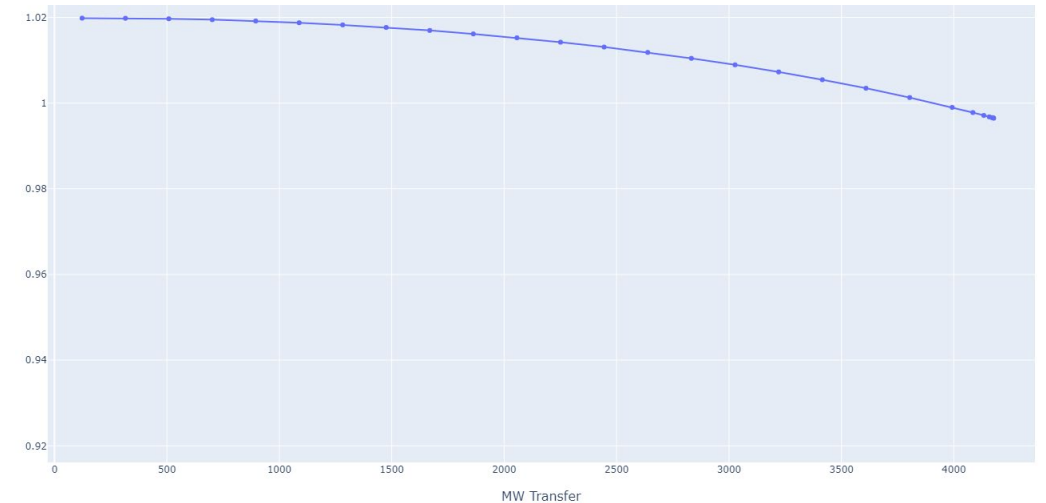
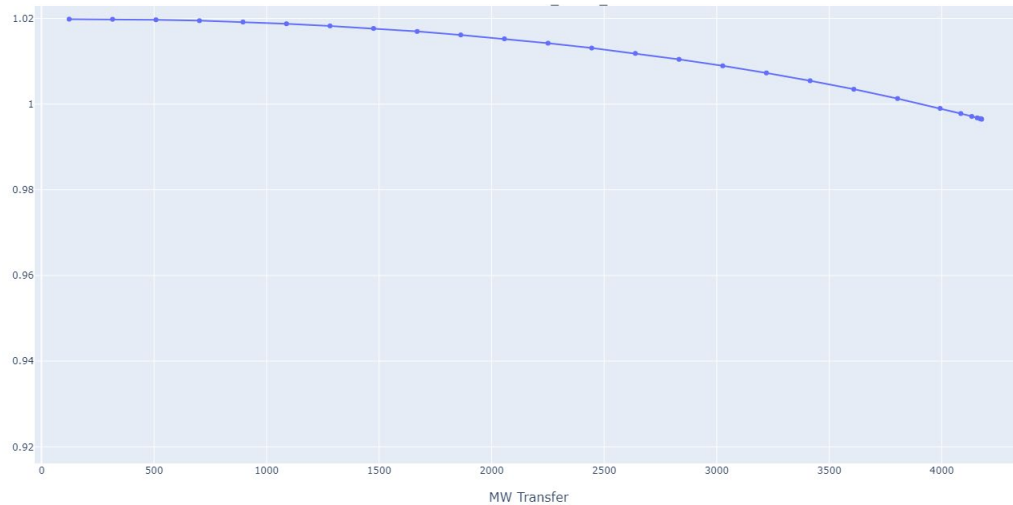
Poor Grid Strengthening
Low-Admittance aka
High-Impedance
Resources



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)

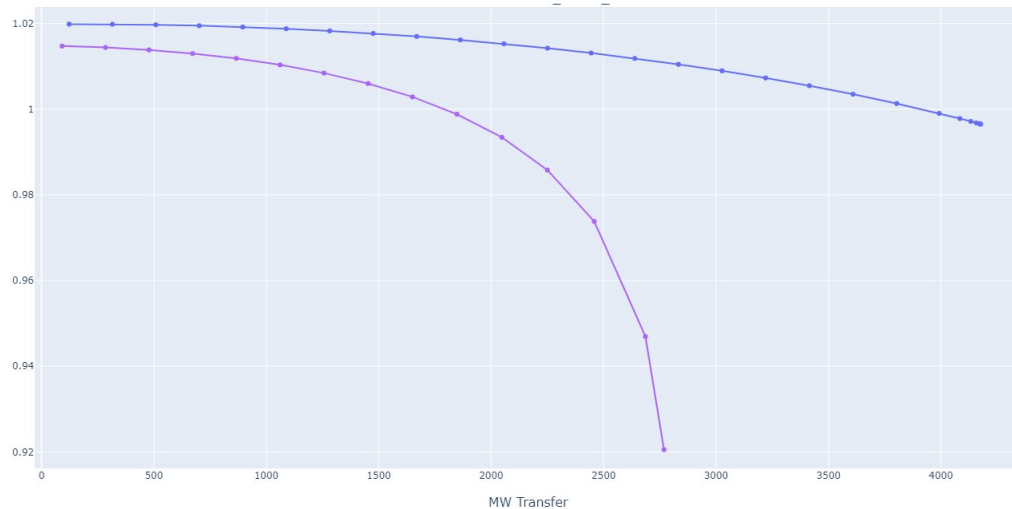


A Dynamic Stability Metric for Large Systems

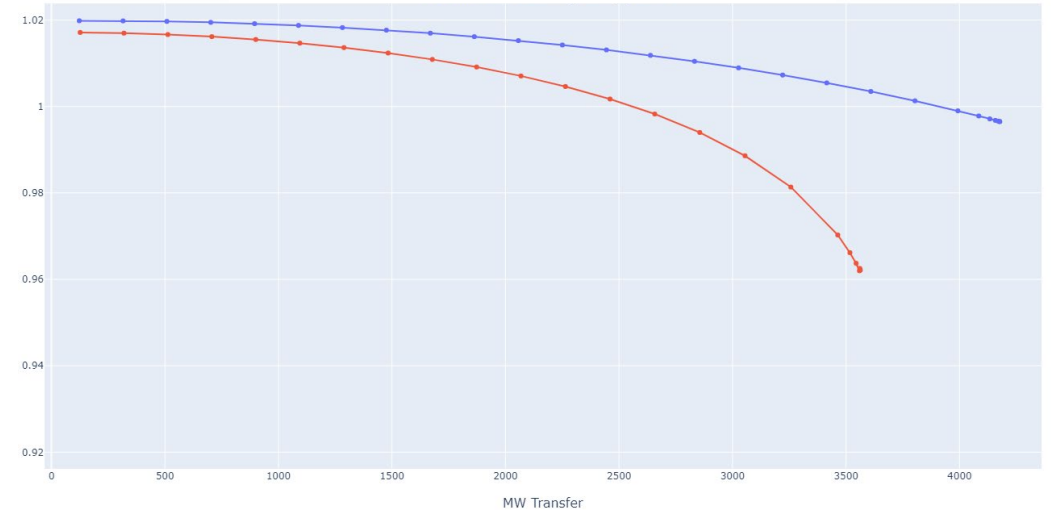
Consider a Steady-State Voltage Stability Analysis (P-V Curve)

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

GFL-like resource at sending-end



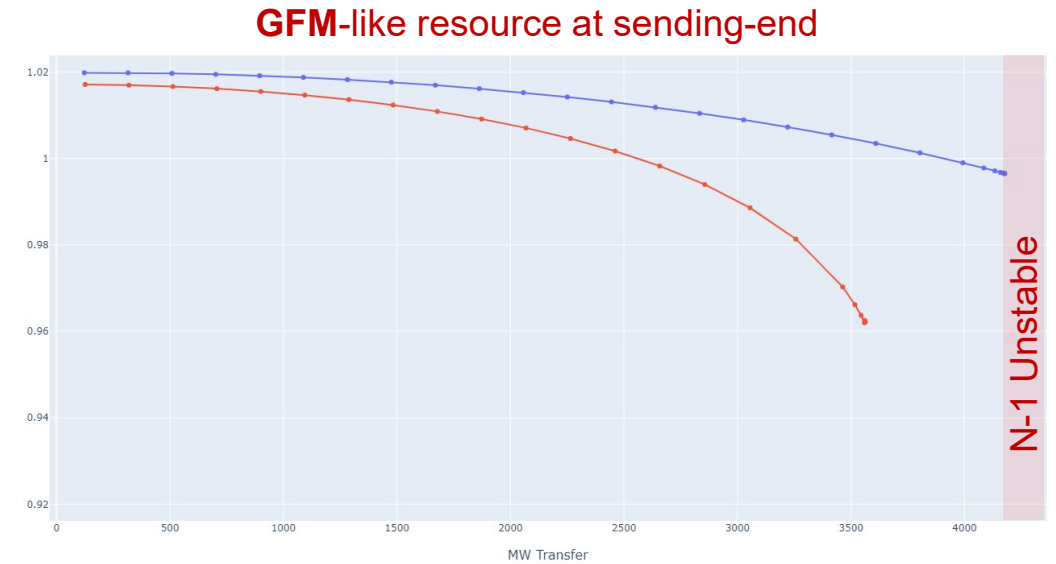
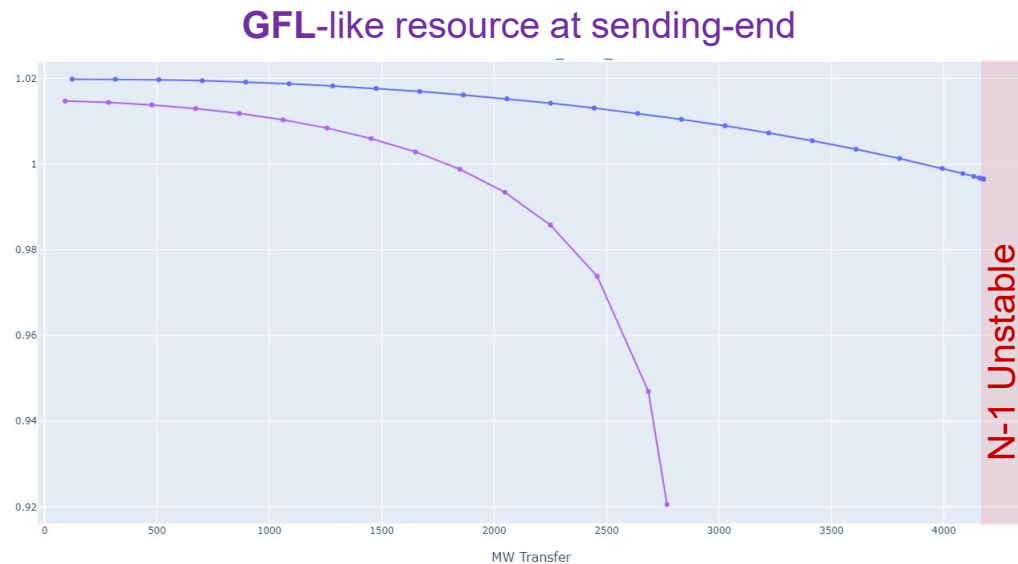
GFM-like resource at sending-end



A Dynamic Stability Metric for Large Systems

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

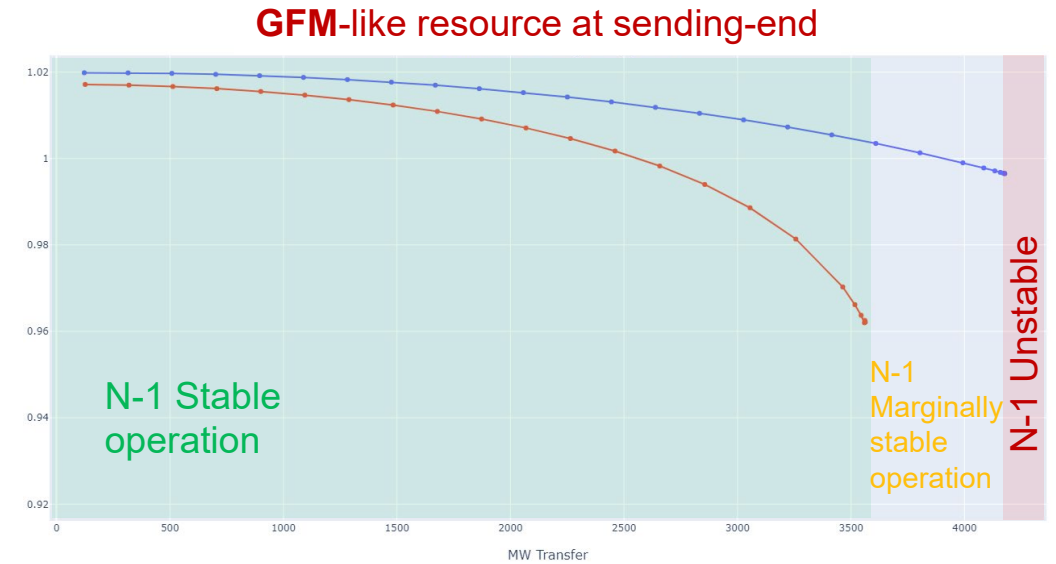
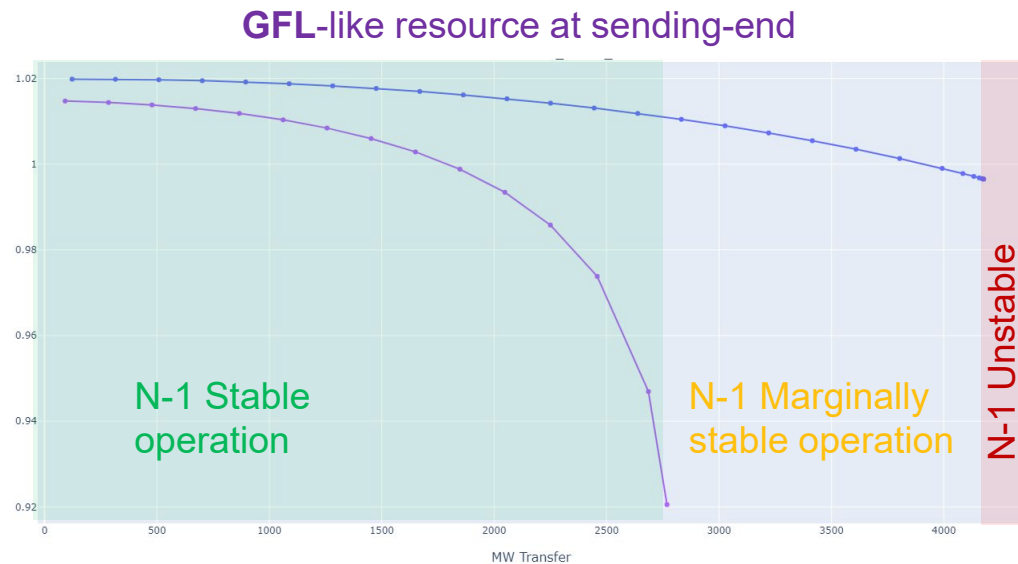
P-V Curve for a N-1 Contingency Event (No dynamic impedance utilized)



A Dynamic Stability Metric for Large Systems

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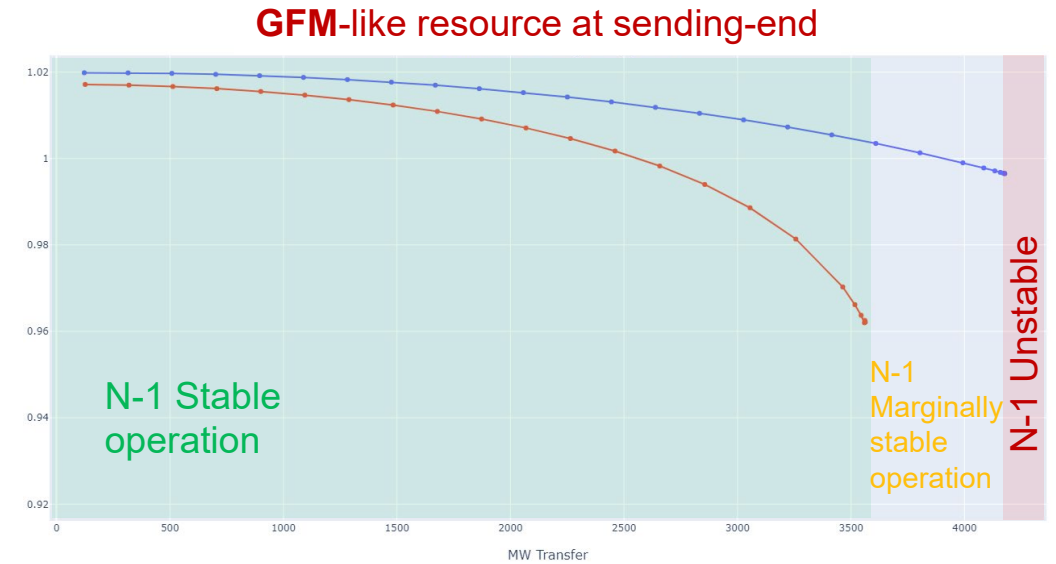
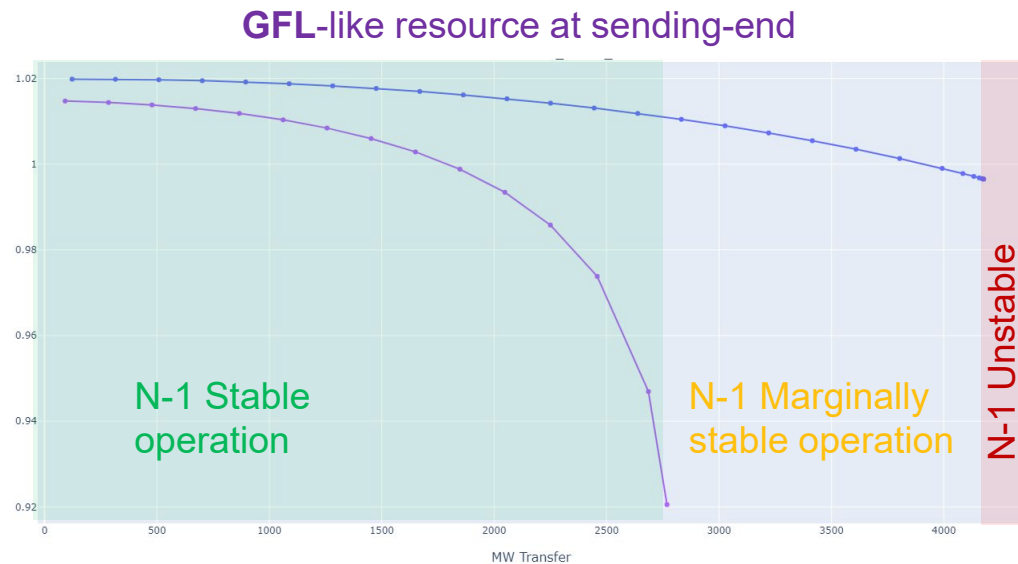
P-V Curve for a N-1 Contingency Event (No dynamic impedance utilized)



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

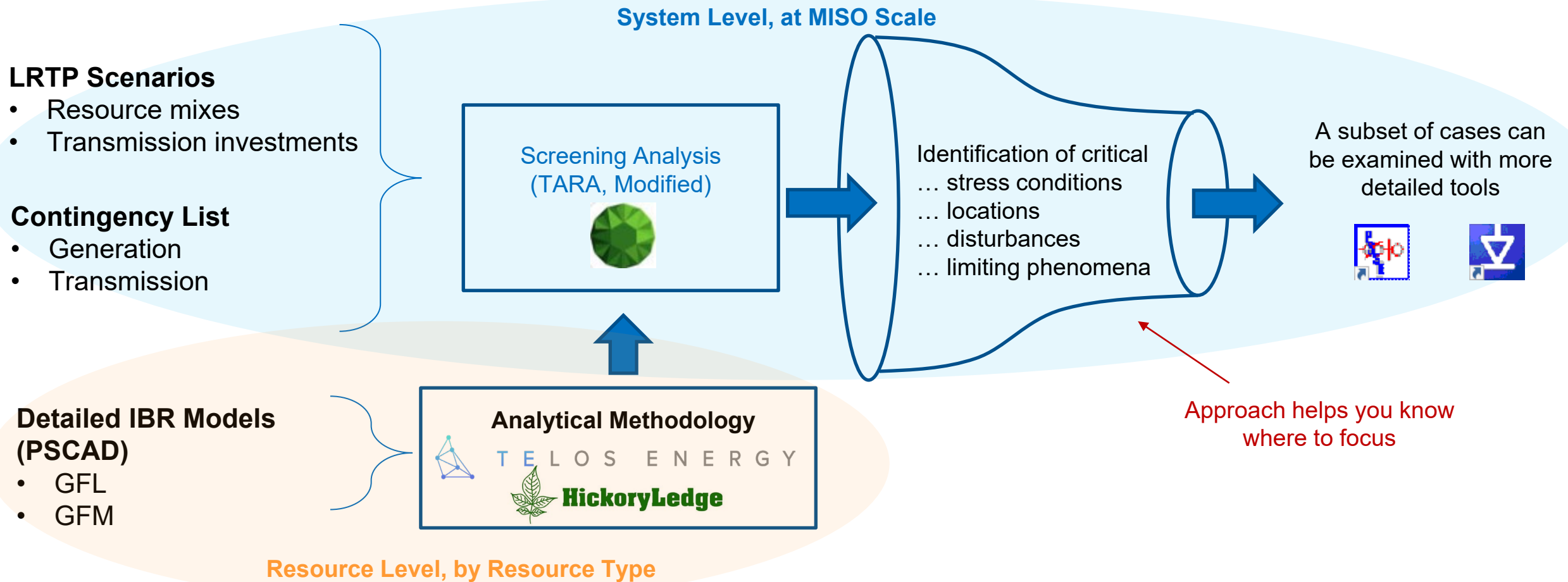
P-V Curve for a N-1 Contingency Event (No dynamic impedance utilized)



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



Integration with MISO LRTP



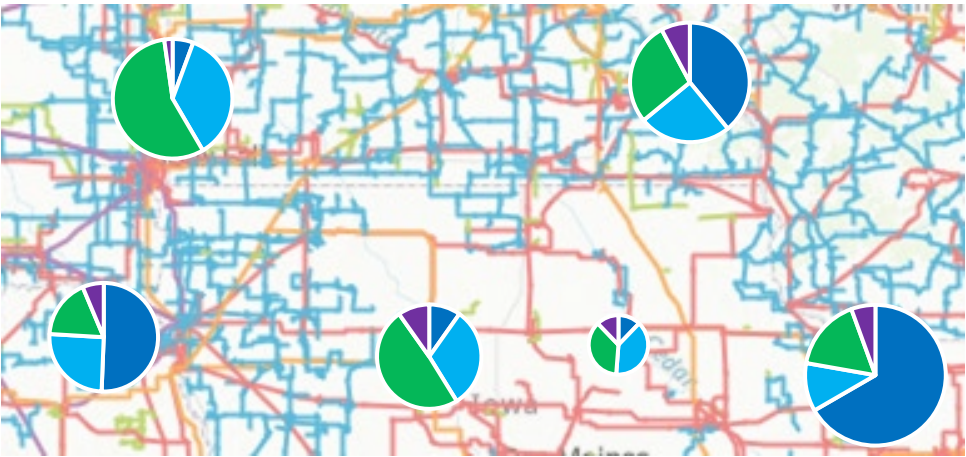
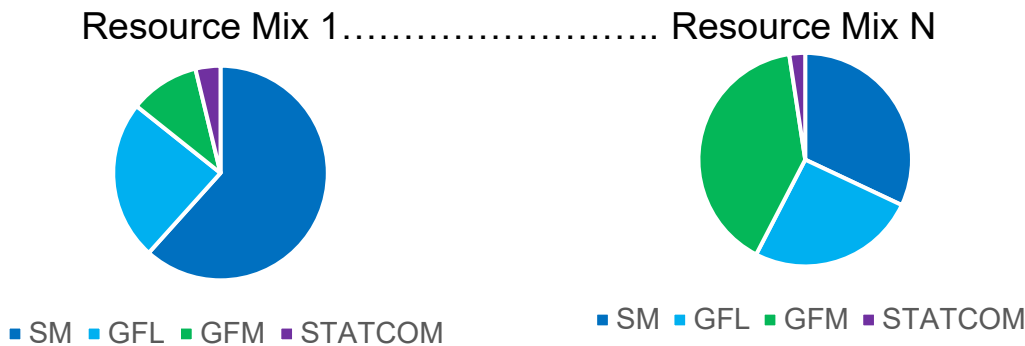
Fast method that will include representation of IBR Types → Enables evaluation of a large set of scenarios with varied resource technologies



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!

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