Industry Applications of Services Framework

ESIG
ENERGY SYSTEMS INTEGRATION GROUP

Framework Applications

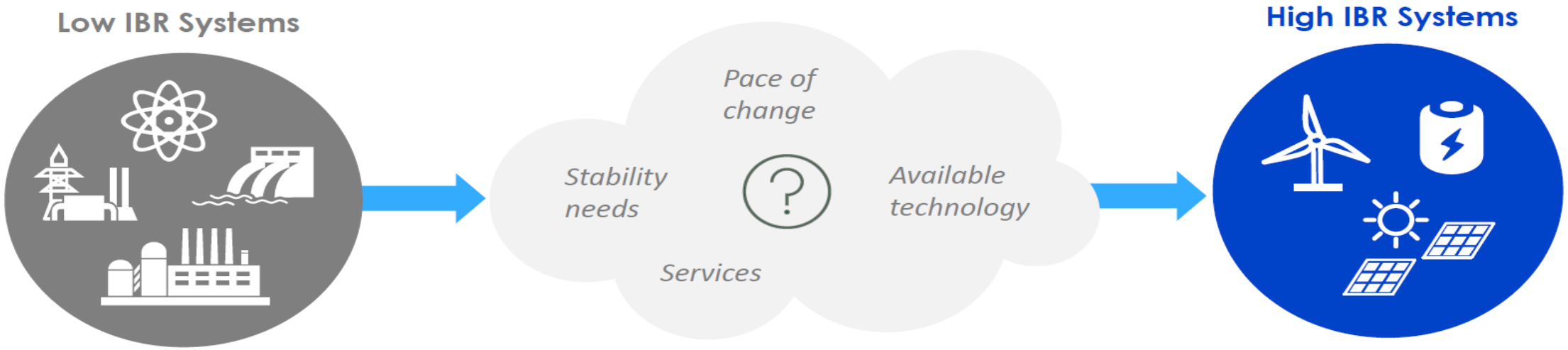
- Highlight in future scenarios / resource portfolios where there are "**weak pockets**" lacking sufficient services
- Inform how **transmission investments** may be located to deliver energy AND stability services
- Identify **potential plant retirements** that would likely to cause stability problems

Applications for Planning

- Inform where **Grid-Forming (GFM) inverter technology** should be strategically located, and how much, what reserves to maintain
- Show how **changing grid operations** (even within a day/week/seasonal) can impact the level of services and therefore, stability

Applications for Operations

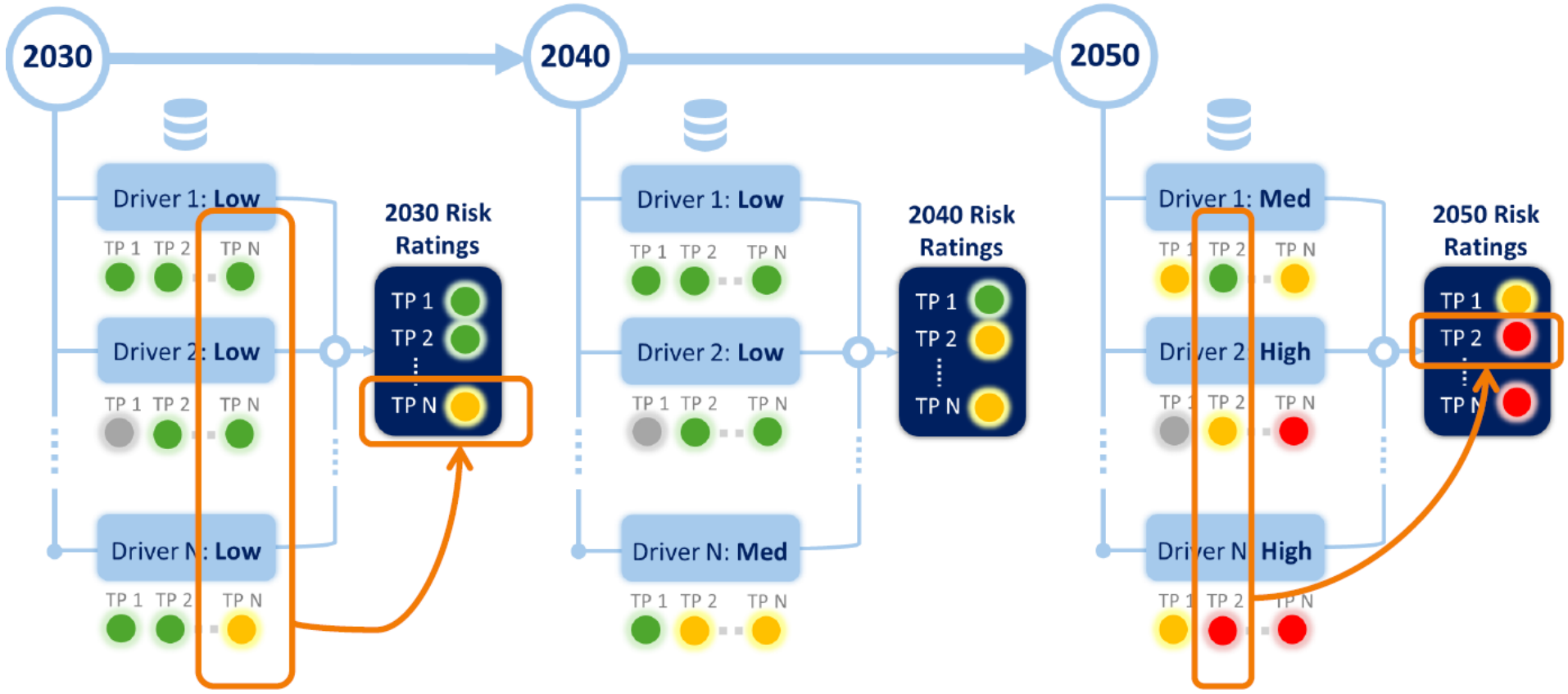
Application of the framework by a planner



L. Lederman, et. al, "System Analysis Framework to Enable Transition to NET-zero (SAFE-T NET)", NERC IRPS Presentation, August 2025

- Assessment and comparison of future scenarios in terms of stability and resilience requires multiple risk assessment frameworks, with assessment of services being critical
- Quantifying services in a seamless manner becomes a critical piece of these risk assessment framework

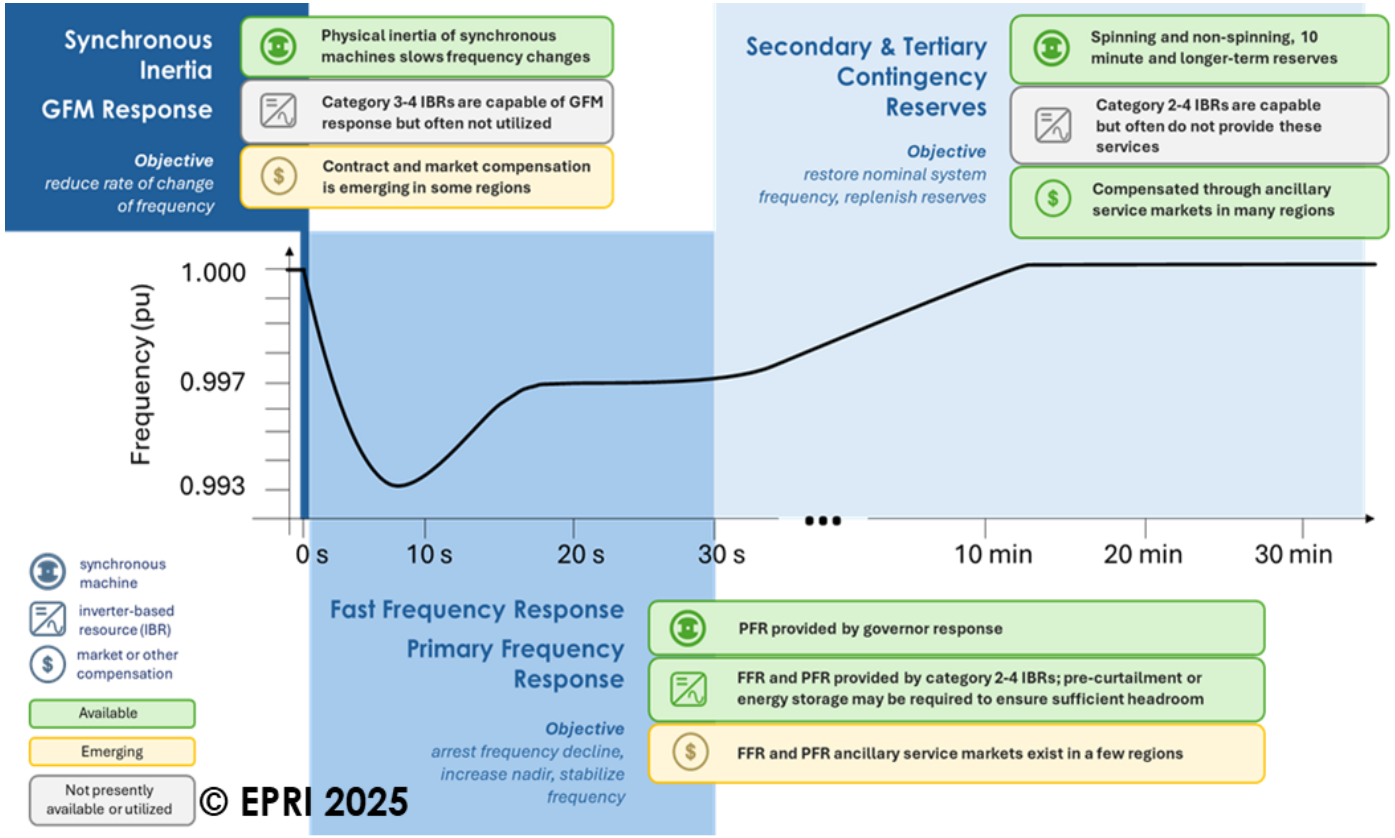
Application within a risk assessment framework



System Analysis Framework to Enable Transition to NET-zero (SAFE-T NET), EPRI Palo Alto, CA: 2025, 3002033340 [Link]

- Service available within a region of the system, or for a particular event, can be a technical parameter (TP) for multiple drivers of change in long term planning decisions
- The magnitude of service that is available, determined from the services framework, can help determine the risk rating

Gaps today in ascertaining services for frequency stability

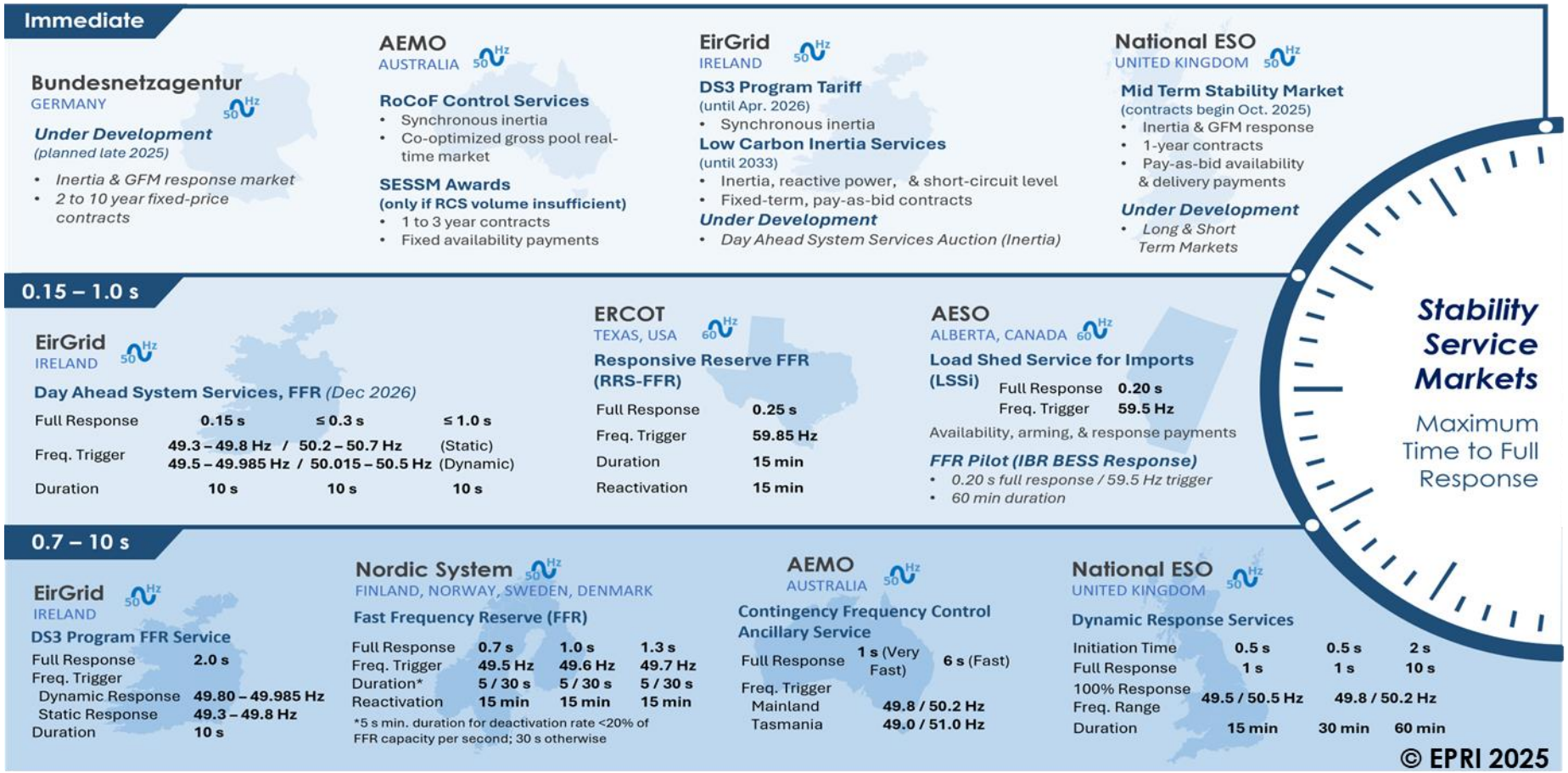


Emerging Grid Services for Reliable Decarbonized Systems, EPRI Palo Alto, CA: 2025, 3002032375 [Link]

- There are various emerging market mechanisms related to procuring services from IBRs
- Majority of these mechanisms concentrate on the short time scale
- However, ascertaining the needs for a particular service from the grid perspective is presently lacking
- If the need (and amount) is not quantified, then procurement can be non-efficient, which can also impact time to market for a product.

A services framework allows for planning/operations teams to identify how much of a service is needed in a particular area/zone to develop a mechanism for procurement

Examples of emerging stability service markets



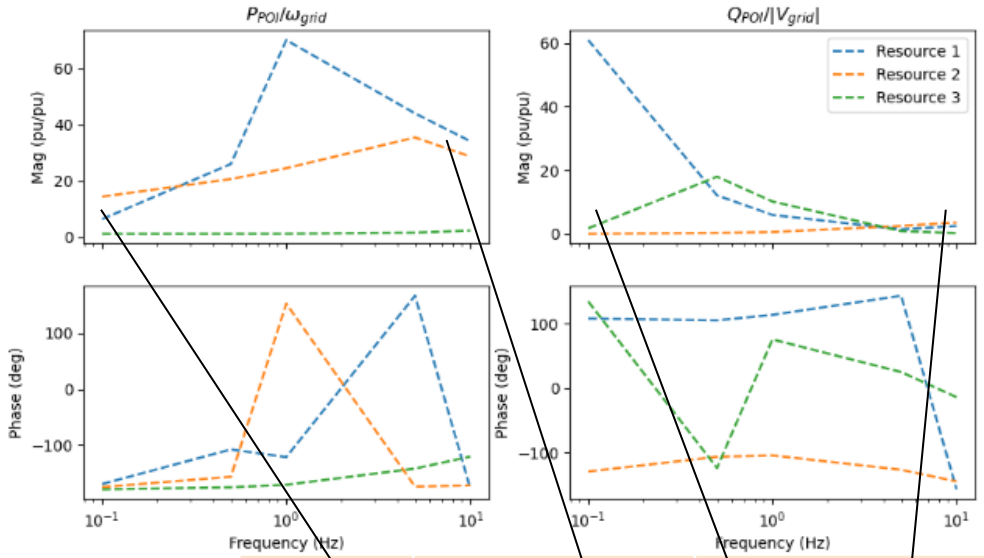
Emerging Grid Services for Reliable Decarbonized Systems, EPRI Palo Alto, CA: 2025, 3002032375 [Link]

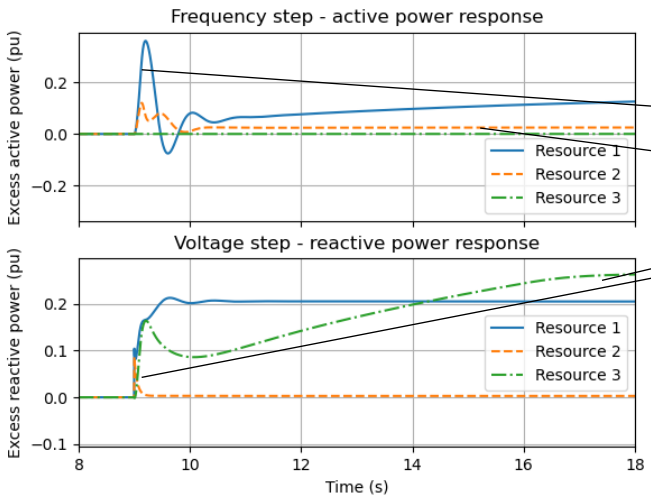
- Stability service markets are designed to require a magnitude of response expected to be delivered in certain time frame
- Quantification of the response actually delivered is however dependent on the control architecture that is present in the resource.

A technology agnostic framework to compare across different technology is required.

Application of the framework by a planner and/or Generator Owner

- An individual resource's service offering into a market can be evaluated and compared against other resources' offering
- Nuances associated with technology type and/or control architecture can be identified
- Total available service within a region can be determined by the planner
- Impact of UC and ED on availability of services can be identified





Resource	Frequency/Active Power		Voltage/Reactive Power	
	Slow	Fast	Slow	Fast
1				
2				
.				
.				
n				
Total	=Σ…			

IBR-ID/CA

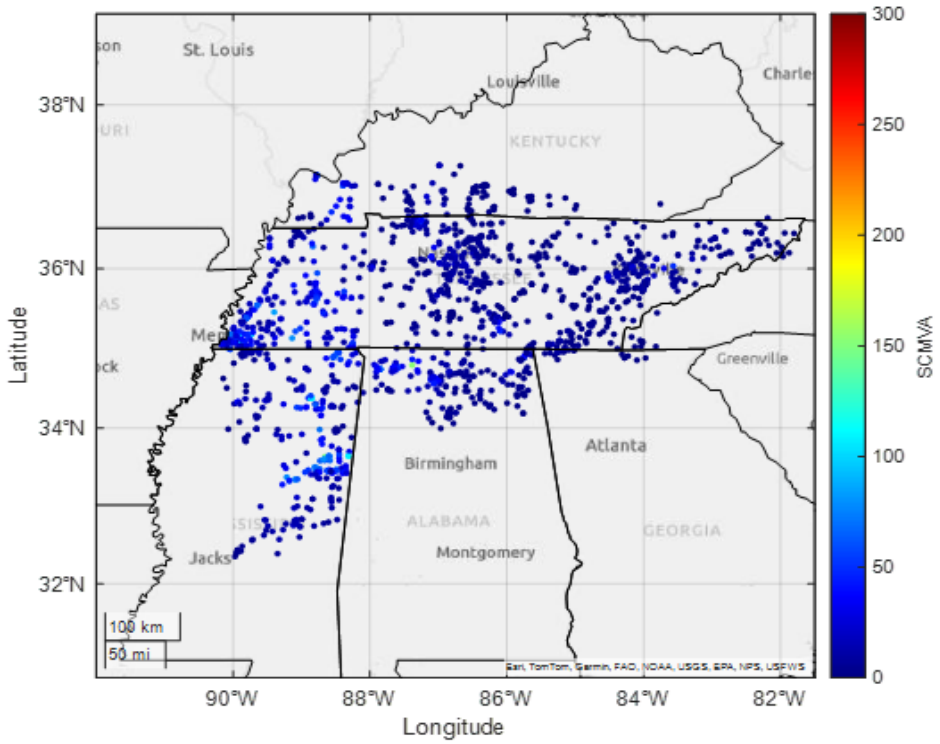
Application of framework to assess system performance

SCMVA Changes with Xsource Characterization for Different Parameterizations

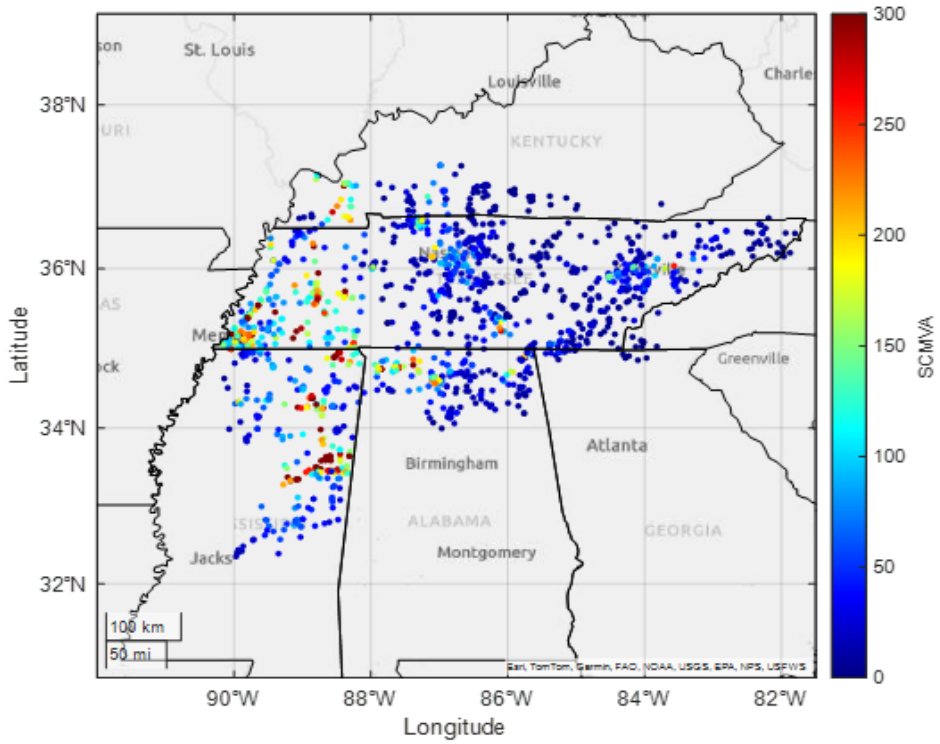
EPRI
GSAT

- The colors represents the increase in SCMVA at 161kV Buses, compared with original Xsource = 999 p.u.
- Xsource equivalent for Slow/Med/Fast parameterizations are similar at ~5.76 p.u., and Cat-III is 0.88 p.u.

Slow/Med/Fast Parameterization – Equivalent Xsource: ~5.76 p.u.



Cat-III Parameterization – Equivalent Xsource: 0.88 p.u.



- The services framework can be used to identify more accurate impedance characteristics of sources w.r.t. their control objectives
- The increase in accuracy of impedance translates into improved visibility into services across the network

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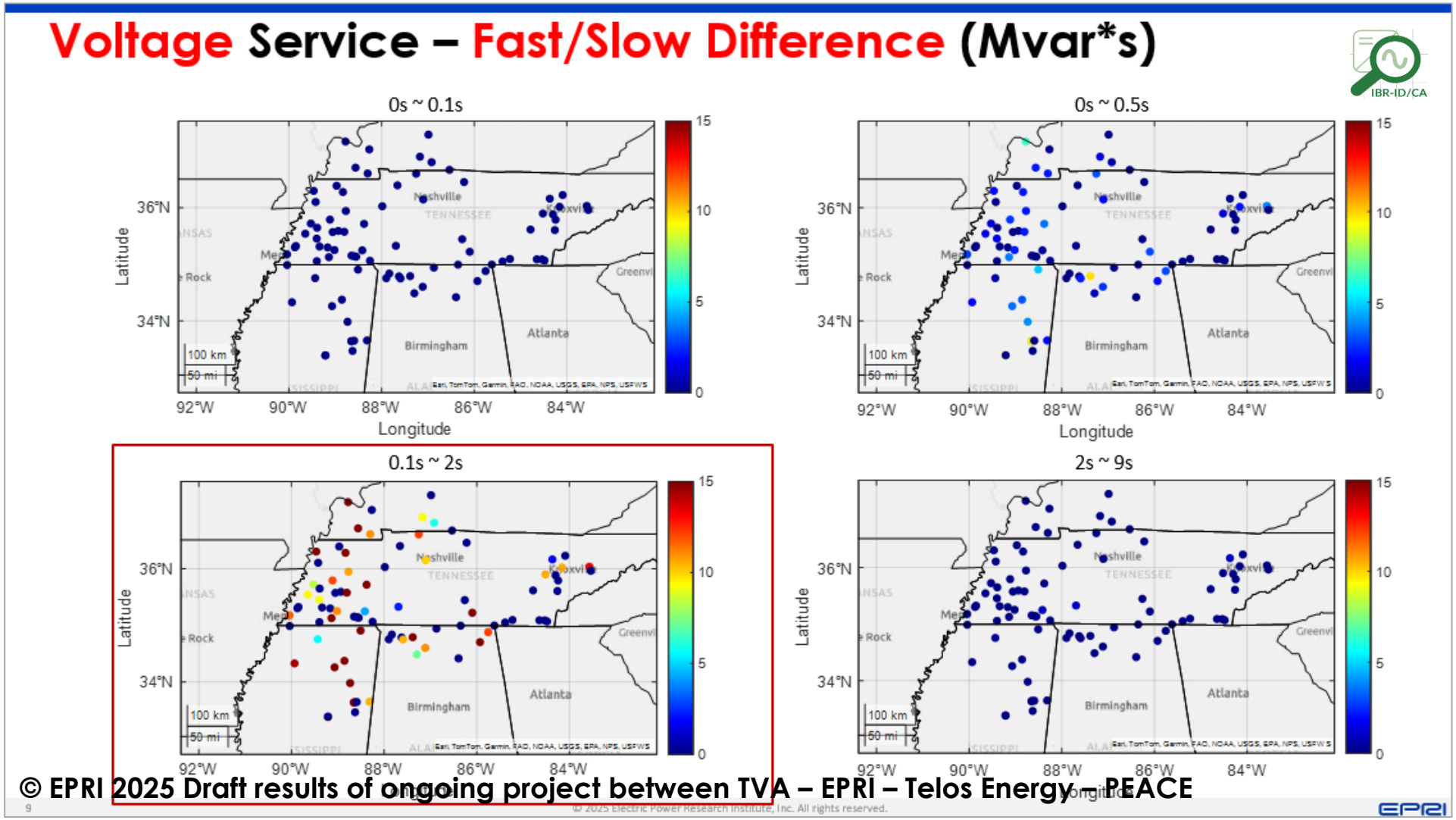
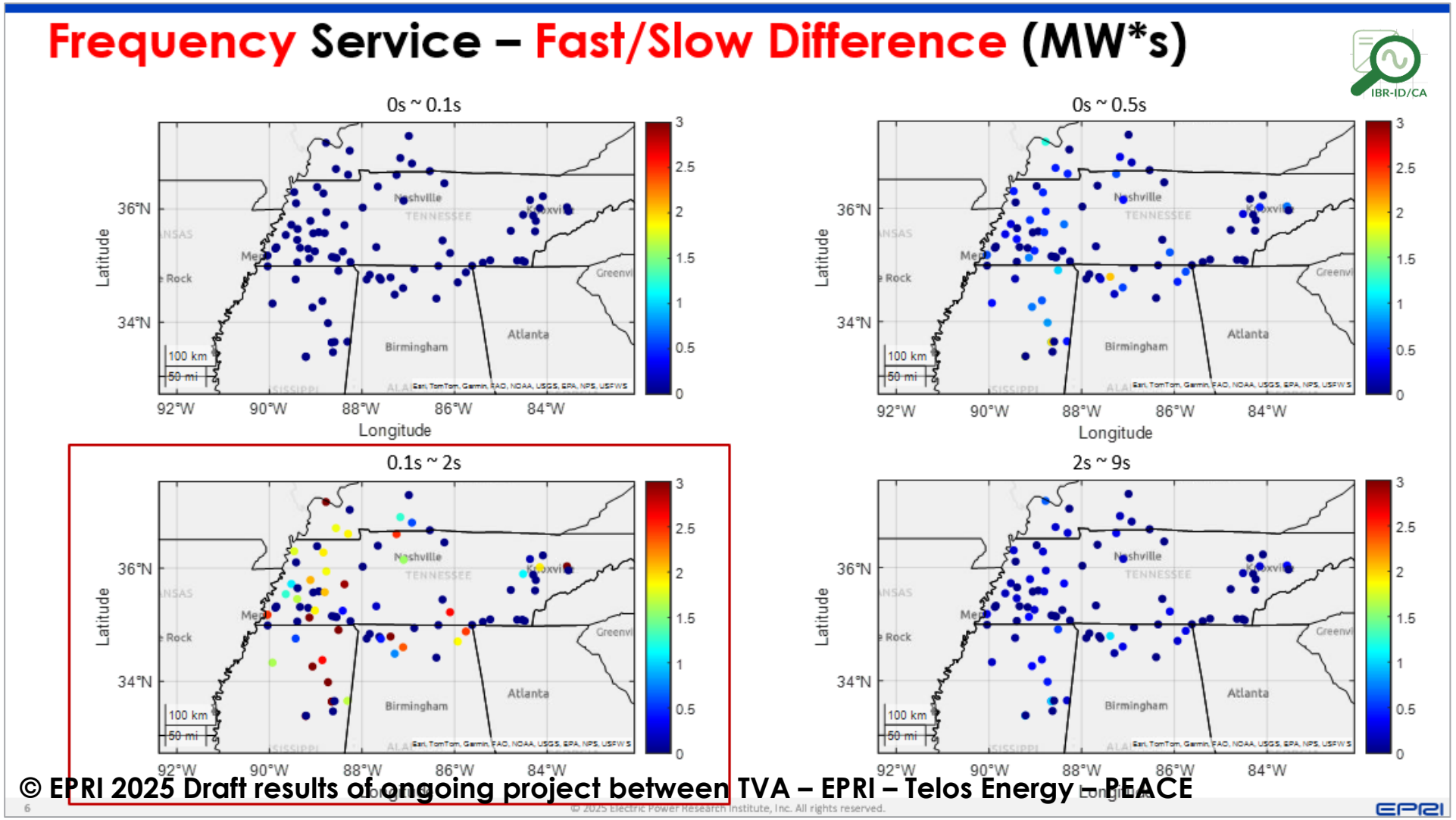
Application of framework to assess system performance



- The services framework also identifies differences in response to a contingency w.r.t. time and w.r.t. control architecture of devices
- It allows for identification of type of response that may be available or lacking in the network

Application of framework to assess system performance



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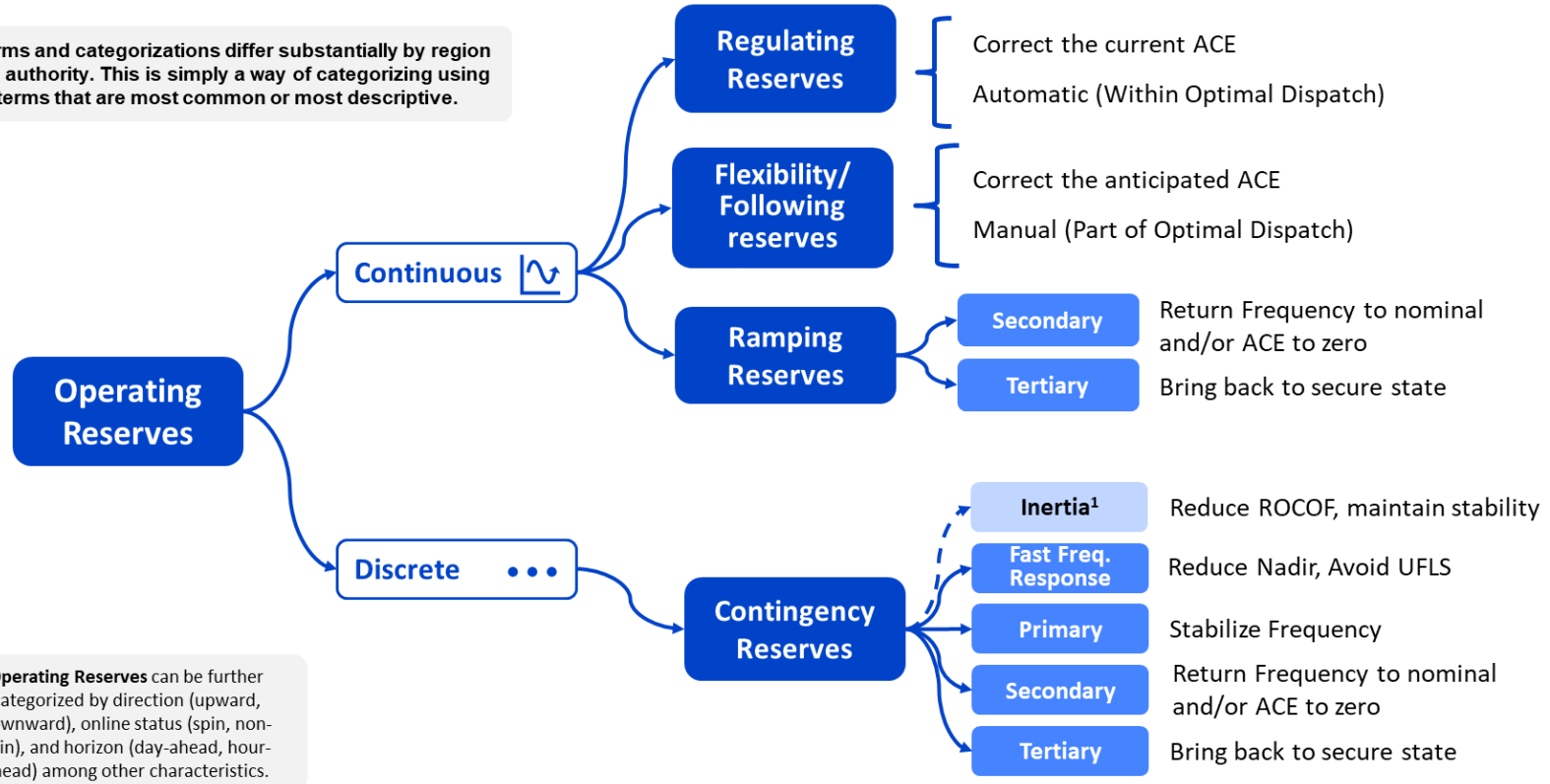
- The services framework also helps identify the type of system support device that may be needed in a network, and where it should be located

Use of the services framework by an operator

[1] Inertia is not a reserve but part of the instantaneous event correction process.

*Terms and categorizations differ substantially by region and authority. This is simply a way of categorizing using terms that are most common or most descriptive.



Operating Reserves can be further categorized by direction (upward, downward), online status (spin, non-spin), and horizon (day-ahead, hour-ahead) among other characteristics.

- Reserves, and their determination, helps ensure system remains within its risk ceiling
- Data from the services framework can be used to help determine both continuous and discrete operating reserves

"Video Tutorial: Illustrating Operating Reserve Needs and Methods—Operational Support Tools to Help Meet Variability and Uncertainty, Version 4.0," EPRI, Palo Alto, CA, Rep. No. 3002021781, Nov. 2021.

Services framework can help with answering:

How should contingency reserve requirements be assigned to each area of a system?

- Divide total reserve of the system equally among all areas?
- Prorate as a function of installed capacity?
- Prorate as a function of load?
- As a function of their risk contribution to the system?

Reserve is assigned by areas to ensure that each area has enough generation capacity to meet its demand and maintain a reliable operation. Different areas may have different reserve requirements, depending on their load, generation, transmission, and regulatory characteristics. Areas with limited transmission interconnection need more reserve to deal with contingencies and avoid voltage collapse.

Application of the framework for both planning and operations

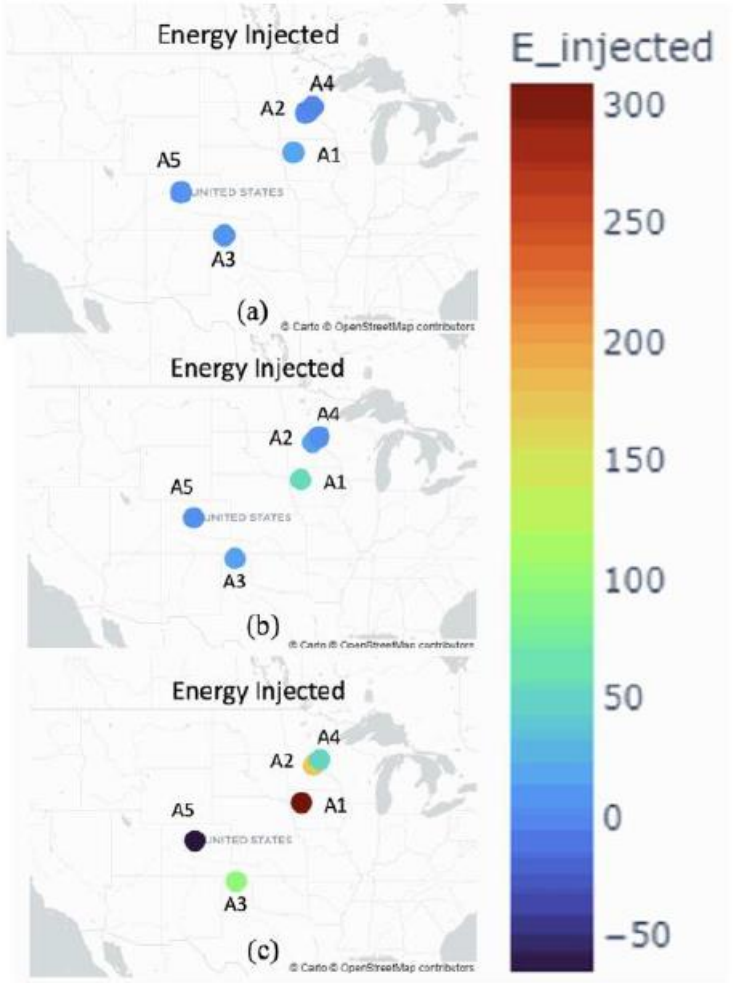
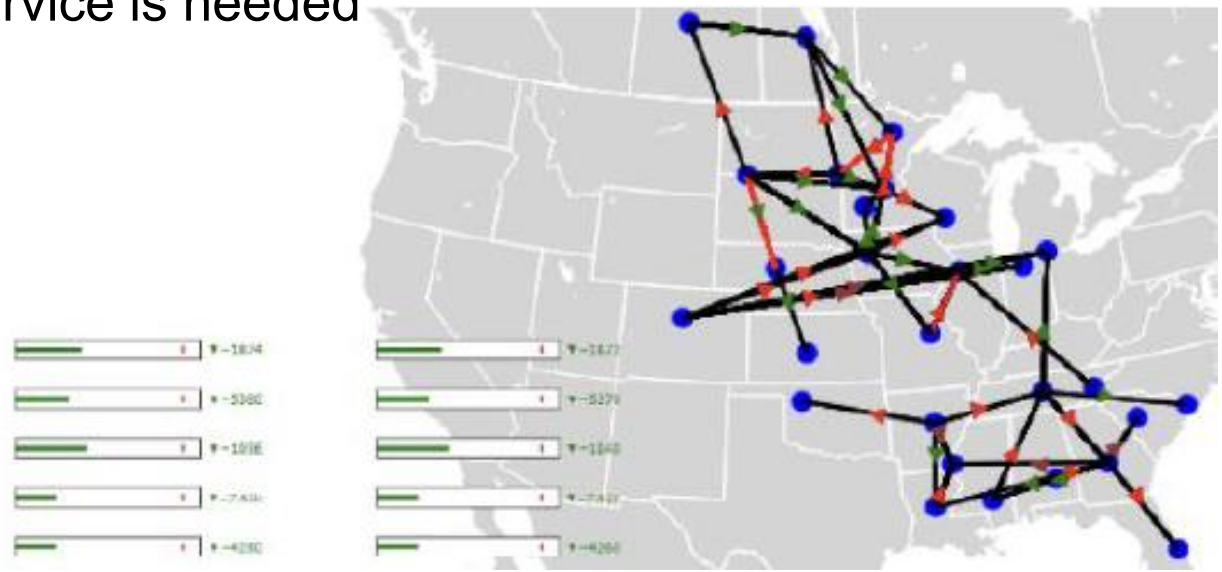


Fig. 4. Area-wise *IBR* momentary energy injection from areas A1-A5 between time intervals, $t =$ (a) 1 s and 4 s, (b) 4 s and 8 s, and (c) 8 s and 40 s.

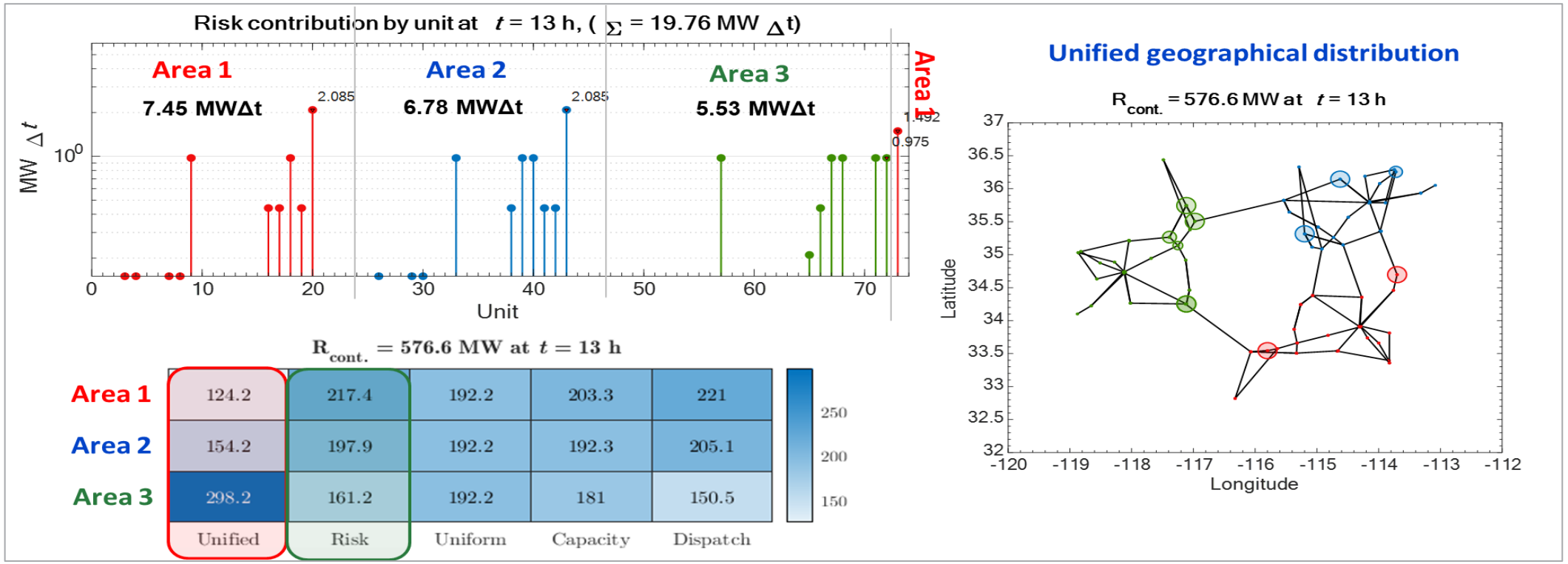
- Upon occurrence of an event, 'services' can flow from one area to another, with flows potentially changing over time
- The evolution of services from devices over time, obtained from the framework, can be used to visualize the location on the network where a particular additional service is needed



G. Iswaran, et. al, "Visualization for Quicker Insights into Dynamic Response of Large Power Network", *2025 IEEE PES General Meeting*

Framework that operator can adopt

- Using the developed services framework, contingencies in which each unit participates can be identified, thereby estimating its overall risk contribution.
- Using this information, allocation of reserves by area can be determined.



Energy Storage: Boosting System Performance and Cutting Costs — But What About Operating Risk?: 2024 Technical Update. EPRI, Palo Alto, CA: 2024. 3002031321