Exploring Modeling Challenges with Wide-Area Energy Assessments

POWERGEM

Agenda

1 **SERVM Topology for Wide Area Assessments**

Commitment & dispatch across 50+ zones

2 **Modeling Market Friction**

Reserve sharing, EOPs, economic constraints on power flow

3 **Visualizing Diversity**

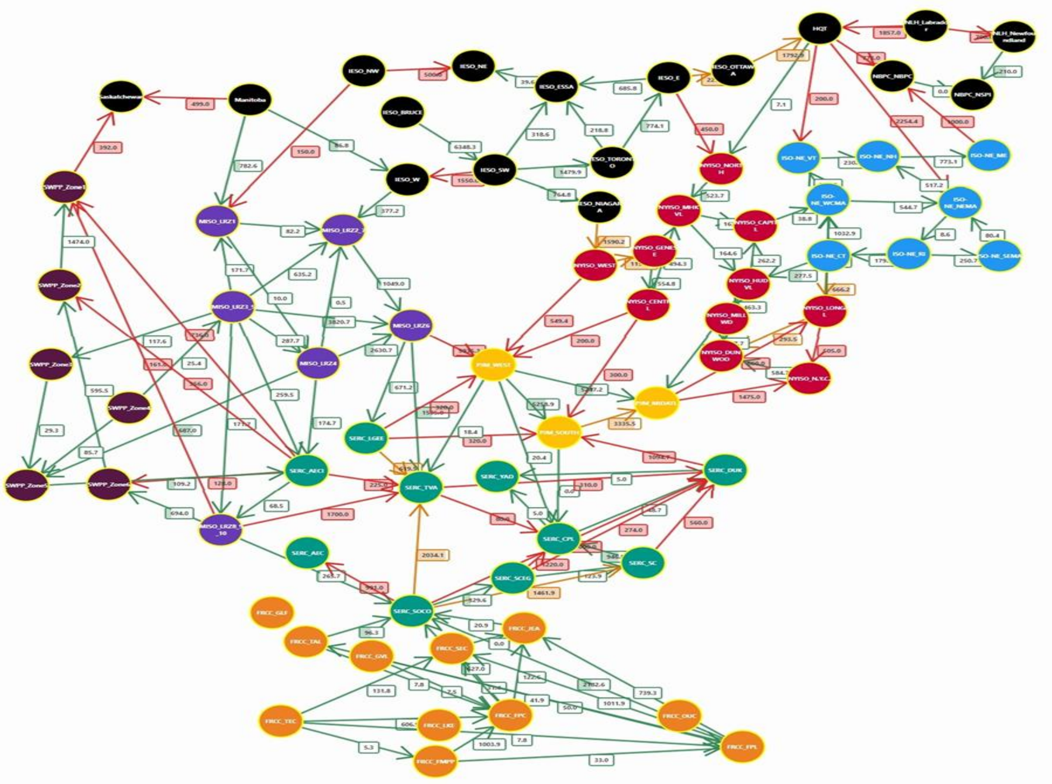
Wind, solar, load, and outage variation across wide footprints

4 **Visualizing Outcomes**

EUE risk-drivers and identifying solutions

Topology: 50+ Zone Commitment & Dispatch in SERVM

Modeling challenges scale dramatically with interconnected multi-area systems



Commitment Complexity

Unit commitment decisions across 50+ zones require modeling generator-level constraints, min up/down times, and start costs simultaneously

Transfer Limits

Inter-area transmission constraints create path-dependent dispatch; solutions must respect simultaneous transfer limits

Temporal Coupling

Storage, demand response, and hydro create intertemporal dependencies that span hours to weeks across the footprint

Computational Scale

Full chronological simulation with stochastic weather across all zones requires careful decomposition strategies

Market Friction

Resource adequacy is not an accounting exercise — real-world constraints shape power flow

Reserve Sharing Agreements

Contractual arrangements between balancing authorities determine how reserves are shared during emergencies. Modeling must reflect actual agreement terms, not idealized assumptions of perfect pooling.

Emergency Operating Procedures

Voltage reductions, public appeals, load management programs, and manual load shedding each have trigger thresholds and operational sequences that affect how much capacity is available under stress.

Economic Considerations

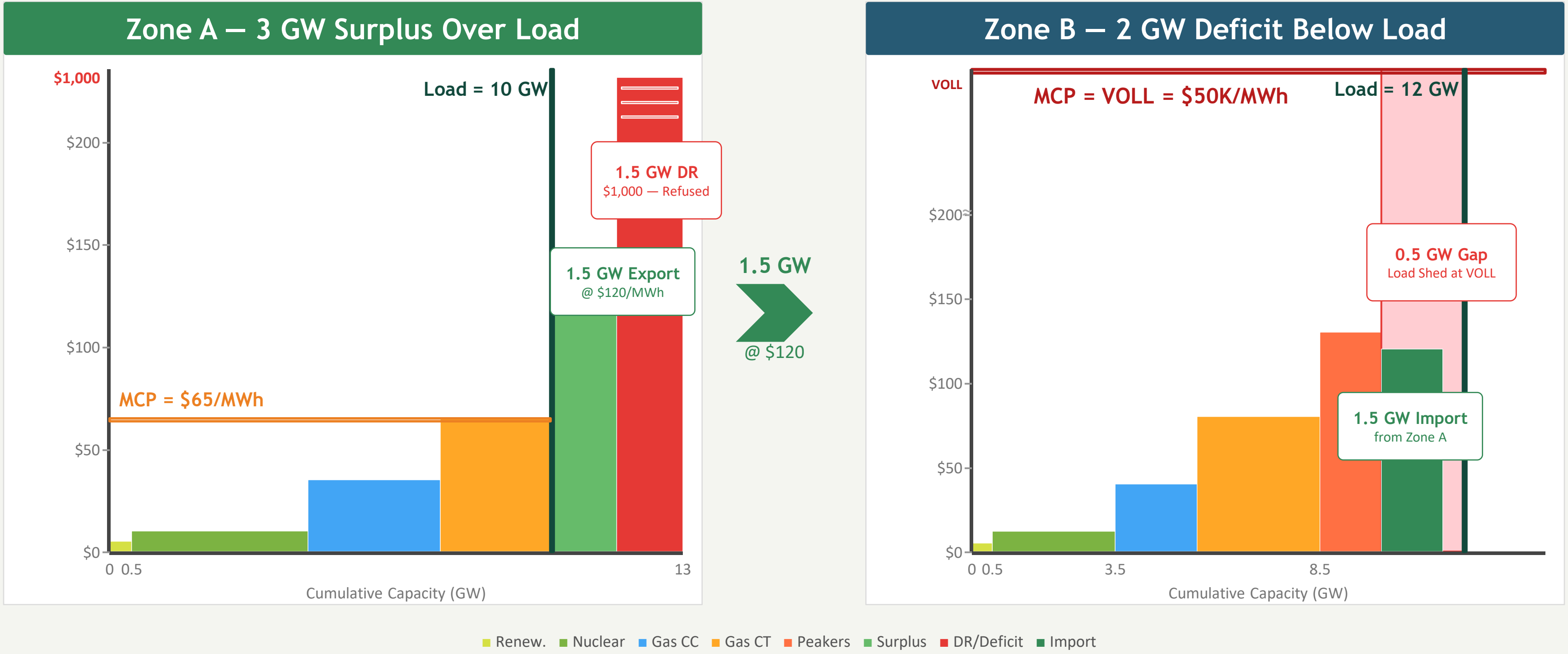
Hurdle rates, wheeling charges, and sales price thresholds mean power doesn't always flow to where it's needed most. Economic barriers can prevent emergency assistance even when physical capacity exists.

The Gap Between Modeling & Reality

- "Copper sheet" models assume perfect deliverability
- Accounting models miss economic friction
- Single-area models ignore neighbor behavior
- Simplified commitment overstates flexibility

Market Friction: Supply Stack Dynamics Between Zones

Zone A has 3 GW surplus but will not activate $1,000/MWh DR to export; Zone B faces a 2 GW deficit and prices at VOLL



Zone A — 3 GW Surplus Over Load

Zone B — 2 GW Deficit Below Load

EXPECTED CLEARING Zone A exports 1.5 GW at $120/MWh but will not activate $1,000/MWh DR to serve Zone B
Zone B prices at VOLL ($50,000/MWh) with 0.5 GW of involuntary load shed — market friction leaves reliability gap

Visualizing Diversity

Wind, solar, load, and outage conditions vary widely across large footprints

Wind Diversity

Wind resources across a continent-scale footprint exhibit dramatically different temporal patterns. A calm day in the Midwest may coincide with strong coastal winds — but only if the model captures correlated weather.

Solar Diversity

Cloud cover, latitude, and time zone differences mean solar output peaks at different times across the footprint. East-to-west geographic spread provides natural smoothing — if transmission can deliver it.

Load Diversity

Coincident vs. non-coincident peak loads differ substantially across regions. Temperature-driven load in the South may not coincide with heating load in the North. Time zone offsets shift daily patterns.

Generator Outages

Correlated forced outage events (e.g., cold weather) can simultaneously affect generators across multiple zones. Common-cause failures undermine the assumed independence in probabilistic models.

Load & Renewable Output Diversity Across Zones

Wind, solar, and load patterns vary dramatically across the SPP N → MISO Central → SERC SE corridor, enabling interregional diversity benefits

	SPP North	MISO Central	SERC Southeast
LOAD PROFILE			
Summer Peak	18.2 GW	62.5 GW	95.3 GW
Winter Peak	16.8 GW	52.1 GW	88.6 GW
Peak Timing	Jul-Aug, 3-6 PM CT	Jul-Aug, 4-7 PM CT	Jul-Sep, 4-7 PM ET
WIND OUTPUT			
Installed Cap.	32.4 GW	24.8 GW	2.1 GW
Avg Cap. Factor	38-42%	32-36%	18-22%
Peak Production	Night / Spring	Night / Spring	Variable
SOLAR OUTPUT			
Installed Cap.	4.1 GW	8.7 GW	22.3 GW
Avg Cap. Factor	22-26%	20-24%	24-28%
Peak Production	Midday / Summer	1-4 PM / Summer	Noon-3 PM / Summer

KEY INSIGHT Wind-heavy SPP N complements solar-rich SERC SE | 1-2 hr peak load offsets enable diversity | Non-coincident peak ~12% below zonal sum

Data Coordination Challenges

Ensuring consistency across datasets is critical for meaningful wide-area results

Temporal Alignment

All input data — load, wind, solar, temperature — must be time-synchronized. Misaligned timestamps (even by one hour) can create artificial diversity or mask real risk.

Coincident vs. Non-Coincident Forecasts

Summing individual zone peaks overstates system peak. Wide-area models must use coincident load forecasts that reflect the actual simultaneous demand across the footprint.

Time Zone & Daylight Savings

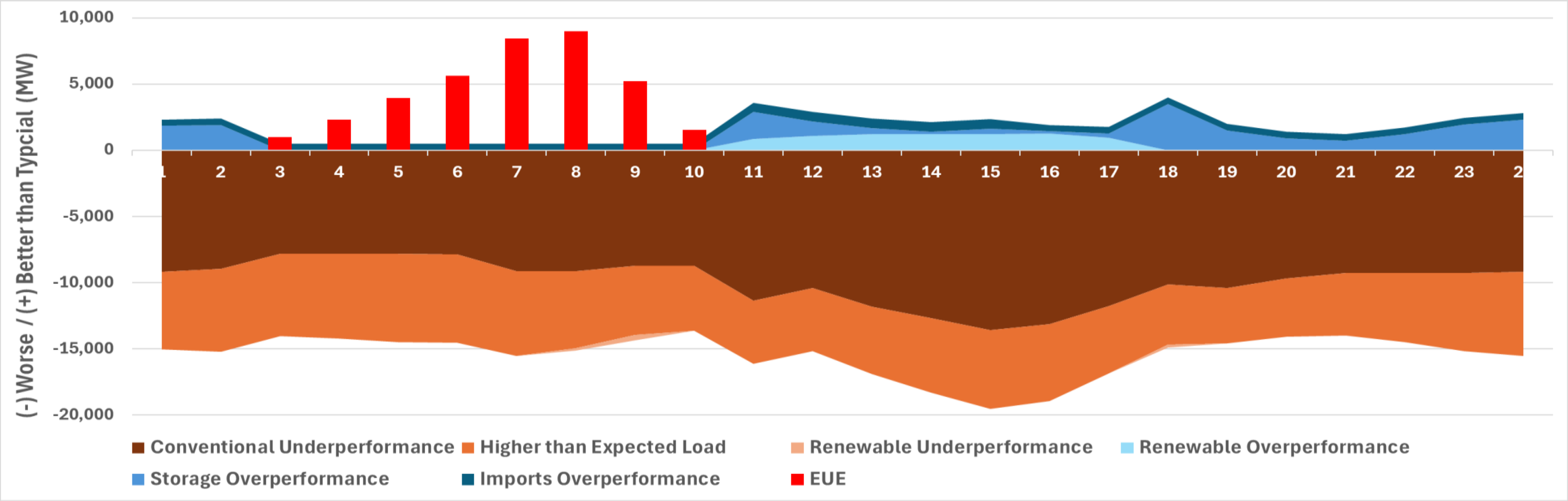
A footprint spanning Eastern to Pacific time zones means "Hour Ending 17" is three different clock hours. DST transitions create 23-hour and 25-hour days that must be handled consistently.

Data Source Coordination

Weather data, load forecasts, and generator characteristics often come from different entities with different vintages, assumptions, and formats. Harmonization is essential.

Visualizing Outcomes: EUE Risk-Drivers

Knowing what drives unserved energy helps identify targeted solutions



Thermal Forced Outages

Conventional underperformance during extreme cold

Extreme Cold → High Load

Demand exceeding forecast from weather events

Solar PV Less than Typical

Renewable underperformance during winter conditions

Imports + Storage Help

Extra imports and battery dispatch reduce afternoon EUE

Key Takeaways

Wide-area topology with 50+ zones demands sophisticated commitment and dispatch modeling — simplification has consequences

Market friction is real: reserve sharing agreements, EOPs, and economic barriers all constrain how power flows in emergencies

Diversity across wind, solar, load, and outages is a critical modeling input — but only valuable if data is temporally aligned and coincident

Visualizing outcomes — decomposing EUE into risk-drivers — transforms raw reliability metrics into actionable planning intelligence

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