Dispatch Effects on Storage ELCC in PJM

PJM CCSTF

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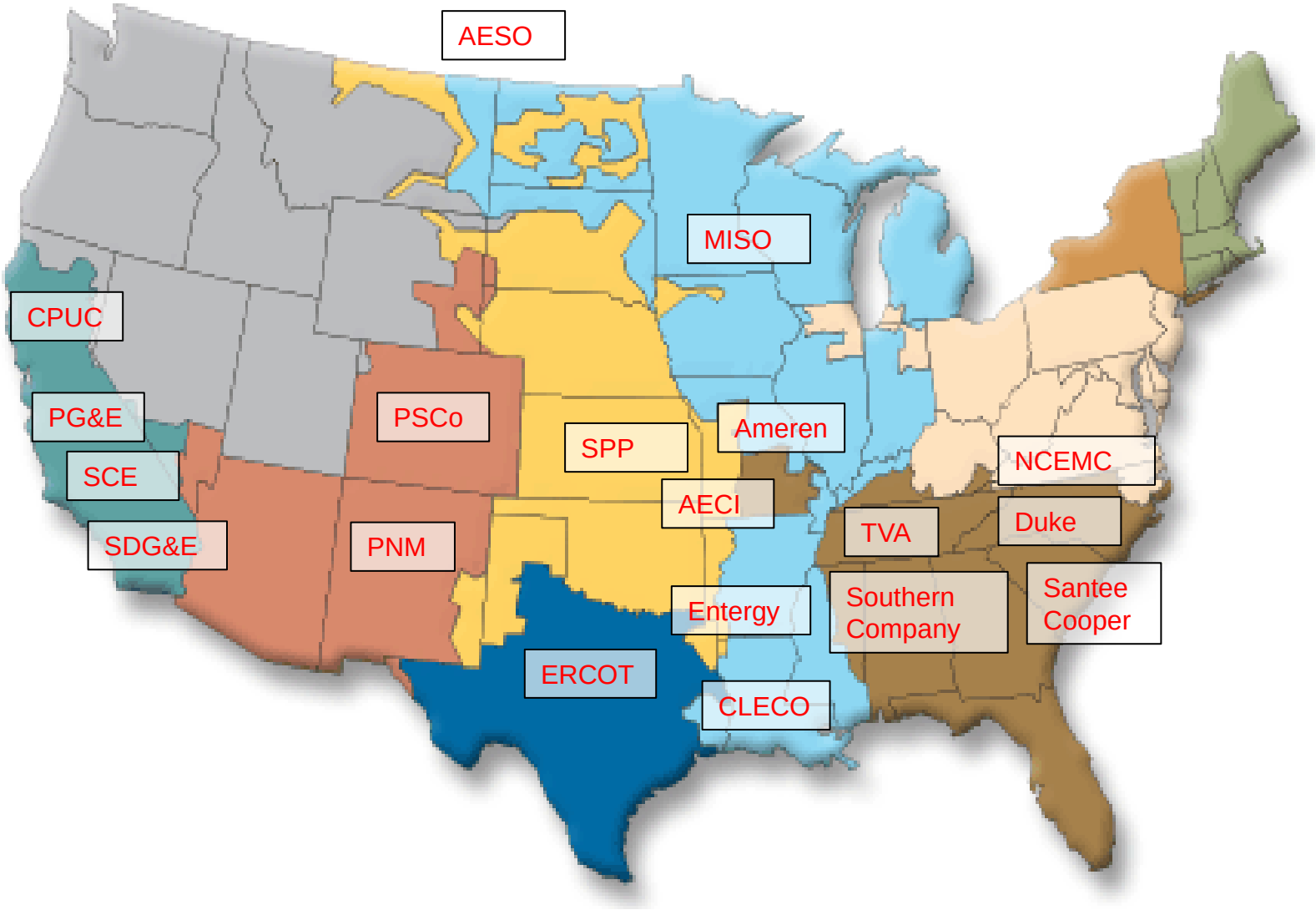
Astrapé Resource Adequacy Clients



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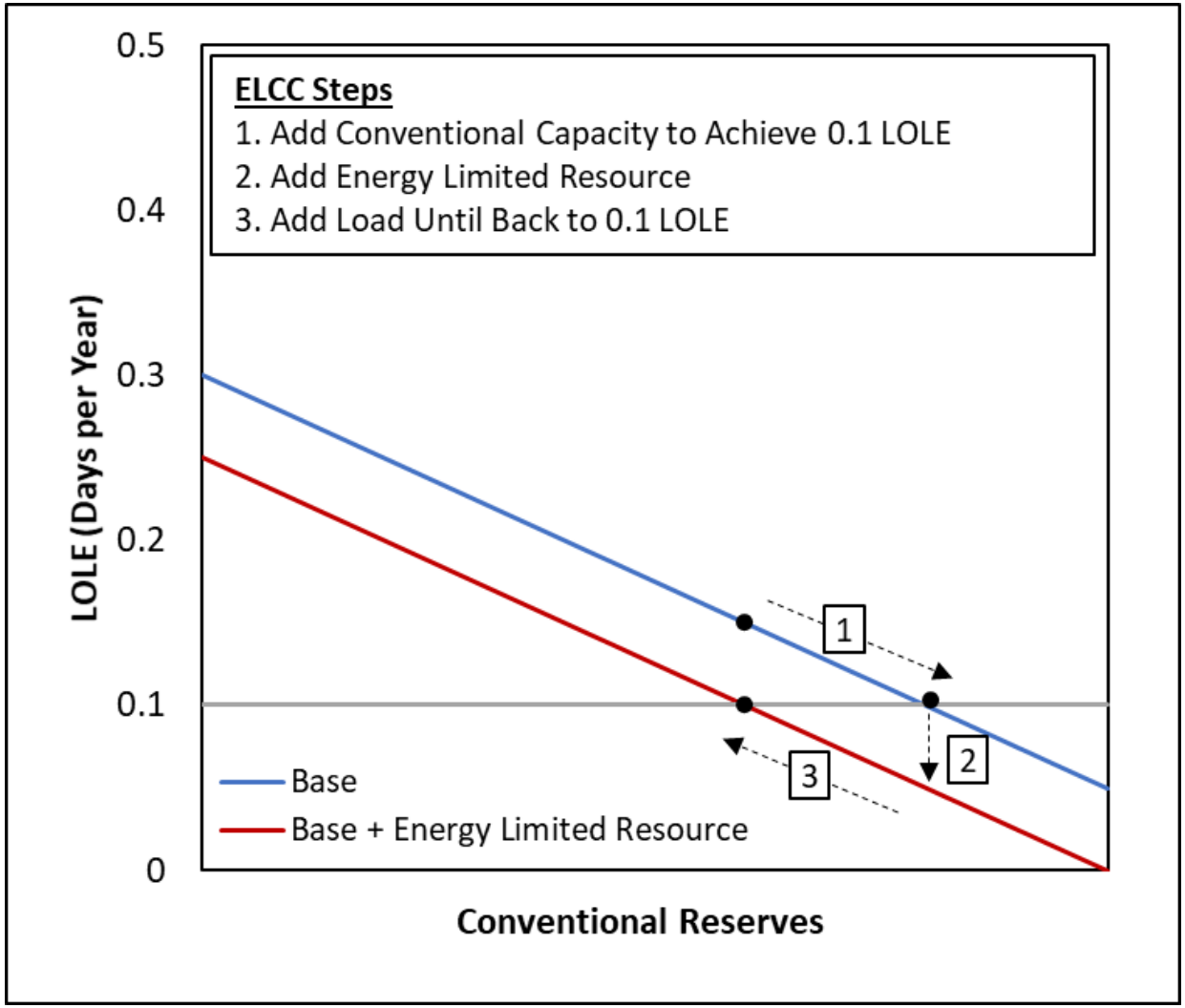
SERVM Framework

- **Simulate PJM as an Island**
  - 2019 Projected Portfolio Plus Incremental Battery Storage
- **Capture Uncertainty in the Following Variables**
  - Weather (35 years of weather history)
    - Impact on Load and Resources (hydro, wind, PV, temp derates on thermal resources)
  - Economic Load Forecast Error (distribution of 5 points)
  - Unit Outage Modeling (1000s of iterations)
- **Multi-Area Modeling – Pipe and Bubble Representation within PJM**
- **Total Base Case Scenario Breakdown**

35 **Weather Years** (Equal Probability)	x	**5** **LFE Points** (Associated Probabilities)	=	**175** **Load Scenarios** (Associated Probabilities)
175 **Load Scenarios**	x	**100** **Unit Outage Draws**	=	**17,500** **8760 Hour Simulations**

ELCC Methodology

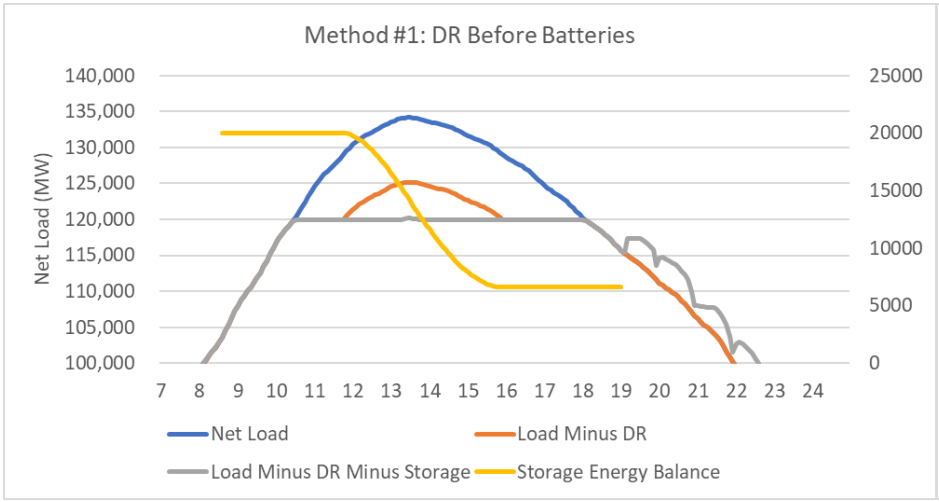


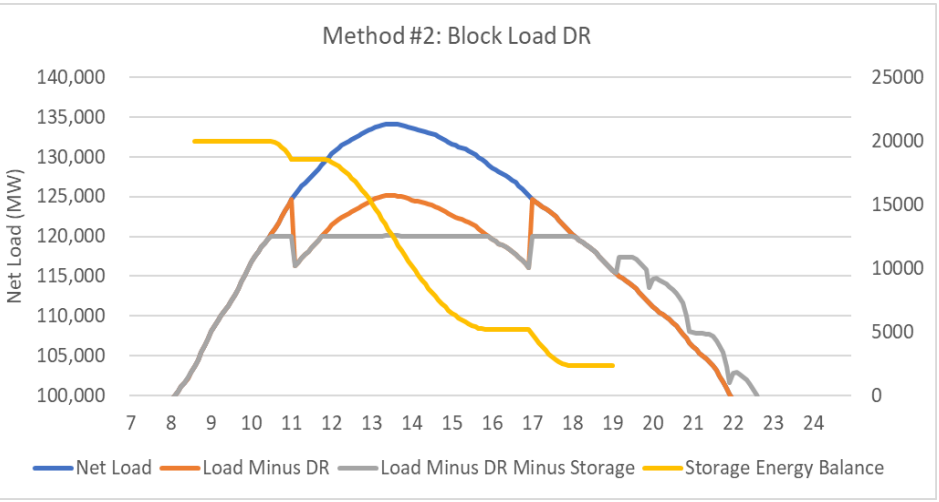
Scenarios

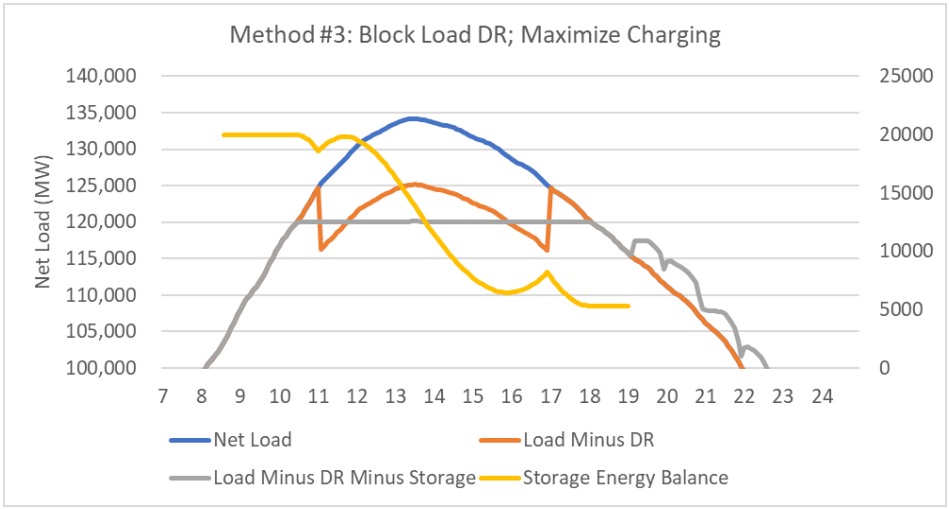
- **4-Hour Battery Penetrations Studied**
  - 2,000 MW
  - 5,000 MW
- **Emergency Dispatch Method***
  1. Storage Dispatched After DR
  2. Storage Dispatched Before DR; Entire DR Fleet Dispatched Together; Storage Used to Balance Load
  3. Storage Dispatched Before DR; Entire DR Fleet Dispatched Together; Excess Generation Used to Charge Storage

**Batteries dispatched economically if not in emergency conditions*

Dispatch Method Illustrations







	Method 1	Method 2	Method 3
DR Hours	6.03	5.92	5.92
Battery Hours Used	2.67	3.53	2.93

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ELCCs From SERVM Simulations

		Battery Portfolio	
		2GW Storage	**5GW Storage**
Emergency Dispatch Method	1) Storage Last	97%	92%
	2) DR Last; Entire DR Dispatched	88%	85%
	3) DR Last; Entire DR; Charge Storage	88%*	85%*

**Preliminary*

Projected DR Utilization – Hours Per Year

At 0.1 LOLE

		Battery Portfolio	
		2GW Storage	**5GW Storage**
Emergency Dispatch Method	1) Storage Last	16.4	15.1
	2) DR Last; Entire DR Dispatched	28.5	28.0
	3) DR Last; Entire DR; Charge Storage	28.9	28.4

+7,500 MW Reserves

		Battery Portfolio	
		2GW Storage	**5GW Storage**
Emergency Dispatch Method	1) Storage Last	2.8	2.4
	2) DR Last; Entire DR Dispatched	6.1	5.4
	3) DR Last; Entire DR; Charge Storage	6.1	5.4

Conservative Assumptions

- **No reserves preserved during firm load shed, so batteries can only provide reliability benefit by discharging energy**
- **Modeled as an island which ignores the potential steepening effect of neighbor support (neighbors more likely to support before and after peak)**

Implications

- **PJM's dispatch methodology underestimates capacity value by > 40%**
- **Underestimating capacity value when battery penetration reaches 5GW equates to >2GW lost capacity from batteries**
- **Dispatch order has the potential to have minimal impact on estimated DR activations with more refined block loading dispatch of DR**

Wind/Solar Modeling

- **Does the PJM selection of weather shapes adequately capture variability and weighting of ELCC contribution?**