# Valuing Capacity for Resources with Energy Limitations – Independent Assessment

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# Executive Summary

- **Capacity value of 4-hour+ resources is high in the planning window**
- **To accurately capture capacity value, accurate load and resource representation critical in study framework**
  - Wide range of weather years
  - Economic commitment and dispatch
  - Realistic diversity between regions
- **Capacity value changes as penetration and composition of energy limited resources change, and as renewable resources are added**

# Overview

- **Base Case Results Update**
  - Astrapé Neighbor Modeling Review
  - Results
  - High Renewable Scenarios
    - 2025 with 37% Renewable
    - 2030 with 50% Renewable
- **GE Input and Framework Simulation Comparison**
  - Load Shapes
  - Commitment Methodology
  - Transmission Limitations
    - Single Zone Scenario
- **Conclusions**
  - Study Framework Requirements
  - Study Update Frequency

# Base Case Results Update

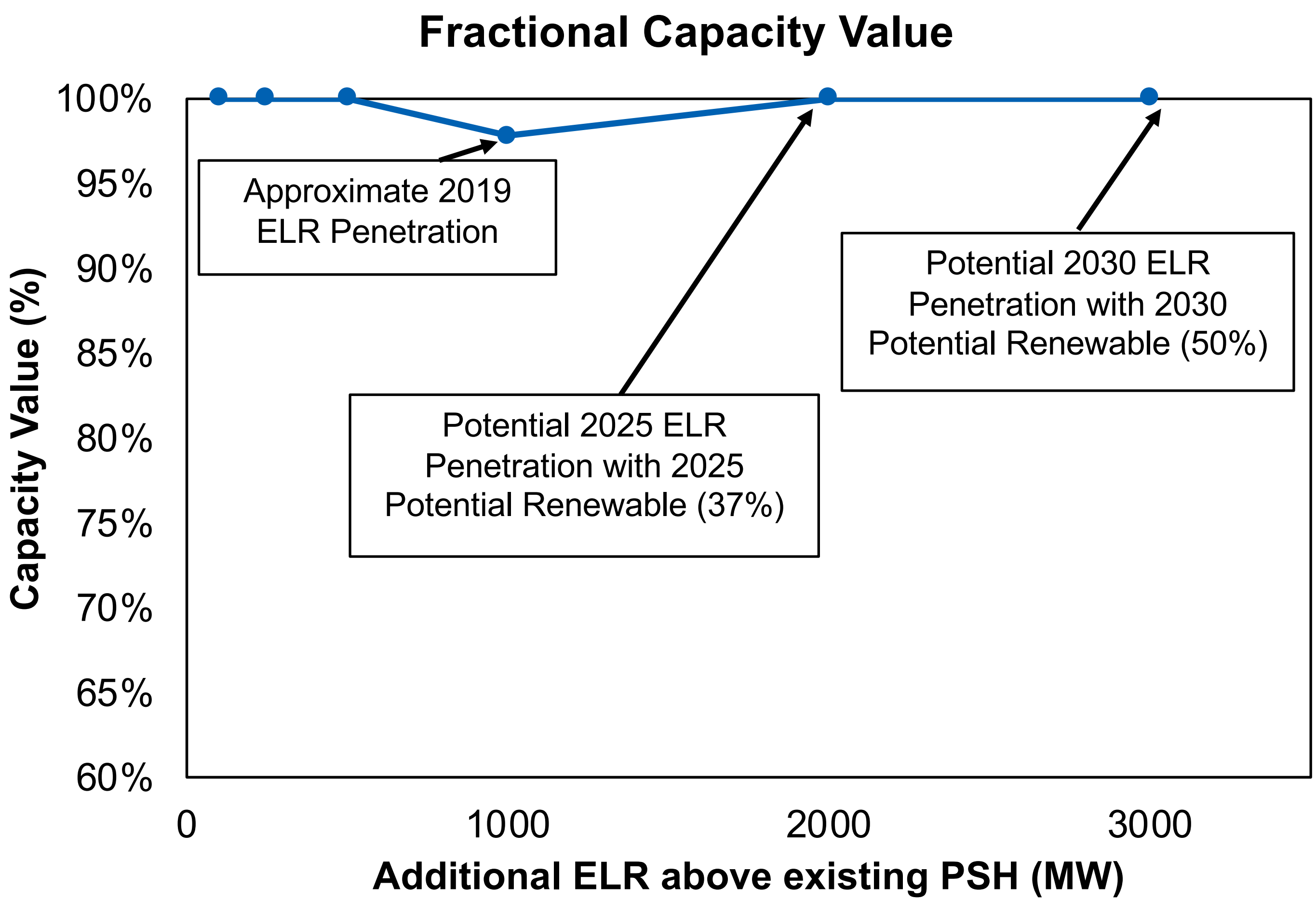
# Astrapé Neighbor Modeling Review

- **Neighbor Modeling in SERVM**
  - Neighbors are modeled at target reliability (0.1 LOLE)
  - Neighbors are modeled with existing energy limited and emergency resources
    - Neighbors are not allowed to sell from emergency resources
  - Load data was further reviewed for historical correlation
    - An error was corrected in PJM load data

## Astrapé Load Summary

| | Peak Load (MW) | Load Diversity (% below non-coincident 50/50 peak) | | | |
|---|---|---|---|---|---|
| | Non-Coincident Peak Load | At System Coincident Peak | | At NYISO Coincident Peak | |
| | | New | Old | New | Old |
| **NYISO** | **36,427** | **-5.9%** | -10.7% | **0.0%** | 0.0% |
| **PJM** | **163,597** | **-0.9%** | -4.1% | **-3.8%** | -16.9% |
| **ISONE** | **26,762** | **-7.9%** | -12.9% | **-3.3%** | -3.2% |
| **IESO** | **24,404** | **-9.1%** | -10.2% | **-14.2%** | -14.5% |
| **System** | **291,297** | **0.0%** | 0.0% | **-2.3%** | -6.6% |

# 4 Hour Duration Results




**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

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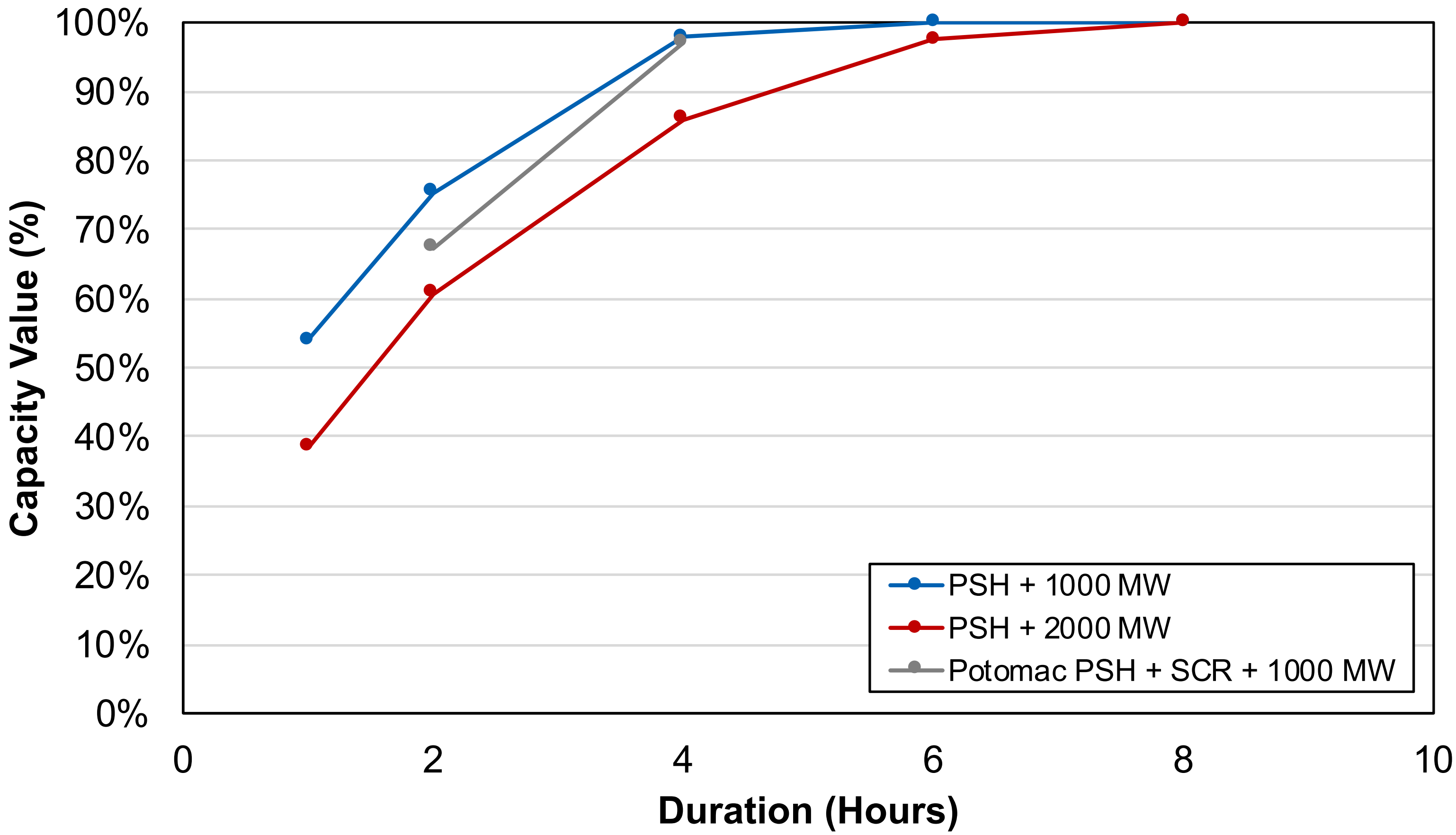
# 2019 Resource Mix: 1-8 Hour Duration Results




**All SERVM energy-limited resource portfolios include 1408 MW of 8-hour PSH*

**All results from 2019 resource mix*

**Potomac results converted to represent average capacity value*

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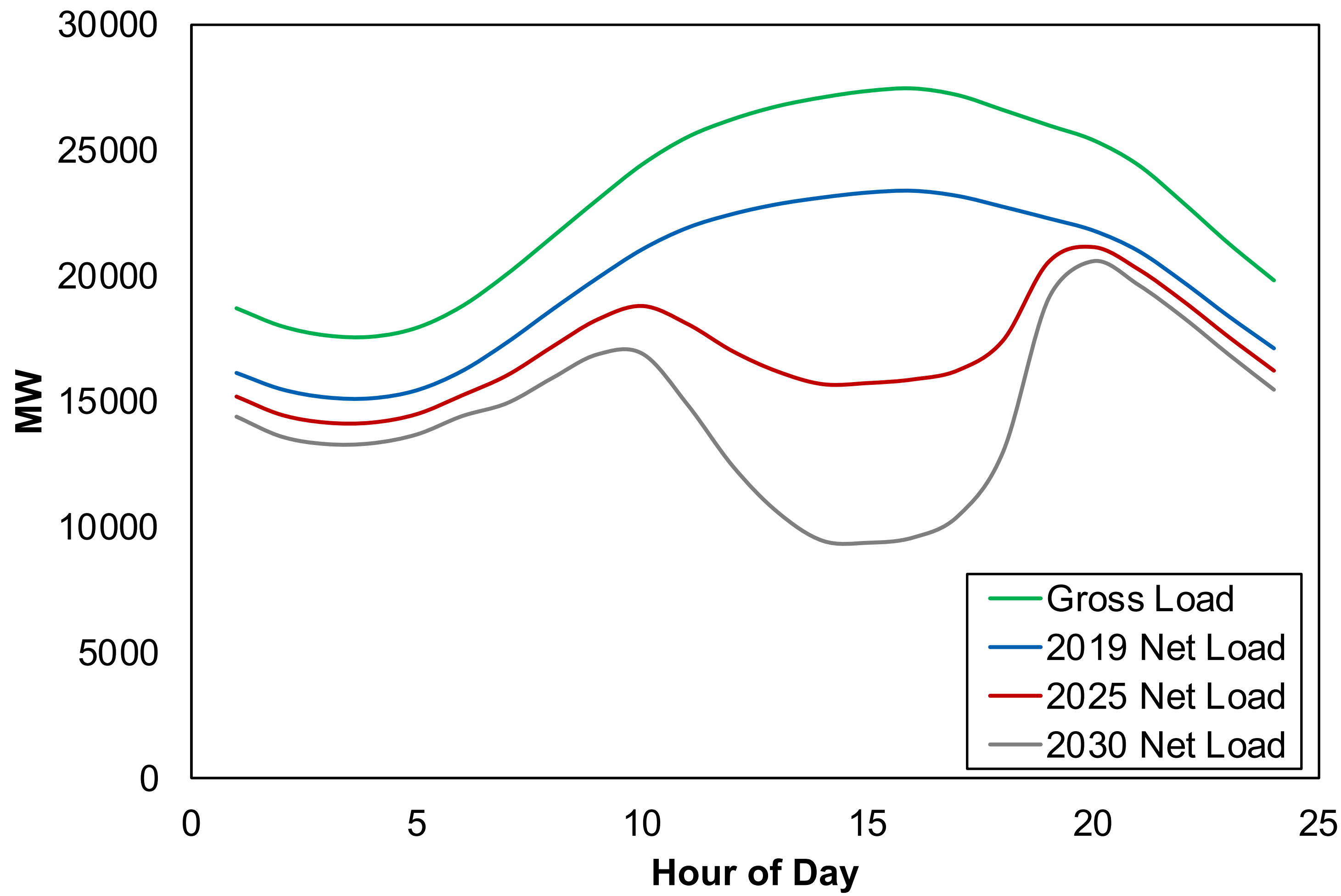
# Renewable Shapes and Capacity Amounts

- **Astrapé constructed a renewable portfolio that reached 50% penetration by 2030.**

| Study Year | 2019 | 2025 | 2030 |
|---|---|---|---|
| Hydro Energy (GWh) | 27,721 | 27,721 | 27,721 |
| Solar Energy (GWh) | 42 | 13,234 | 24,245 |
| Wind Energy (GWh) | 4,384 | 16,297 | 26,436 |
| Total Renewable (GWh) | 32,147 | 57,252 | 78,402 |
| Total Renewable (% of Load) | 21% | 37% | 50% |

# Net Load Shape Comparison




**Net Load = Gross Load – Solar Energy – Wind Energy – Hydro Energy*

**August 2016 Load Data*

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# 2025 Renewables

- **Addition of renewable energy steepens daily net load shape, shortening the need for duration.**

| Penetration (MW) | 4 Hour Fractional Capacity Value for 2019 Resources (%) | 4 Hour Fractional Capacity Value for 2025 Resources (%) |
|---|---|---|
| PSH + 2000 MW | 86.1% | 100.0% |
| PSH + 3000 MW | Not Studied | 94.8% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# 2030 Renewables

- **Further additions continue to steepen the daily net load shape, further reducing the need for duration.**

| Penetration (MW) | Capacity Value (%) | |
|---|---|---|
| | 4 Hour Duration | 6 Hour Duration |
| PSH + 2000 MW | 100.0% | 100.0% |
| PSH + 3000 MW | 100.0% | 100.0% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# GE Input and Framework Simulation Comparison

# GE MARS Comparison – Load Shapes

- **SERVM simulations were performed with IRM Load Shapes**
- **IRM load shapes show lower value for all durations simulated**

| Penetration (MW) | Capacity Value (%) | | | |
|---|---|---|---|---|
| | 4 Hour Duration | | 6 Hour Duration | |
| | Astrapé Load Shapes | IRM Load Shapes | Astrapé Load Shapes | IRM Load Shapes |
| PSH + 1000 MW | 97.8% | 87.7% | 100.0% | 96.6% |
| PSH + 2000 MW | 86.1% | 80.6% | 97.6% | 94.5% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# GE MARS Comparison – Commitment Method

- **SERVM simulations were performed using must-run commitment to mimic GE MARS**
- **Must run commitment does not capture correct shape of generator outages**

| Penetration (MW) | Capacity Value (%) | | | |
|---|---|---|---|---|
| | 4 Hour Duration | | 6 Hour Duration | |
| | Economic Commitment | Must Run Commitment | Economic Commitment | Must Run Commitment |
| PSH + 1000 MW | 97.8% | TBD | 100.0% | TBD |
| PSH + 2000 MW | 86.1% | TBD | 97.6% | TBD |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# Transmission Limit Scenario

- **The IRM process requires artificial movement of generators across zones**
  - This surfaces unrealistic reliability events, but still uses the original transmission constraints
- **Astrapé relaxed constraints slightly instead of moving generators**
- **Results were still very similar**

| Penetration (MW) | Capacity Value (%) | | | |
|---|---|---|---|---|
| | 4 Hour Duration | | 6 Hour Duration | |
| | Relaxed Constraints | Transmission Limited | Relaxed Constraints | Transmission Limited |
| PSH + 1000 MW | 97.8% | 95.4% | 100.0% | 99.3% |
| PSH + 2000 MW | 86.1% | 85.8% | 97.6% | 92.7% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*



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# Single Zone Scenario

- **Zone J modeled with all energy-limited capacity**
- **Little difference between single zone analysis and control area results**

| **Penetration (MW)** | **Capacity Value (%)** | | | |
|---|---|---|---|---|
| | **4 Hour Duration** | | **6 Hour Duration** | |
| | **Zone J** | **NYISO** | **Zone J** | **NYISO** |
| PSH + 1000 MW | 97.4% | 97.8% | 97.5% | 100.0% |
| PSH + 2000 MW | TBD | 86.1% | TBD | 97.6% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# Drivers of Differences from GE Study

| Driver | Astrapé Approach | GE Approach |
|---|---|---|
| Treatment of Load Uncertainties | Use 38 Years of Historical Weather Patterns; 5 Economic Load Forecast Uncertainties | Scale Weather Shapes Using the Same Multiplier Every Hour; 3 Weather Shapes; 7 Load Forecast Uncertainties |
| Diversity with Neighbors | 38 Years of Historical Diversity | Artificial Diversity for Top 3 Load Days |
| Treatment of Resource Interactions | Endogenous Treatment of all Interactions | Post-Processing of Energy Limited Dispatch |
| Commitment Method | Economic Commitment and Dispatch | Must-Run Commitment |
| Internal Transmission Constraints | IRM Base Case with Slight Relaxation | IRM Base Case with Generator Relocation |

# Conclusions

# Conclusions

- **Capacity value of 4-hour+ resources is high in the planning window**
- **To accurately capture capacity value, accurate load and resource representation critical in study framework**
  - Wide range of weather years
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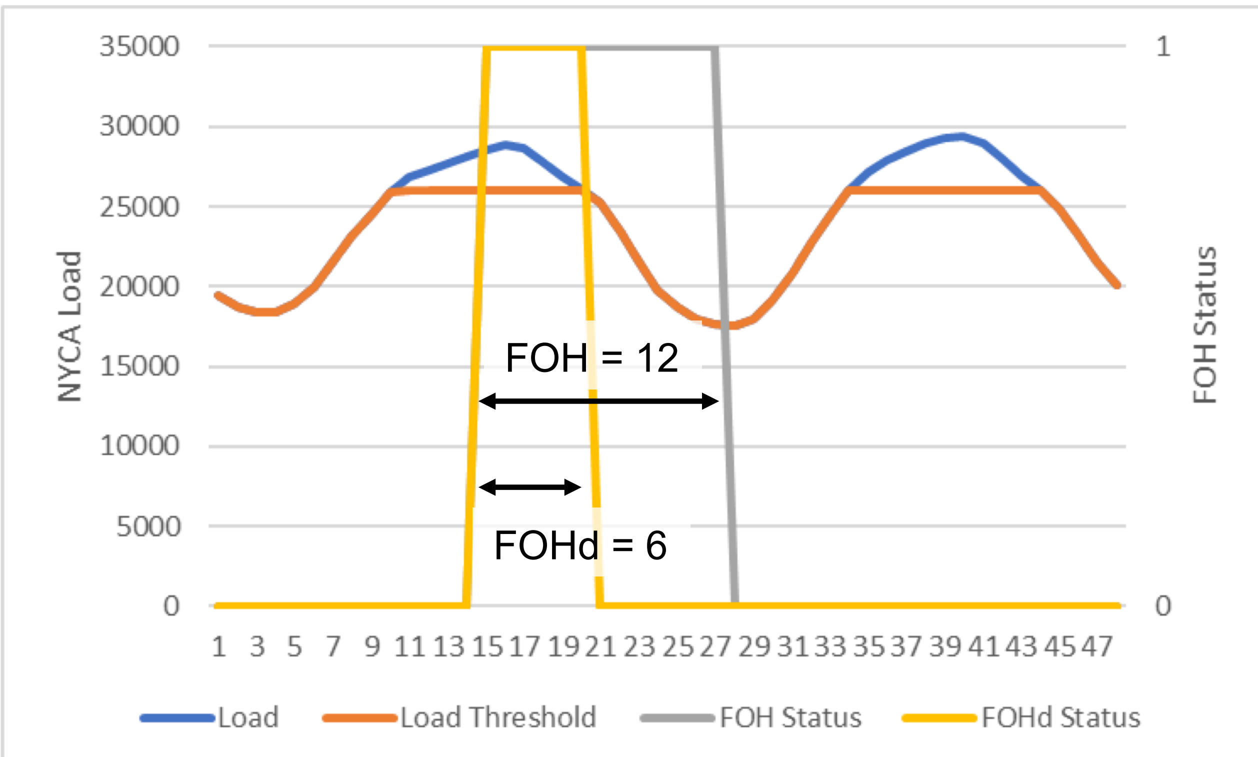
- **Capacity value changes as penetration and composition of energy limited resources change, and as renewable resources are added**

# Appendix

# EFOR vs EFORd

| | NYCA |
|---|---|
| SERVM EFOR | 12.9% |
| SERVM EFORd | 7.2% |

$FOHd =$ Hours forced out AND unit would have been operated




$$FOR = \frac{FOH}{FOH + SH}$$

$$FOR = \frac{12}{12+100} = 10.7\%$$

$$FORd = \frac{FOHd}{FOHd + SH}$$

$$FORd = \frac{6}{6+100} = 5.6\%$$

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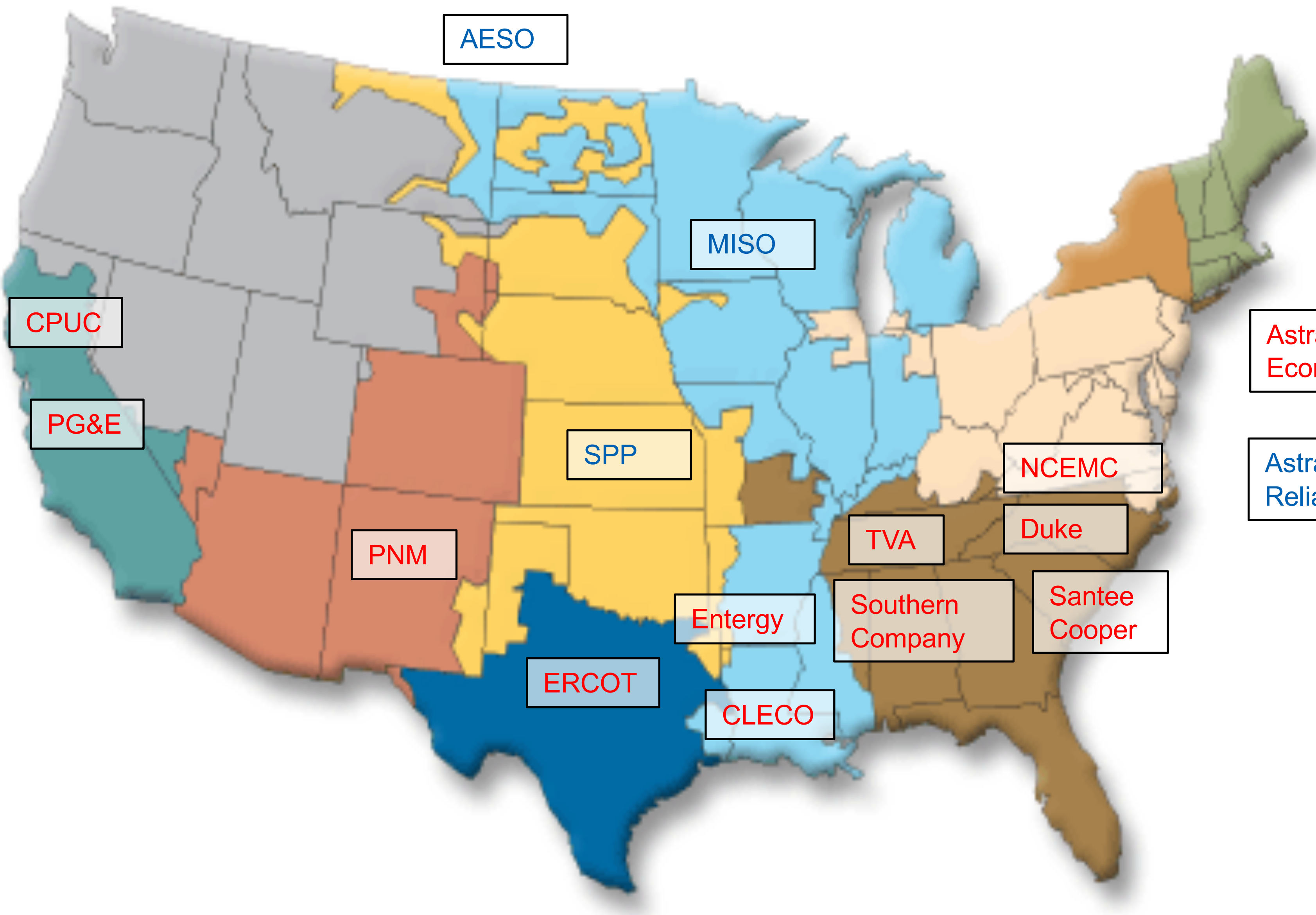
# Astrapé Resource Adequacy Clients




Astrapé Clients – Economic/Physical

Astrapé Clients –Physical Reliability



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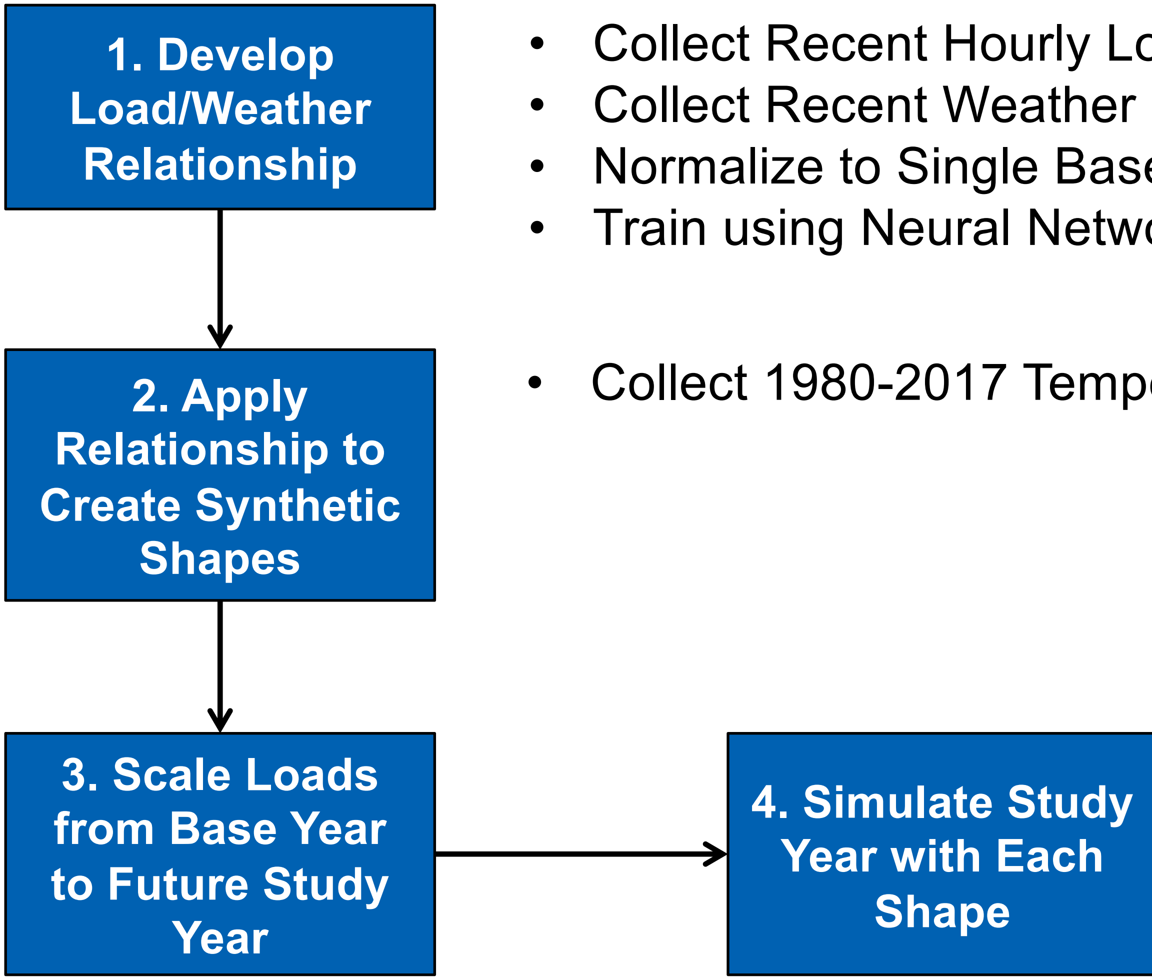
# SERVM Framework

- **Capture Uncertainty in the Following Variables**
  - Weather (38 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 (100s of iterations)
- **Multi-Area Modeling – Pipe and Bubble Representation**
- **Total Base Case Scenario Breakdown**

| | | | | |
|---|---|---|---|---|
| **38**<br>**Weather Years**<br>(Equal Probability) | x | **5**<br>**LFE Points**<br>(Associated Probabilities) | = | **190**<br>**Load Scenarios**<br>(Associated Probabilities) |
| **190**<br>**Load Scenarios** | x | **100**<br>**Unit Outage Draws** | = | **19,000**<br>**8760 Hour Simulations** |

# Incorporating Weather Uncertainty for Load




- Collect Recent Hourly Loads
- Collect Recent Weather Data
- Normalize to Single Base Year
- Train using Neural Network Software

- Collect 1980-2017 Temperature



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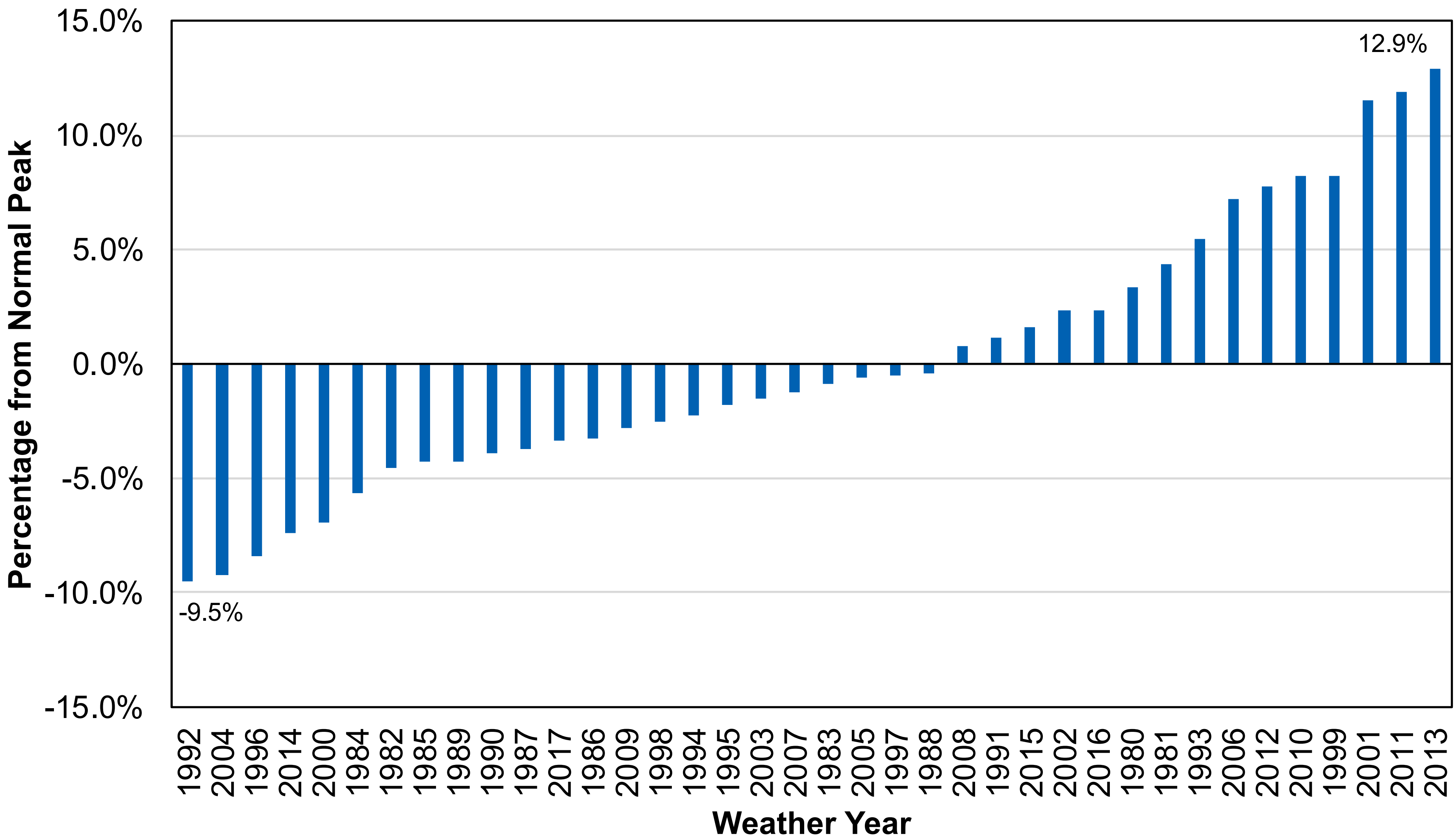
# Peak Load Variability by Weather Year

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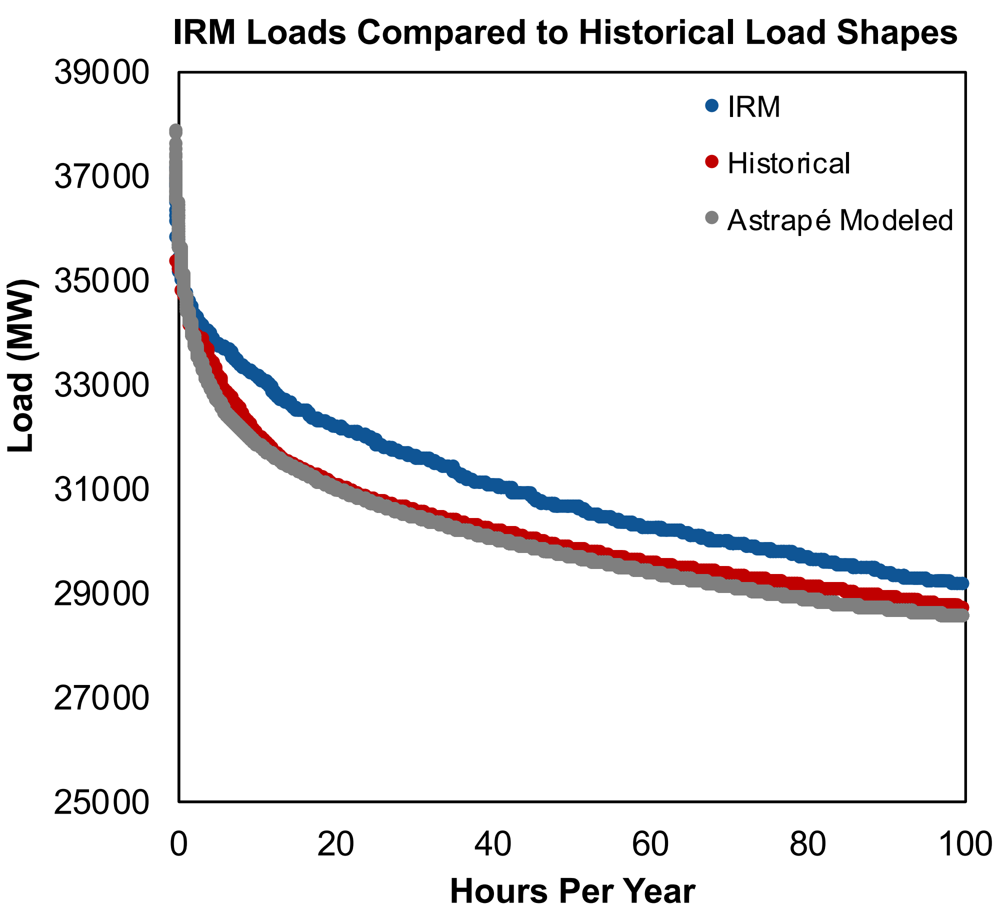
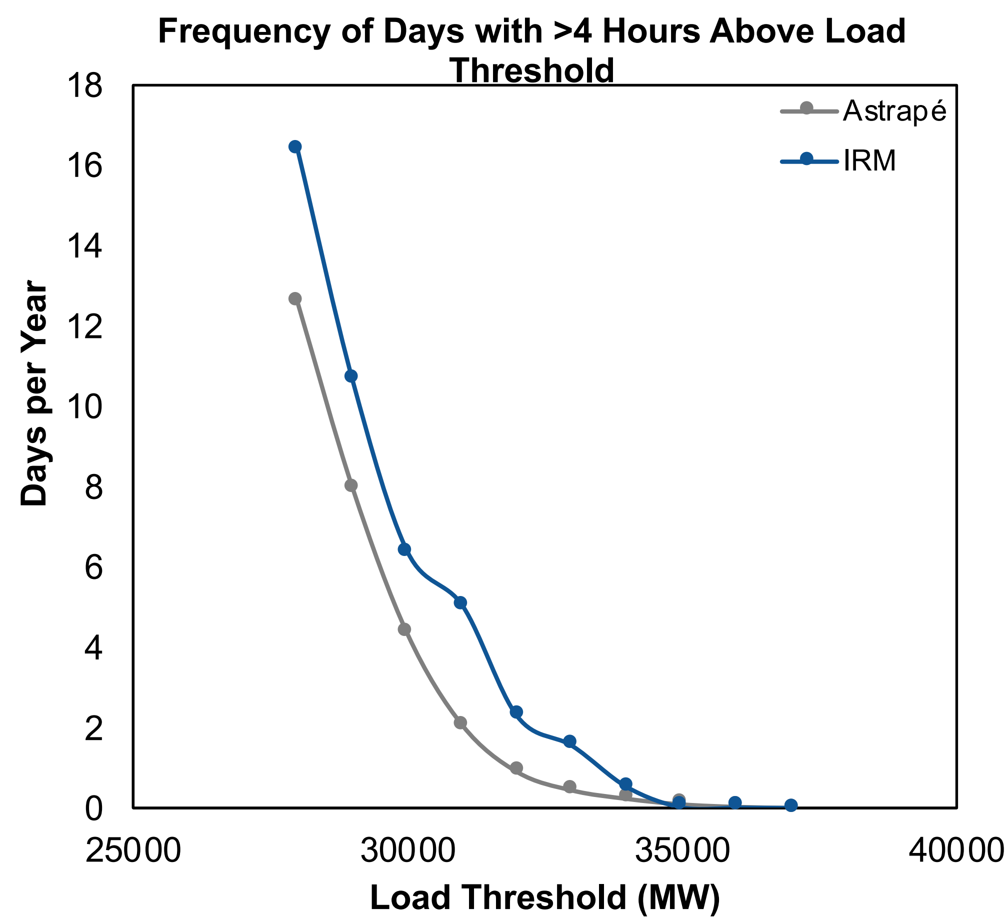
# Effect of Load Scaling for Uncertainty

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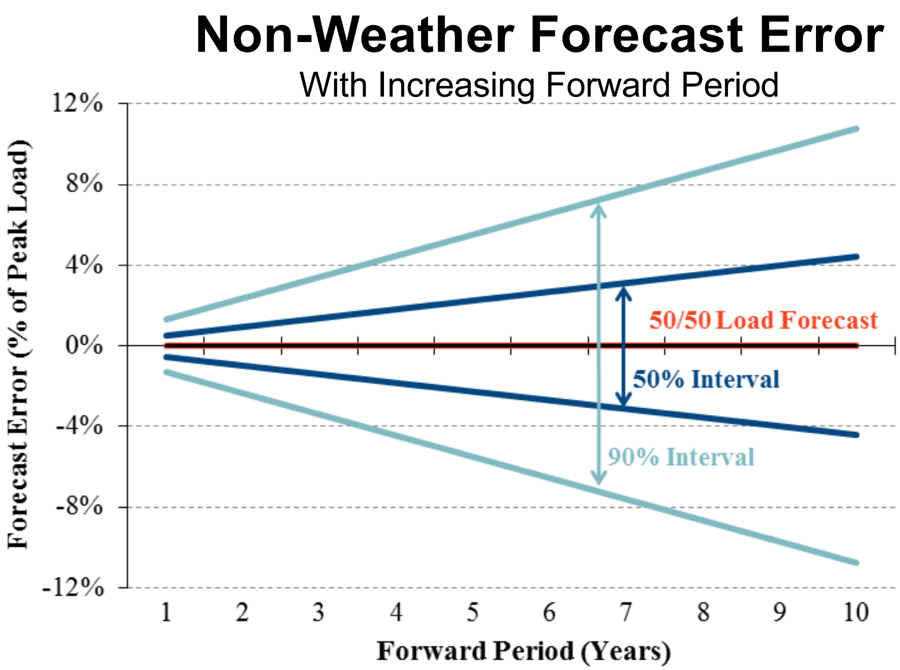
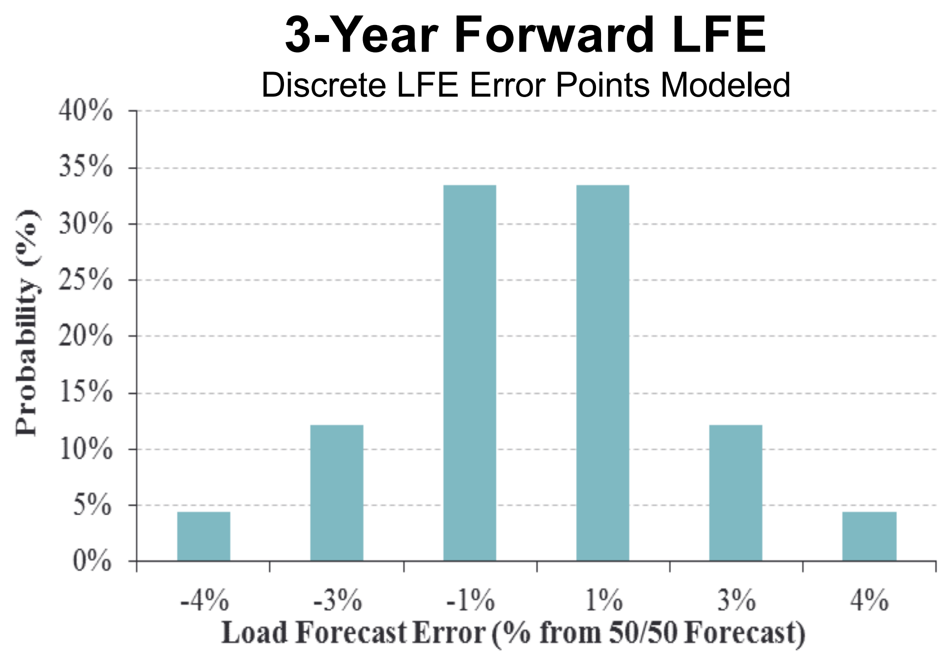
# Load Forecast Uncertainty and Forward Period

- **Non-weather load forecast error increases with forward period**
- **Each weather shape simulated with each LFE and associated probabilities**

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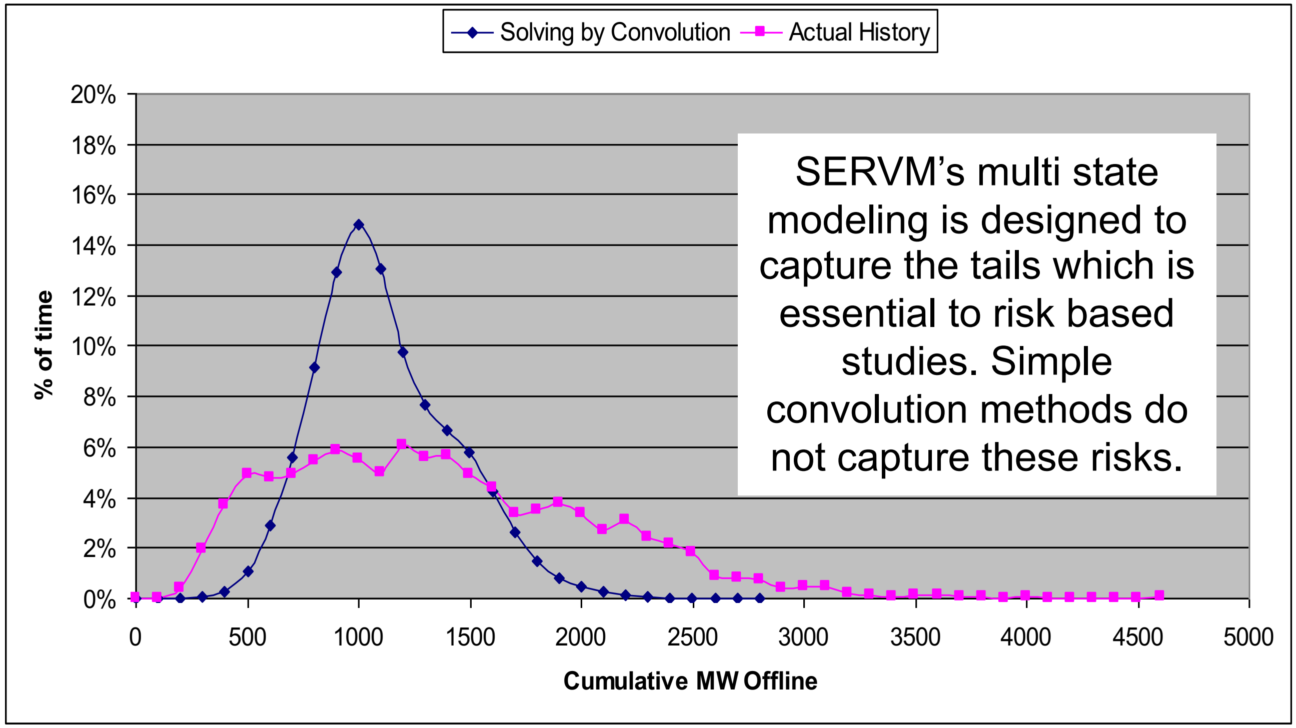
# Unit Outage Modeling

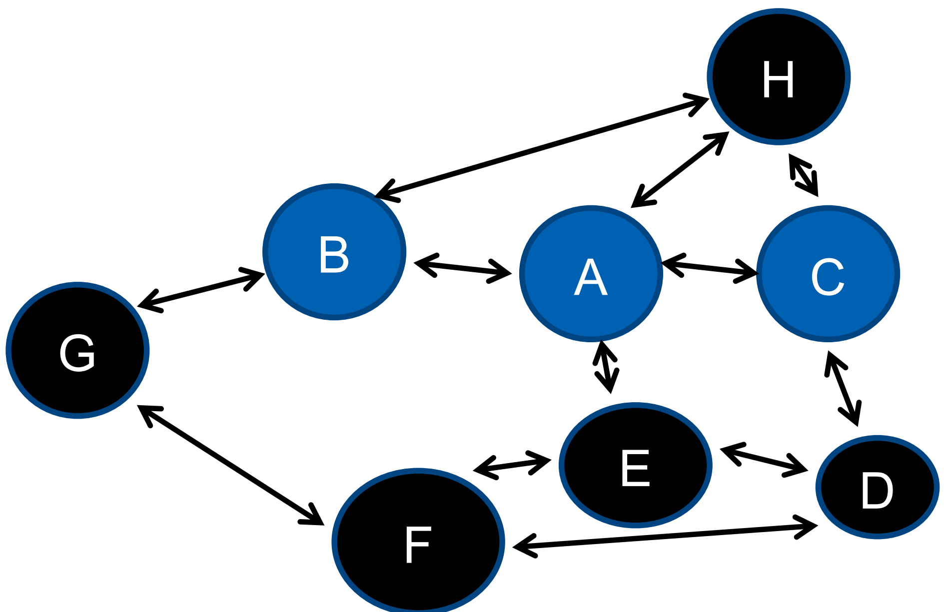
- **Full Outages**
  - Time to Repair
  - Time to Failure
- **Partial Outages**
  - Time to Repair
  - Time to Failure
  - Derate Percentage
- **Startup Failures**
- **Maintenance Outages**
- **Planned Outages**
- **Created Based on Historical GADS Data**

- Multi State Frequency and Duration Modeling vs Convolution



# Multi-Area Modeling

- Pipe and Bubble Representation with import and export constraints
- Constraints can be constants, distributions, tied to load level, or input by month
- Ties can be modeled with random outages
- Areas will share resources based on economic pricing and physical constraints
- Load/Wind/Hydro diversity is embedded in each region's input data



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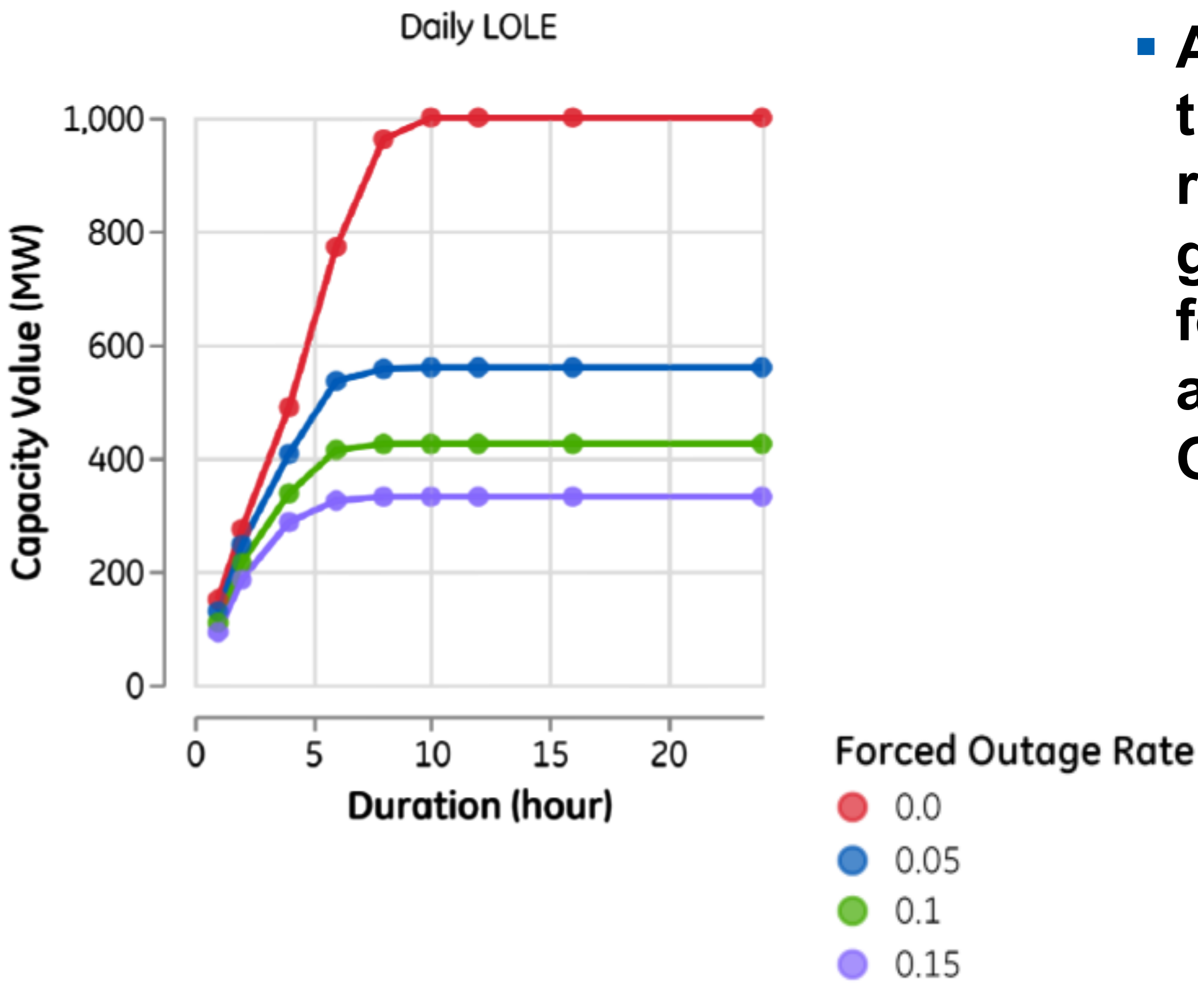
# Energy Limited Duration Approach

- **Study Steps**
  - Model all loads and resources in NYCA, ISO-NE, PJM, IESO, HQ
    - Include existing PSH with constraints in NYCA
    - Include energy limited resources (DR and PSH) in neighboring regions
  - Calibrate reliability in NYCA and neighboring regions to 0.1 LOLE
  - Add energy limited capacity
  - Remove perfect (no duration limit and no forced outage rate) conventional capacity until NYCA reliability again meets 0.1 LOLE
  - Fractional capacity value = Perfect capacity removed / energy limited capacity added

# Key Assumptions

- Simulated at criterion for NYCA and neighbors
- Reserves fully exhausted before shedding firm load
- Capacity value instead of ELCC
- Energy limited resources compared to perfect capacity
- Endogenous simulations
- 2019 resource mix
- Existing pumped storage hydro always modeled with 8-hour duration
- Magnitude of each portfolio directly comparable to GE portfolios, although composition is different due to PSH treatment.

# Forced Outage Rate Discussion




- **Astrapé modified transmission constraints rather than shifting generators because of the forced-outage rate effect asymmetry present in the GE MARS simulations.**

*Figure Source: "Valuing Capacity for Resources with Energy Limitations" Slide 43*
*https://www.nyiso.com/documents/20142/3698135/09242018%20Capacity%20Value%20of%20Resources%20with%20Energy%20Limitations.pdf/c271ef4f-6378-72ac-203e-c59ff3884ef8*

# 4 Hour Duration Results

| Additional ELR Above Existing PSH (MW) | Capacity Value (%) |
|---|---|
| 100 | 100.0% |
| 250 | 100.0% |
| 500 | 100.0% |
| 1000 | 97.8% |
| 2000 MW with 2025 Renewable | 100.0% |
| 3000 MW with 2030 Renewable | 100.0% |

**All energy limited resource portfolios include 1408 MW of 8-hour PSH.*

# 2019 1-8 Hour Duration Results

| Duration (Hours) | Capacity Value (%) | | |
|---|---|---|---|
| | PSH + 1000 MW | PSH + 2000 MW | Potomac PSH + SCR + 1000 MW |
| 1 | 54.1 | 38.4 | [redacted] |
| 2 | 75.4 | 60.7 | 67.3 |
| 4 | 97.8 | 86.1 | 97.1 |
| 6 | 100.0 | 97.6 | [redacted] |
| 8 | 100.0 | 100.0 | [redacted] |

**All SERVM energy-limited resource portfolios include 1408 MW of 8-hour PSH*

**All results from 2019 resource mix*

**Potomac results converted to represent average capacity value*



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