Stakeholder Meeting

Astrapé Consulting

04/23/2019

ASTRAPÉ CONSULTING
innovation in electric system planning

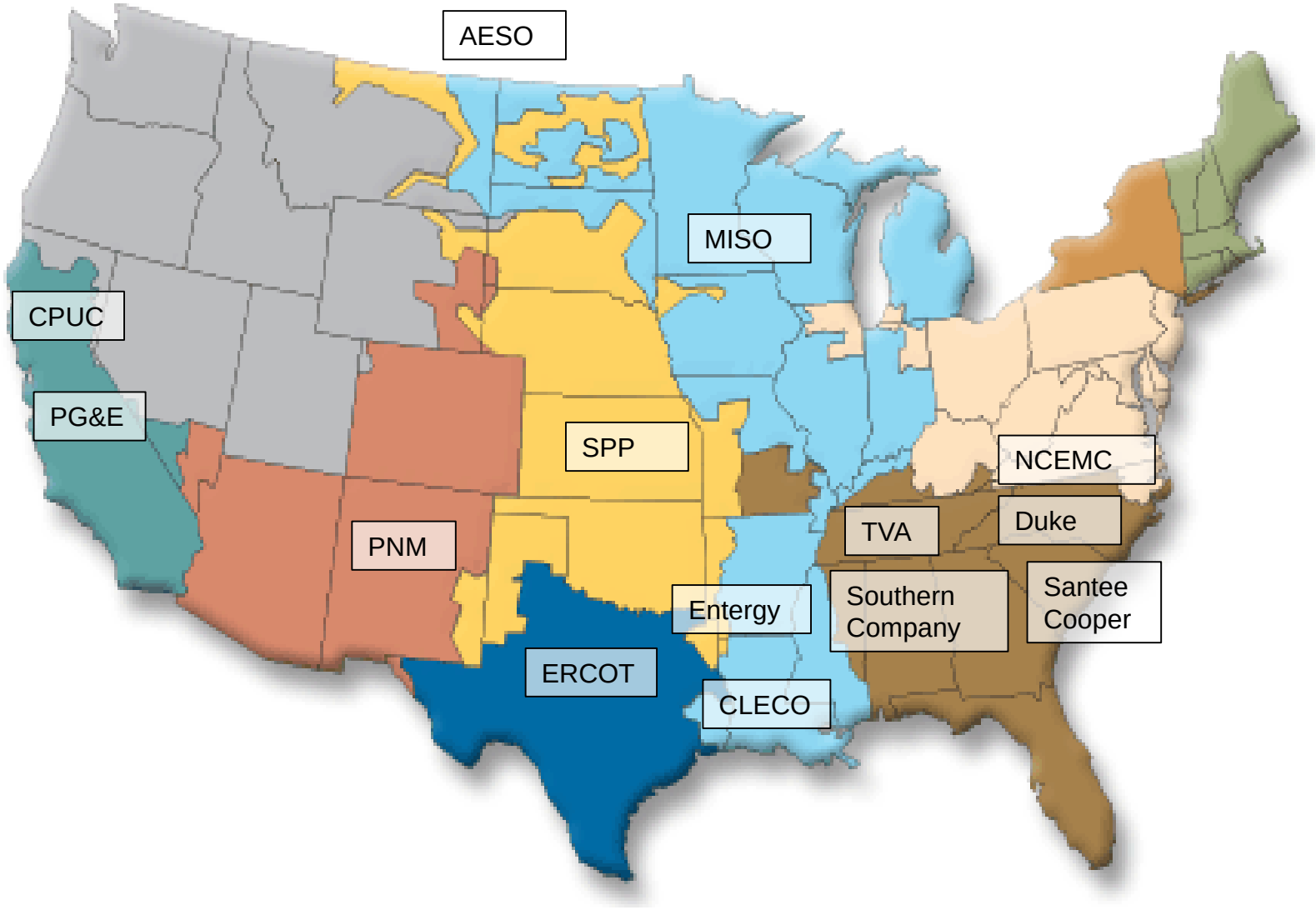
SERVM Model Overview

Strategic Energy Risk Valuation Model (SERVM)

- **SERVM has over 30 years of use and development**
- **Probabilistic hourly and intra-hour chronological production cost model designed specifically for resource adequacy and system flexibility studies**
- **SERVM calculates both resource adequacy metrics and costs**
- **SERVM used in a variety of applications for the following entities:**

- Southern Company
- TVA
- Louisville Gas & Electric
- Kentucky Utilities
- Duke Energy
- Progress Energy
- FERC
- NARUC
- PNM
- TNB (Malaysia)
- Sarawak (Malaysia)
- EPRI
- Santee Cooper
- CLECO
- California Public Utilities Commission
- Pacific Gas & Electric
- ERCOT
- MISO
- PJM
- Terna (Italian Transmission Operator)
- NCEMC
- Oglethorpe Power

Astrapé Resource Adequacy Clients

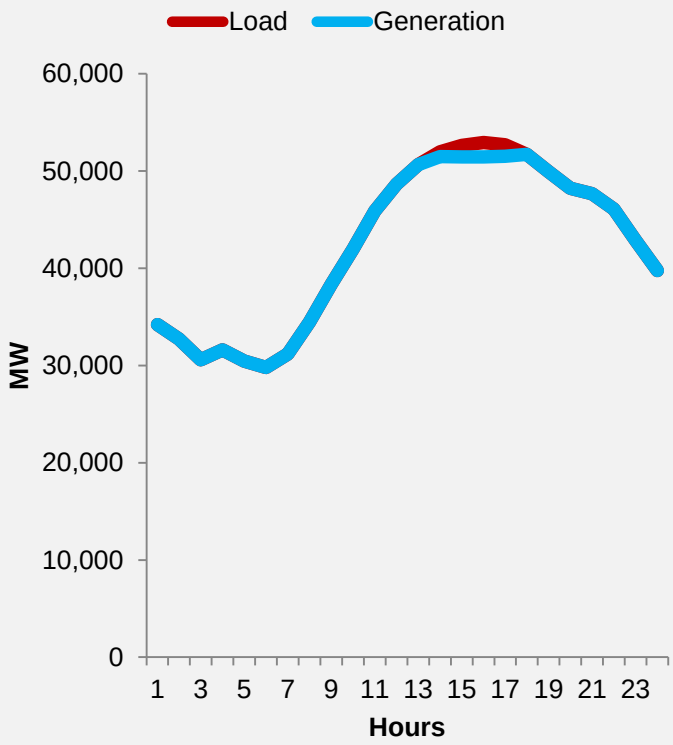


Definitions of Existing and New Reliability Metrics

Traditional "Generic Capacity" Metrics

$LOLE_{Cap}$ = 0.2 Target

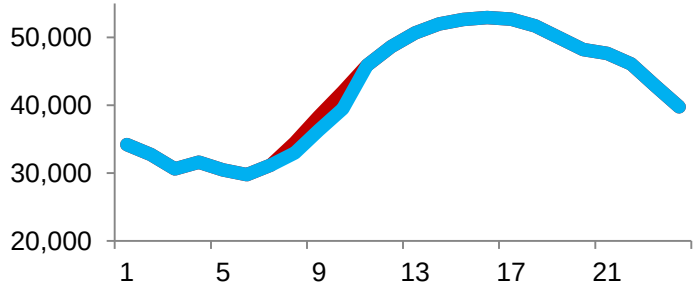
Traditional metric to capture events that occur due to capacity shortfalls in peak conditions



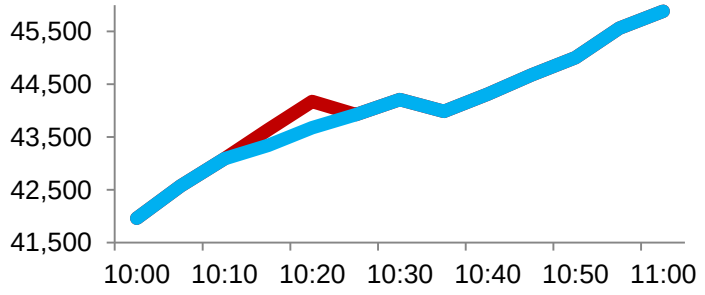
New "Flexible Capacity" Metrics

$LOLE_{FLEX}$ = 0.2 Target

New metric to capture events due to system ramping deficiencies of longer than one hour in duration



New metric to capture events due to system ramping deficiencies inside a single hour



SERVM Framework

- **Base Case Study Years (2023, 2028, 2033)**
  - Weather (36 years of weather history)
    - Impact on Load
    - Impact on Intermittent Resources
  - Economic Load Forecast Error (distribution of 5 points)
  - Unit Outage Modeling (thousands of iterations)
    - Multi-State Monte Carlo
    - Frequency and Duration

- Base Case Total Scenario Breakdown: 36 weather years x 7 LFE points = 252 scenarios
- Base Case Total Iteration Breakdown: 252 scenarios * 10 unit outage iterations = 2,520 iterations

- Intra Hour Simulations at 5-minute Intervals

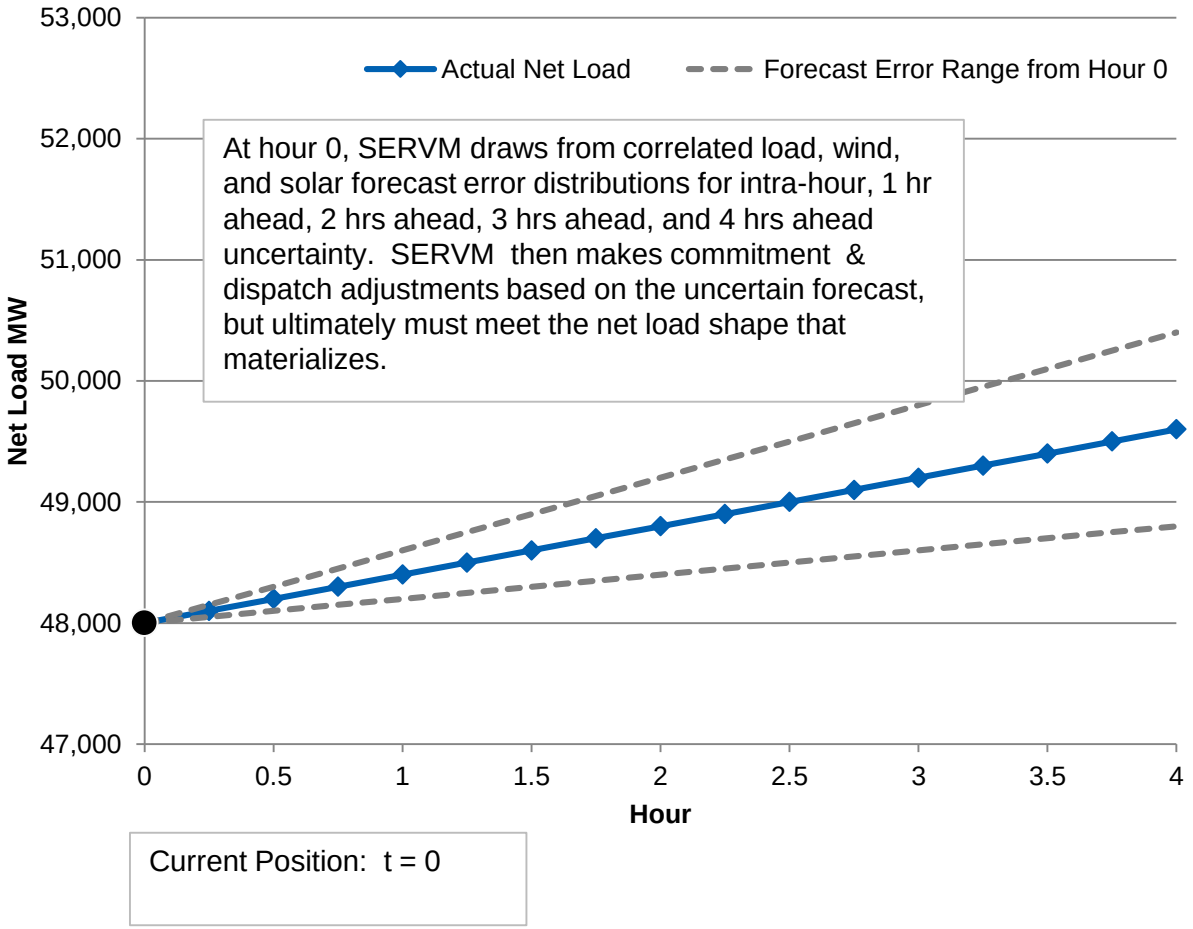
Resource Commitment and Dispatch

- **8760 Hourly Chronological Commitment and Dispatch Model**
- **Simulates 1 year in approximately 1 minute allowing for thousands of scenarios to be simulated which vary weather, load, unit performance, and fuel price**
- **Capability to dispatch to 1 minute interval**
- **Respects all unit constraints**
  - Capacity maximums and minimums
  - Heat rates
  - Startup times and costs
  - Variable O&M
  - Emissions
  - Minimum up times, minimum down times
  - Must run designations
  - Ramp rates

Resource Commitment and Dispatch

- **Commitment Decisions on the Following Time Intervals allowing for recourse**
  - Week Ahead
  - Day Ahead
  - 4 Hour Ahead, 3 Hour Ahead, 2 Hour Ahead, 1 Hour Ahead, and Intra-Hour
- **Load, Wind, and Solar Volatility**
  - **Captures the flexibility benefit of fast ramping resources and the integration costs of intermittent resources.**

1 - 4 Hour Ahead Forecast Error



Ancillary Service Modeling

- **Ancillary Services Captured**
  - Regulation Up Reserves
  - Regulation Down Reserves
  - Spinning Reserves
  - Non Spinning Reserves
  - Load Following Reserves
- **Co-Optimization of Energy and Ancillary Services**
  - Each committed resource is designated as serving energy or energy plus one of the ancillary services for each period

Post IRP – Preliminary Fall Analysis

Post IRP Fall 2017 Modeling

- **Modeled 11 Portfolios including different penetrations of the following resources**
  - Small, flexible GT Capacity
  - Frame GT Capacity
  - Combined Cycle Capacity
  - Wind
  - Solar
  - Battery Storage
- **Analyzed total costs and reliability metrics of each portfolio**
- **Implications on RFP**
  - Based on this preliminary analysis, all technologies (gas, wind, solar, energy storage) were invited to be part of the RFP. Dependent on actual bid pricing, a mixture of these technologies will be the best overall portfolio from a reliability and economic perspective
- **Other Conclusions**
  - Economic analysis very dependent on capital costs and PPA prices assumed for solar/wind in the actual RFP but the Fall analysis showed the following:
  - A mixture of small, flexible and/or frame capacity may be economic but the smaller units will produce lower renewable curtailment and benefit reliability
  - Reliability metrics showed that additional renewable resources can be integrated
  - Battery storage assuming the IRP pricing was not economic however bid prices are lower than the assumptions made in the fall analysis
  - As solar and wind penetrations increase, renewable curtailment increases making it less valuable

Preliminary RFP Analysis

Astrapé Evaluation Framework

- **20 Year NPV Analysis using SERVM**
  - Simulate reliability and production costs for 2023, 2028, and 2033 for all portfolios.
  - Interpolate production costs between years to develop 20 year production costs.
  - Include 20 years fixed costs (capacity payments, revenue requirements, fixed O&M, fixed gas transportation, transmission) for incremental portfolio
  - Portfolios must meet capacity and flexibility reliability criteria of at or near 0.2 events per year

RFP Portfolio Modeling

- **Step 1: Received Short list based on the PNM and HDR Evaluation**
  - Split into Tier 1 and Tier 2 resources
    - Tier 1 resources represent most economic resources for each technology
- **Step 2: Develop portfolios that meet reliability using the Tier 1 resources**
  - Vary wind, solar, gas, battery resources to meet reliability
- **Step 3: Determine the best portfolio made up of Tier 1 resources**
- **Step 4: Add Tier 2 resources to determine if the best portfolio improves**
- **Step 5: Perform sensitivity with high gas/CO2 prices**
- **Step 6: Develop recommendation which must meet RPS**