



Use of Renewable Forecasts in System Operations under Extreme Events

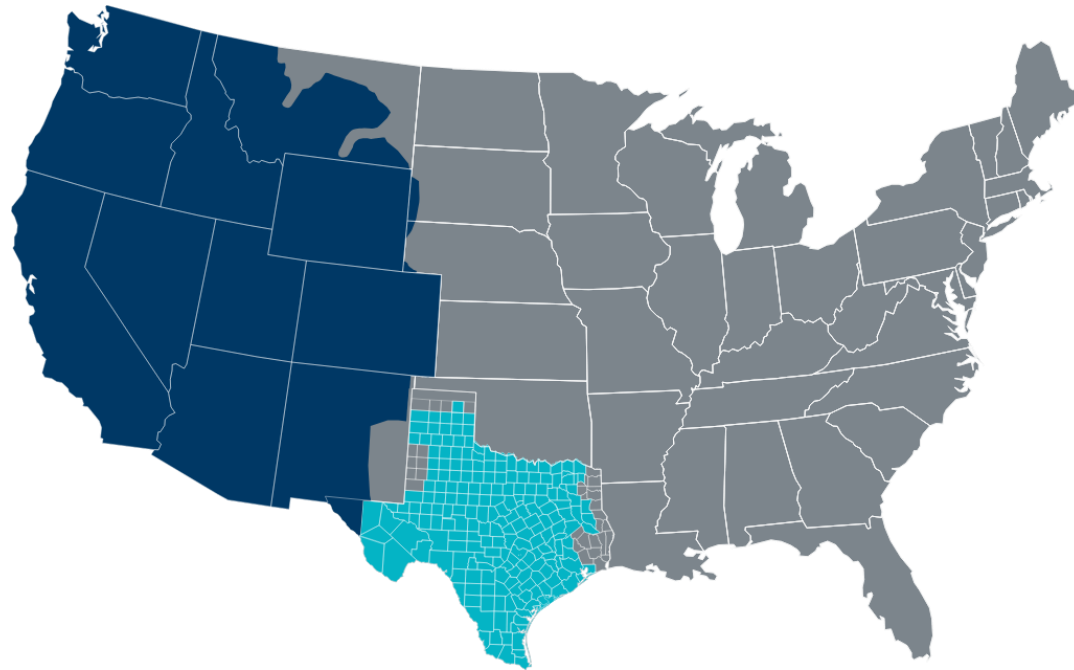
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The ERCOT Region



US

Interconnections

 Western Interconnection
Includes El Paso and Far West Texas

 ERCOT Interconnection

 Eastern Interconnection
Includes portions of East Texas and Panhandle region

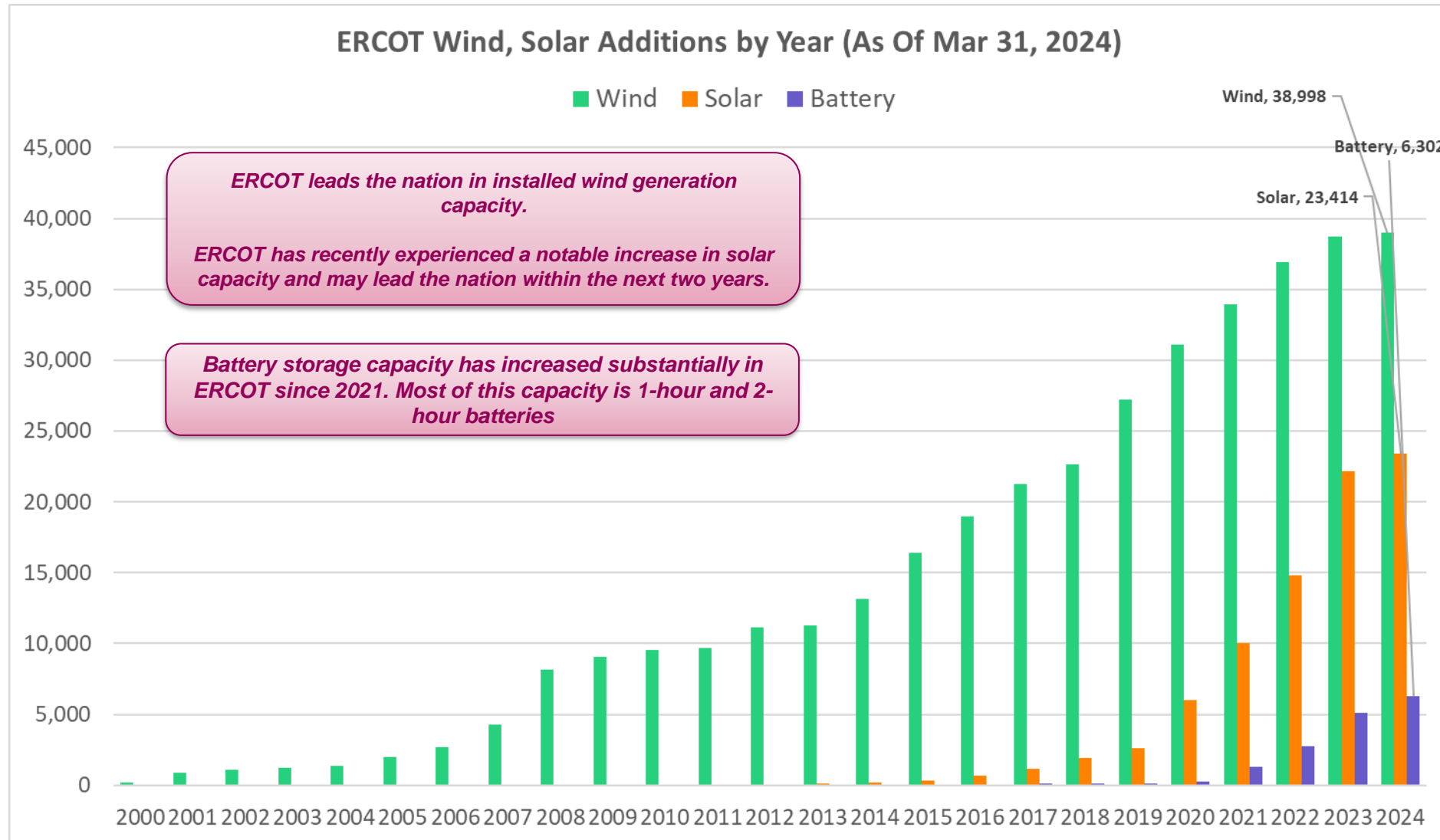
The interconnected electrical system serving most of Texas, with limited external connections

- 90% of Texas electric load; 75% of Texas land
- 85,508 MW peak, Aug. 10, 2023
- More than 54,100 miles of transmission lines
- 1,250+ generation units (including PUNs)

ERCOT connections to other grids are limited to ~1,220 MW of direct current (DC) ties, which allow control overflow of electricity

Wind, Solar, Battery Additions By Year*

*As of March 31st, 2024



Wind and Solar Forecasts

ERCOT implemented a centralized forecast for wind in 2009 and for solar in 2016.

- Second vendor added: Wind 2017, Solar 2022

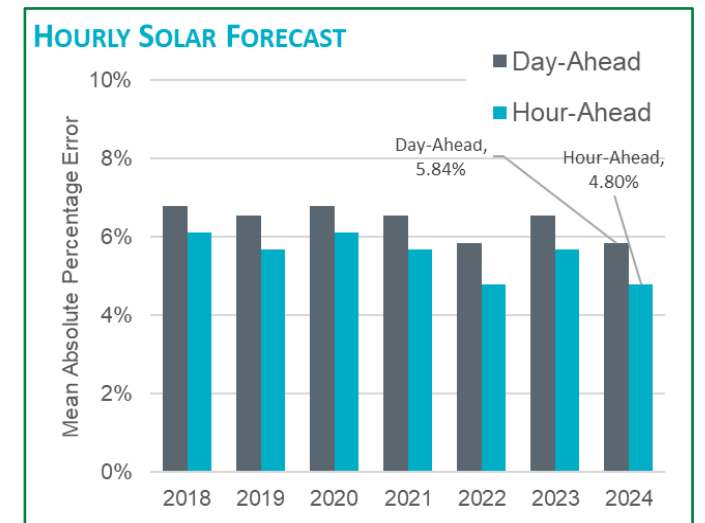
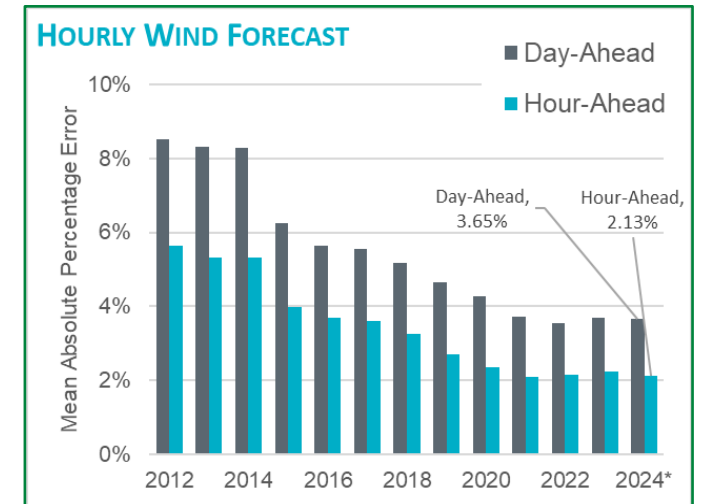
Model Description

- Four Hourly Wind and Solar Forecasts per Vendor
 - Rolling 168-hr forecast; hourly resolution; updated every hour
 - POE80, POE50 and 2 Extreme Event Forecast are received from each vendor for each wind resource and solar
- One Intra-Hour Wind and Solar Forecasts per Vendor
 - 2-hour rolling forecast; 5-min resolution; updated every 5-min
- Four 15-min Probabilistic Forecasts
 - Rolling 6-hr forecast; 15-min resolution; updated every hour
 - 50th, 85th, 90th, 95th, 98th.

Primary Inputs,

- Site geo-location; Met tower geo-location; Wind Speed and Temperature Operational limits; Telemetered site-specific data; Scheduled outages & de-rates; Generic power curves; Weather variables like wind speed/direction, *irradiance*, cloud cover

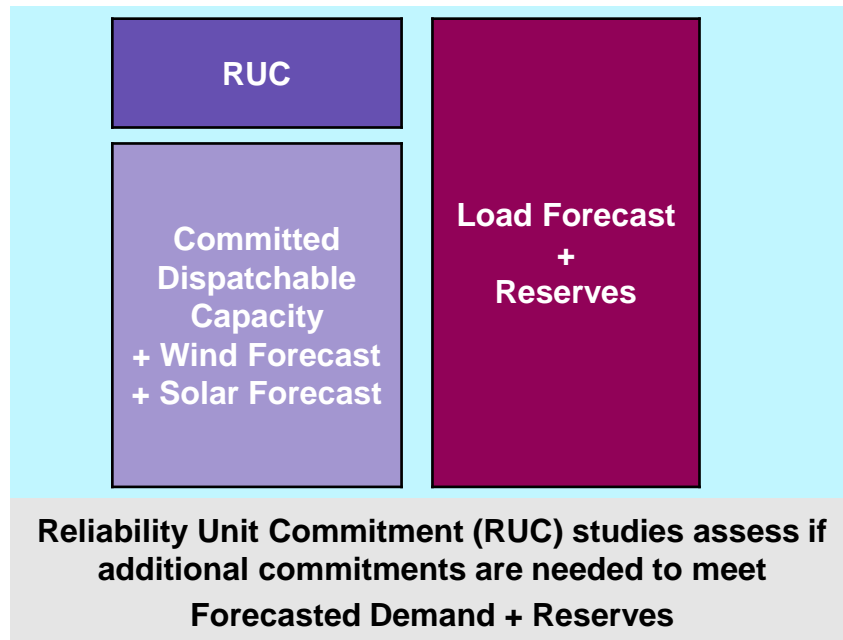
*In the graphs below, 2024 represents the average forecast error between 01/01/2024 and 03/31/2024



Studies that Use Renewable Forecasts

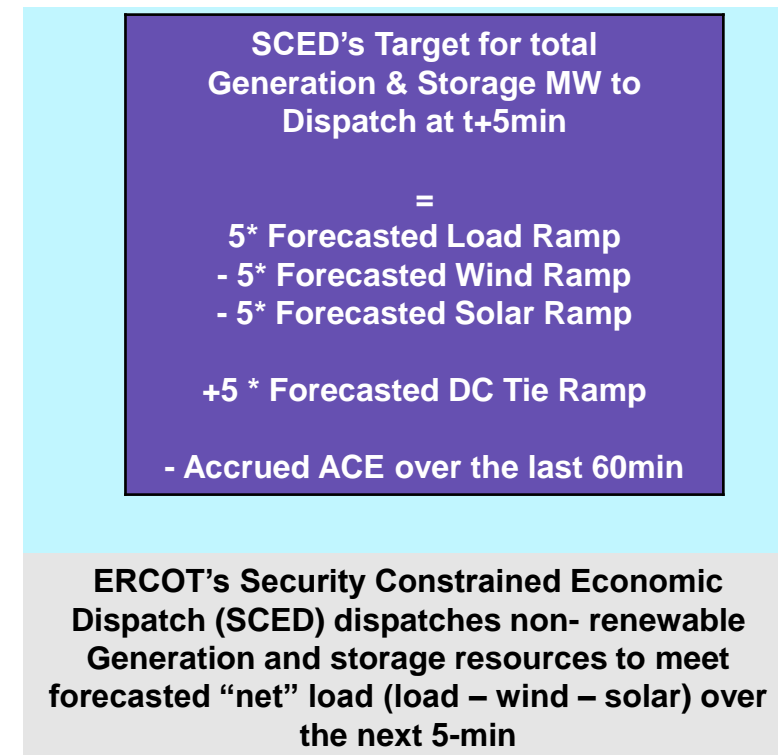
UNIT COMMITMENT STUDIES

Active hourly Wind and Solar forecast are used in hourly Reliability **Unit Commitment studies** to determine if sufficient capacity is available to cover active forecasted demand plus reserves. Also used in look ahead studies like **Outage Coordination and Next Day Study**.



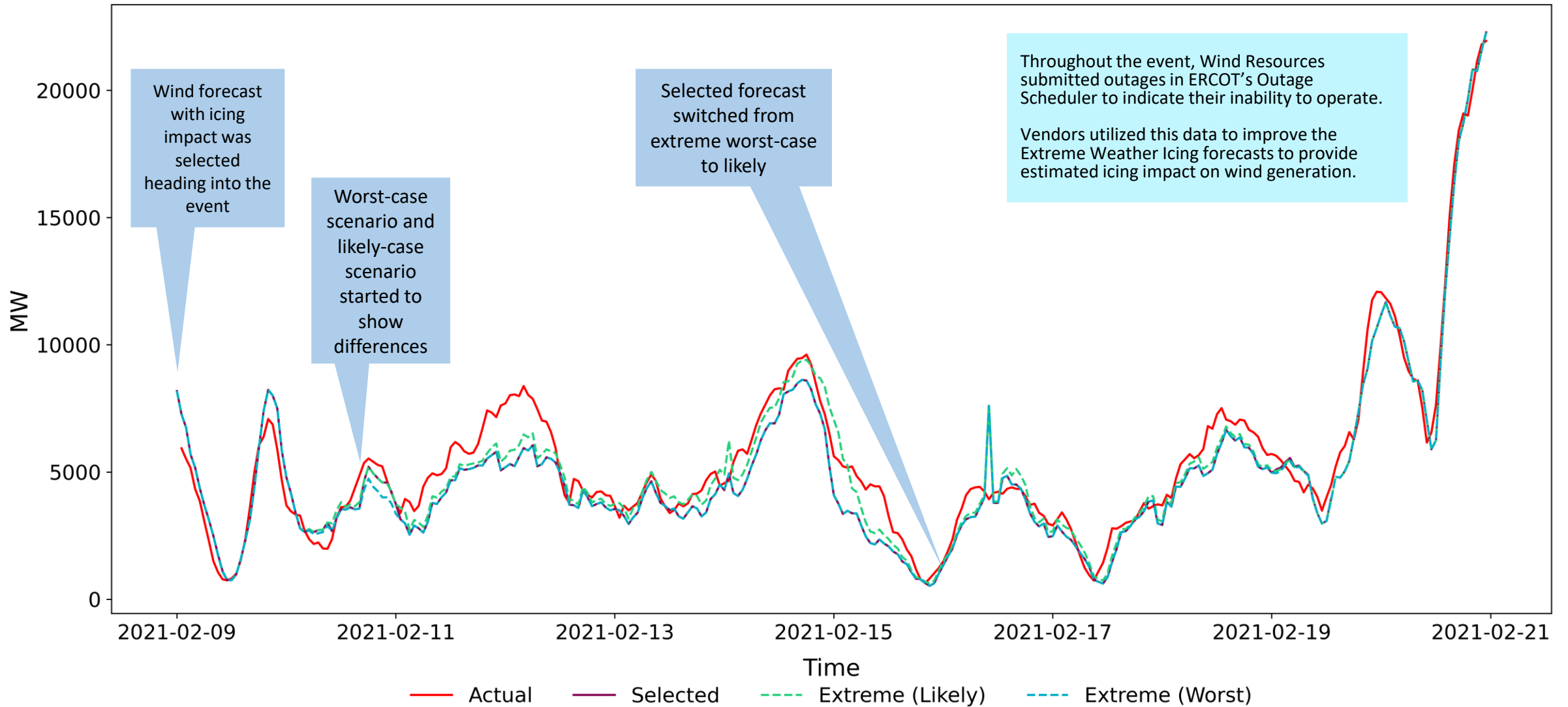
SECURITY CONSTRAINED ECONOMIC DISPATCH

Active Intra-hour 5-min Wind and Solar forecast are used in **5-min Real Time dispatch** preposition dispatchable Resources in anticipation of wind and solar ramps.



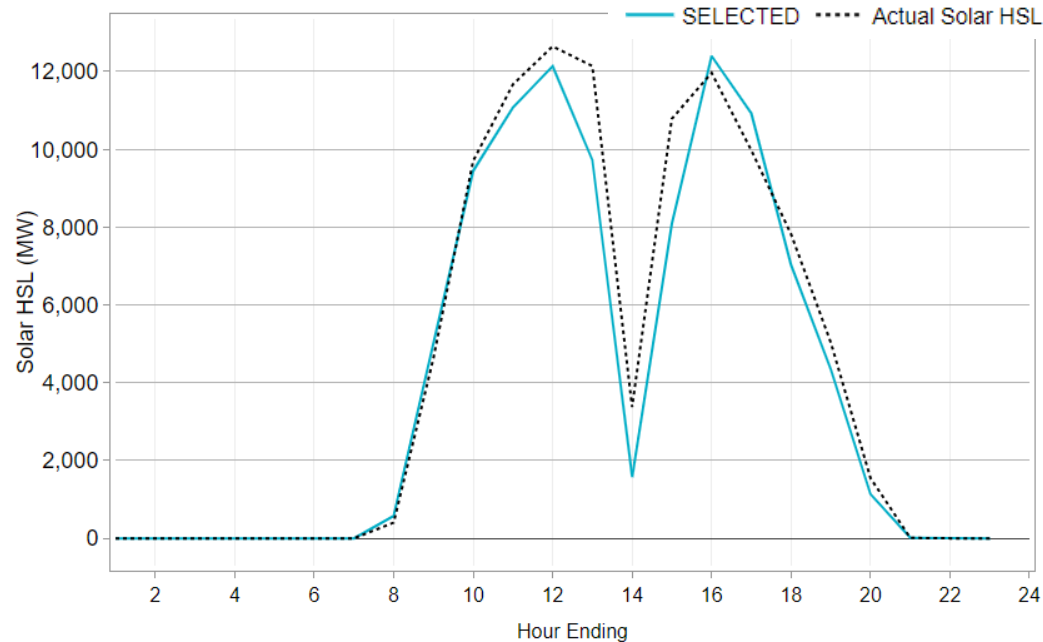
Winter Storm Uri Wind Forecast*

* 1 hour-ahead forecasts are shown in the graph

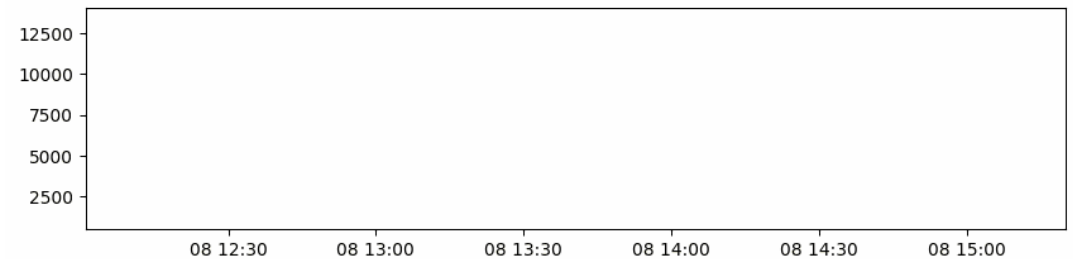
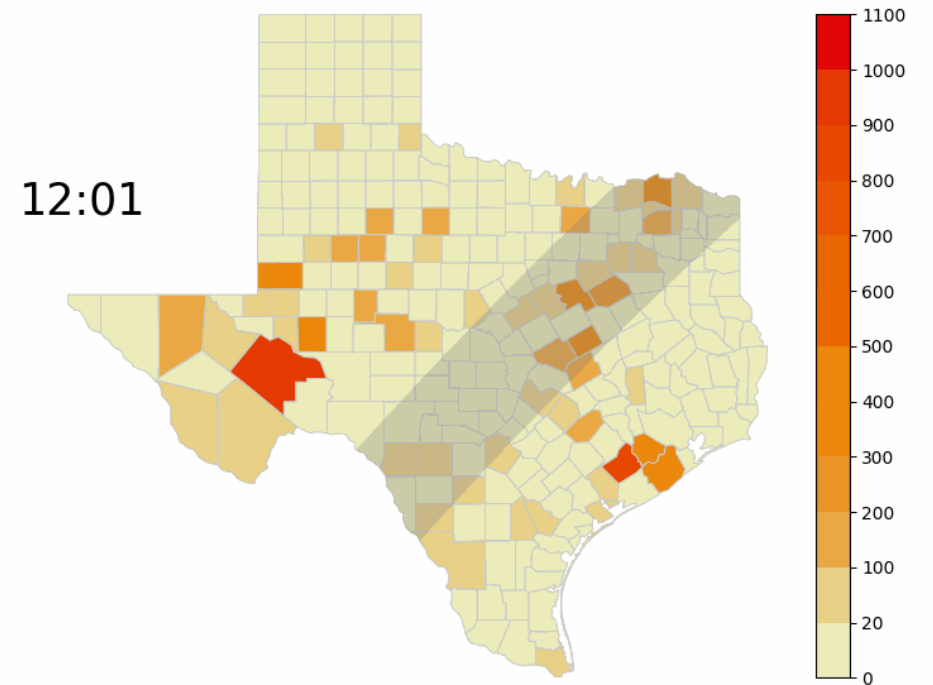


April 8 Eclipse Forecast

- Solar generation was reduced during the eclipse, dropping from an instantaneous peak of **13.8 GW** at the beginning of the eclipse to a low output of **0.7 GW at 1:36 p.m.**, and then rising to approximately **13.8 GW by 3:10 p.m.**
- ERCOT procured additional Ancillary Services (AS), committed additional generation, took manual actions to increase ramping capability, and deployed AS to maintain reliability.



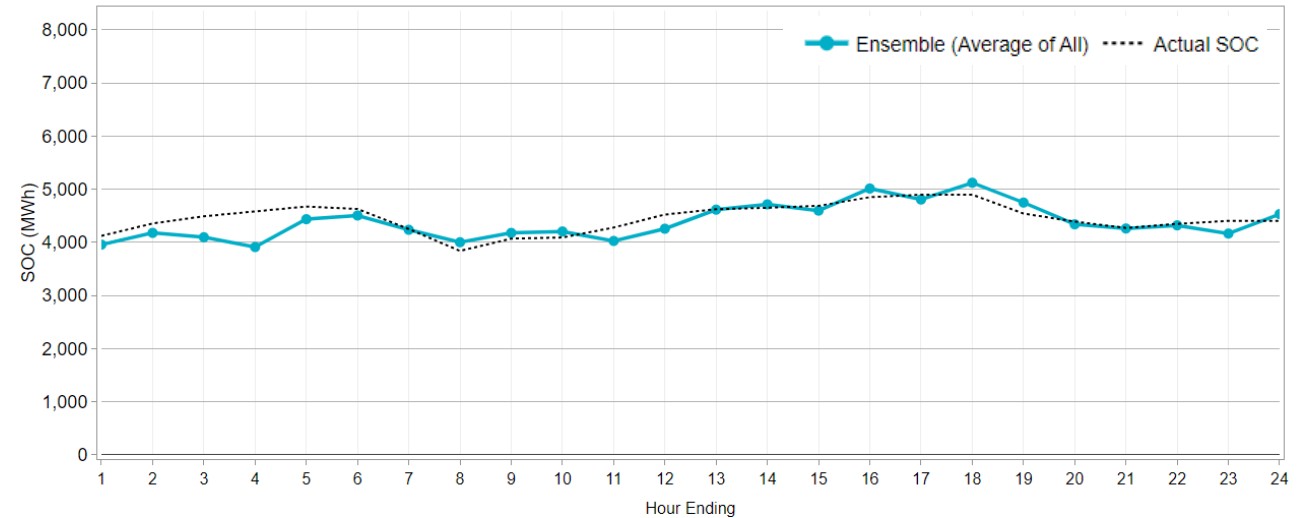
April 8, 2024, County-level and System-level Solar Generation



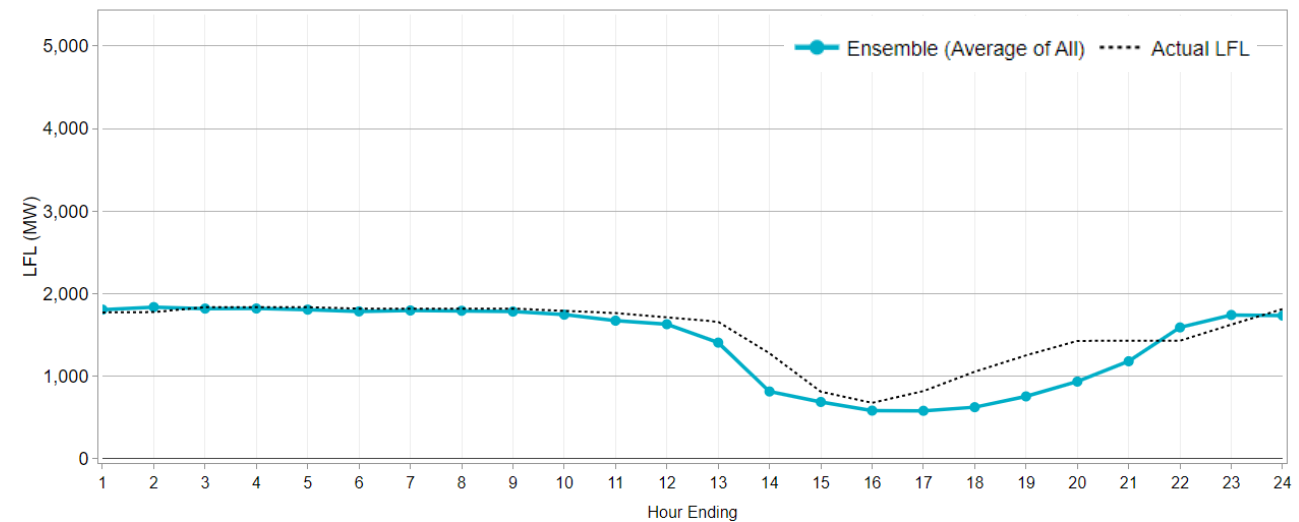
SOC and LFL Forecast

- Ensemble method is implemented to forecast battery storage State Of Charge (SOC) and Large Flexible Loads (LFL)
 - Multiple machine learning models such as Support Vector Regression, Gradient Boosting, and Random Forest are used
- Deep-learning models such as RNN and CNN-LSTM models are also being explored for improved forecast performance
- Challenges
 - Both battery storage units and LFLs have extremely high ramp rate
 - Not enough information/data to properly train a machine learning model to consider spatial-temporal features

System-Wide SOC Forecast Performance on 02/14/2024 from Latest Forecast



System-Wide LFL Forecast Performance on 06/21/2023 from Latest Forecast



Probabilistic risk assessment to support grid operations

- When planning for operations in the next 7-day horizon, ERCOT currently uses deterministic approach for measuring risk of an emergency events.
 - Available capacity is determined based on specific combination of the load, solar, and wind forecasts
 - The **capacity availability tool (CAT)** runs for the next 48 hours
- As ERCOT's grid evolves, uncertainty and variability of load, wind and solar are expected to grow even further and this method of evaluating risk is not sufficient.
- Need to shift from a deterministic risk assessment in next 7-day horizon to probabilistic.

Input

- Hourly COP Data
- Hourly Load Forecast Data
- Hourly Solar Forecast Data
- Hourly Wind Forecast Data

Extras

- Energy Storage Resources SOC Forecast
- Price Responsive Demand Forecast

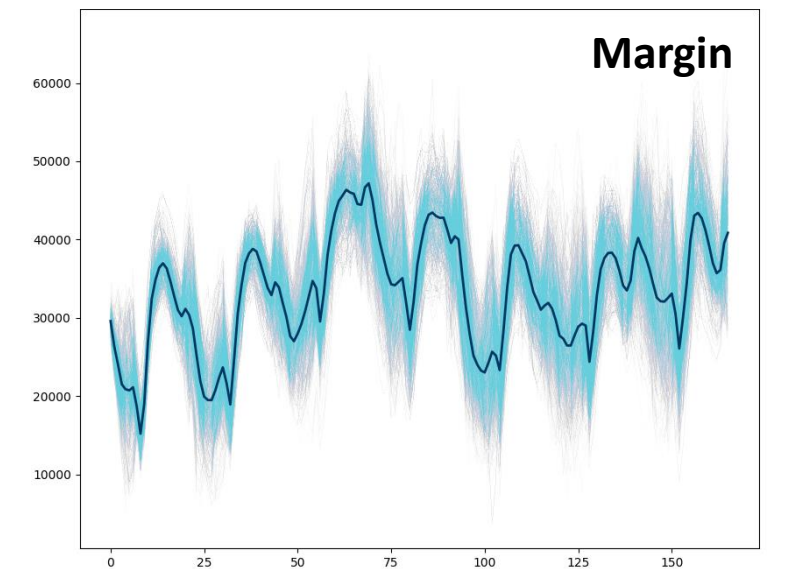
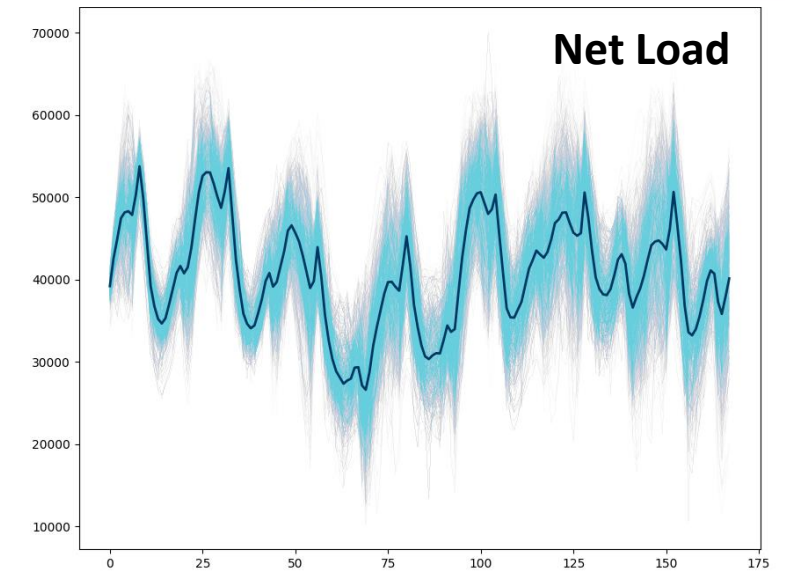
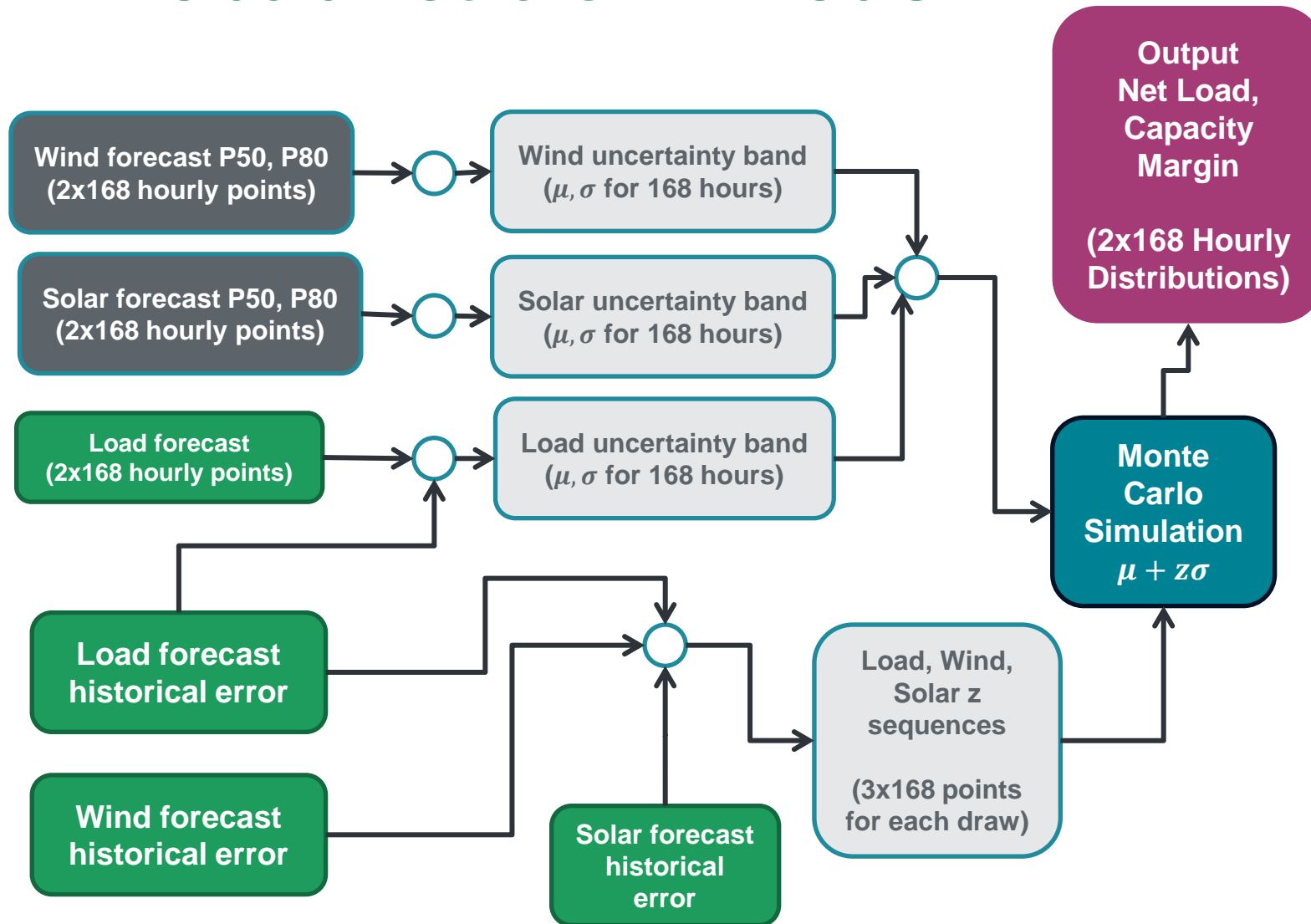
Process

- Calculate uncertainty for load, solar and wind forecast
- Apply the forecast uncertainty for the forecast period (168 hours) with information from history
- Create distribution of net load forecast ($net\ load = total\ load - solar - wind$) using Monte Carlo (MC) simulation
- Determine forecasted capacity margin distribution from COP data and MC output

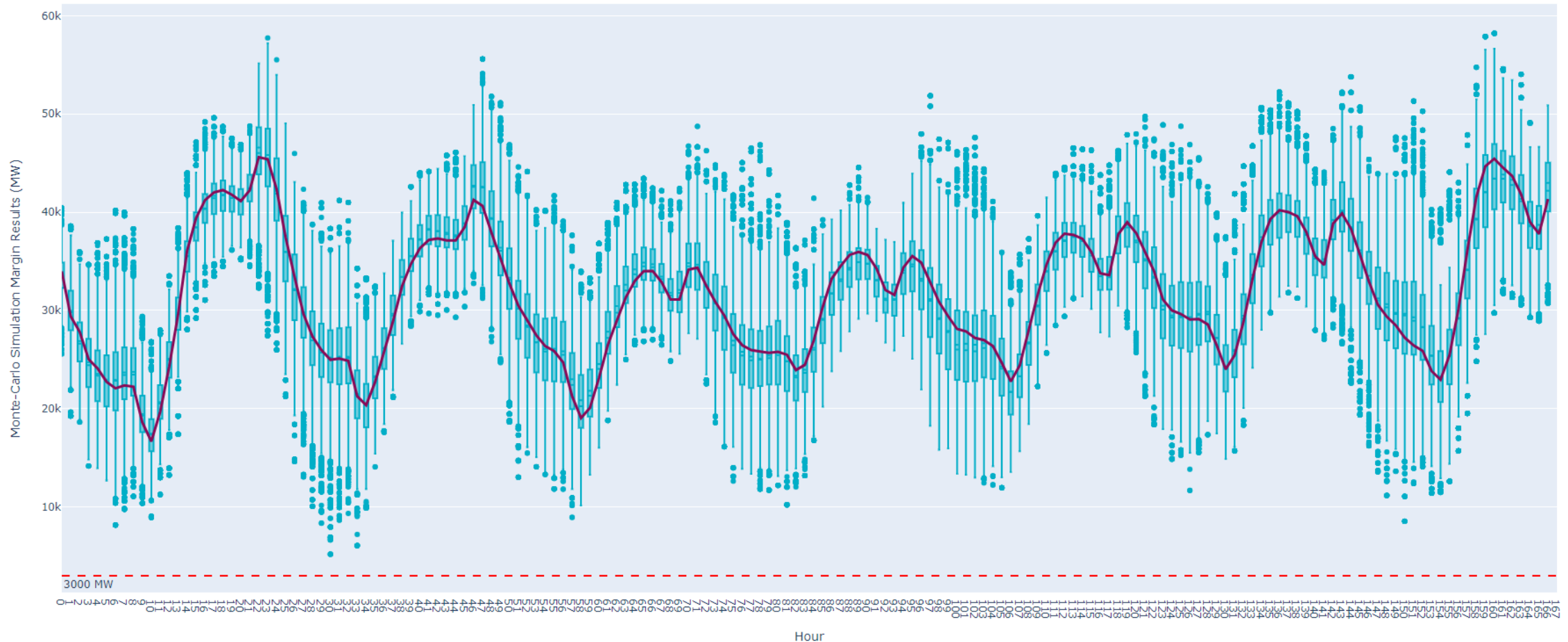
Output

- Event Occurrence Probability – hourly probability of capacity margin falling below certain threshold (168 hours)
- Statistics on forecasted capacity margin (min, max, average, median, k^{th} percentile, etc.)

Probabilistic CAT Model



Probabilistic CAT Model Results



Challenges

- Unknown actual distribution
- Forecast error pattern is ever-changing
- Increasing solar/wind capacity and load

Next Steps

- Summer of 2024
- Continue to tune assumptions
- Incorporate battery storage and price-responsive load

Thank you!

Questions?
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