Real-Time Reserve Requirements

Emily Barrett

Sr. Lead Market Design Specialist

Reserve Certainty Senior Task Force

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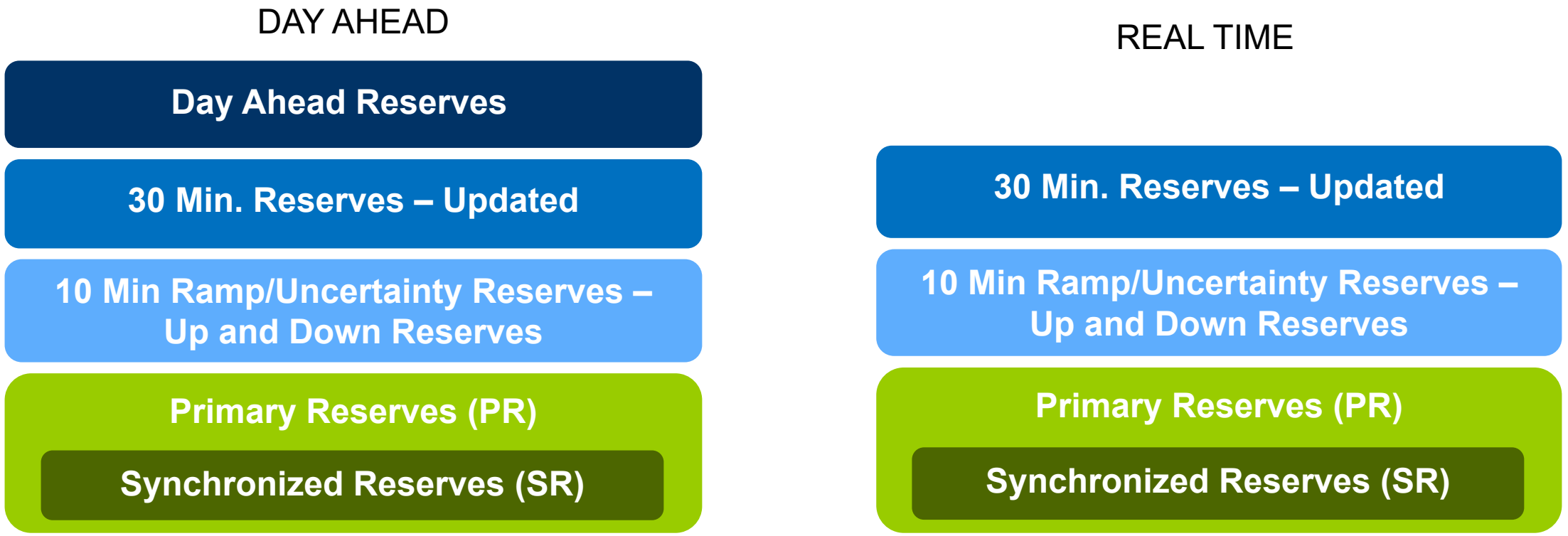
Reserve Design

PJM is building a proposal around a suite of day-ahead and real-time reserve products, each of which will need reserve requirements to set the procurement targets in the market clearing engines.



RECALL

DA – RCSTF

Day Ahead Reserves
Addresses uncertainty DA that does not need to be carried into RT.
Inclusive of the need to have energy and reserve commitments to meet the next day load forecast (energy gap)

30 Min. Reserves – Updated
Replacement reserves for contingency events and capturing uncertainty

10 Min Ramp/Uncertainty Reserves – Up and Down Reserves
Addresses net-load ramping needs and allows PJM to meet interval by interval energy and reserve needs

Reserve products would not be nested

Primary Reserves (PR) (10-minute reserves)– 150% SR
Contingency reserves and ACE recovery

Synchronized Reserves (SR) (10-minute reserves) – 100% MSSC*
Contingency reserves and ACE recovery

SR/PR would remain nested

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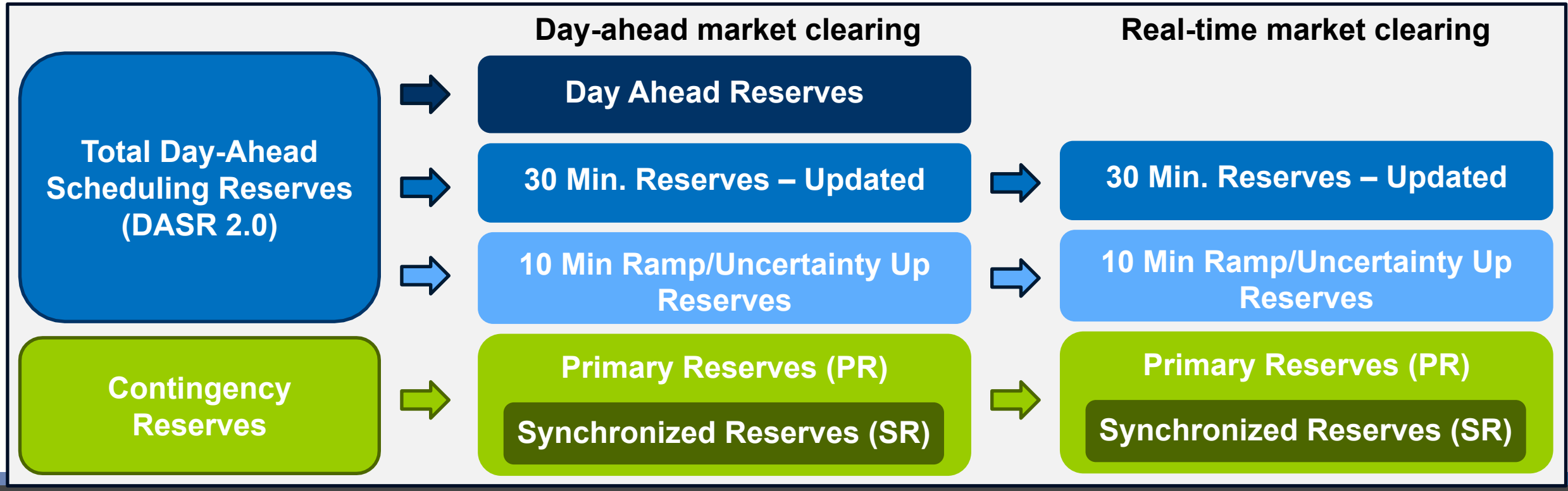
Reserve Requirement Overview

DASR 2.0 is the total reserve quantity PJM needs to carry day-ahead to schedule the system for reliability above the reserves needed for unit loss.

The total DASR 2.0 quantity would be divided across reserve products to reflect the services needed and what would be carried into real-time based on expected real-time reserve needs.

The real-time reserve quantities would be cleared both day-ahead and real-time based on the defined reserve requirements.



Reserve Requirement Overview

Total Day-Ahead Scheduling Reserves (DASR 2.0)

Day Ahead Reserves

The residual DASR 2.0 requirement would be allocated to Day-Ahead-Only Reserves. This is the quantity of reserves we need to clear day-ahead to schedule the system, but don't expect to need to clear during the operating day.

30 Min. Reserves – Updated

The portion of the total DASR 2.0 requirement allocated to the 30-Min Reserve Requirement would be based on the amount of 30-Min Reserves we expect to need during the operating day.

10 Min Ramp/Uncertainty Up Reserves

The portion of the total DASR 2.0 requirement allocated to the 10-Min RUR Requirement would be based on the amount of 10-Min RUR we expect to need during the operating day.

10-Minute RUR MW Quantities

10-Min Ramp/Uncertainty Reserves (10-Min RUR) would be cleared to manage net-load forecast uncertainty and to ensure that the system is positioned to meet expected net-load ramping needs in upcoming intervals.

- ***Uncertainty component of the requirement:*** Near-term load, wind and solar forecast error (e.g., 30 minutes ahead of the target time).
- ***Deterministic component of the requirement:*** Forecasted net-load ramp for intervals beyond the current target interval (e.g., the next 10 minutes beyond the target time).
- Both up and down 10-Min Ramp/Uncertainty Reserve products would be defined and the factors dictating the reserve quantities would be the same. However, the actual quantities could be different depending on system need.

30-Minute Reserve MW Quantities

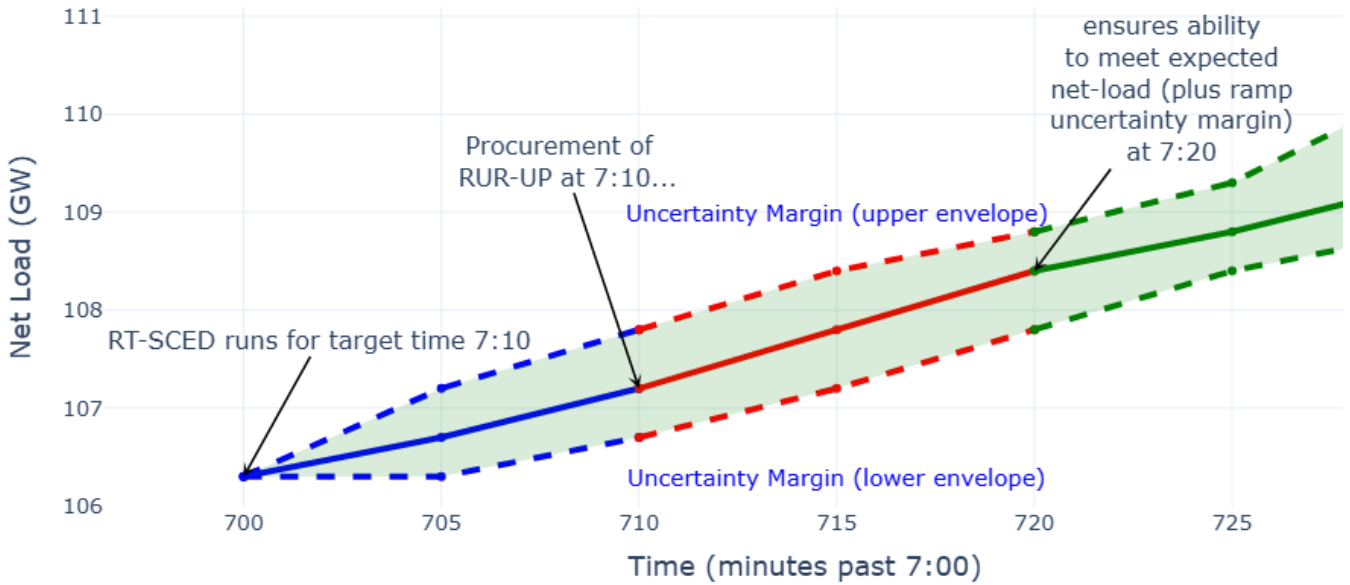
30-Min Reserves (30-Min) would be cleared to manage net-load forecast uncertainty and to ensure that the system has sufficient Secondary Reserves to replace our Primary Reserves in the event of a unit loss.

- ***Uncertainty component of the requirement:*** Load, wind and solar forecast error (e.g., 2-hours ahead of the target time).
- ***Deterministic component of the requirement:*** Replacement reserves for the largest contingency at any given time.

Calculating the Deterministic Component of Real-Time Reserves

10-Min Ramp/Uncertainty Reserves

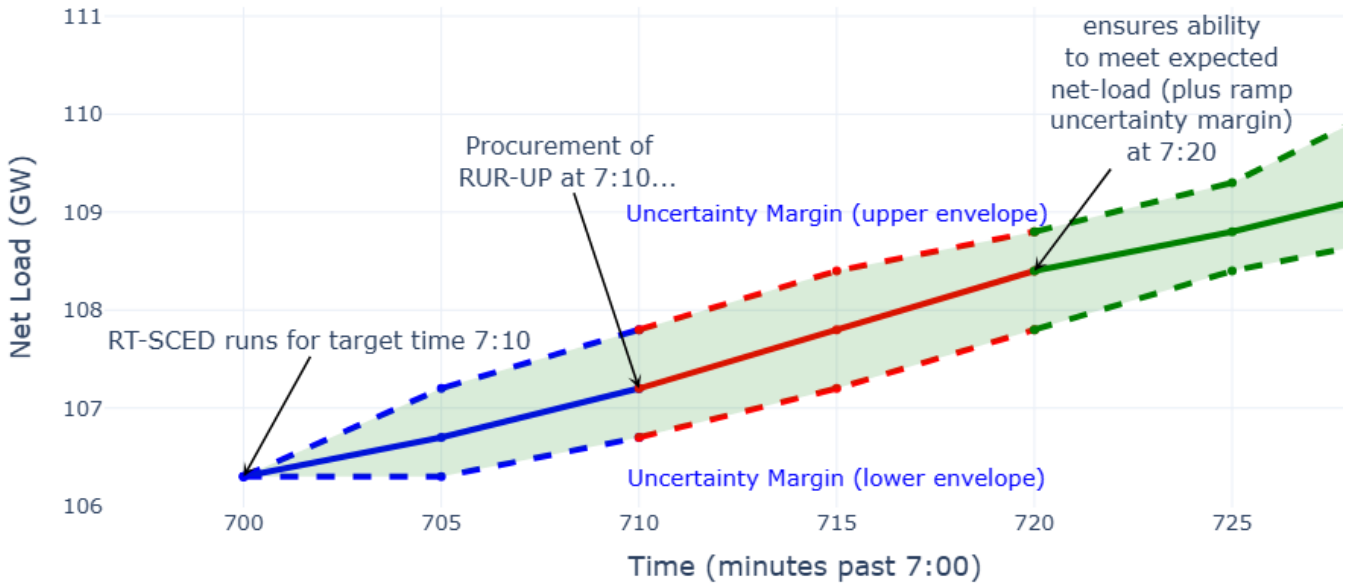
The deterministic portion of 10-Min RUR Requirement would be calculated based on the forecast net-load ramp for the 10 minutes following the target time.



- In the figure above and to the right, the dotted lines around the central line are the uncertainty bounds around the forecasted net-load.
- The central (solid) line is the net-load forecast that PJM is operating to.

10-Min Ramp/Uncertainty Reserves

- The net-load forecast at the target time (7:10) is 107,210 MW
- The net-load forecast at the 10 minutes past the target time (7:20) is 108,400 MW
- The expected net-load ramp for the 10 minutes past the target time is therefore 108,400 MW – 107,210 MW = 1,190 MW



- Note that this number can be positive (for a ramp up event) or negative (for a ramp down event)
- Positive values would be used to inform the 10-Min RUR Up requirement. Negative values would be used to inform the 10-Min RUR Down requirement.

30-Min Reserves

- The deterministic component of the 30-Min Reserve Requirement would be based on the largest active contingency on the system.
- This is to ensure that we have sufficient replacement MWs available on the system to backfill our contingency reserves in the case of an event.
- This quantity would therefore be set based on the resources committed to the system, and which unit loss represents our most severe single contingency. The methodology for identifying the size of this contingency would be the same for 30-Min Reserves as for Synchronized Reserves.*

***Note:** any performance adjustment to the Synchronized Reserve Requirement to account for SR resource performance would not be applied to the 30-Min Reserve Requirement.*

Calculating the Uncertainty Component of Real-Time Reserves

Methodology – Net-Load Uncertainty

Solar/Wind Forecast Error

- Forecast Error = Forecasted MW generated minus Actual MW generated
- Indicates shortage/surplus of supply

Load Forecast Error

- Actual MW Consumed – Forecasted MW Consumed
- Indicates under/over-forecasting demand

Net-Load Error = Solar Error + Wind Error + Load Error

- Indicates the ramping need due to forecasting errors in demand or supply

Rationale

- Examining the net-load forecast error percentiles (such as 1%, 2.5%, 97.5%, 99% etc.) helps to characterize our net-load uncertainty.

- Selecting a percentile to use for setting requirement levels is ultimately a question of risk tolerance. For example, using 97.5% equates to how many reserves we would need to address our net-load uncertainty 97.5% of the time.

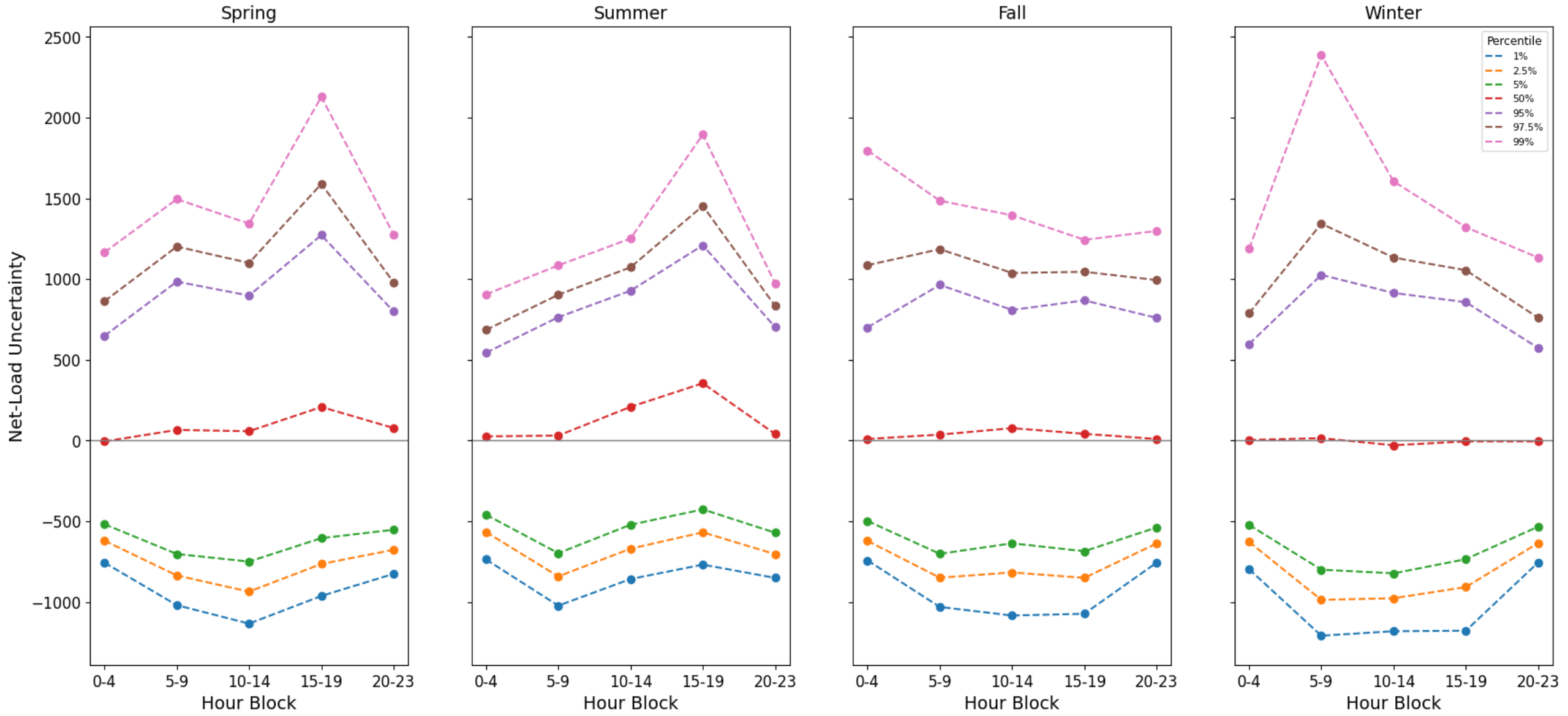
Data Used in the Analysis

- One year of data covering the 2024-2025 Delivery Year (June 1, 2024 – May 31, 2025)
- Two uncertainty lookahead periods:
  - Forecast error 20 minutes ahead of the target time
  - Forecast error 2-hours ahead of the target time
- Binned by season (i.e., spring, summer, fall and winter)
- Evaluated at two temporal granularities:
  - In “hour block” to group together similar hours
  - Hourly

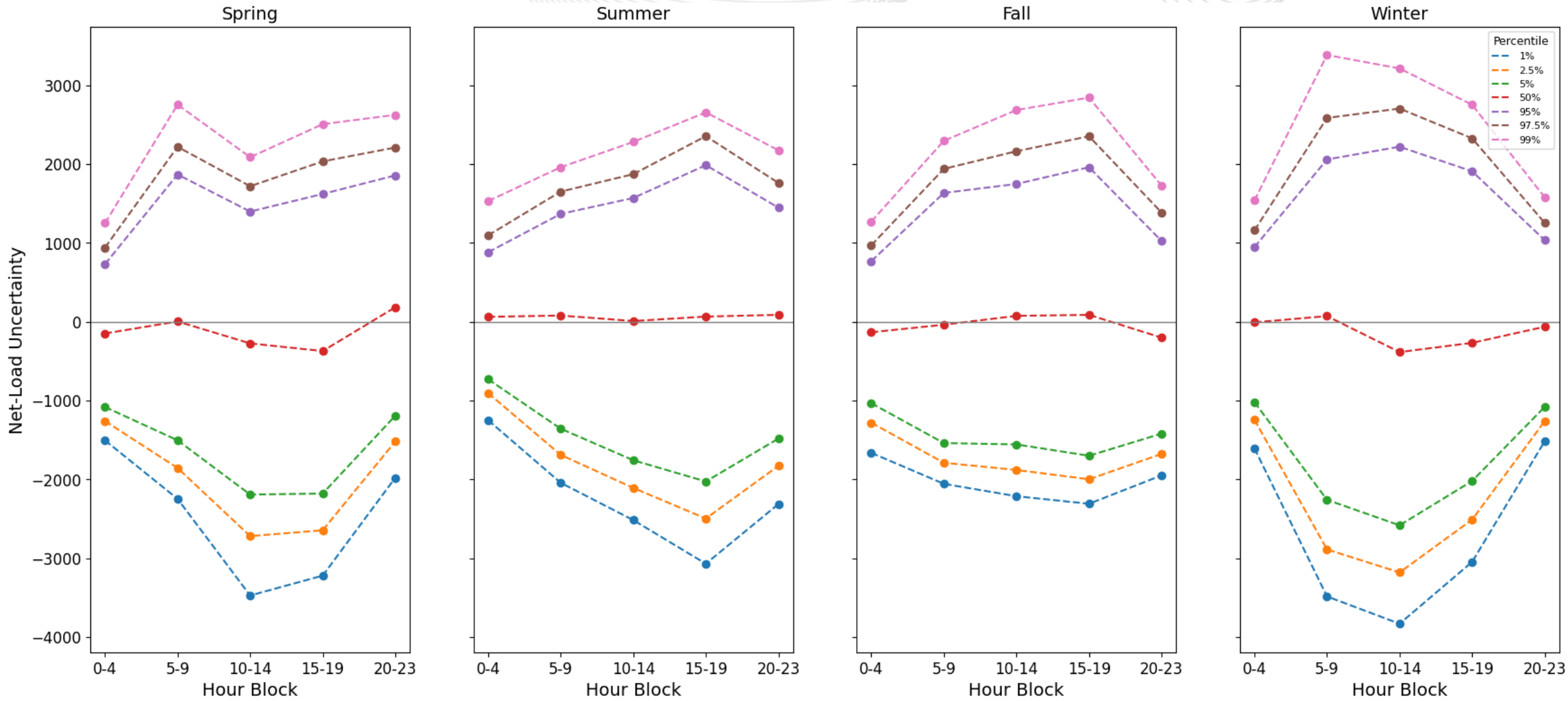
Hour Block Definition

Hour Block	Meaning
Hours 0 to 4	Overnight
Hours 5 to 9	Early Morning
Hours 10 to 14	Mid-morning/Early afternoon
Hours 15 to 19	Late afternoon/Early evening
Hours 20 to 23	Evening

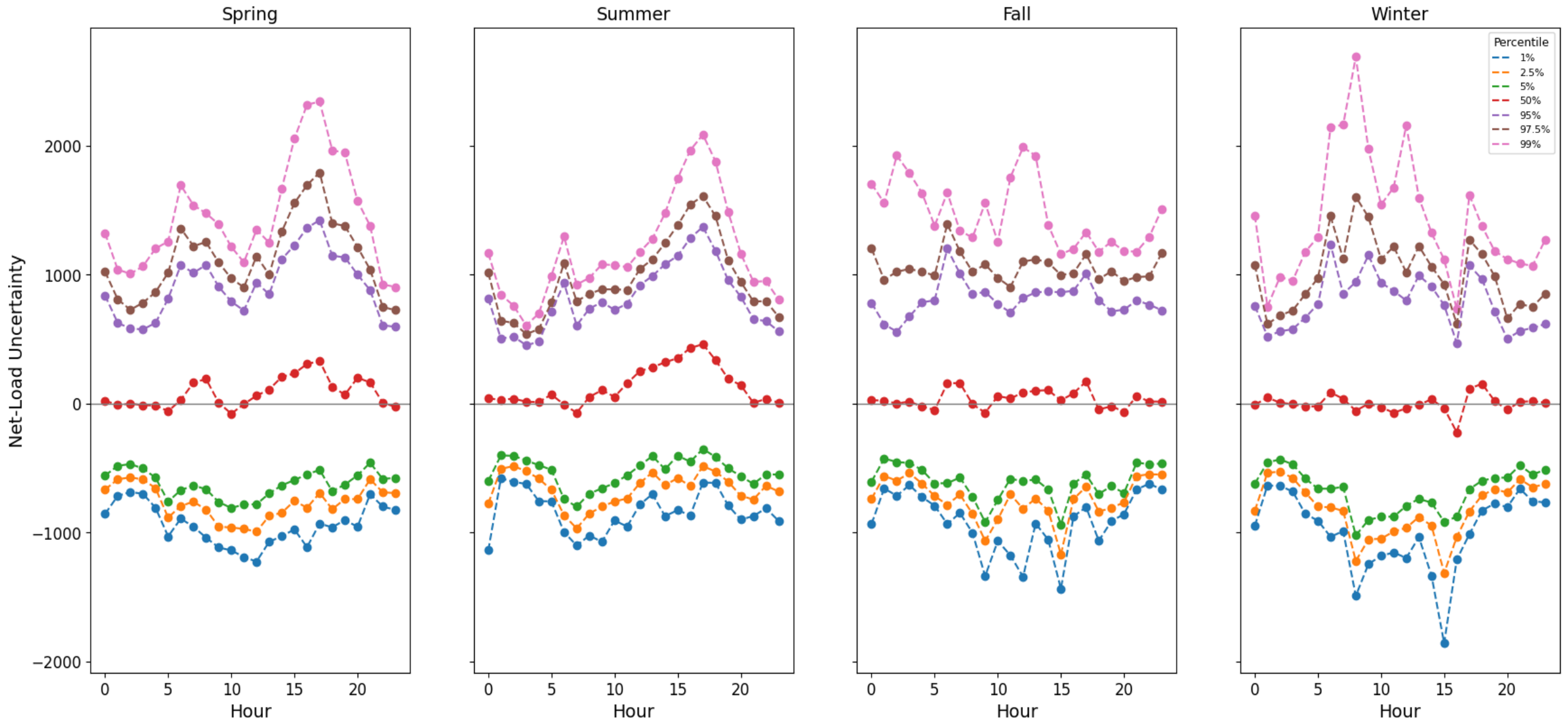
Net-Load Forecast Uncertainty by Hour Block and Season for 10-Min Ramp/Uncertainty Reserve Product



Net-Load Forecast Uncertainty by Hour Block and Season for 30-Minute Reserve Product



Net-Load Forecast Uncertainty by Hour and Season for 10-Min Ramp/Uncertainty Reserve Product



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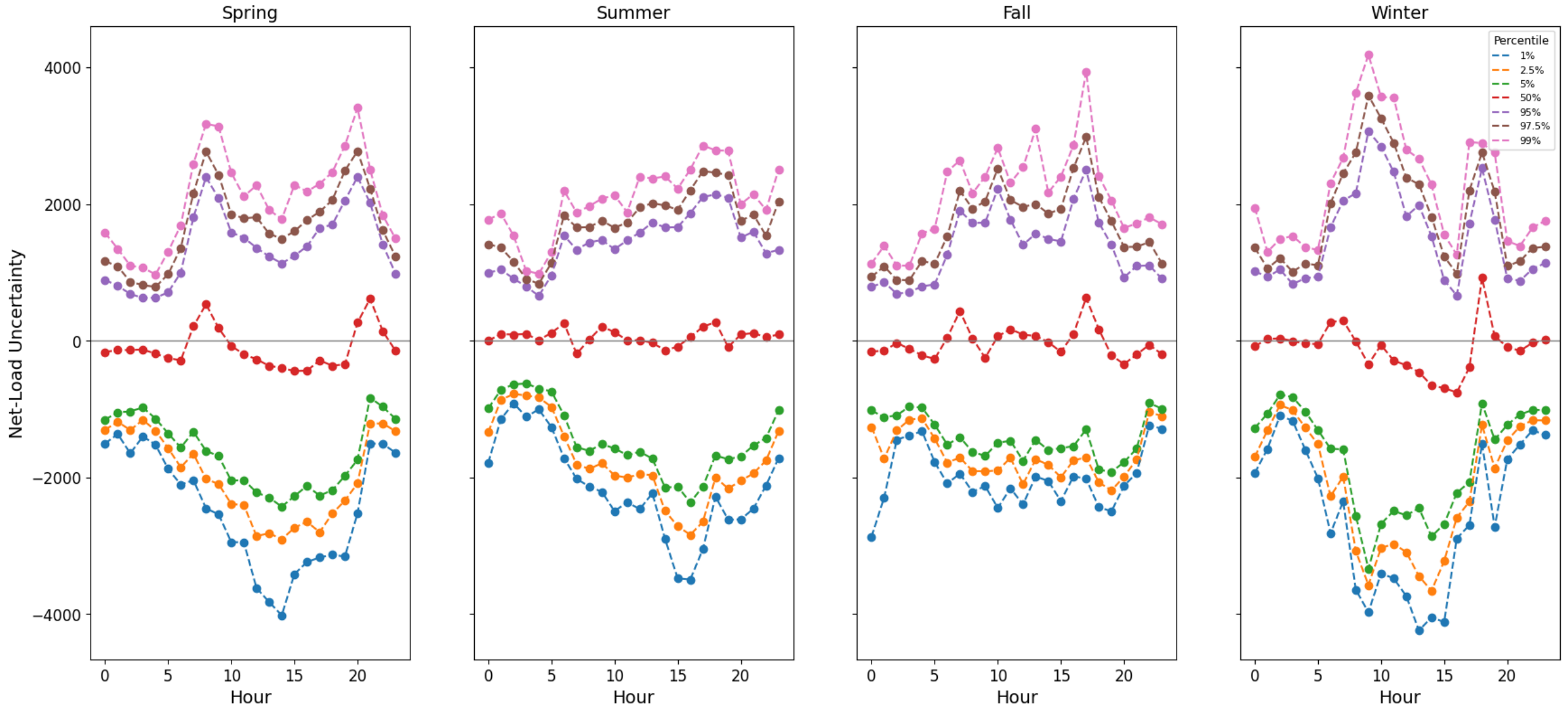
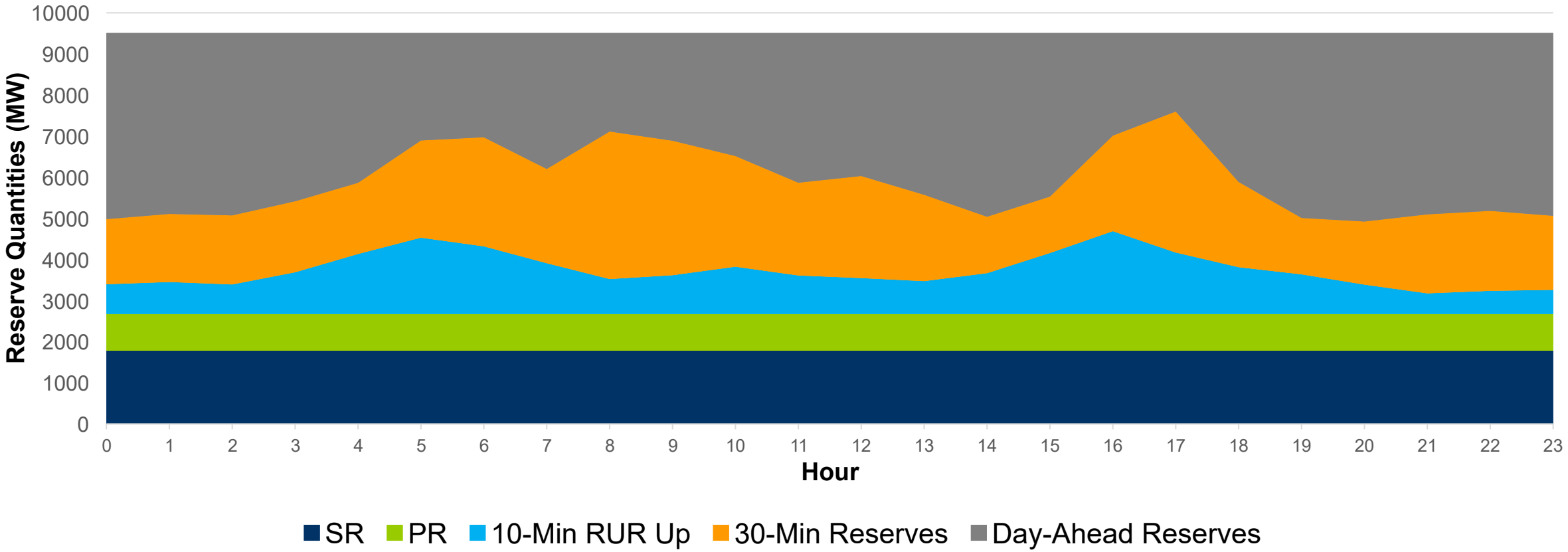


Example Set of Draft Requirements

Disclaimer: *The reserve quantities depicted below are drawn from some of the example values presented previously (i.e., the DASR 2.0 value of 6,833 MW presented for a low-risk winter day, the hourly uncertainty values for winter, with an assumption of a 1,372 MW largest contingency and some historical net-load ramp numbers). These quantities do no reflect finalized proposed requirement definitions but are presented to provide stakeholders with a more concrete example of how these values fit together.*



Limitations of Historical Data

- Looking only at historical values is informative to contextualize the challenge but may not always accurately predict the uncertainty of a particular day. Only looking at history ignores the information that we have about the operating day in question (e.g., forecasted weather, load, etc.)
- There are also challenges in identifying how much historical data to use: go back too far, and the values don't accurately capture current operating conditions (e.g., the current resource mix), but only looking at very recent history limits the size of the dataset (i.e., the number of observations).
- The DASR calculation uses percent uncertainty values and multiplies these values by the forecast at the peak load hour, so uncertainty scales with the forecasted load, solar and wind during peak for that particular day.
- CAISO sets some of their real-time uncertainty requirements using near-term forecast information and a quantile regression model built on historical data.

Next Steps

- Today we presented historical values to provide context around what our operational data look like, but we are also in the process of exploring other approaches that better incorporate forecasted information to see if they provide additional value in defining more predictive requirements.
- PJM will continue to evaluate how day-ahead reserve needs (i.e., DASR 2.0) translate into real-time reserve needs with more examples and analysis, including how our risk assessment may inform our real-time reserve quantities.
- We will also define how the mathematical constraints will be formulated in the optimizations. This will be important for understanding how resource eligibility, capability sharing, etc., will be modeled and dictate reserve clearing. This may inform further refinements to the reserve requirement definitions.

Contact

Facilitator:
Lisa Morelli, Lisa.Morelli@pjm.com

Secretary:
Amanda Egan, Amanda.Egan@pjm.com

SME/Presenter:
Emily Barrett, Emily.Barrett@pjm.com

Real-Time Reserve Requirements

Member Hotline

(610) 666 – 8980

(866) 400 – 8980

custsvc@pjm.com

Acronyms

Acronym	Term & Definition
SR	**Synchronized Reserves** are reserves provided by resources that are synchronized to the grid and can respond within 10 minutes.
PR	**Primary Reserves** are reserves provided by resources that are either synchronized or not synchronized to the grid and can respond within 10 minutes.
RUR	**Ramping/Uncertainty Reserves** are reserves that would be procured to manage forecasted ramp and uncertainty operational flexibility needs.
MW	A **Megawatt** is a unit of power equaling one million watts (1 MW = 1,000,000 watts) or one thousand kilowatts (1 MW = 1,000 KW).

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