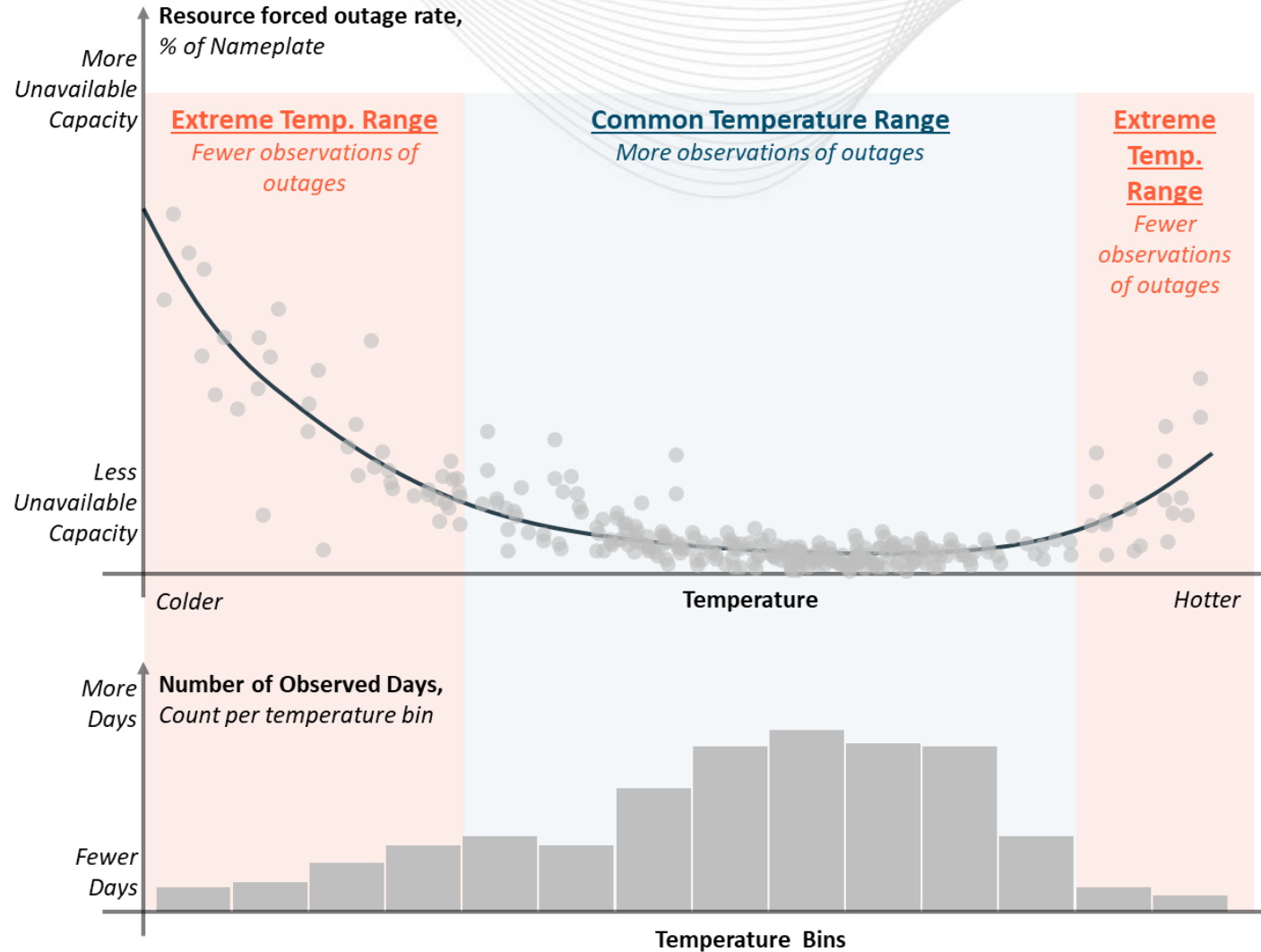


Resource Adequacy Risk Modeling and Capacity Accreditation in PJM

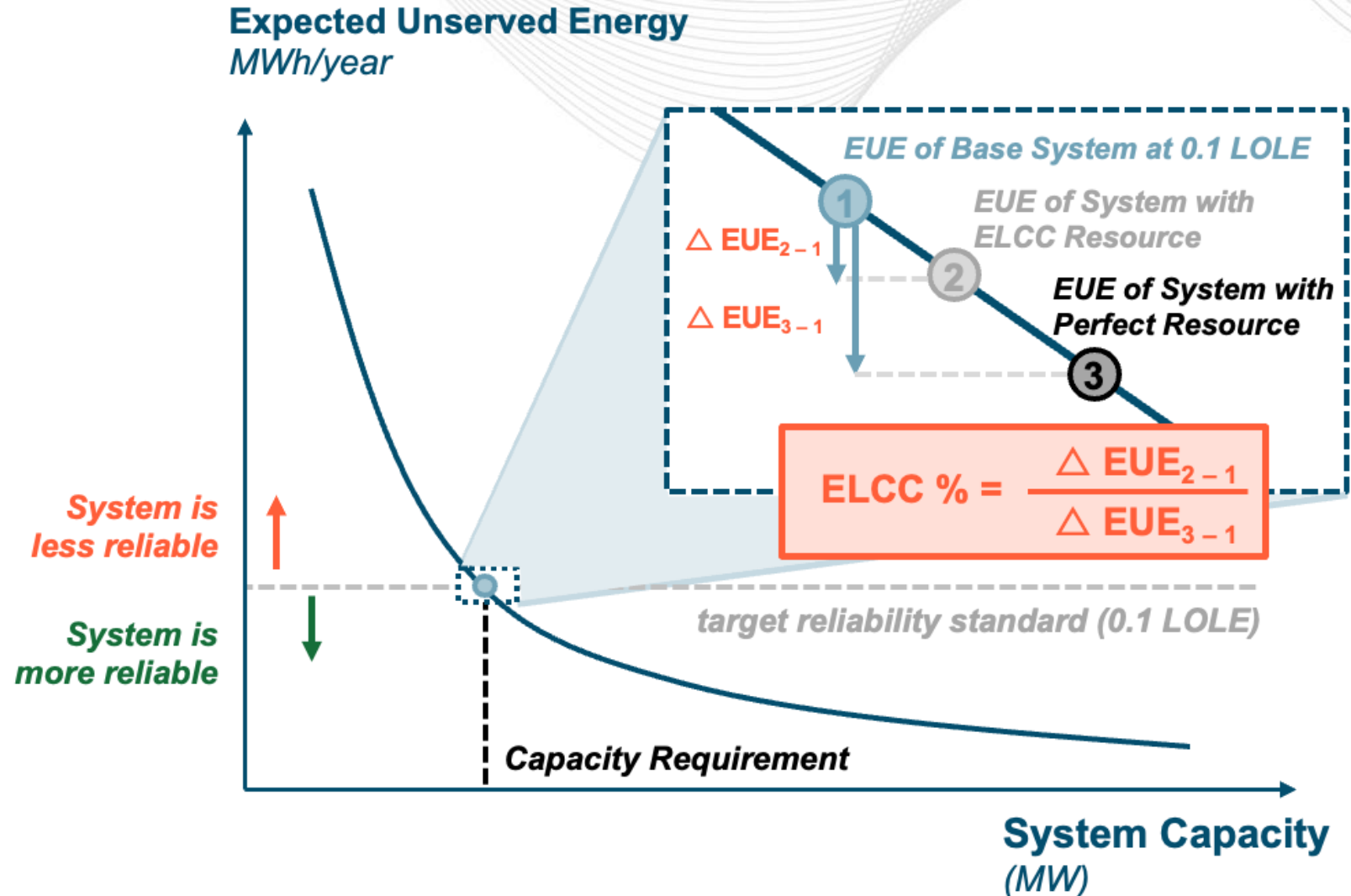
Walter Graf
Chief Economist

28 October 2025

Motivation: Forced Outages Are Correlated Across the Fleet



PJM Uses a Marginal Capacity Accreditation Approach



Weather Scenarios



Historical weather patterns captured back to 1993 (31 years)

Load Scenarios

Hourly load profiles derived from PJM's Load Forecast model for each historical weather scenario

- *Weather patterns shifted +/- 6 days to account for day of the week / holiday variables*

Projected Resource Mix and Performance

Unit, class, and fleet performance for thermal and variable generation modeled as a function of temperature by resampling against historical availability back to 2012 using a binning methodology

- *Dispatch of Demand Resources and Limited Duration Resources simulated in model*

Loss-of-Load Risk Modeling

System simulated under thousands of alternative scenarios to capture a broad range of potential system conditions and reliability outcomes.

31 Alternative Weather Years *

13 Alternative Load Scenarios *

100 Alternative Resource Performance Draws

= 40,300 Simulated Years

Patterns of Risk

LOLE vs. LOLH vs EUE

- *Summer vs. winter?
Morning vs. midday vs. evening? Long vs. short events? Deep vs. shallow?*

ELCC Ratings

Measure of resources' contribution to reliability given patterns of loss-of-load risk

- Historical weather patterns back to June 1, 1993 are used to derive the Weather Scenarios used in the loss-of-load risk analysis (ELCC/RRS studies)
- The Weather Scenarios are used in the model to:
 - Construct hourly load scenarios using latest PJM Load Forecast Model
 - Characterize historical resource performance as a function of temperature back to 2012 using a binning methodology
 - Capture the observed relationship that weather has on both load levels and resource availability in the simulated analysis

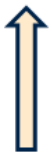
Notable Extreme Weather Days used in Model

Summer			Winter		
Date	HE	Temp.	Date	HE	Temp.
July 15, 1995	15	97	Jan. 19, 1994	8	-11
July 21, 2011	15	95	Jan. 7, 2014	7	-1
July 5, 1999	17	96	Feb. 20, 2015	8	-2
Aug. 1, 2006	16	94	Dec. 23, 2022	23	5

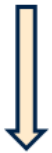
Temp. columns reflects maximum or minimum hourly RTO-weighted average temperatures for the day

- Hourly load scenarios constructed from historical weather years using Load Forecast Model
- Weather rotations are applied where the historical weather is shifted 6 days forward and 6 days backward. This results in 12 additional load scenarios, or 13 in total, for each weather year providing **403 unique annual hourly load profiles** (31 weather years * 13 load scenarios)
 - Weather rotations allow the model to capture the fact that an extreme weather day that historically occurred on a weekend or holiday (e.g. Winter Storm Elliott) could potentially occur on a weekday where the resulting load profiles may be quite different (or vice versa). Example of rotations provided to the right.
 - Hourly load profiles published on [Load Forecast Webpage](#)
- Load variability is modeled in the analysis to account for Load Forecast Error. When drawing the hourly load profiles from a load scenario for a day, the load is randomly sampled from a normal distribution with mean zero and standard deviation equal to approximately 1.2%.

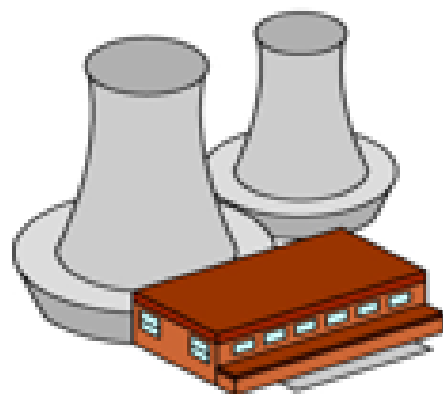
Forecast Date	Weather Date	Scenario
August, 9, 2024	August 3, 2010	M2010
August, 9, 2024	August 4, 2010	L2010
August, 9, 2024	August 5, 2010	K2010
August, 9, 2024	August 6, 2010	J2010
August, 9, 2024	August 7, 2010	I2010
August, 9, 2024	August 8, 2010	H2010
August, 9, 2024	August 9, 2010	A2010
August, 9, 2024	August 10, 2010	B2010
August, 9, 2024	August 11, 2010	C2010
August, 9, 2024	August 12, 2010	D2010
August, 9, 2024	August 13, 2010	E2010
August, 9, 2024	August 14, 2010	F2010
August, 9, 2024	August 15, 2010	G2010



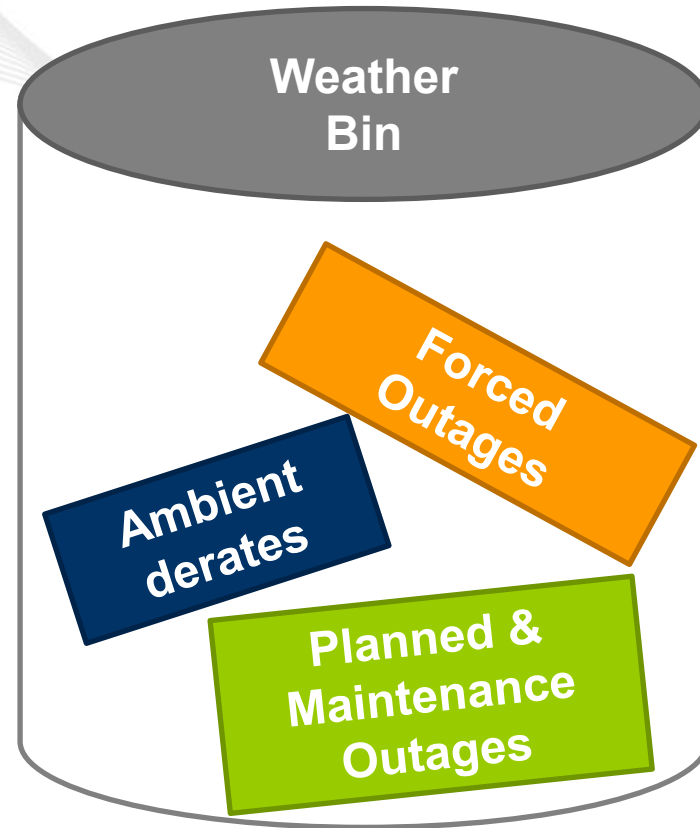
shift weather 6 days backward



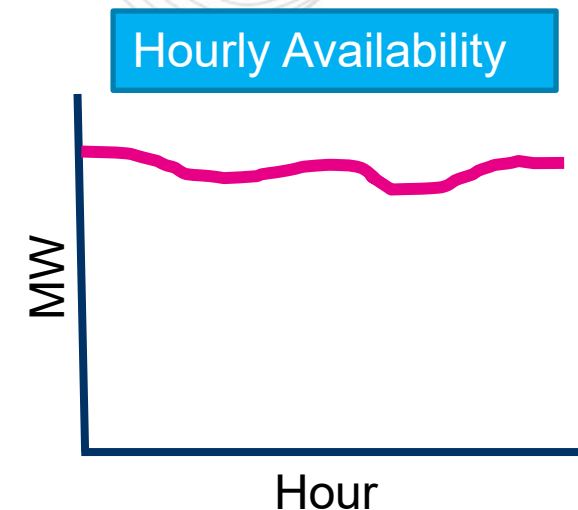
shift weather 6 days forward



ICAP



Unlimited Resources



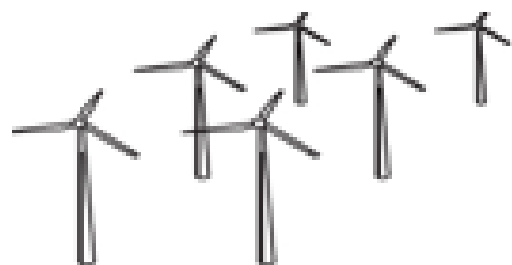
Modeling Approach

Forced Outages and
Ambient De-rates

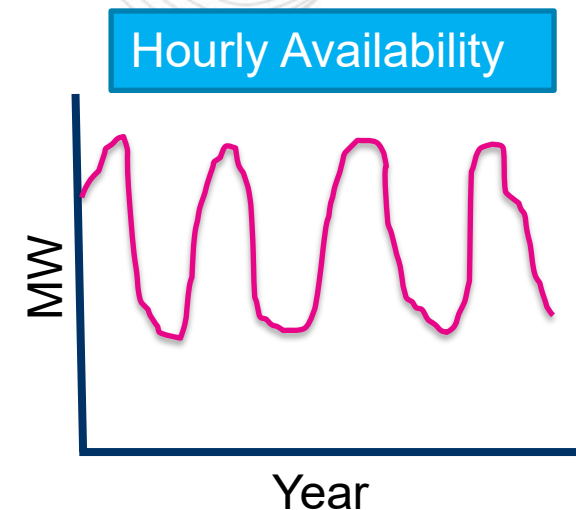
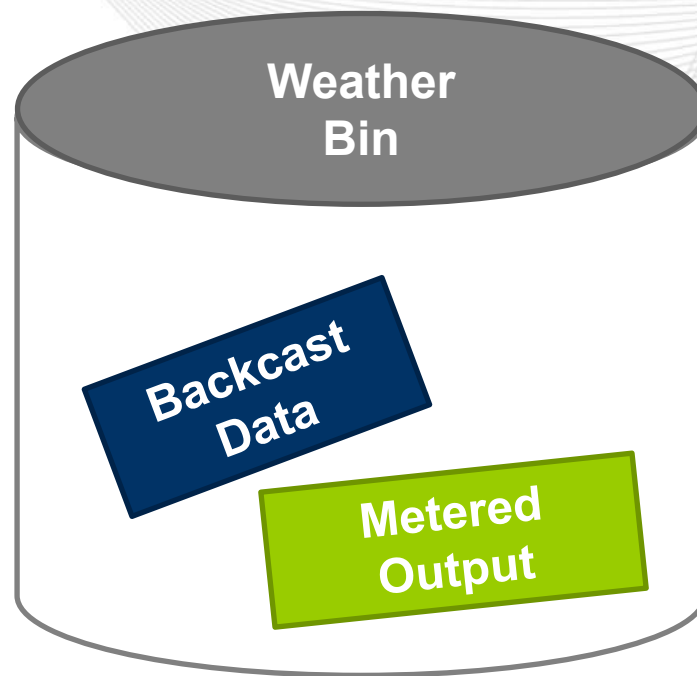
Historical weather and corresponding forced outages and ambient de-rates since June 1, 2012 used to characterize thermal outage rates as a function of weather based on a binning methodology

Planned &
Maintenance Outages

The amount (MW-weeks) of planned and maintenance outages per year based on historical data since June 1, 2012.
Heuristic used to schedule planned and maintenance outages during periods of lower loads

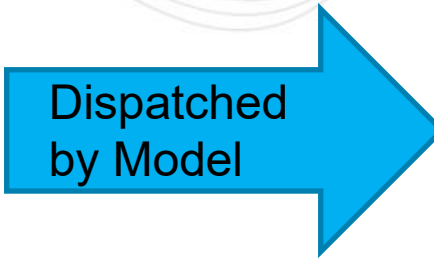


ENC



Modeling Approach

Variable Resource Availability	Historical weather and corresponding variable resource performance (actual and putative) since June 1, 2012 used to characterize performance as a function of weather based on a binning methodology
Intermittent Hydro	Annual draw of performance since 2012 as a function of closest matching seasonal peak loads



Modeling Approach

Limited Duration Storage
& Combination Resources

Simulated dispatch in the model that depends on other system conditions (e.g. load, other resources' performance, remaining storage) during the hour

Demand Resources

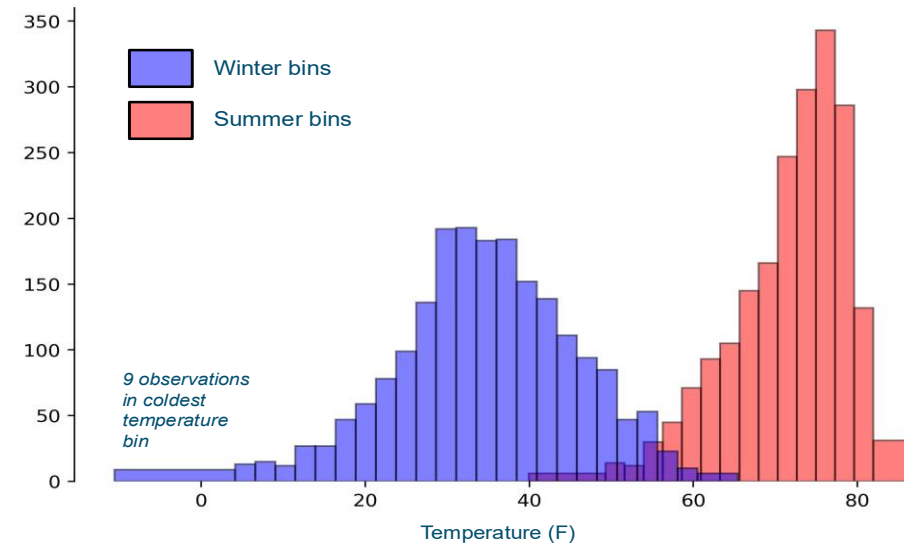
Simulated dispatch in the model where DR is deployed during hours within its defined performance windows when total available Unlimited and Variable Resources is less than the load

A binning methodology is used as a means to mix and match (or “sample”) load and resource performance that occurred within similar weather conditions or “temperature bins.”

Temperature Binning Methodology

- Each historical day in the analysis is assigned to a temperature bin based on either (a) the minimum hourly RTO-wide THI for days in the winter, or (b) the maximum hourly RTO-wide THI for days in the summer
- The temperatures are grouped using binning methods employed in the development of histograms
- The historical days since June 1, 2012 and corresponding temperature bins form the “Resource Performance Bins” used to derive the 100 different resource performance patterns used in the analysis

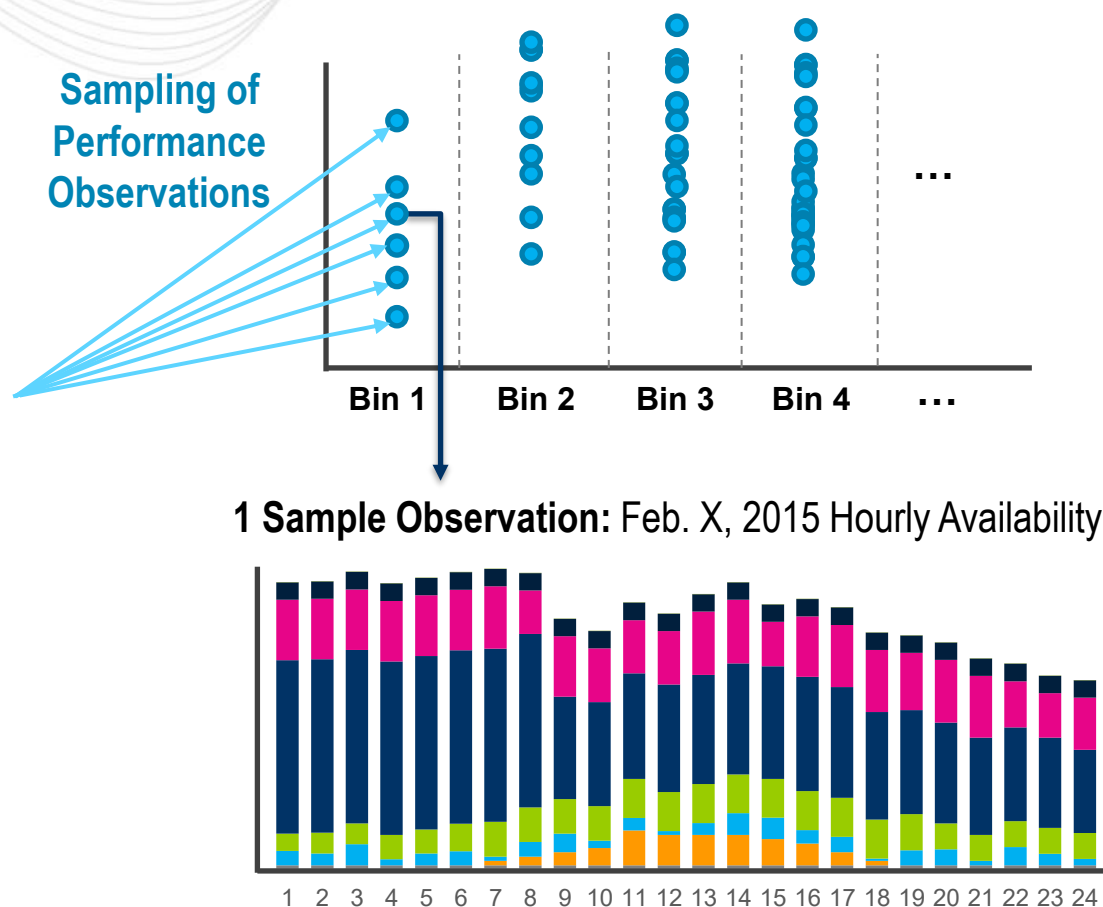
Number of historical days within each temperature bin of Resource Performance Bins



Weather Scenarios

Weather Year	Date	Season	Daily Temp.
197X	Jan. 1	Winter	4° (min)
197X	Jan. 2	Winter	8° (min)
197X	Jan. 3	Winter	7° (min)
...	...	...	...
1994	Jan. X	Winter	-5° (min)
...	...	...	...
2012	7/15/12	Summer	92° (max)
2012	7/16/22	Summer	89° (max)
...	...	...	...
2022	Dec. 31	Winter	12° (min)

Winter Resource Performance Bins (Illustrative)



Distribution of Expected Unserved Energy (2026/2027)

