Balancing Intermittency: Uncertainty Reserve Requirement Calculation

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Previous Presentations

Date	Working Group	Discussion Points and Links to Materials
07-19-2023	ICAPWG/MIWG	Balancing Intermittency: Initial Analysis https://www.nyiso.com/documents/20142/38852999/Balancing%20Intermittency%20Initial%20Analyses_ICAPWG_MIWG_071923_Final.pdf/c4adb509-3c09-0361-7f52-b52cae880997
02-21-2023	ICAPWG/MIWG	Balancing Intermittency: Project Kickoff https://www.nyiso.com/documents/20142/36339783/Balancing%20Intermittency_MIWG_022123_FINAL%20(002).pdf/5ff99fc1-1eb2-8bec-d385-b4983568802a

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Updated Definitions

- DAM : Day-Ahead Market
- DAM Net Load Forecast : Day-Ahead gross load forecast – Day-Ahead behind-the-meter (BTM) solar forecast
- Net Load Actual : Observed real-time actual load, which captures the effect of BTM Solar
- DAM Net Load Forecast Error : Net Load Actual– DAM Net Load Forecast
- Reserve Notification Time : The lead time that a reserve product is scheduled for (*i.e.*, 10-minute reserves, 30-minute reserves, etc.)
- Reserve Sustainability : The duration (number of hours) that reserve providers can sustain energy output upon conversion from reserves to energy. The current reserve sustainability requirement in the NYISO markets is 1 hour. This characteristic will be defined further in upcoming project presentations.
- MHFE : Multi-Hour Forecast Error
- Uncertainty Reserves: Reserves to address forecast error.

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Background

- **Leveraging the findings in the 2022 Grid in Transition Study, the Balancing Intermittency effort is evaluating whether new market products are necessary to continue reliably maintaining system balance, given a future grid characterized by large quantities of intermittent renewable resources, ESR, and DER.**
  - Update regulation requirements [Completed]
  - Determine if there is a need for additional ancillary services to balance intermittency [Completed]
  - Determine the uncertainty reserve requirement calculation methodology [Review in this presentation]
  - Examine locational distribution and ORDCs for the uncertainty reserves [Sept]
  - New Uncertainty Reserve Product Evaluation [Sept/Oct]
  - Reserve Sustainability Evaluation [Oct]

- **The 2023 project deliverable is a Market Design Concept Proposed [Mid-Late Nov].**

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Objective of Today's Discussion

- Today's presentation will provide a recap to the last MIWG presentation and share additional analysis that the NYISO has performed to assess the best method for addressing the need for additional reserves to balance uncertainty.

Review of 7/19 MIWG

Recap from 7/19 MIWG

- **Analysis conducted by the NYISO indicates that the basis of the current reserve procurements is likely inadequate to sustain reliability in the grid of the future.**
  - Analysis supports that reserve requirements need to consider forecast error in addition to the single largest contingency.
- **The next few slides contain figures that were presented during the previous MIWG presentation.**

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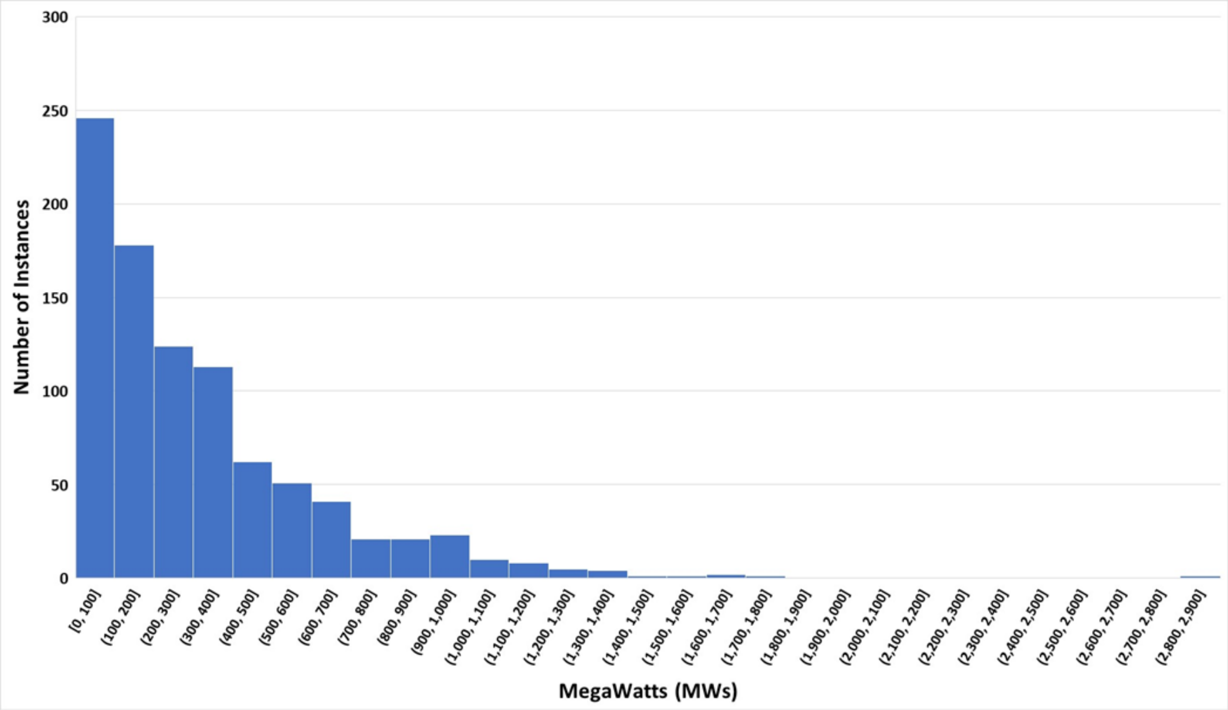
Multi-Hour DAM Net Load Maximum Forecast Error Frequency Analysis (2021-2022)



*In this section, Net Load is Load net of BTM Solar and Wind

Net Load DAM Forecasting Error Frequency Analysis (2021-2022)

Total Under-forecasting Error (Ramp Up Energy) MWh

Duration of Error (Hours)

	400	800	1310	1600	2000	2620	3000	4000	6000	10000	14000
1	147	0	0	0	0	0	0	0	0	0	0
2	110	5	0	0	0	0	0	0	0	0	0
3	57	14	1	0	0	0	0	0	0	0	0
4	26	34	8	1	0	0	0	0	0	0	0
5	12	30	17	2	3	1	0	0	0	0	0
6	5	20	21	5	3	0	0	0	0	0	0
7	1	11	11	6	4	2	0	1	0	0	0
8	1	8	13	4	11	7	2	2	1	0	0
9	0	4	6	4	3	5	2	3	1	0	0
10	0	0	0	9	3	2	0	0	0	1	0
11	0	0	1	2	8	10	0	1	1	0	0
12	0	0	1	2	2	1	1	2	2	1	0
13	0	1	0	2	1	4	8	2	2	2	1
14	0	0	0	3	2	1	1	0	5	4	0
15	0	0	0	1	1	1	1	3	9	2	0
16	0	0	1	0	0	1	2	0	4	2	1
17	0	0	0	0	0	3	2	1	4	3	0
18	0	0	1	0	0	0	0	2	10	3	1
19	0	0	0	0	0	1	1	2	3	3	0
20	0	0	0	0	0	0	2	0	10	2	0
21	0	0	0	0	0	0	0	0	2	6	2
22	0	0	0	0	0	0	1	0	2	4	2
23	0	0	0	0	0	0	0	0	2	1	0
24	0	0	0	0	0	0	0	0	0	2	1

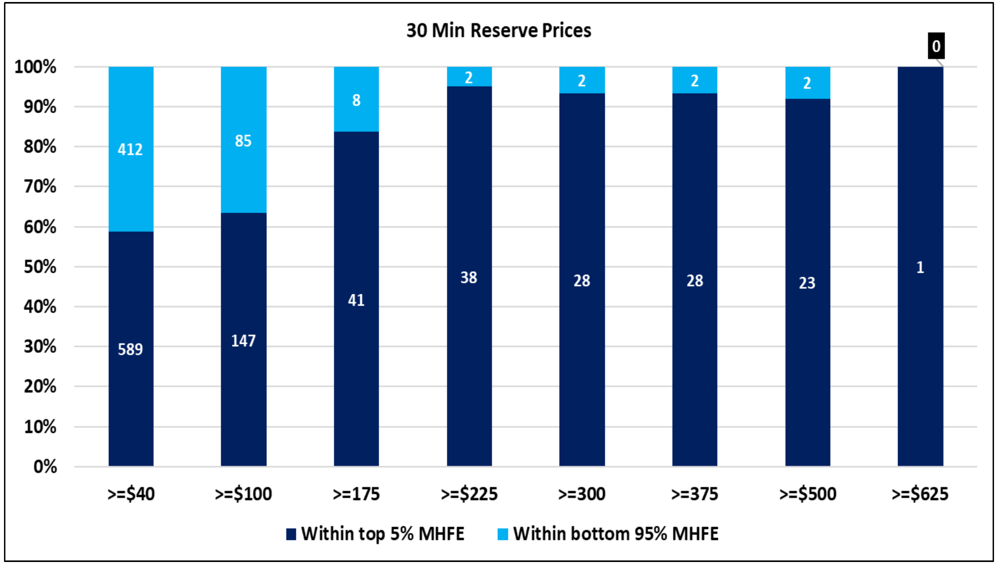
*In this section, Net load is Load net of BTM Solar and Wind

For example, there are 10 instances of 18-hour forecast error with a magnitude ranging from 4,000-6,000 MWh (hourly avg range of 222-333 MWh).

Additional Information Supporting the Need for Reserves to Manage Forecast Uncertainty

Reserve Shortage Prices during High MHFE Events

- The durations of events with reserve shortage prices were mapped to the DAM Net Load Multi-Hour Forecast Error events to determine the frequency of reserve shortages during multi-hour forecast error events.
- For different reserve shortage price steps, the instances were counted to construct the stacked frequency chart on the right.
  - 30-min, 10-min spin, and 10-min non-spin RT prices were studied.
- In total, there are 1827 MHFE events for 2021-2022.
- Two categories of multi-hour forecast error events were chosen:
  - Top 5% of Multi-Hour Forecast Error Events (91 events)
  - Bottom 95% of Multi-Hour Forecast Error Events (1736 events)
- It is observed that reserve shortages seem to occur more during events of high MHFE as is displayed in the chart on the right and in the next slide.



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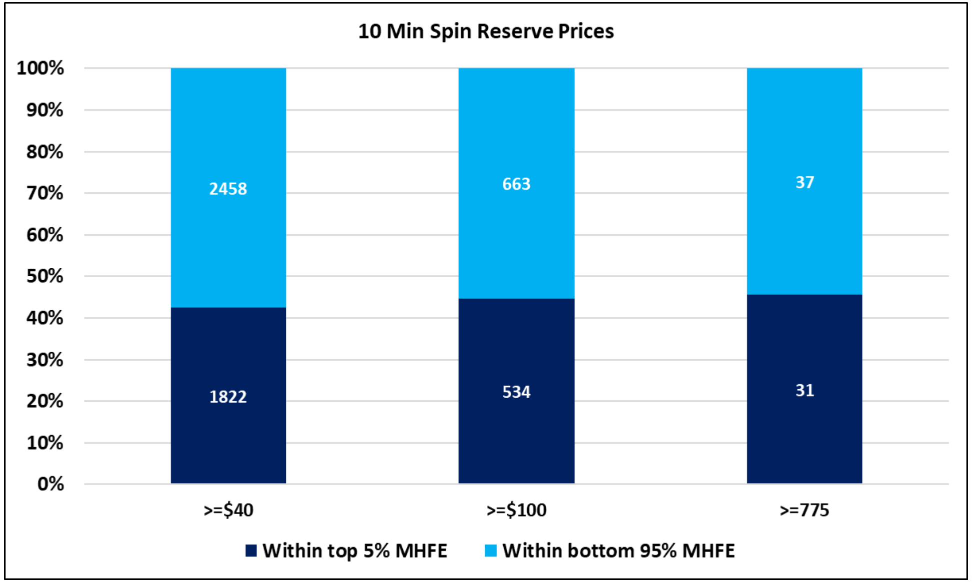
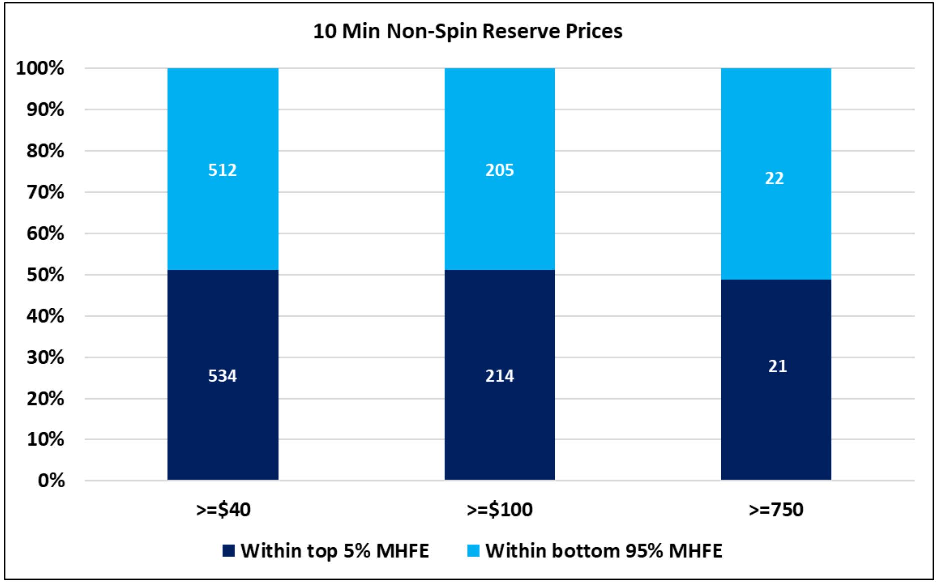
Reserve Shortage Prices during High MHFE Events





Reserve Pickups during High MHFE

- **During 2021 – 2022, there were 142 reserve pickups.**
  - Within the top 5% of MHFE events, there were 46 activations of reserve pick-ups.
    - The remainder occurred during the bottom 95% of the MHFE events.
      - **This shows that 32% of the reserve pickups happened during the top 91 events of MHFE while the rest 68% occurred during bottom 1837 events of MHFE.**
- **Proportionally, a single reserve pickup activation seemed to occur for every 2 events from the top 5% of the MHFE category while a single reserve pickup activation occurred for every 19 events from the bottom 95% of MHFE category.**
- **This data is not determinative of the cause of reserve pickups, it simply identifies that reserve pickups in 2021-2022 occurred more during high MHFE events.**

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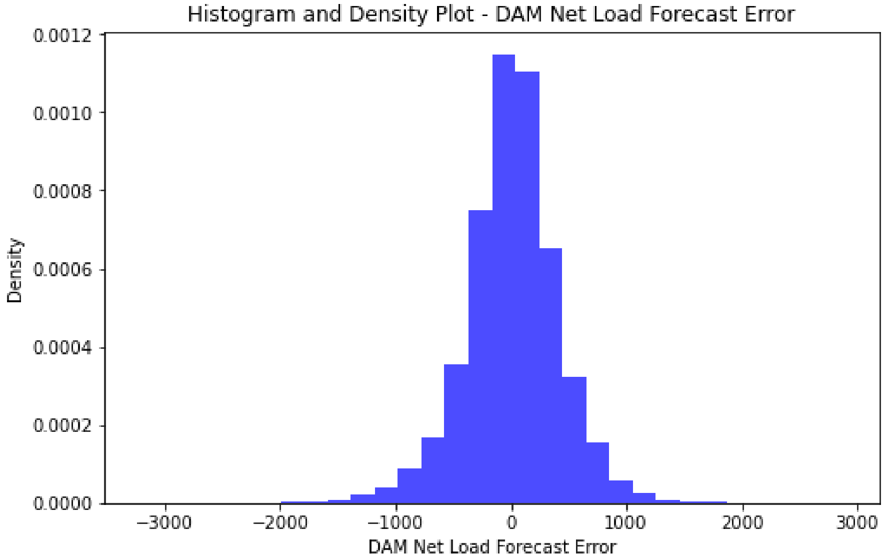
Key Takeaways

- **In 2021-2022, reserve shortages occurred proportionately more frequently during high MHFE events during low MHFE events.**
  - Reserve Pickups are activated proportionately more during events of high MHFE, though they are not explicitly activated by operators to address high forecast error.

Potential Methods to Set Uncertainty Reserve Requirements

DAM Net Load Forecast Error Distribution

- The underlying data distribution of the single hour forecast error was studied for 2021-2022 to understand what model could be used to set the uncertainty requirement for the future.
- The distribution of the DAM net load forecast error data is non-normal, *i.e.*, the distribution of the data does not follow a normal or Gaussian distribution.
- This means that the data is not symmetrically distributed around the mean, with most values not clustering around the center.
- Outliers (*i.e.*, the extreme forecast error events) and Skewness (distributions on the left and right are not equal) seem to be the cause of this non-normality that we observe.



*In this section, Net Load is Load net of BTM Solar and Wind

Seasonal Stats

Summer 2021 Statistics	
count	2208.000000
mean	-64.831462
std	603.915193
min	-3213.412623
25%	-408.276051
50%	-82.363402
75%	282.958450
max	2882.246614

Summer 2022 Statistics	
count	2208.000000
mean	-91.527318
std	473.605952
min	-3027.443513
25%	-327.572808
50%	-27.937076
75%	203.518853
max	1532.873344

Winter 2021 Statistics	
count	2160.000000
mean	74.924524
std	317.807896
min	-1270.072710
25%	-127.803915
50%	74.905619
75%	267.661343
max	1128.090575

Winter 2022 Statistics	
count	2160.000000
mean	76.050489
std	390.660951
min	-1334.346164
25%	-157.631169
50%	55.044852
75%	313.040619
max	1312.029621

Fall 2021 Statistics	
count	2184.000000
mean	0.367058
std	321.878078
min	-1295.712000
25%	-182.486830
50%	20.653823
75%	199.509586
max	1150.271789

Fall 2022 Statistics	
count	2184.000000
mean	17.122452
std	332.970335
min	-1255.296701
25%	-175.359856
50%	21.384549
75%	209.846872
max	1262.418086

Spring 2021 Statistics	
count	2208.000000
mean	9.547912
std	360.197500
min	-1129.954198
25%	-215.301597
50%	1.914210
75%	231.048521
max	1355.944014

Spring 2022 Statistics	
count	2208.000000
mean	38.080684
std	352.440109
min	-1248.015666
25%	-186.196513
50%	15.484973
75%	250.289552
max	1436.539876

*In this section, Net Load is Load net of BTM Solar and Wind

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Uncertainty Reserve Requirement Method Option #1: Historical Analysis

- **Taking the difference between actual outcomes (*e.g.*, actual Load) and forecast outcomes (*e.g.*, MW of Net Load Forecast) for a historical period, we calculated historically observed forecast error.**
  - Next, given a desired level of reliability, we can determine the MWs of reserves based on the historically observed forecast error. Several options also exist here, including :
    - Direct Observation: Select the MW value from the applicable point (*e.g.*, 90th percentile) on the distribution of historically observed forecast error,
    - Regression Analysis. Regress historically observed forecast error data and explanatory variables and selecting the MW value from the applicable point (*e.g.*, 90th percentile) of the best-fitting regression equation.

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Historical Method: Direct Observation

- **NYISO performed an in-depth analysis of the Direct Observation option while Regression Analysis options were not selected for evaluation.**
  - Historically observed forecast errors were non-normal, which rules out regression methods to characterize the error.
  - Regression Analysis was not selected after an initial review that determined forecast errors tend to be random (the intuition here is that if we could predict when our errors would occur and their magnitude, we would incorporate that knowledge into the forecast model and reduce the error).
- **The following slides discuss the NYISO's evaluation of setting uncertainty reserve requirements using the distribution of historically observed forecast error.**
  - Additionally, as described in subsequent slides, the NYISO's proposed requirement-setting method will vary with Net Load forecast and wind forecast levels.
  - The evaluation of uncertainty reserve requirements were carried out separately for Wind and Net Load (Load with BTM Solar Impacts) since it has been observed that the Wind errors are not correlated with Load errors and so calculating reserve requirements of the Net* Load (Load with BTM Solar and Wind impacts) could be incorrect.

*In this particular point in the bullet, Net Load is Load net of BTM Solar and Wind

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Evaluating the "Historical Analysis" Method

- **NYISO developed uncertainty requirements using a sub-set of the historically observed forecast error data and then performed "out of sample testing" to evaluate the accuracy and stability of the uncertainty requirement. NYISO tested multiple sub-sets of historically observed forecast error data.**
  - 7-day Requirement
    - Utilizing the forecast errors in the past 7 days to set the requirement for the current day.
  - 30-day Requirement
    - Utilizing the forecast errors in the past 30 days to set the requirement for the current day.
  - 90-day Requirement
    - Utilizing the forecast errors in the past 90 days to set the requirement for the current day.
  - Historical Like-Month Errors
    - Utilizing the forecast error observed in same month from the prior year to set the Uncertainty Reserve requirement for the current month.
  - Historical Annual Errors
    - Utilizing the forecast error from the entire previous year to set the Uncertainty Reserve requirement for the current year.

Evaluating a Combination of Historical Long-Term and Short-Term Error Metrics

- **Using shorter-term data allows model errors to reflect recent forecast performance, but potentially suffer from a small sample size that doesn't accurately characterize the overall error of the forecasts. Conversely, using longer-term data captures a large amount of data and reflects the overall error of the forecasts but will be unable to capture changes in recent forecast performance or system changes.**
- **NYISO looked at blending historical long-term uncertainty requirements with historical short-term uncertainty requirements to capture benefits from both the worlds.**
- **For the historical long-term uncertainty requirement, NYISO is using the static historical annual error from the prior year while for the historical short-term uncertainty requirement, NYISO is using the last 2 months from the current month.**
  - For example, for setting the uncertainty reserve requirement for the month of June 2022, NYISO would be using the static historical annual error from 2021 and the 2-month error metric from April-May 2022.
  - The short-term timeframe of 2 months was chosen against 30-day or 90-day timeframe since anomalies within a 30-day timeframe could skew the requirement for the next month while seasonal impacts from one season could be applied to the other season when choosing a 90-day metric.

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Evaluating a Combination of Historic Long-Term and Short-Term Error Metrics

- **Different weights (From 0 to 1 in the steps of 0.1) were assigned to the historical long-term uncertainty and short-term uncertainty values to assess the performance of the uncertainty reserve requirements using the testing data (March 1, 2022 – Dec 31, 2022).**
  - Taking the example from the prior slide, when a weight of 0.1 is chosen, 10% of the historical short-term uncertainty value from April-May 2022 is added to 90% of the historical long-term uncertainty value from 2021 to determine the uncertainty reserve requirement for June 2022.
    - Upon implementation, there will be a time buffer between calculating the next short-term uncertainty reserve requirement percentage, which is to be decided.
- **Based on the results from the above step, the optimal blending split has been determined to be 80/20, meaning that 80% of historical long-term uncertainty value would be added to 20% of historical short-term uncertainty value to calculate the uncertainty reserve requirement.**
  - Note that the Historical Annual Error method produces a slightly better performance (~1% performance improvement) in the testing data for Wind Errors than the 80/20 blending method, but the 80/20 blending method has been chosen to incorporate any system or forecast model performance changes that might occur in the short term as described in the previous slide.

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Evaluating the Performance

- **For each of the methods examined, we calculated four different requirements to determine the best performance: The mean, 75th percentile, 90th percentile, and 95th percentile values of observed forecast errors.**
  - Performance is measured by calculating a requirement using the given historical period (training sample), and then applying that requirement to a different historical dataset (testing sample) to determine whether the requirement would procure enough uncertainty reserves to cover forecast errors in the out-of-sample testing dataset.
    - For example, using the historical annual calculation method, if the 95th percentile of observed errors in 2021 was 2% of the DAM Net Load Forecast, we set a 2% uncertainty reserve requirement for March-December 2022, and calculated the percentage of intervals in which a 2% uncertainty reserve requirement would procure adequate uncertainty reserves to cover the observed DAM Net Load Forecast errors in March-December 2022.
  - The model performs well when the historical uncertainty estimate accurately characterizes out-of-sample uncertainty.
    - For example, assume the design goal is to ensure sufficient reserves exist to meet the 90th percentile of historical uncertainty.
      - Strong performance would be if the model sets a reserve requirement that procures sufficient reserves to cover exactly 90% of out-of-sample uncertainty.
      - Poor performance would be if the model procured reserves that satisfy much less (e.g., <80%) or much more (e.g., 100%) than 90% of uncertainty.

- **The results on the following slides demonstrate the model performs well.**

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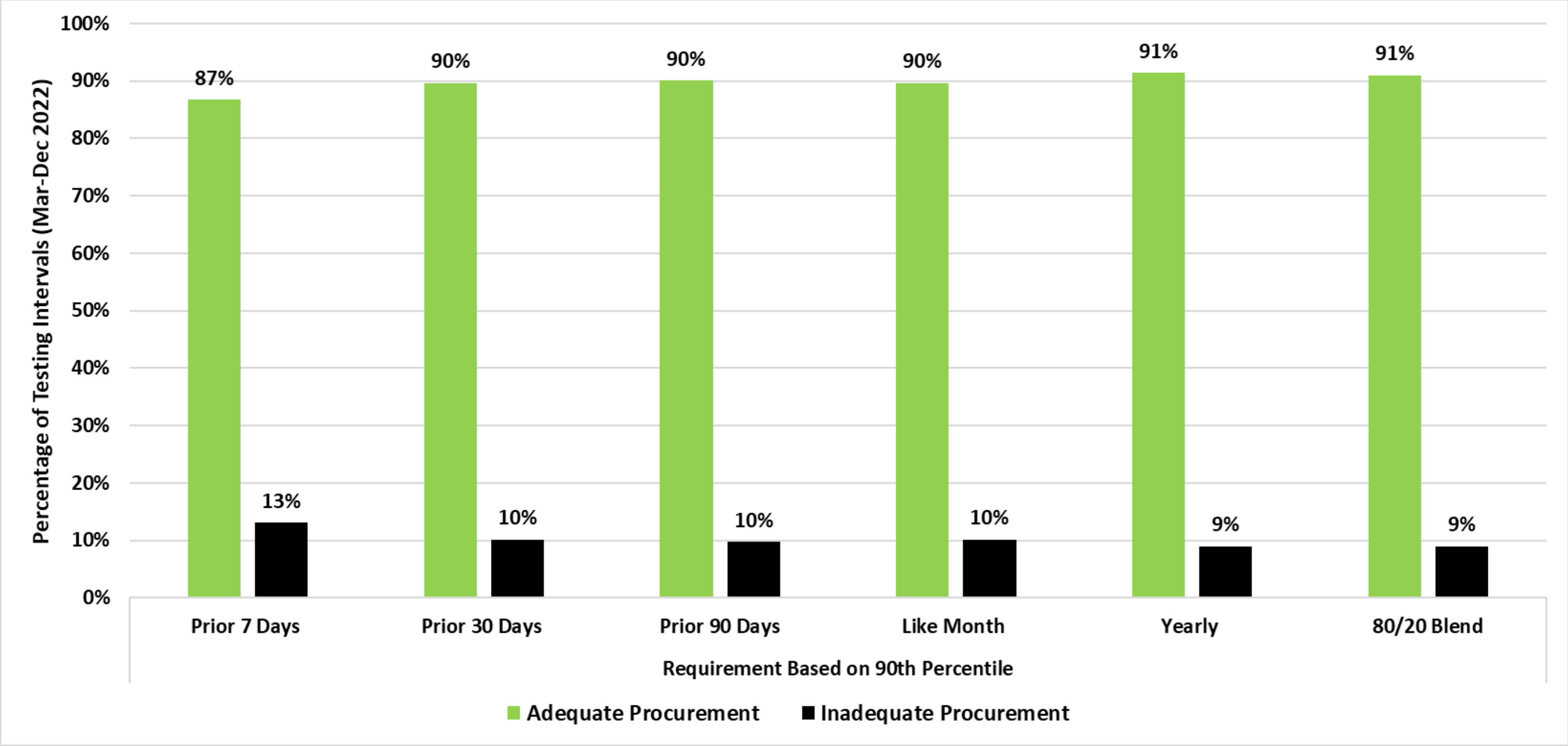
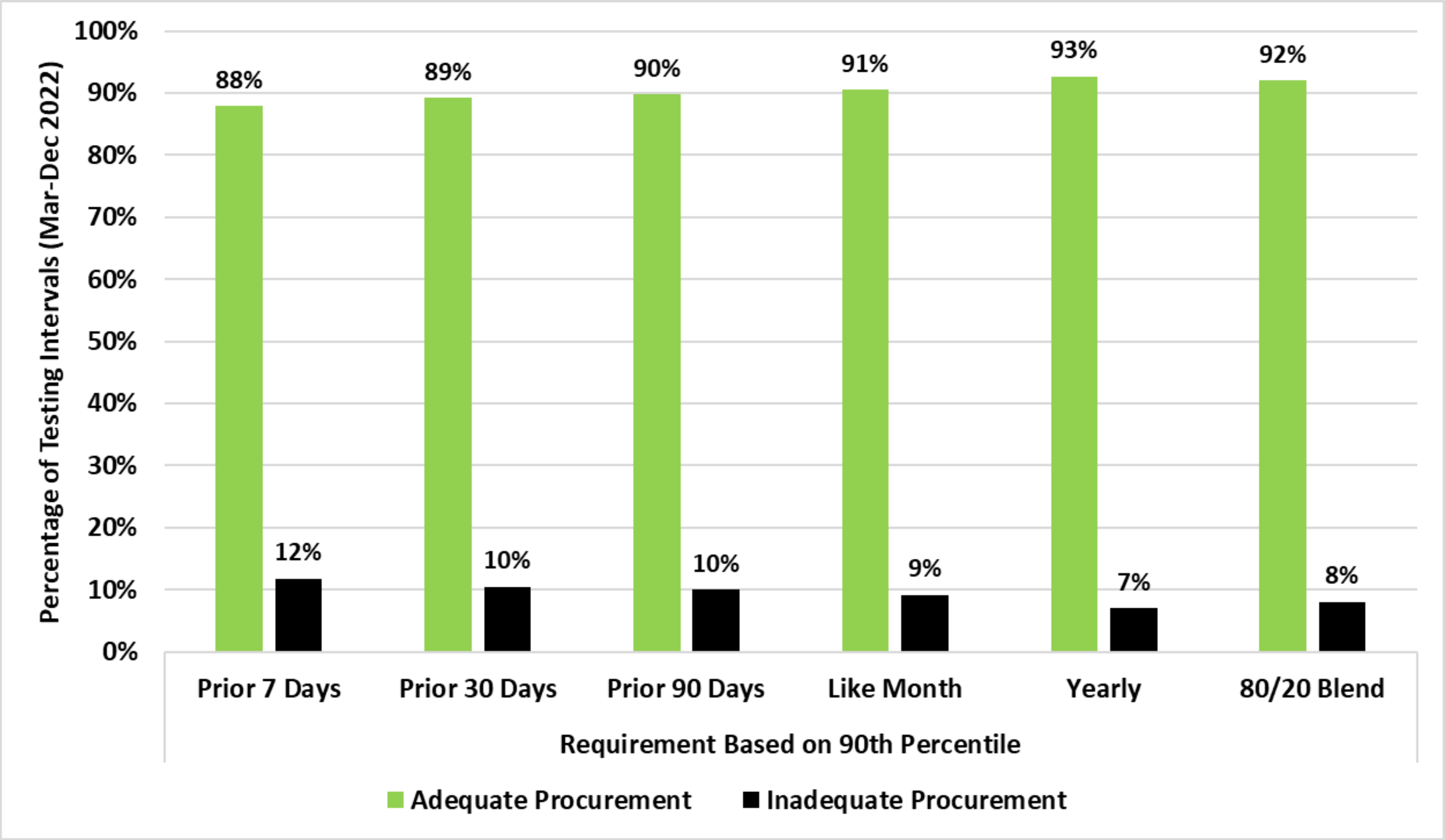
Historical DAM Requirement-Setting Performance - Net Load



Historical DAM Requirement-Setting Performance - Wind



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Evaluation of the “Historical Analysis” Method: Conclusions

- The historical analysis method produced reasonably stable error estimates across time-scales.
- Out-of-sample testing indicates that procuring reserves based on historically observed forecast errors will facilitate sufficient reserve procurement to manage current forecast error risk.

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Uncertainty Reserve Requirement Method Option #2: Forward Looking

- **Forecasts of load, wind, solar, and other variables are uncertain (hence the observed differences between forecast and actual values).**
- **This uncertainty may be characterized and quantified as part of the process of producing the forecast (*i.e.*, forward looking assessment of uncertainty).**
  - For example, a solar forecast could produce an expected value that goes into the market engine and probabilistic data (e.g., 95% chance solar exceeds some level).
  - Such data may provide more granular and potentially more accurate estimates of uncertainty.
- **NYISO is working to enhance its forecasting tools and data streams to potentially receive such data in the future.**
  - The NYISO does currently generate 90/10 peak-load forecasts which could potentially be expanded with further research to include a 24-hour error band.
  - Thus, NYISO does not have the data to evaluate the robustness of such a design at the current time and will not pursue a forward-looking requirement setting process at this time.
- **NYISO MDCP will propose a periodic review of the uncertainty reserve requirement setting process to ensure it remains robust and up-to-date.**

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Options Comparison

	Pros	Cons
Option 1: Historical, short-term	- Quickly updates to reflect changes in forecast error - Performed well in out-of-sample testing	- May not capture sufficient data to accurately represent forecast error
Option 2: Historical, long-term	- Captures sufficient data accurately represent forecast error - Performed well in out-of-sample testing	- Will be slower to reflect recent changes in forecast errors
Option 3: Historical, blended	- Balances desire for accurate representation of forecast error and responsiveness to recent changes in forecast error/system - Performed well in out-of-sample testing	- Similar out-of-sample performance as other historical methods with greater administrative burden
Option 4: Forward-Looking	- May provide more granular and accurate expectations of net load uncertainty	- Software infrastructure is not currently available

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DRAFT – FOR DISCUSSION PURPOSES ONLY

Uncertainty Reserve DAM and RT Requirement Methodology Proposal

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Uncertainty Reserve Requirement Methodology Proposal

- **The NYISO is proposing an uncertainty requirement-setting methodology that incorporates the following:**
  - An annual historical error metric to comprise 80% of the uncertainty reserve requirement, combined with a 2-month rolling historical error metric to comprise 20% of the uncertainty reserve requirement.
    - The 80% / 20% division in the requirement represents a balance between long-term data (*e.g.*, good characterization of overall error distribution) and short-term data (*e.g.*, capturing recent forecast errors).
      - The annual component of the formula will update once per year.
      - The 2-month rolling average component of the formula will update once per month. Exact process timing TBD.
    - This approach yields similar performance results between the 7-day, 30-day, 90-day, like-month, and annual methods.
  - This method will be applied to DAM and RT separately to establish DA and RT reserve requirements, and these will differ due to the reduction in uncertainty as we approach RT. See the Appendix for additional information.
  - The requirement will be assigned to products (*e.g.*, 30min, 10min) based on which products can satisfy the need.
    - That is, the fraction of day-ahead uncertainty that is resolved by 60 minutes from the RT interval can be satisfied with a 30-minute reserve provider.
      - The fraction of day-ahead uncertainty that is resolved 30 minutes from the RT interval cannot be satisfied by a 30min reserve provider and will thus be assigned to a 10min requirement.
  - The locational distribution of the requirement and the related ORDCs for this requirement will be discussed at an upcoming MIWG.

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Proposed Uncertainty Reserve Requirement Calculation

- Uncertainty Reserve Requirement =

  80% x (Prior Year Static Net Load Forecast Error x Net Load Forecast) +
  20% x (Previous 2-month Rolling Net Load Forecast Error x Net Load Forecast) +
  80% x (Prior Year Static Wind Forecast Bin Requirement % x Wind Forecast) +
  20% x (Previous 2-month Rolling Wind Forecast Bin Requirement % x Wind Forecast)
- This design allows uncertainty reserves to scale independently with respect to load with solar (which tend to be correlated) and wind.
- Front the Meter ("FTM") Solar component's uncertainty would be incorporated once there has been an adequate amount of FTM Solar resources in the future to examine the historical forecast error of FTM Solar.

Example Uncertainty Reserve Procurement: DAM

- **Assumptions:**
  - DAM Net Load Forecast = 20,000 MW, DAM Wind Forecast = 500 MW, Annual Uncertainty Reserve Requirement % = 2%, 2-month Uncertainty Reserve Requirement = 1%, DAM Annual Wind Uncertainty Reserve Requirement % = 30%, DAM 2-Month Wind Uncertainty Reserve Requirement % = 20%
- **Annual Net Load Uncertainty Reserve = 80% x (2% x 20,000 MW) = 320 MW**
- **2-Month Net Load Uncertainty Reserve = 20% x (1% x 20,000) = 40 MW**
- **Annual Wind Uncertainty Reserve = 80% x (30% x 500 MW) = 120 MW**
- **2-Month Wind Uncertainty Reserve = 20% x (20% x 500) = 20 MW**
- **Total DAM Uncertainty Reserve Procurement =**

  320 MW + 40 MW + 120 MW + 20 MW = 500 MW

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Example Uncertainty Reserve Procurement: RT 30-minute

- **Assumptions:**
  - 60-min ahead Net Load Forecast = 20,000 MW, 60-min ahead Wind Forecast = 500 MW, 60-min ahead Annual Uncertainty Reserve Requirement % = 0.75%, 60-min ahead 60-Day Uncertainty Reserve Requirement = 0.4%, 60-min ahead Annual Wind Uncertainty Reserve Requirement % = 10%, 60-min ahead 2-Month Wind Uncertainty Reserve Requirement % = 8%
- **Annual Net Load Uncertainty Reserve = 80% x (0.75% x 20,000 MW) = 120 MW**
- **2-Month Net Load Uncertainty Reserve = 20% x (0.4% x 20,000) = 16 MW**
- **Annual Wind Uncertainty Reserve = 80% x (10% x 500 MW) = 40 MW**
- **2-Month Wind Uncertainty Reserve = 20% x (8% x 500) = 8 MW**
- **Total RT 30-min Uncertainty Reserve Procurement =**

  120 MW + 16 MW + 40 MW + 8 MW = 184 MW

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Example Uncertainty Reserve Procurement: RT 10-minute

- Assumptions:
  - 30-min ahead Net Load Forecast = 20,000 MW, 30-min ahead Wind Forecast = 500 MW, 30-min ahead Annual Uncertainty Reserve Requirement % = 0.6%, 30-min ahead 60-Day Uncertainty Reserve Requirement = 0.3%, 30-min ahead Annual Wind Uncertainty Reserve Requirement % = 8%, 30-min ahead 2-Month Wind Uncertainty Reserve Requirement % = 6%
- Annual Net Load Uncertainty Reserve = 80% x (0.6% x 20,000 MW) = 96 MW
- 2-Month Net Load Uncertainty Reserve = 20% x (0.3% x 20,000) = 12 MW
- Annual Wind Uncertainty Reserve = 80% x (8% x 500 MW) = 32 MW
- 2-Month Wind Uncertainty Reserve = 20% x (6% x 500) = 6 MW
- Total RT 10-min Uncertainty Reserve Procurement =

  96 MW + 12 MW + 32 MW + 6 MW = 146 MW

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Summary and Next Steps

Summary

- **There is a need for the NYISO to schedule reserves to help balance uncertainty driven by increased levels of intermittent resources, as well as to reduce reliance on latent reserves.**
    - As discussed in this presentation, the NYISO is proposing to procure uncertainty reserves based on historical forecast errors.
- **The NYISO will return to an upcoming working group to discuss the locational distribution and ORDCs of these reserves, and allocation amongst existing (*e.g.*, 10T, 30T) and new products (*e.g.*, 60T), if such new products are proposed.**

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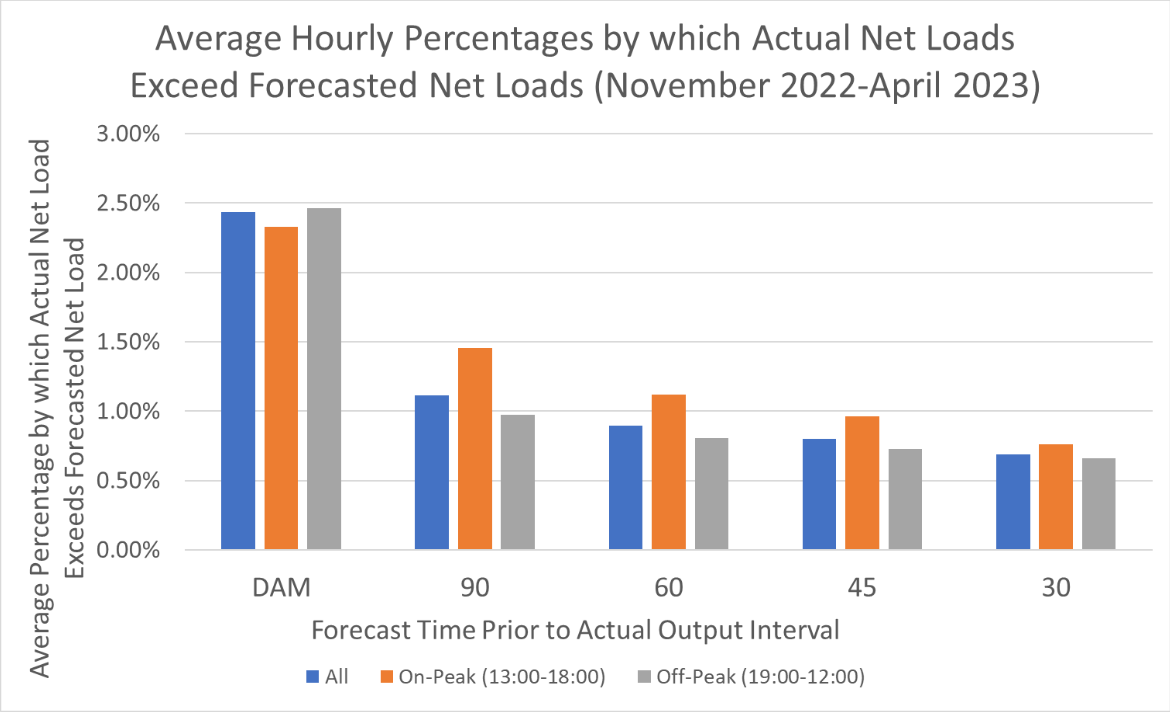
Next Steps

- September 2023
  - Return to ICAPWG/MIWG to continue discussions on necessary enhancements to the reserves market to balance uncertainty.
- 2023 Project Milestone: Q4 Market Design Concept Proposed
- 2025: Target implementation of any uncertainty reserve requirements on existing 10- and 30-minute products

Appendix

Net Load* Forecast Error Evolution



- **The evolution of forecast error between DAM and RT on the right chart showcases the point that the uncertainty reduces as we move from DAM to RT forecasting intervals.**
- **On average, roughly 45% of the DAM under forecast error is present 90 minutes out, and 36% is present 60 minutes out from the actual output interval.**

*In this slide, Net Load is Load net of BTM Solar and Wind

Requirement-Setting Based on Historical Net Load Error Data

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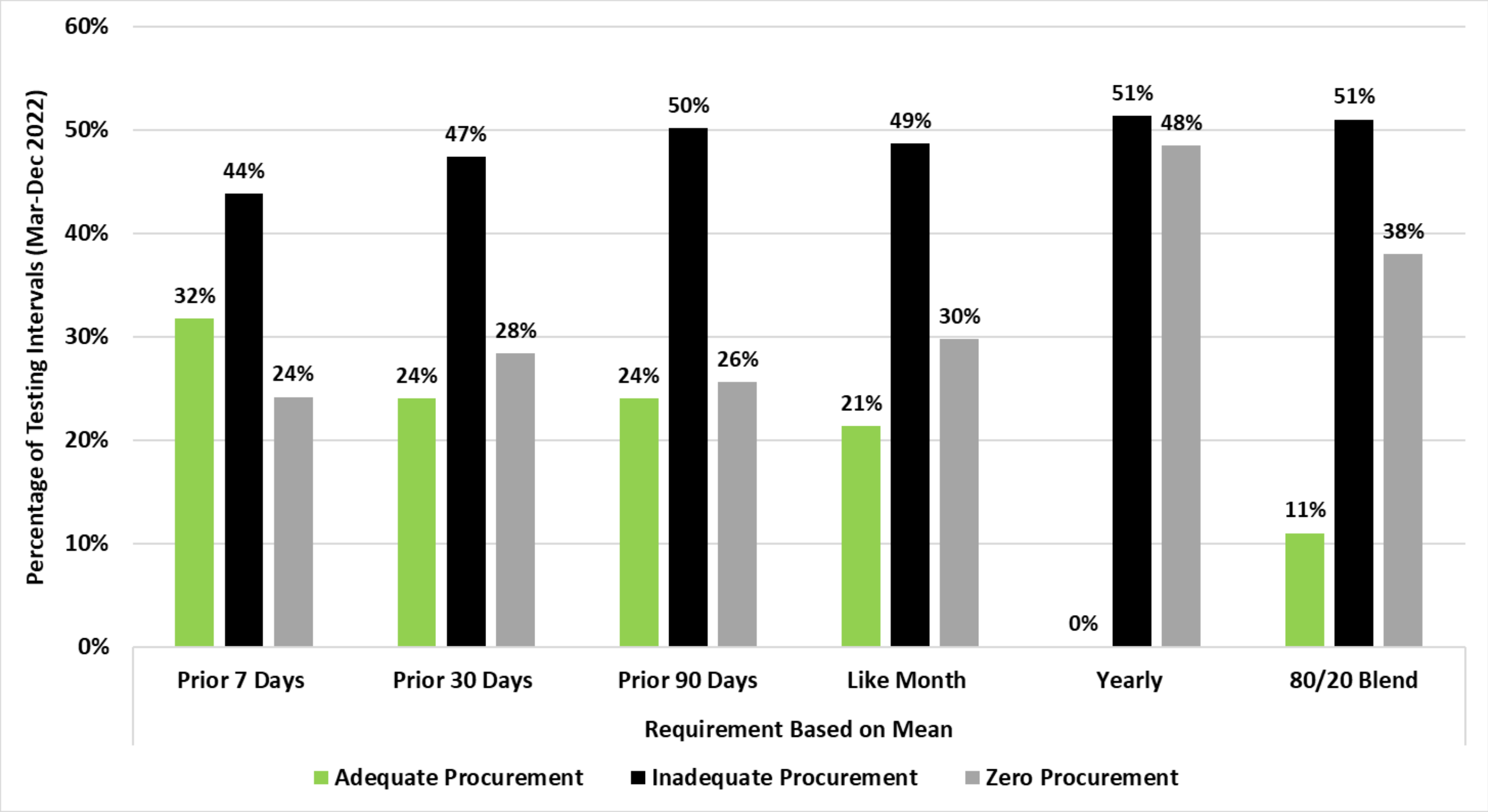
Historical DAM Requirement Percentages Comparison – Net Load

Calculation Period

Error Percentile	7-day	30-day	90-day	Like Month	1 year	80/20 Blend
Average	-0.01%	-0.04%	-0.07%	-0.16%	-0.08%	-0.07%
75th	1.2%	1.19%	1.22%	1.19%	1.18%	1.2%
90th	2.34%	2.34%	2.37%	2.46%	2.53%	2.51%
95th	3%	3%	3.13%	3.27%	3.5%	3.43%

Historical DAM Requirement-Setting Performance - Net Load



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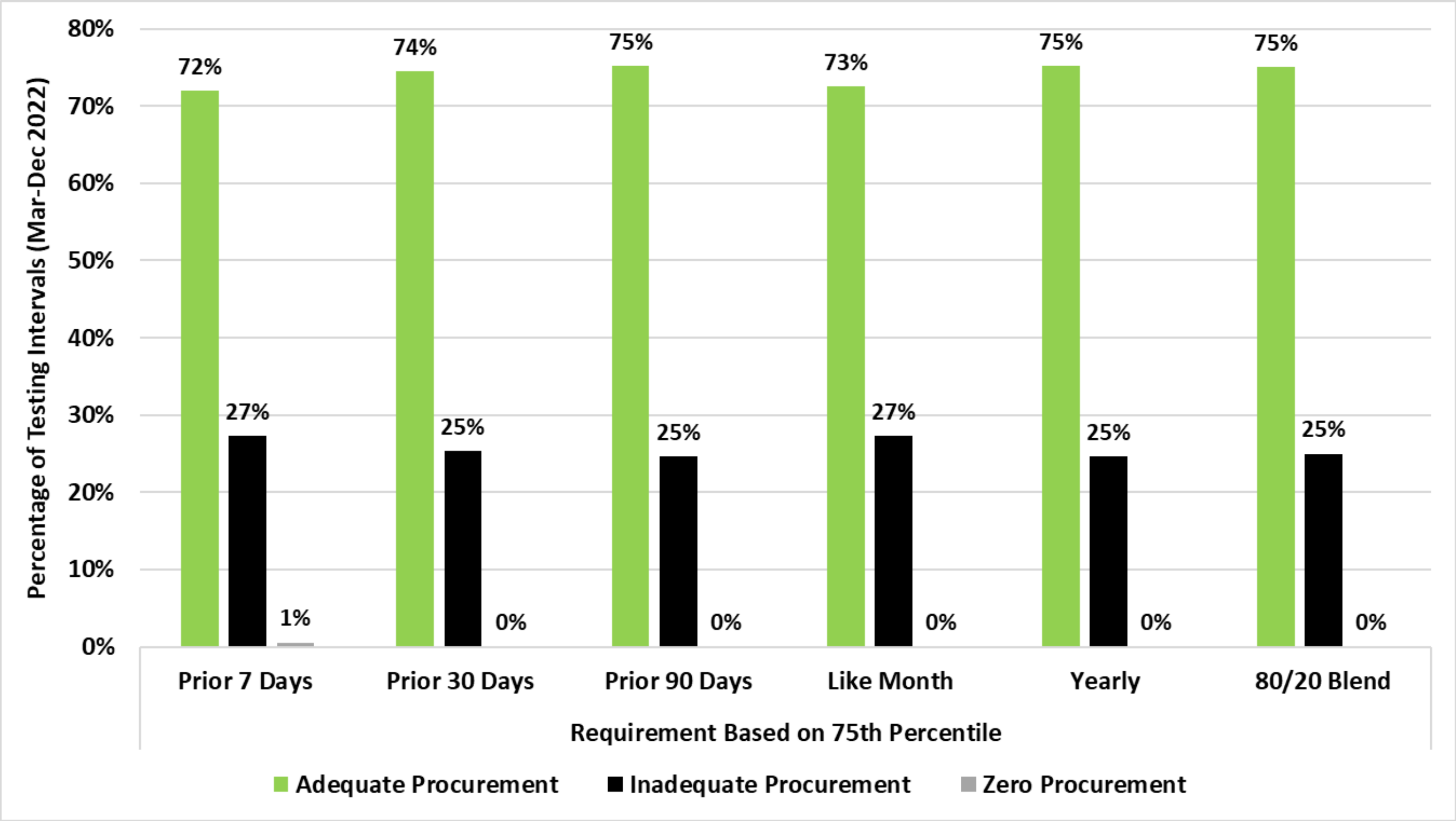
Historical DAM Requirement-Setting Performance - Net Load



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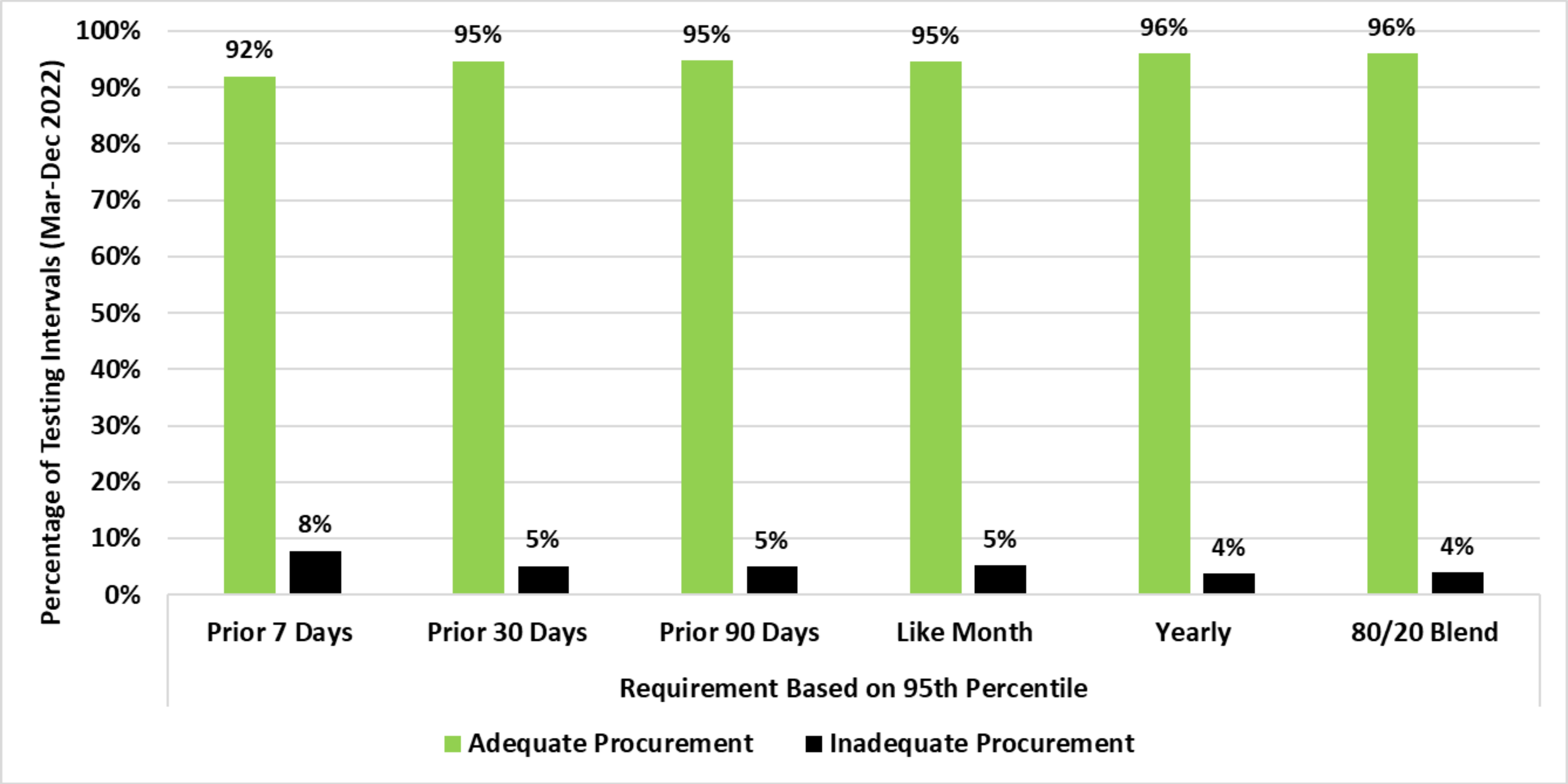
Historical DAM Requirement-Setting Performance - Net Load



New York ISO

DAM vs. RT Uncertainty Reserves

- **Since forecast accuracy improves as it approaches the real-time interval, it is appropriate to adjust the uncertainty reserve requirement between Day-Ahead and real time.**
  - Day-Ahead uncertainty reserve procurement enables commitment of resources to be available in real-time.
  - Real-time scheduling of uncertainty reserves incorporates more accurate forecasts.

Error Percentile	DAM 2021 Net Load Forecast Error	30-minute 6-month Net Load Forecast Error (Nov'22- Apr'23)
Average	-0.08%	-0.02%
75^{th}	1.18%	0.25%
90^{th}	2.53%	0.86%
95^{th}	3.50%	1.34%

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Requirement-Setting Based on Historical Wind Error Data

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Incorporating Wind Forecast Errors

- The NYISO has observed that Wind Forecast error percentages tend to be larger than Net Load Forecast error percentages though the Wind forecast values are much lower than the Net Load Forecast values
  - Additionally, wind forecast errors are not observed to be correlated with Net Load Forecast errors.
- The NYISO is proposing to incorporate wind forecast errors as a separate component of the uncertainty reserve requirement.

Wind DAM Forecast MW Range	% of 2021 Intervals	% of Current Wind Capacity	Average	75th	90th	95th
0-195	25%	0-8%	28%	67%	92%	108%
196-372	25%	9-15%	7%	34%	56%	66%
373-724	25%	16-30%	5%	24%	39%	49%
725-1,104	15%	31-46%	1%	13%	25%	34%
1,105-1,349	5%	47-56%	2%	10%	19%	27%
1,350-1,937	5%	57-77%	4%	9%	17%	21%

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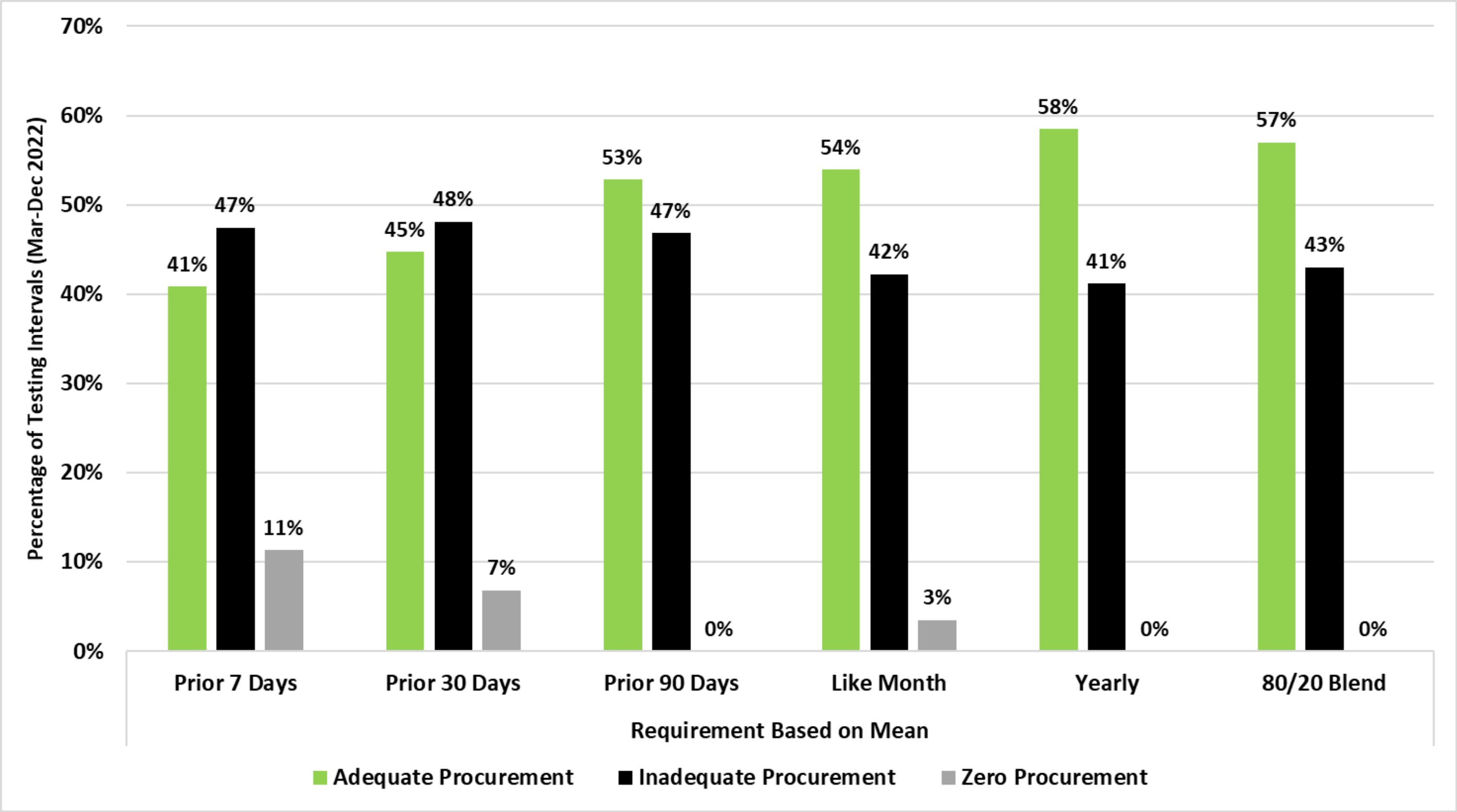
Historical DAM Requirement-Setting Performance - Wind



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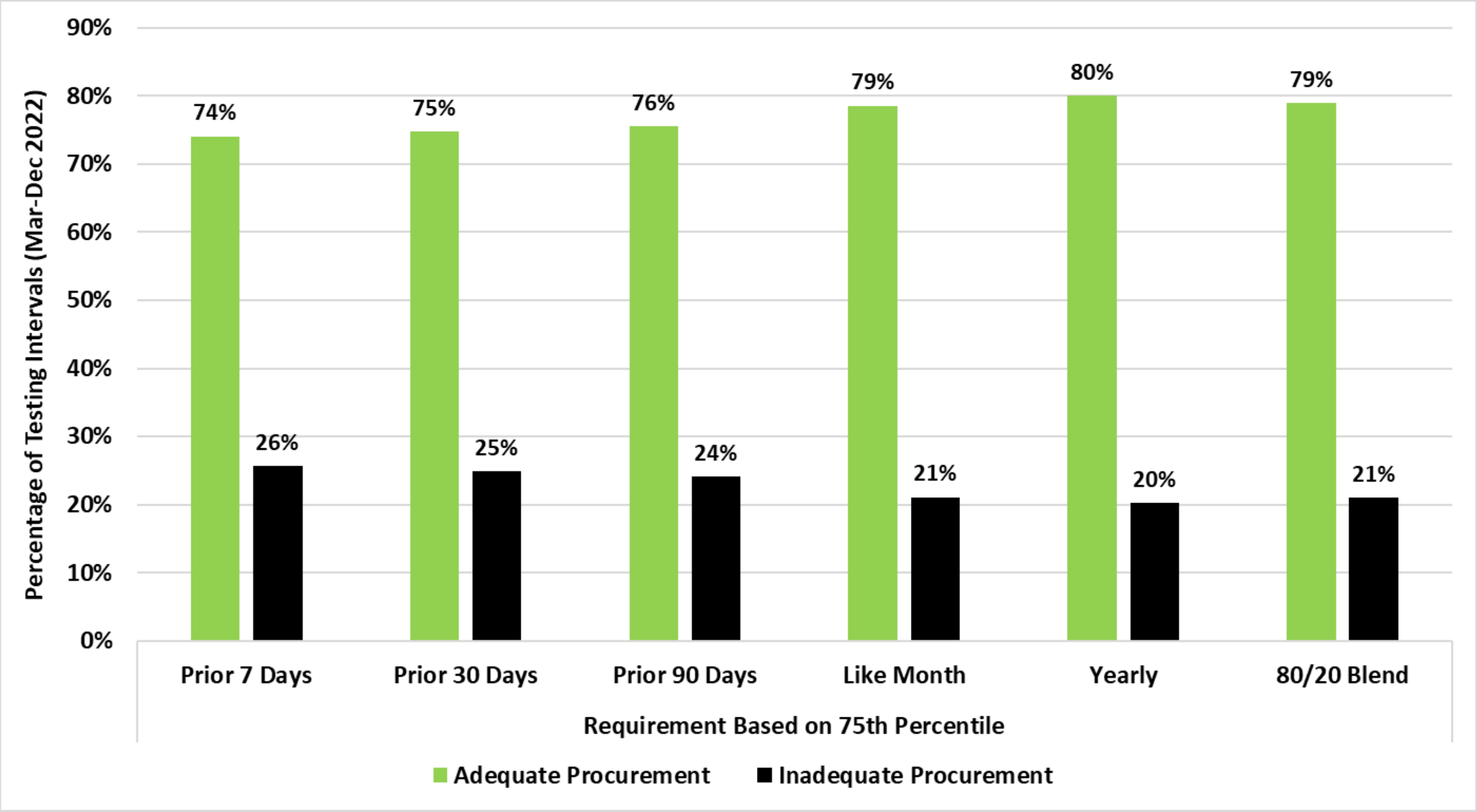
Historical DAM Requirement-Setting Performance - Wind



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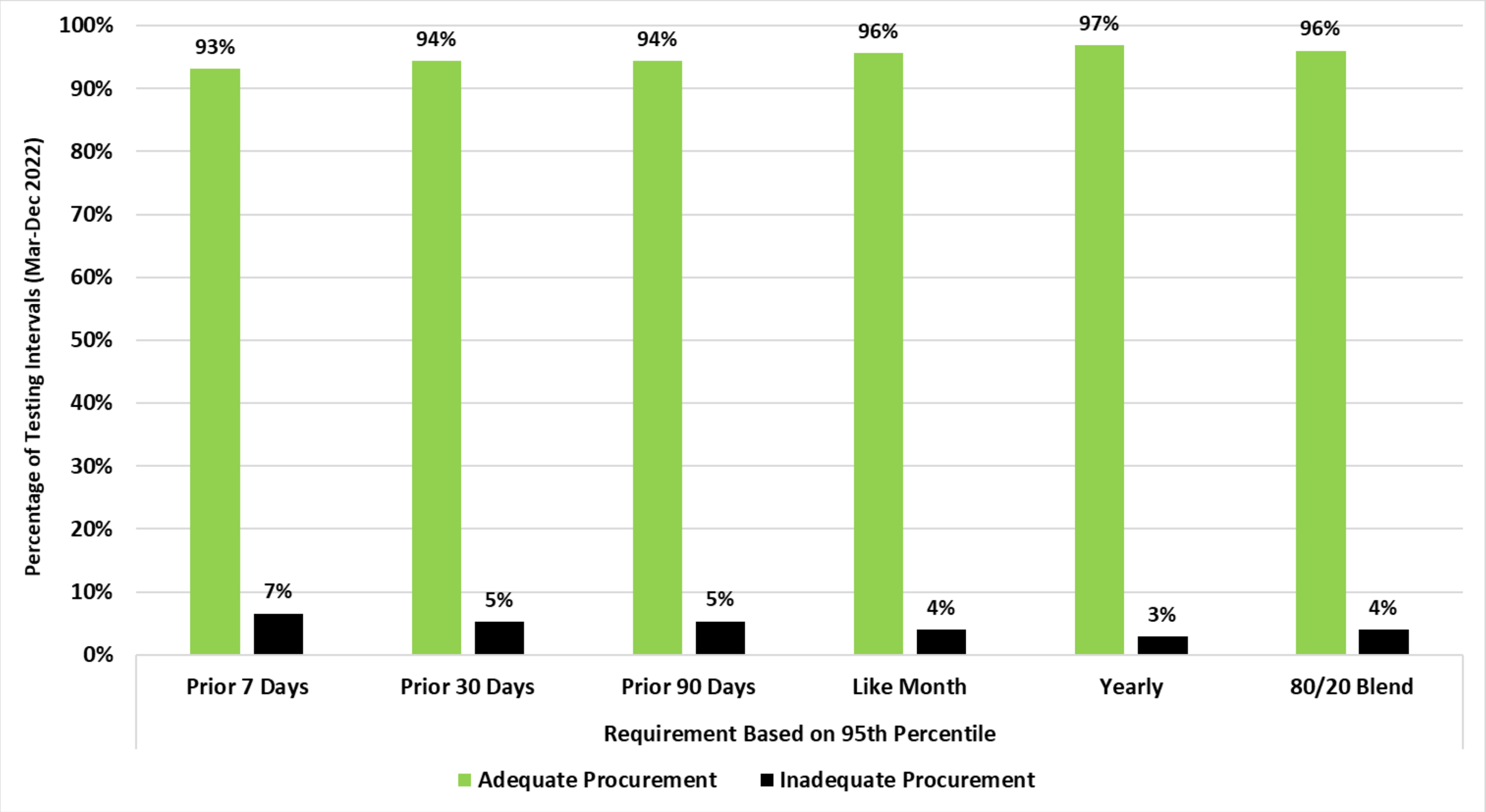
Historical DAM Requirement-Setting Performance - Wind



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Our Mission & Vision

Mission

Ensure power system reliability and competitive markets for New York in a clean energy future

Vision

Working together with stakeholders to build the cleanest, most reliable electric system in the nation

New York ISO