Elevated Risk Days in PJM's Reserve Markets

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What challenge are we trying to fix?

- Align commitments & reserves with operational risk
- Align markets and operations on challenging days
  - DA bid in load vs forecasted load
  - DA reserves vs operational reserve needs
- Have a method for defining when we would need additional reserves
  - PJM Day Ahead Scheduling Reserve % is the same every day
  - Reserves would be allocated through PJM day ahead market

Why do we want more resources online on medium & high risk days

PROVIDES GREATER RELIABILITY AND REDUCES RISK

LESS OUT OF MARKET COMMITMENTS

GIVES US MORE MARGIN TO MITIGATE IDENTIFIED RISK

Provides broader consistency with commitment to generators

Earlier notification for fuel commitment

On average PJM observes less failures to start for CTs when units have an advanced commitment

Changes to Reserve Market Clearing During Elevated Risk Days

1. Increase the Day-Ahead Scheduling Reserve requirement to reflect our "Medium" or "High" Risk Percentile reserve procurement targets.

2. Extend the Day-Ahead Scheduling Reserve requirement to reflect any calculated "energy gap" that may exist to meet PJM's load forecast.

3. Require a minimum portion of procured reserves to be held on online resources.

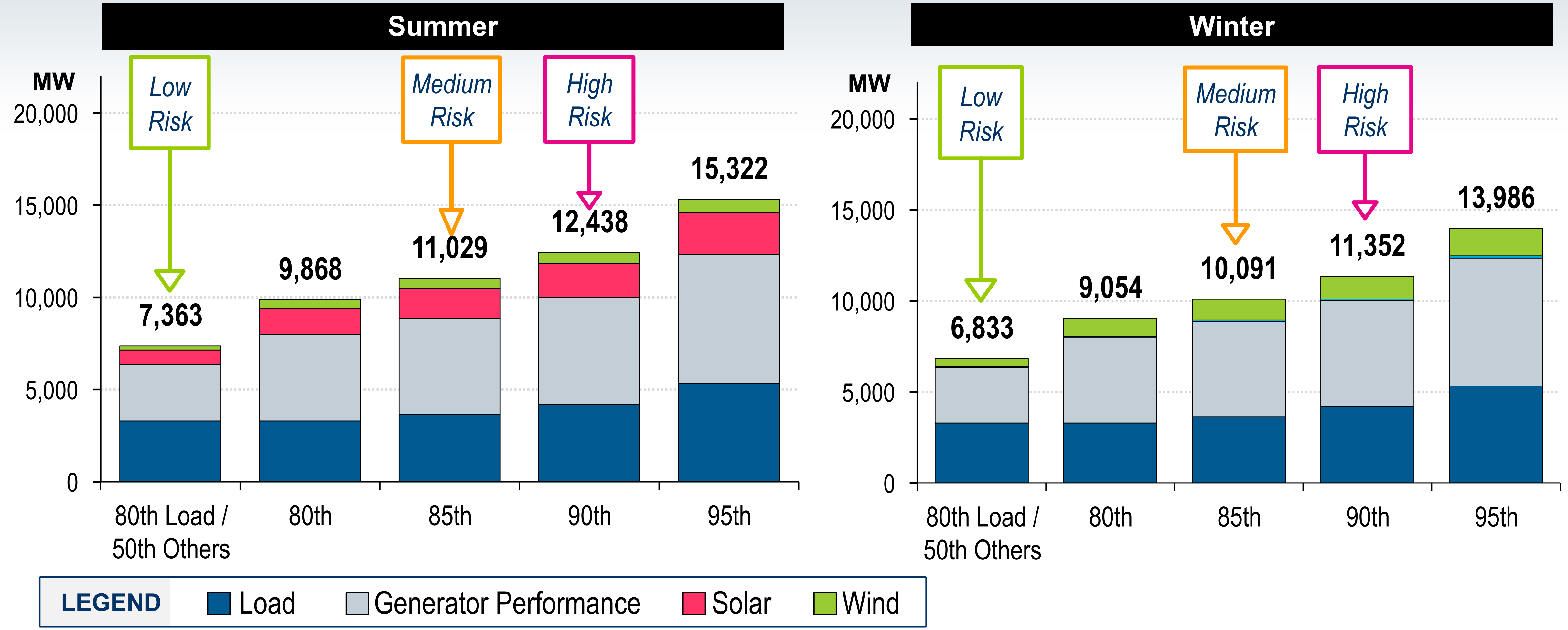
DASR 2.0 Requirement on Elevated Risk Days

Risk Percentiles

Proposed Risk Values	Percentile	Load	Generator Performance	Solar	Wind
Low	80th Load / 50th Others	2.19%	2.03%	11.28%	9.68%
	80th All	2.19%	3.12%	19.71%	21.48%
Medium	85th All	2.42%	3.49%	22.50%	24.19%
High	90th All	2.79%	3.88%	25.51%	26.54%
	95th All	3.55%	4.68%	31.33%	32.43%

Total Risk Megawatts – High-Load-Day Example

Risk Example: 150 GW Peak Load, Average Solar and Wind



Reserves to Address the “Energy Gap”

DASR Adder to Address the Energy Gap

- As previously discussed, one of the risks that PJM considers, particularly on days of elevated operational and reliability risk, is if the risk of not clearing enough physical supply through the Day-Ahead Market to serve expected real-time load.

- This is a risk that PJM mitigates today using its RAC commitment process after the Day-Ahead Market clears.

- However, prior to the implementation of Reserve Price Formation, this risk was addressed on elevated risk days by increasing the DASR requirement with a DASR Adder.

- This presentation is intended to provide some education on how this process worked and to highlight how a similar approach might be applied under the proposed reforms.

Energy Gap: Background and Motivation

- If we ignore interchange, which is not included in PJM's load forecast, the Day-Ahead Market clears supply based on the following power balance equation.

Physical Supply + Increment Bids – Decrement Bids – Price Sensitive Demand = Fixed Demand + Expected Losses

- If the Day-Ahead Market does not clear sufficient physical supply to meet its load forecast PJM will mitigate this risk by committing additional resources using its RAC commitment process.
- This is something that PJM is particularly concerned about during days of elevated risk, when reliability requires that some of the resources PJM depends on make advanced arrangements to be ready to operate (e.g., fuel procurement).
- Going forward, PJM proposes to address this reliability need in its Day-Ahead Market rather than through a separate RAC process later in the day. This will more transparently reflect these reliability needs in the market, provide earlier notice to resources that they may be required to operate, and provide resources that are needed for reliability with a Day-Ahead Market position that includes clear performance expectations.

Quantifying the Energy Gap

Physical Supply + Increment Bids – Decrement Bids – Price Sensitive Demand = Fixed Demand + Expected Losses

- Rearranging this equation yields:

Physical Supply = Fixed Demand + Expected Losses + Price Sensitive Demand + Decs – Incs

- Ultimately the goal is to estimate the difference between the Physical Supply and PJM's Load Forecast, which is how the Energy Gap adder to the Day-Ahead Scheduling Reserve requirement would be calculated.

Energy Gap Adder = PJM Load Forecast – Expected Cleared Physical Supply

- Substitution then yields:

Energy Gap Adder = PJM Load Forecast – Fixed Demand + Expected Losses + Price Sensitive Demand + Decs – Incs

Quantifying the Energy Gap

Energy Gap Adder = PJM Load Forecast –
Fixed Demand + Expected Losses + Price Sensitive Demand + Decs – Incs

- The PJM Load Forecast for the next operating day is calculated PJM and known before the Day-Ahead Market executes
- Fixed Demand is bid into the Day-Ahead Market by Market Participants and is known before the Day-Ahead Market executes
- Expected Losses, cleared Price Sensitive Demand, cleared Decrement Bids and cleared Increment Bids are an outcome of Day-Ahead Market clearing and therefore would need to be estimated based on historical data from similar operating dates. PJM had an approach to tackle this problem before Reserve Price Formation was implemented.

DASR Adder to Address the Energy Gap

- Prior to the implementation of Reserve Price Formation, PJM would increase its DASR requirement on Hot and Cold Weather Alert days to account for the difference in PJM’s load forecast and what was then referred to as “Adjusted Fixed Demand.”
- This DASR adder was used to mitigate the risk of any difference between PJM’s load forecast and the amount of demand expected to clear in the Day-Ahead Market, which is the gap we’ve been talking about as the “Energy Gap.”
- This process allowed the DASR adder to be calculated before the Day-Ahead Market was executed, which has the advantage of simplifying the optimization problem (by establishing a fixed quantity) and providing a clear expectation to Market Participants on what reserve requirements would be.
- This process was fully documented in PJM Manual 11 Section 11.2.1 (see M11 Revision 113 for details).

Past Process for Calculating the "Energy Gap" based on Historical Operating Data

1. Calculate the "Adjusted Fixed Demand" for the operating day to reflect how virtual activity and Price Responsive Demand is expected to affect the total cleared supply.

2. Calculate the difference between PJM's load forecast and the Adjusted Fixed Demand.

3. Use this calculated quantity to increase the DASR requirement on days of elevated operational risk.

Calculation of the DASR Adder Prior to Reserve Price Formation

From Manual 11 Section 11.2.1 Revision 113 page 157:

"For each hour of the day, the additional DASR Requirement is calculated as the greater of:

- *Forecasted Real-time load minus Adjusted Fixed Demand Bids, or*
- *Zero."*

From Manual 11 Section 11.2.1 Revision 113 page 157:

*"Adjusted Fixed Demand = Total Fixed Demand * (1 + Seasonal Conditional Demand Factor)*

- *The Seasonal Conditional Demand Factor scales up the sum of Fixed Demand Bids by the average percentage of additional net demand that historically cleared from the net of price sensitive demand bids, decrement bids and increment offers during peak hours (conditional demand)."*

From Manual 11 Section 11.2.1 Revision 113 page 157:

"The Seasonal Conditional Demand Factor is calculated separately for the winter and summer seasons. The Winter Seasonal Conditional Demand Factor is based on the top ten peak load days from November through March of the prior year.

- *The Hourly Conditional Demand Factor is calculated as:*
  - *Sum(price sensitive demand + decrement bids – increment offers) / Sum(fixed demand)*
- *The Hourly Conditional Demand Factors for each day are then averaged to calculate a Daily Conditional Demand Factor.*
- *The ten Daily Conditional Demand Factors are then averaged to arrive at the Seasonal Conditional Demand Factor."*

Why might we want to consider expected losses in the energy gap calculation?

- An estimate of expected real-time losses is included in the power balance equation when the Day-Ahead Market is cleared as was illustrated in the previous slides on “Quantifying the Energy Gap.”
- Additionally, losses are included in PJM’s day-ahead load forecast.
- To ensure that the comparison of the Adjusted Fixed Demand and PJM’s load forecast is an apples-to-apples comparison, and to reflect the quantities that drive supply procurement in the Day-Ahead Market, PJM is proposing to add an “expected losses” factor to the energy gap calculation.

Possible Approach for Calculating a Seasonal Expected Losses Factor

Use the same historical peak days and peak hours to calculated an "Seasonal Expected Losses Factor" as would be used to calculate the Seasonal Conditional Demand Factor.

For each season, the Hourly Expected Losses Factor would be calculated as:

- **Sum(expected losses) / Sum(fixed demand)**

The Hourly Expected Losses Factors for each day would then be averaged to calculate a Daily Expected Losses Factor.

The ten Daily Expected Losses Factors would then be averaged to arrive at the Seasonal Expected Losses Factor."

Possible Approach for Calculating Expected Losses

Multiply the Seasonal Expected Losses Factor by the fixed demand for the operating day to calculate the Expected Losses for that day.

Expected Losses = Fixed Demand x Seasonal Expected Losses Factor

Summary of the Possible Approach for Quantifying Energy Gap for Elevated Risk Days

- On Medium- and High-Risk days, PJM would increase its reserve requirements in the Day-Ahead Market to procure reserves to manage the Energy Gap, which reflects the difference between the physical supply cleared in the market and PJM's load forecast.

- This increased requirement level would be calculated based on the difference between PJM's load forecast and the Adjusted Fixed Demand for that day plus Expected Losses.

- The factors used to adjust fixed demand to calculate the expected losses would be based on historical operational data from peak demand days and peak hours in the appropriate season (i.e., winter and summer).

Energy Gap Requirement = MAX(Load Forecast – (Adjusted Fixed Demand + Expected Losses), 0)

- The peak forecasted load hour of January 15th, 2025, was selected as an example, which occurred at 7:00 am that day.
- This day was selected because it was the sixth highest peak load forecast day this past winter, and the five days with higher forecasted peak loads occurred during or adjacent to the Martin Luther Jr. holiday weekend.
- This day is used as an example and may not be representative of this approach's accuracy during other peak days. More analysis would be needed for a full evaluation.

Numerical Example for January 15, 2025, 7:00: Seasonal Conditional Demand Factor

- A Seasonal Conditional Demand Factor was calculated based on data from the Winter of 23/24. A similar methodology was used as was just described and was previously documented in M11.
- Data from December 1, 2023 – February 28, 2024, was used
- The 10 days with the highest PJM Load Forecast were selected
- The “peak hours” from those days were then used, which for winter is hours 7-10 and 17-20
- The Hourly Conditional Demand Factor was then calculated as:
  - *Sum(price sensitive demand + decrement bids – increment offers) / Sum(fixed demand)*
- The Daily Conditional Demand Factor was taken as the average of these hourly values for each of the 10 peak days, and the Seasonal Conditional Demand factor was taken as the average of these Daily Conditional Demand Factor values
- The calculated Seasonal Conditional Demand Factor was calculated as **1.3%**

Numerical Example for January 15, 2025, 7:00: Adjusted Demand

- The Peak Forecast for January 15, 2025, occurred at hour beginning 7:00
- The total bid fixed demand for that hour was 121,172 MW
- The Adjusted Demand for this time would therefore have been:
  – *Adjusted Demand = Fixed Demand x (1 + SCDF)*

    = 121,172 MW x (1 + 0.013)

    = ***122,747 MW***
- As a point of comparison, the actual total cleared price responsive demand for that hour (including cleared virtual bids) was 122,623 MW.

Numerical Example for January 15, 2025, 7:00: Seasonal Losses Factor

- A Seasonal Losses Factor was calculated based on data from the same data in Winter of 23/24. A similar methodology was used as was previously employed for calculating the Seasonal Conditional Demand Factor.
- Data from December 1, 2023 – February 28, 2024, was used
- The 10 days with the highest PJM Load Forecast were selected
- The "peak hours" from those days were then used, which for winter is hours 7-10 and 17-20
- The Hourly Losses Factor was then calculated as:
  - *Sum(losses) / Sum(fixed demand)*
- The Daily Losses Factor was taken as the average of these hourly values for each of the 10 peak days, and the Seasonal Losses Factor was taken as the average of these Daily Losses Factor values
- The calculated Seasonal Losses Factor was calculated as **3.1%**

Numerical Example for January 15, 2025, 7:00: Adjusted Demand

- The Peak Forecast for January 22, 2025, occurred at hour beginning 7:00
- The total bid fixed demand for that hour was 121,172 MW
- The Estimated Losses for this time would therefore have been:
  - *Estimated = Fixed Demand x SLF*

    = 121,171 MW x (0.031)

    = ***3,756 MW***
- As a point of comparison, the actual total losses cleared in the Day-Ahead Market for that hour were 3,758 MW

Numerical Example for January 15, 2025, 7:00: Energy Gap at the Peak Forecast Hour

- The peak forecast for January 15, 2025, was 130,356 MW* effective for hour beginning 7:00
- The calculated Energy Gap Adder for the DASR requirement would therefore have been:
  - *Energy Gap Adder = PJM Load Forecast – (Adjusted Demand + Expected Losses)*

    = 130,356 MW – 122,747 MW – 3,756 MW

    = 3,853 MW
- As a point of comparison, the actual Energy Gap that day as defined by the difference between PJM's load forecast and physical supply + net-exports for that hour was 3,975 MW.

**As evaluated at 1/14/2025 9:45 EPT*

Advantages and Limitations of this Possible Approach

Advantages

- ✓ PJM already had experience with the Seasonal Conditional Demand Factor approach given that it was used prior to Reserve Price Formation.
- ✓ The approach for calculating Expected Losses would be structural similar.
- ✓ The approach uses quantities that are specific to the operating day (i.e., PJM Forecast, Bid Fixed Demand).
- ✓ The process for calculating the Energy Gap Adder would be transparently documented and easily replicable.

Limitations

- × An analysis of the total cleared demand (including cleared virtual bids), which the Adjusted Demand is attempting to model shows that this quantity varies significantly day-to-day.
- × Further analysis is needed to determine to evaluate how accurately this approach would estimate the Energy Gap on elevated risk days.
- × This analysis may be complicated by the fact that the status quo (including the need for out of market actions on elevated days) may affect expected outcomes.

Ensuring a Minimum Quantity of Online Reserves

Online Reserves during Elevated Risk Days

- PJM's current position is that to ensure a reliable operating plan, any resources eligible to meet the Energy Gap adder to its day-ahead reserve requirements would need to have an energy commitment and be expected to be online during those hours.
- This Energy Gap adder would be only effectuated during Medium- and High-Risk days, which would serve to address the elevated reliability risk that exists during those times.
- PJM is also exploring whether additional online reserves are needed during High-Risk days to mitigate elevated generator failure-to-start performance risk.
- This might include requiring some additional portion of the DASR 2.0 reserves to be served by online resources during these High-Risk days or requiring that all 30-Min Reserves be held on online resources.

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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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