Ancillary Service Study: Initial IMM Results

Presented to:

ERCOT Technical Advisory Committee

ERCOT IMM
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Introduction

- Senate Bill 3 from the 87th Texas legislative session required the PUC to produce an Ancillary Services Study
- The PUC requested that ERCOT and the IMM collaborate in producing the Study, which will include a review of:
  - The types and quantities of ancillary service products needed to meet the reliability needs of the ERCOT system, and
  - Improvements in the procurement of ancillary services that will improve efficiency and lower costs
- As part of this project, the IMM has developed a stochastic modeling approach for evaluating the reliability risks that AS products address
- This presentation discusses this approach and presents initial results that can inform improvements to the AS Methodology related to the procurement volumes for ancillary services

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The Purpose of Ancillary Services

- A reasonable and efficient AS Methodology must recognizes the role of each AS product:
  - Regulation is used to maintain system frequency by balancing supply and demand on a 4-second basis
  - Responsive Reserve Service (RRS) is a primary frequency response (PFR) and spinning reserve product that helps address frequency deviations after forced outages or other operational issues
  - ERCOT Contingency Reserve Service (ECRS) is a 10-minute reserve product (one or offline) to quickly restore RRS and address supply shortfalls due to system contingencies or net load forecast errors
  - Non-spinning reserves (NSPIN) is a 30-minute reserve product held on online or offline resources that is intended to restore the higher-value reserve products after they are deployed and address under-commitment of resources resulting from net load forecast errors.

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Developing a Reasonable Ancillary Services Methodology

- To determine the quantity of each class of reserves needed, it is critical to model the reliability risks the AS products are designed to address.
  - Since the risks are associated with random factors, we have developed a stochastic model to analyze them.
  - This allows us to balance costs and reliability by estimating the quantity of reserves needed for ERCOT to meet a reliability standard.
- ERCOTs current AS procurement methodology is based on deterministic metrics that do not reflect a probabilistic analysis of reliability risks.
  - For example, its current procurement quantities are based primarily on net load forecast errors, which is only one relevant risk factor.
  - We hope the AS Study will provide an opportunity to collaborate with ERCOT to improve its operating reliability analyses and procedures.

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Summary of Recommendations

- AS procurement volumes should be informed by a probabilistic analysis of the reliability risks addressed by the AS products
  - We developed a stochastic model to perform such an analysis, which is the basis for our recommendations
- ECRS and NSPIN procurement volumes can be substantially reduced on average while maintaining reliability:
  - The 1-in-10 reliability standard could be satisfied even after reducing ECRS procurement by 50% and NSPIN by 35%
  - ERCOT could achieve a more conservative 1-in-20 level of reliability after reducing ECRS procurements by more than 40% and NSPIN by 20%
  - We are working on incorporating forward-looking estimates of changes in the reliability risk profiles that may lower these procurement reductions
- Larger benefits can be achieved by making the AS procurement quantities dynamically based on the factors that tend to affect the reliability risks
- ESR duration requirements are currently set unnecessarily high and should be lowered to one hour, consistent with the risks they address

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Model Summary

- Objective: estimate the reliability value of different levels of reserves to inform procurement targets and corresponding reliability value
- Model approach: determine how reserve levels correspond to the “loss of load probability” (LOLP) based on randomly occurring forced generator outages and load and renewable output forecast errors.
  - Forced generator outages cause an immediate reduction in available reserves as they are deployed
  - Under-forecasts of net load (load – renewable output) can lead to under-commitment of dispatchable resources and fewer available reserves
- We developed a Monte Carlo model that starts with a set of historical hours with different load, supply commitments and renewable output
  - With different assumed reserve levels, the model then produces thousands of iterations with random forced outages and net load forecast errors
  - In each iteration, reserves are assumed to be deployed and the model determines whether load shedding would have occurred
  - The frequency of iterations with load shedding determines the LOLP

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Identifying the Reserve Levels Needed

- To determine the recommendations for the quantity of each class of reserves to be procured, the analysis includes the following steps:

  1. For each historic hour in the study period, we initially run the Monte Carlo using the historical quantity of reserves present in the system.
  2. We then decrement the quantity of reserves by 10% of the AS Plan.
     - Example: If the ECRS MW procurement requirement is 2,500 MW for a given interval, a 10-step scenario would result in 250 MW decrements.
     - Those 250 MW decrements would then be sequentially removed from the 10-minute MW reserves observed in SCED for the given interval until reaching 0 MW for ECRS.
  3. We identify the LOLP at each reserve procurement level to determine the amount of reserves that are needed to satisfy a 1-in-10 and 1-in-20 reliability standard.

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Reserves Included in the Reliability Model

- To accurately determine when load-shedding would occur in the model iterations, it must recognize all available supply
- Therefore, the model includes all classes of resources that could be utilized to mitigate a potential loss of load, including:
  - Any online headroom that can be converted to energy within 10 or 30 minutes, respectively, for the ECRS and NSPIN analyses
  - Offline resources providing ECRS and NSPIN
  - Quick-start units scaled for their start-time
  - Load Resources providing RRS, ECRS, and/or NSPIN
  - Large Flexible Loads – already provide a large amount of reserves and predictably curtail when conditions are tight (see appendix)
  - Duration-limited ESRs
  - Up-configurations for combined-cycle resources

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Analysis of 10-Minute Reserves

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ECRS Analysis

- ECRS provides 10-minute reserves that, along with RRS and regulation, address the following risks:
  - Net load forecast errors with lead-times of 30-minutes or shorter that can cause: a) generation under-commitments, or b) dispatch instructions from SCED that do not satisfy the system load
  - Forced outages that could occur over 30 minutes that only be addressed by 10-minute reserves
- How do we account for this risk in our model?
  - The model utilizes all capacity that can be accessed in ten minutes and the required duration for batteries is assumed to be 1-hour
  - The model uses the distribution of thirty-minute net load forecast errors and forced outages probabilities to model the risks in each iteration
  - If these risks cause the reserves to fall to 1500 MW, we include the iteration as a load shedding event
- The following figure shows the results of this modeling

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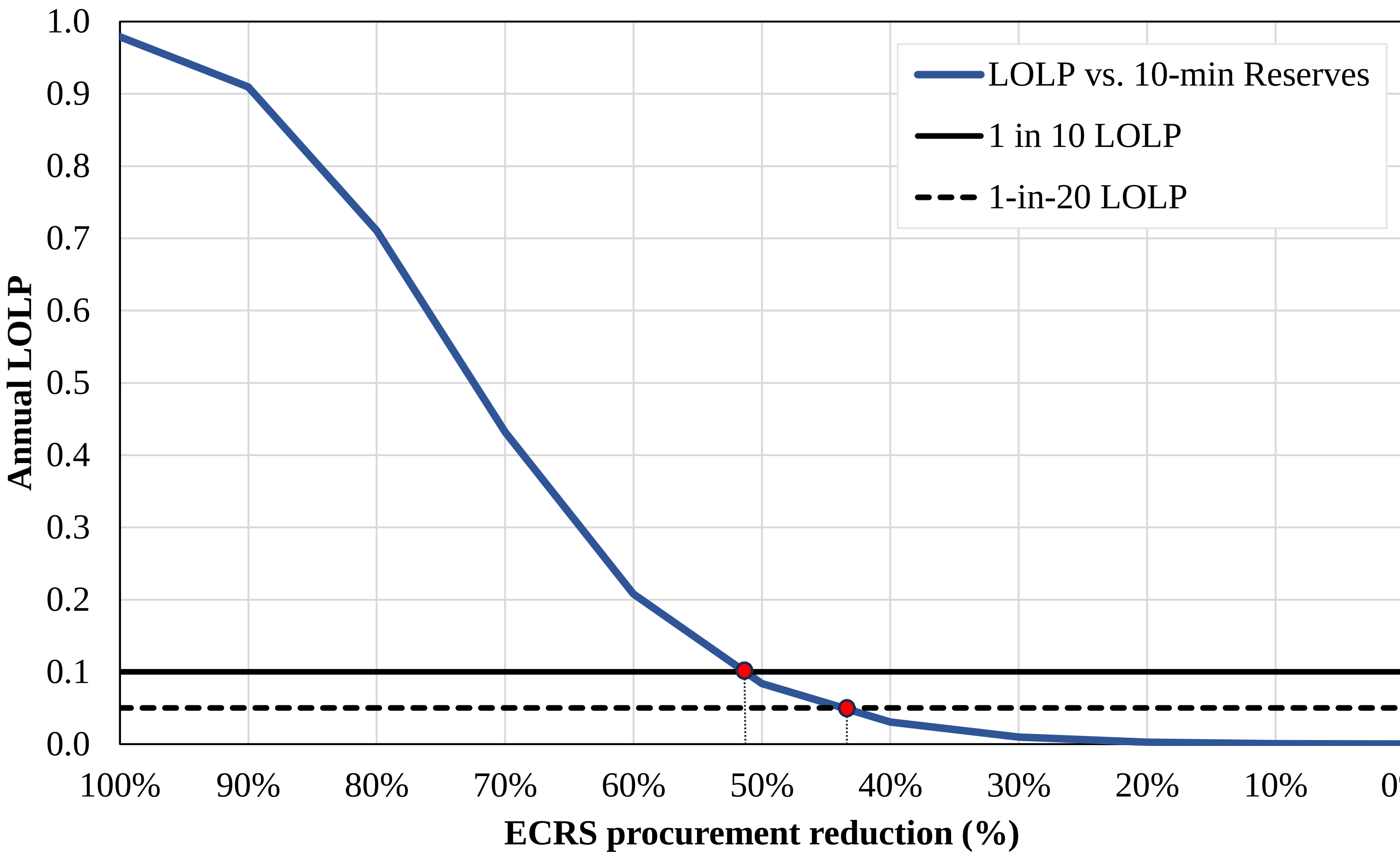
ECRS Procurement Volumes



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Optimizing ECRS Procurement Volumes

- These results indicate that ERCOT could reduce ECRS procurement by:
  - 52% in all hours and achieve a 1-in-10 reliability level (LOLP of 0.1)
  - 43% in all hours and achieve a 1-in-20 reliability level (LOLP of 0.05)
- However, the LOLP is driven by relatively small number of hours with much high probabilities of load shedding
- Instead of uniformly reducing the AS Plan, larger savings could be achieved by reducing procurements more in low-risk hours and by less in high-risk hours.
- For example, an annual LOLP of 0.05 could be achieved with an average reduction in ECRS procurements of more than 84% by:
  - Reducing ECRS procurements by 40% from 4 p.m. through 9 p.m. in June through September and in hours with expected cold weather
  - Reducing ECRS procurements by 90% for all other periods
- Greater savings could be achieved by varying procurements more dynamically based on expected conditions (load and renewable output) the following day.

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Analysis of 30-Minute Reserves

Non-Spinning Reserves Analysis

- Non-Spin provides 30-minute reserves that address the following risks:
  - Net load forecast errors with lead-times of 1 hour that can cause: a) generation under-commitments and 10-minute reserve shortages
  - Forecast errors become evident over longer time horizons are better addressed by commitment of longer-lead time resources through the RUC
  - Forced outages that could occur over an hour that may require the deployment of 30-minute reserves
- How do we account for this risk in our model?
  - The model utilizes all capacity that can be accessed in thirty minutes and the required duration for batteries is assumed to be one hour
  - The model uses the distribution of one-hour net load forecast errors and forced outages probabilities to model the risks in each iteration
  - If these risks cause the reserves to fall to 1500 MW, we include the iteration as a load shedding event
- The following figure shows the results of this modeling

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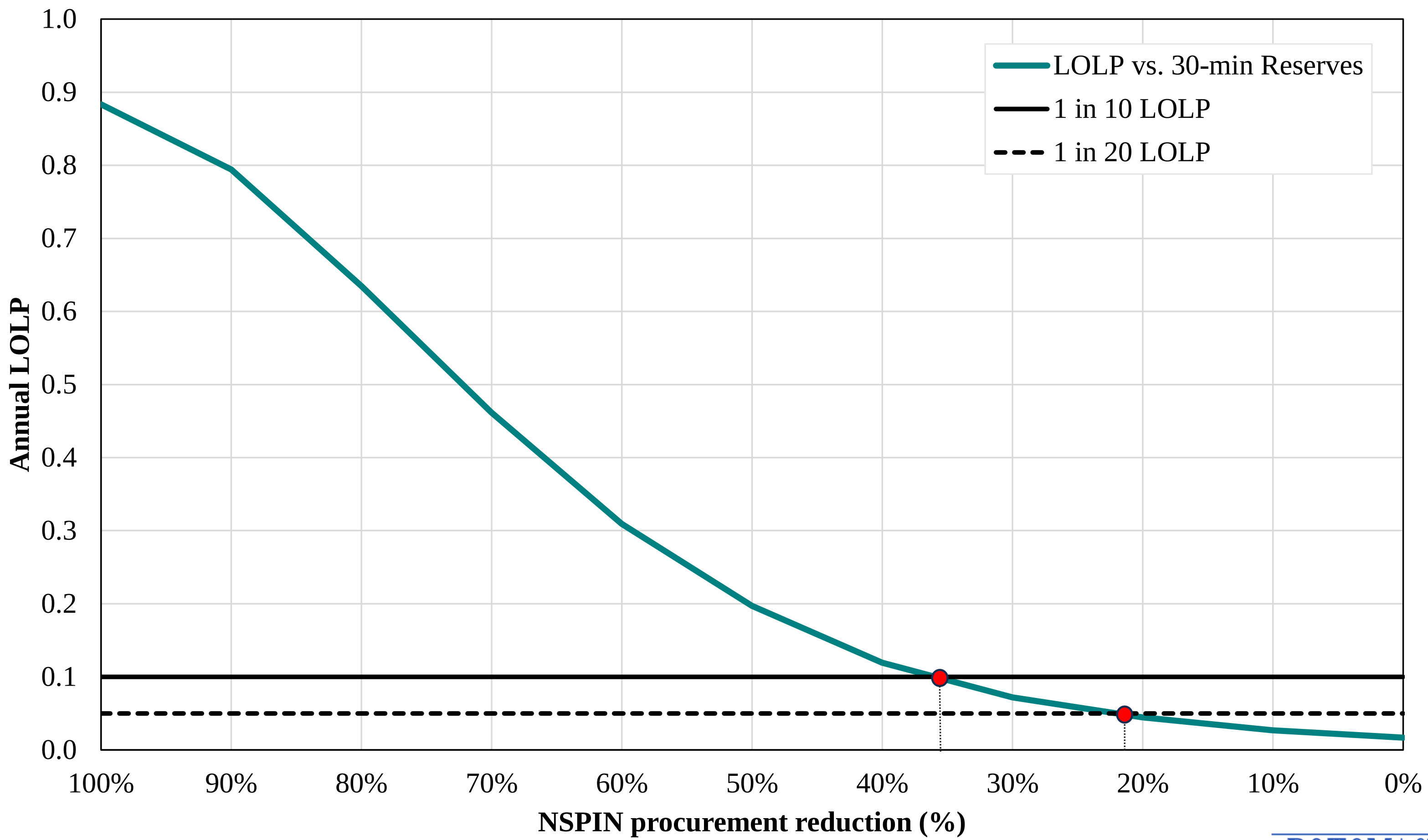
Non-Spin Procurement Volumes



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Optimizing Non-Spin Procurement Volumes

- These results show that ERCOT could reduce NSPIN procurement by:
  - 35% in all hours and achieve a 1-in-10 reliability level (LOLP of 0.1)
  - 22% in all hours and achieve a 1-in-20 reliability level (LOLP of 0.05)
- Like ECRS, the LOLP is driven by relatively small number of hours with much high probabilities of load shedding
- Instead of uniformly reducing the AS Plan, larger savings could be achieved by reducing procurements more in low-risk hours and by less in high-risk hours.
- For example, an annual LOLP of 0.05 could be achieved with an average reduction in NSPIN procurements of more than 75% by:
  - Reducing NSPIN procurements by 10% from 5 p.m. through 9 p.m. in May through September and in hours with expected cold weather
  - Reducing NSPIN procurements by 80% for all other periods
- Greater savings could be achieved by varying procurements more dynamically based on expected conditions (load and renewable output) the following day.

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Other AS Issues and Ongoing Analyses

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Duration Requirements for Ancillary Services

- As more of the system needs are met by ESRs, duration requirements for the AS products becomes an increasingly important design decision
- Duration requirements that are overly aggressive may:
  - Compel batteries to produce energy when it would be more efficient for them to provide reserves and, consequently
  - Compel gas-fired units to provide reserves when it would be more efficient for them to produce energy
  - This lowers reliability by inefficiently reducing ESRs state of charge
- We have analyzed the events that the reserve products would typically be deployed to address to identify reasonable duration requirements:
  - We consider the duration of net load forecast errors looking into the future from a single point in time
  - We identify consecutive intervals/hours with an under-forecast of at least 1 GW at relatively low levels of PRC when reserve deployments would likely be most needed
- The next two figures show these results for ECRS and NSPIN

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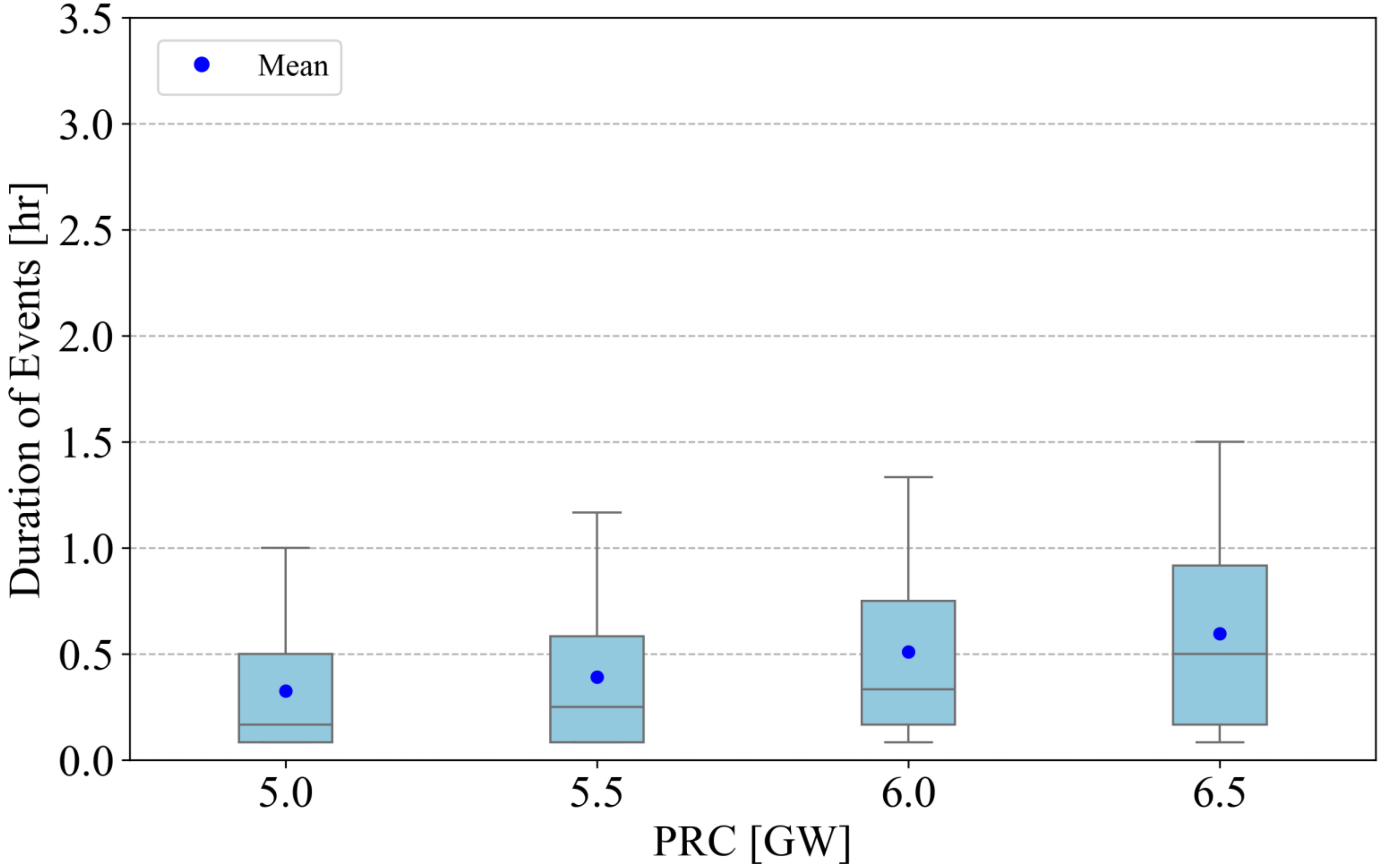
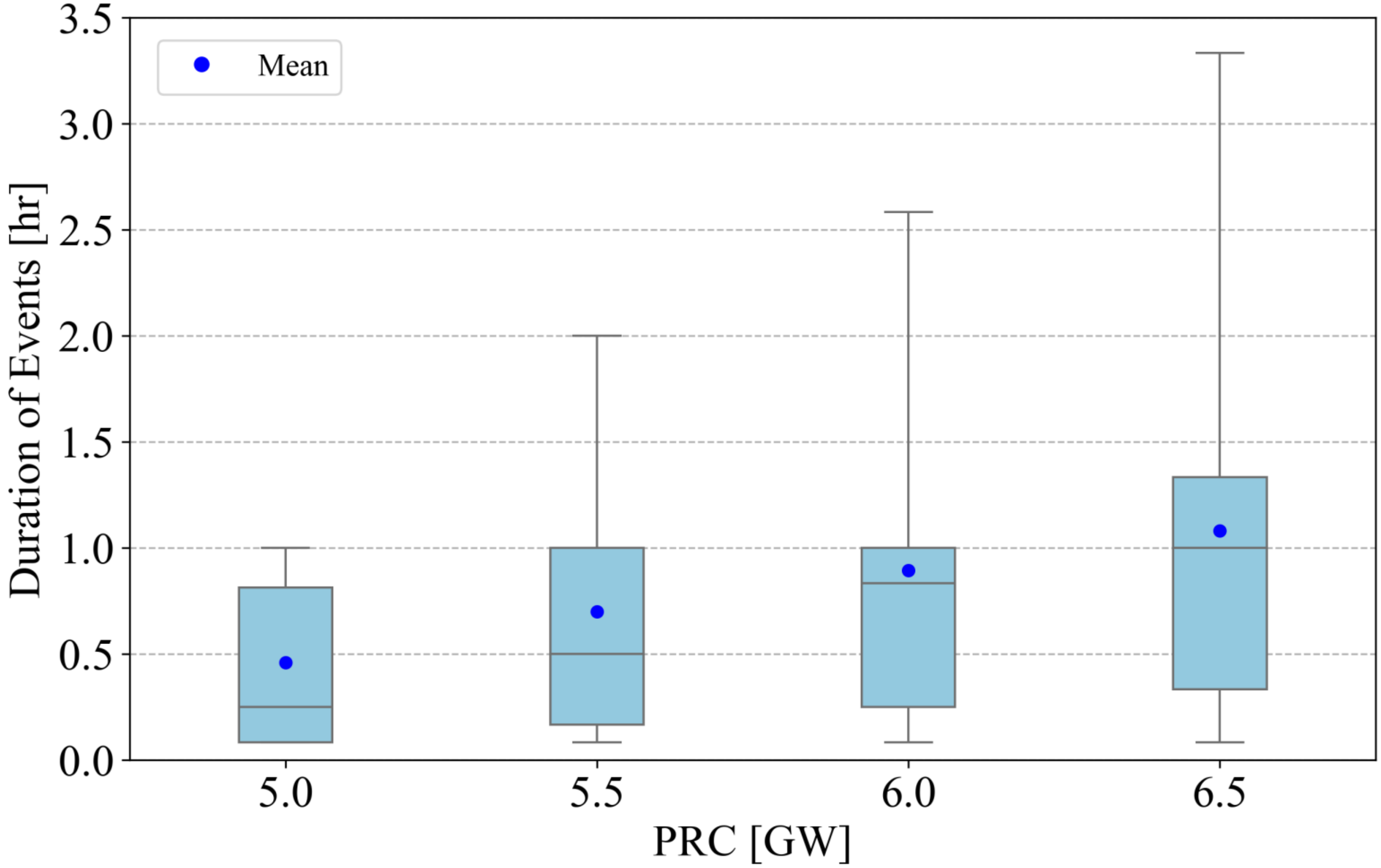
ESR Duration Analysis for ECRS



ESR Duration Analysis for NSPIN



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Duration Requirements for Ancillary Services

ECRS

- These results utilize net load forecast errors for 5 to 120 mins into the future at 5-min increments
- When conditions are tight (PRC ranging from 5 to 6.5 GW), the average duration of net load forecast errors are less than 30 minutes
- Even events approaching the 95th percentile only exceed one hour when PRC is greater than 6 GW.

NSPIN

- These results utilize net load forecast errors for 5 to 120 mins into the future at 5-min increments and then hourly increments for an additional two hours for a total of a four-hour forecast horizon.
- Like ECRS, the average duration is generally less than one hour
- 75 percent of intervals (up to the top of the blue bar) do not exceed one hour until PRC levels rise to 6.5 GW

- These results support a duration requirement for both products of 1 hour
- Caveat: these analyses are inconclusive and would be improved by a more stochastic approach

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Developing a Prospective Analysis to Assess AS Needs

- Our methodology uses recent historical conditions to estimate the reliability risks posed by net load forecast errors and forced outages
- Ideally, the AS methodology should account for changes in the risk profile associated with the rapidly changing resource mix, including:
  - The rapidly increasing penetration of intermittent resources, which will likely increase the magnitude of the net load forecast errors, and
  - The increase in large flexible loads that tend to mitigate system risk by self-curtailing when conditions become tight
- The IMM is developing approaches for including these changes in the risk profile in its methodology

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Dispatchable Reliability Reserve Service (DRRS)

- The IMM has recommended a longer lead time reserve product to address system uncertainties that otherwise compel out of market commitments
  - Senate Bill 3 mandates such a product, the DRRS product, defined as having a product with a two hour start time and four-hour duration
- Pros:
  - DRRS could mitigate over-procurement of NSPIN and ERCOT’s over-reliance on out of market commitments through the RUC process
  - Could be co-optimized so that market prices reflect scarcity of available DRRS reserves
- Cons:
  - If DRRS resources are required to remain out of the market (no self-committing), it could produce inefficient volatility in prices similar to the volatility associated with the ECRS implementation
  - Hence, implementation details and operating procedures associated with DRRS will be critical

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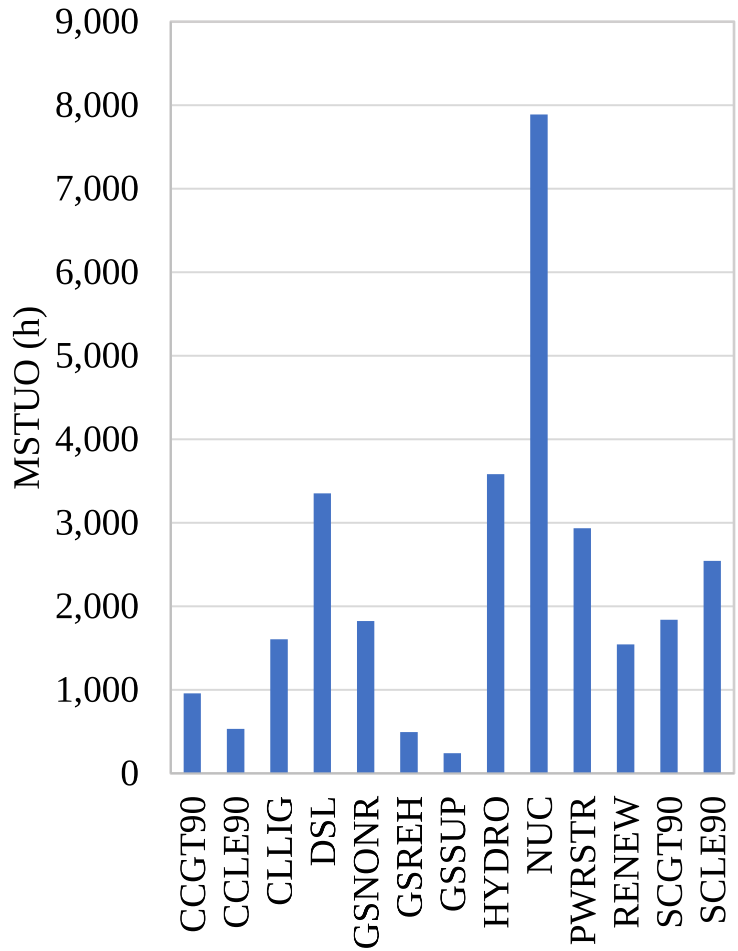
Analytic Appendix

Probability of Forced Outages

- MSTUO = Mean Service Time Until Outages (see right)
- UnitTrip = 1 if random("uniform") < h/MSTUO
- $\text{Unit Trip Capacity} = \sum \text{HSL} * \text{Unit Trip}$
- Note: renewables aren't included in forced outages and are accounted for through forecast error



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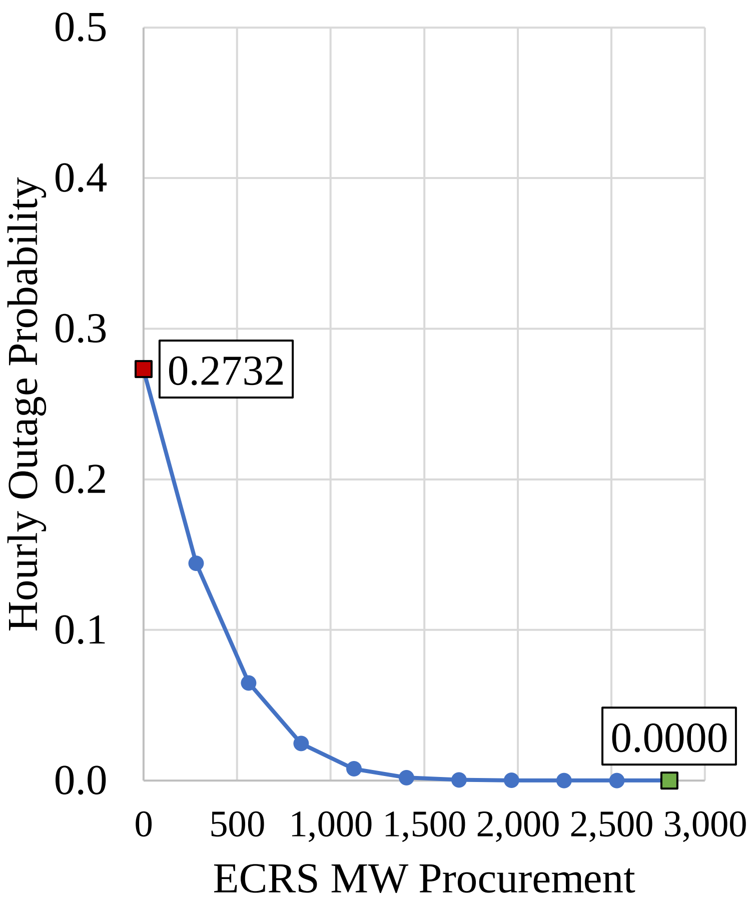
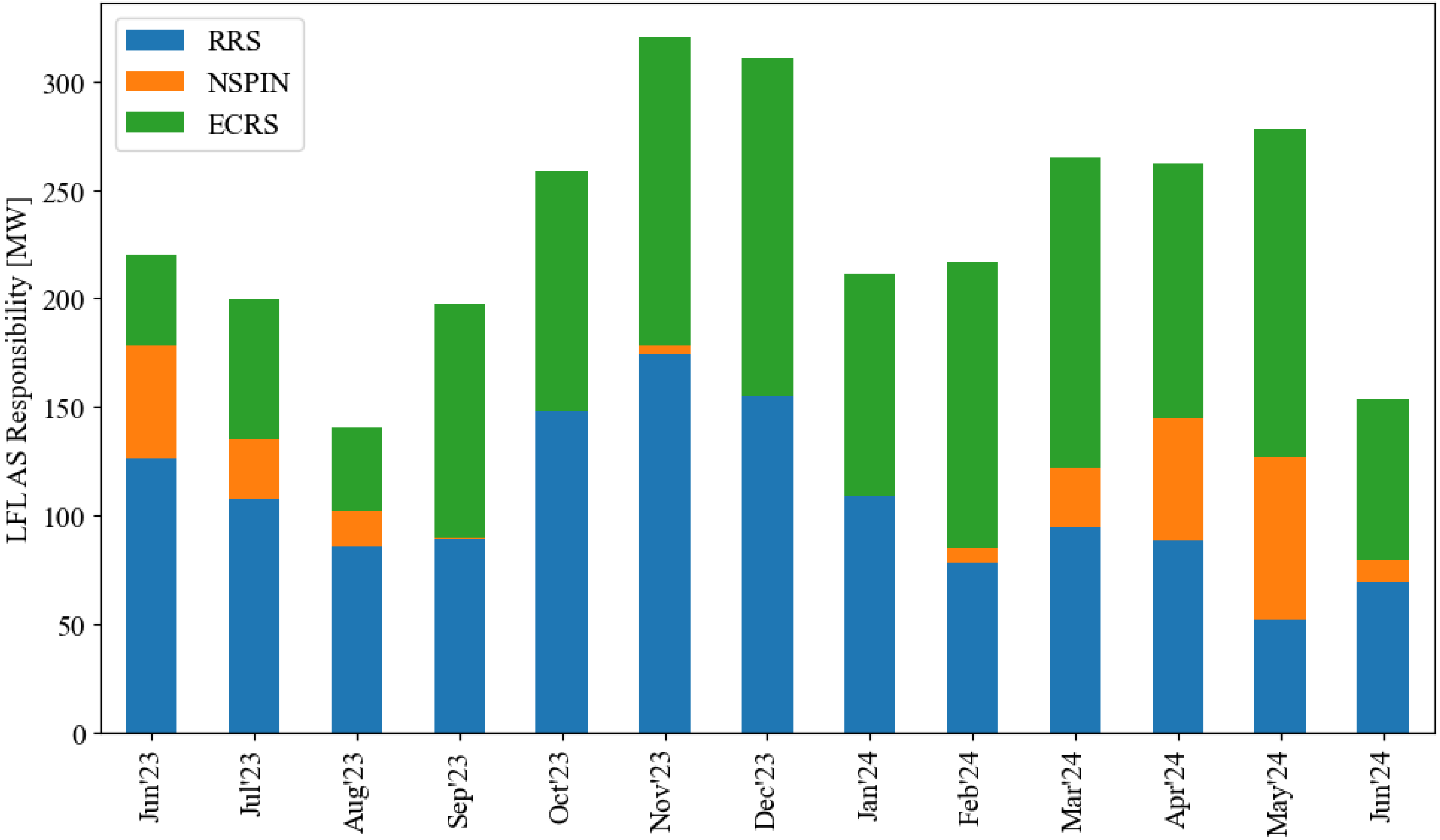
Total Risk from Uncertainty

- Forecast Error Impact (FEI) is the sum of over-forecasts of wind and solar and under-forecasts of load.
  - Net load under-forecasts (negative FEI) contribute to risk
- Load at Risk = Unit Trip Capacity – FEI
- Loss of Load (0,1): Load at Risk > Reserves - 1500
- Hourly Outage Probability = $\frac{\sum \text{Outage}}{\#\text{ iterations}}$
- Annual LOLP is a function of hourly outage probabilities



Large Flexible Loads already provide AS



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Large Flexible Loads tend to be offline when system conditions are tight