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Public Utility Commission of Texas

Memorandum

TO: Interested Parties

FROM: Julie Gauldin, Market Analysis

DATE: January 14, 2025

RE: **Project No. 55845** – *Review of Ancillary Services in the ERCOT Market*
Commission Findings and Final Report

Attached are the Commission findings for Project No. 55845 – *Review of Ancillary Services in the ERCOT Market* that were approved at the December 19, 2024 open meeting.

Additionally, Staff has updated the draft report filed on October 1, 2024 to include Staff's initial recommendations which were filed on November 15, 2024.

Review of Ancillary Services in the ERCOT Market

Commission Findings

Responsive to Public Utility Regulatory Act § 35.004 (g) (Senate Bill 3, 87R)

December 19, 2024

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INTRODUCTION

The *Review of Ancillary Services in the ERCOT Market* (AS Study) was performed to assist the Public Utility Commission of Texas in meeting the requirements of PURA § 35.004(g) (SB3, 87R) which states, in relevant part, that:

> *The commission shall: (1) review the type, volume, and cost of ancillary services to determine whether those services will continue to meet the needs of the electricity market in the ERCOT power region; and (2) evaluate whether additional services are needed for reliability in the ERCOT power region while providing adequate incentives for dispatchable generation.*

The Commission initiated this study as a collaborative effort between ERCOT, the Independent Market Monitor (IMM), and Staff and approved the AS Study scope at the February 15, 2024 open meeting.[1] Over the course of the study, Staff, ERCOT, and the IMM met multiple times to collaborate, share study progress, and discuss interim results.

Stakeholder involvement was integral to the study as well, with ERCOT and the IMM providing opportunity for review and discussion of preliminary and final results at meetings of ERCOT's Technical Advisory Committee (TAC) this past summer.[2,3] On October 1, 2024, Staff filed a draft study report which included ERCOT's and IMM's analyses and recommendations.[4] Staff subsequently posted a set of questions for public comment and held a workshop to allow stakeholders additional opportunities to provide input to assist with finalizing Staff's recommendations.[5]

Staff filed its analysis, recommendations, and suggested next steps for this study on November 15, 2024.[6] These recommendations were intended to address the requirements of PURA § 35.004(g) and were structured around seven policy topics. At the November 21, 2024 and December 12, 2024 open meetings, the commissioners discussed these topics and Staff and ERCOT Staff answered questions and the IMM was also in attendance to assist as needed.

Based on the results of the AS Study, the Commission agreed at the December 19, 2024 open meeting on the following findings and next steps regarding how best to utilize the results of this study to benefit both the ERCOT power region and its wholesale markets and satisfy the requirements of PURA § 35.004(g). These findings are organized around the same policy topics as described in Staff's recommendations. Details on the policy topics, full AS study report, and related public proceeding can be found under Project No. 55845.

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[1] *See* Staff Memo and AS Study Scope, AIS Item No. 2 (Jan. 19, 2024).

[2] *See* Item 13, Other Business, June 24th TAC Meeting at www.ercot.com.

[3] *See* Meeting Materials, August 28th TAC Workshop for Ancillary Services Study at www.ercot.com.

[4] *See* AS Study Draft Report and Next Steps, AIS Item No. 13 (Oct. 1, 2024).

[5] *See* Agenda for Oct 31, 2024 Staff led Workshop, AIS Item No. 39 (Oct. 28, 2024).

[6] *See* Staff Recommendations, AIS Item No. 41 (Nov. 15, 2024).

COMMISSION FINDINGS

TOPIC 1: SUFFICIENCY OF CURRENT ANCILLARY SERVICES

Finding – The current set of AS, combined with the forthcoming Dispatchable Reliability Reserve Service (DRRS), provide ERCOT sufficient AS to comply with North American Electric Reliability Corporation (NERC) requirements and respond to inherent system variability and uncertainty.

Next Steps – ERCOT should continue to monitor the need for new AS. Staff should incorporate an update to this AS review into the 2026 reliability standard assessment.

TOPIC 2: PROVIDING ADEQUATE INCENTIVES FOR DISPATCHABLE GENERATION

Finding – The reliability standard rule (16 TAC § 25.508) has defined a process for assessing and ensuring resource adequacy.

Next Steps – The first holistic reliability standard assessment in 2026 will include an assessment of whether incentives are adequate to support a sustainable level of dispatchable generation, and ERCOT should incorporate the impact of new market features such as Texas Energy Fund, DRRS, and real-time co-optimization plus batteries (RTC+B) into this assessment.

TOPIC 3: APPROPRIATE CRITERION FOR AS PROCUREMENT QUANTITIES

Finding – ERCOT's current posture of maintaining AS quantities that minimize the chance of entering the pre-emergency operational condition of an Operational Watch should be maintained in order to balance system improvements made since Winter Storm Uri until additional data is available to support further Commission evaluation of this operating posture.

Next Steps – ERCOT should develop the capability to provide current estimates of costs and probabilities of experiencing a Watch, Emergency Alert, and Load Shed for several potential alternative target reserve levels as soon as practicable and no later than to support the Commission setting an objective, data-based procurement criteria for the 2027 AS Methodology.

TOPIC 4: DYNAMIC DETERMINATION OF AS QUANTITIES

Finding – Tradeoffs exist between the certainty provided to market participants by calculating AS quantities primarily on an annual basis (as is done currently) and the efficiency of calculating some portion of AS quantities closer to the operating day.

Next Steps – ERCOT should work with stakeholders to explore a dynamic AS methodology that best balances these trade-offs.

TOPIC 5: PROBABALISTIC MODELING TO DETERMINE AS QUANTITIES

Finding – ERCOT's current practice to determine AS quantities relies on a statistical analysis using historical operating conditions and outcomes. This methodology is no longer sufficient as myriad changes to the wholesale markets and operating conditions continue to impact reasonable forecasting needs. Changes such as incorporation of an unknown amount of TEF-supported capacity, how new large loads are integrated into grid operations, or the impact of new market designs present uncertainty for forecasting tools based exclusively on historical data.

Next Steps – ERCOT should develop a suitable probabilistic, forward-looking modeling capability, provide regular updates to TAC, and present options that can be incorporated no later than the 2027 AS Methodology.

TOPIC 6: DISPATCHABLE RELIABILITY RESERVE SERVICE (DRRS)

Finding – DRRS is one of the tools in the market design toolbox that may assist in meeting the ERCOT reliability standard and need not be specially designated as a tool for resource adequacy to be utilized for this purpose in the future.

Next Steps – ERCOT should design DRRS to ensure that it meets its primary role as an ancillary service to mitigate operational risks in real time and reduce the use of Reliability Unit Commitment. ERCOT should also design flexibility into the mechanism for procuring DRRS so that, if the Commission determines that the price for or quantity of DRRS should be modified in the future to provide targeted additional generator revenue, this could be done without requiring significant additional system changes and without creating artificial scarcity or other detrimental effects on the market. ERCOT and stakeholders may have additional ideas to achieve this outcome that merit continued examination.

TOPIC 7: OTHER CONSIDERATIONS

7A. FIRM FUEL SUPPLY SERVICE (FFSS)

Finding – No changes to FFSS are warranted as part of this study as risks mitigated with FFFS do not overlap with risks mitigated by procuring AS.

Next Steps – FFSS has its own project and any improvements to that service will continue there.[7]

7B. EMERGENCY RESPONSE SERVICE (ERS)

[7] See *Firm Fuel Supply Service*, Project No. 56000 (pending).

Finding – Opportunities to expand ERS or create related new demand response products should be pursued.

Next Steps – ERCOT should perform a holistic review of existing and potential voluntary and emergency-related DR programs, including ERS.

7C. INDIVIDUALLY PRICING AS SUB-TYPES

Finding – Creating separate clearing prices for different resource types that provide different sub-types of the same AS will likely benefit the ERCOT market, but it is not currently a top priority, given other market improvement efforts in-flight.

Next Steps – ERCOT and stakeholders should consider pricing AS subtypes separately after RTC+B has stabilized.

7D. DURATION REQUIREMENTS FOR ERCOT CONTINGENCY RESERVE SERVICE AND NON-SPIN RESERVE SERVICE.

Finding – Examining the length of response time required for these two AS will likely benefit the ERCOT market, but it is not currently a top priority, given other market improvement efforts in-flight.

Next Steps – ERCOT and stakeholders should revisit duration requirements for ECRS and Non-Spin after RTC+B has stabilized.

REVIEW OF ANCILLARY SERVICES IN THE ERCOT MARKET

PUBLIC UTILITY COMMISSION OF TEXAS
FINAL STUDY REPORT
PROJECT NO. 55845 – JAN 14, 2025

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Version History

Version	Details / Changes since prior version
Initial Draft Study Report	Initial filed draft. See *Review of Ancillary Services in the ERCOT Market*, Project No. 55845, AIS Item No. 13, (**Oct. 1, 2024**).
Final Study Report	Added Staff Recommendations & Conclusions to Initial Draft. Added footnotes noting that IMM and ERCOT recommendations are representative of their positions as of the initial draft study report's date, Oct. 1 2024. All other sections unchanged from *Initial Draft Study Report*.

Executive Summary

This study was performed to assist the Public Utility Commission of Texas in meeting the requirements of Senate Bill 3 from the 87th regular Texas legislative session, which states, in relevant part, that:

> The commission shall: (1) review the type, volume, and cost of ancillary services to determine whether those services will continue to meet the needs of the electricity market in the ERCOT power region; and (2) evaluate whether additional services are needed for reliability in the ERCOT power region while providing adequate incentives for dispatchable generation.[1]

Ancillary Services (AS) provide operational capabilities to satisfy two purposes:

1. Meet North American Electric Reliability Corporation (NERC) supply/demand balancing standards.
2. Reduce operational risks associated with system variability and uncertainty such as unscheduled generator failures and errors in forecasting net load (load minus renewable resources).

The minimum quantities of each type of AS required for the Electric Reliability Council of Texas (ERCOT) system are determined on an annual basis using a methodology that includes a statistical analysis of the historical drivers for AS while factoring in expected system changes that may impact the needed quantities.

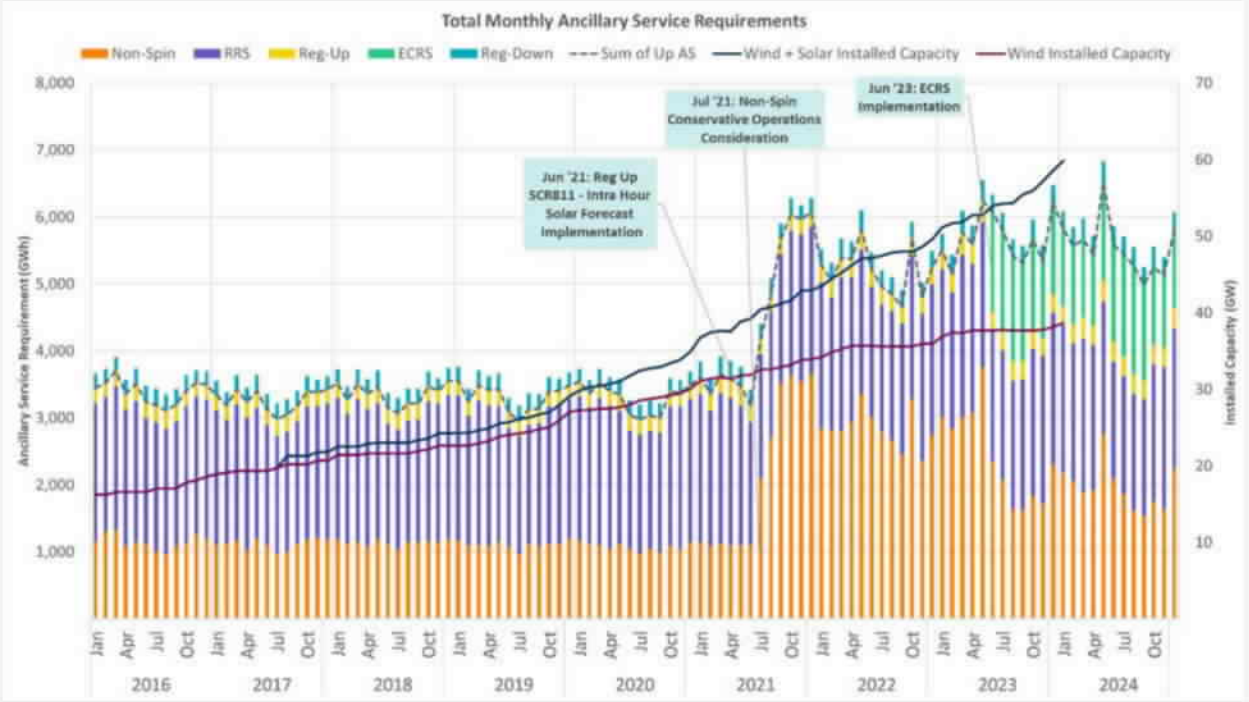

Figure 1 - Historical AS Requirements, Methodology Changes, and Intermittent Resource Capacity

[1] Public Utility Regulatory Act (PURA) §35.004(g)

As variability and uncertainty inherent in the grid have evolved over time, the methodology and procurement quantities for AS have also changed (see Figure 1). The historic changes to AS include a discrete increase in the quantities of some types of AS in 2021 intended to better avoid the need to issue a Watch or enter emergency operations.

Following multiple days of high net load forecast errors or high generator forced outages, or both, in spring and early summer of 2021, ERCOT began operating with higher real-time reserves, including a minimum of 6500 megawatts (MW) of "upward AS" (all AS except Reg Down). The intent of this change in posture was to achieve a higher operational reliability goal; specifically, *to have enough reserves to decrease the likelihood of issuing a Watch due to insufficient reserve capacity, i.e., available reserves falling below 3000 MWs.*[2] Before this change in posture, if ERCOT issued a Watch but did not shed load, AS quantities would have been considered acceptable.

Initially, ERCOT accomplished this change in operating posture by committing additional generation capacity through the Reliability Unit Commitment (RUC) process. Beginning in July 2021, following conversations with stakeholders, ERCOT began to seek additional reserves through increased procurement of AS quantities instead of through RUC.[3]

Ancillary Services in ERCOT Today

AS in ERCOT is an **integrated program** whose critical elements are defined across the ERCOT AS Methodology Document, ERCOT Protocols, Operating Procedures, and a Non-Spin deployment Other Binding Document (OBD). Table 1 describes AS in ERCOT today, including the range of approved 2024 minimum hourly procurements.

Table 1 - AS in ERCOT today

Services, Sub-types & Hourly Quantities	Description, Qualification Characteristics
Regulation Up Service (REG-UP) **Regulation Down Service (REG-DOWN)** **55 to 1110 MW (Up)** **182 to 1020 MW (Down)**	Capacity **automatically deployed by ERCOT systems every 4 seconds to balance supply & demand** between 5-min Security-Constrained Economic Dispatch (SCED) intervals and maintain frequency close to 60 Hz. Provided by: • **Generation resources**, • **Batteries**, and • **Controllable Load Resources (CLRs)**

[2] Per current ERCOT Nodal Protocol § 6.5.9.4.1 "General Procedures Prior to EEA Operations", ERCOT may issue a Watch when PRC drops below 3000 MW. Prior to Oct 1 2023, this language was under § 6.5.9.3.2 (5) and was referred as Advisory for PRC below 3000 MW.

[3] Including at a June 30, 2021 special Technical Advisory Committee (TAC) meeting and the July 28, 2021 TAC meeting.

Services, Sub-types & Hourly Quantities	Description, Qualification Characteristics
Responsive Reserve Service (RRS) Subtypes: **RRS-PFR** (Primary Frequency Response) **RRS-FFR** (Fast FR) **RRS-UFR** (Load w/ high-set under frequency relays) **2300 to 3178 MW**	Frequency responsive capacity that can **respond autonomously within seconds to low frequency events typically triggered by generating unit trips**. **RRS-PFR** – **continuous response to frequency**; provided by generation resources including hydro resources[4], batteries, and CLRs. **RRS-FFR** – (full) response within 250 milliseconds (ms) when frequency < 59.85 Hz; provided by **batteries and "blocky" Load Resources**. **RRS-UFR** – (full) response within 500 ms when frequency < 59.7 Hz; provided **exclusively by "blocky" Load resources**.
ERCOT Contingency Reserve Service (ECRS) Subtypes: **ECRSM** (Manual) **ECRSS** (SCED) **889 to 3007 MW**	**Capacity that can respond in 10 minutes** to recover frequency; cover intra-hour forecast uncertainties; load, wind, and solar variability or ramping issues; and replace deployed reserves. Must be **sustainable for 2 hours**. Provided by: • **Generation resources,** • **Batteries**, and • **Load** (both CLR and blocky).
Non-Spinning Reserve Service (Non-Spin or NSRS) Subtypes: **ONNS** (On-line Non-Spin) **OFFNS** (Off-line Non-Spin) **1430 to 4482 MW**	**Capacity that can be available within 30 minutes** to cover forecast errors; load, wind, and solar variability or ramping issues; forced outages; and replacement of deployed reserves until additional resources can be committed. Must be **sustainable for 4 hours**. ONNS may be provided by: • **Generation resources,** • **Batteries**, and • **Load** (both CLR and blocky). OFFNS may be provided by **Generation resources** only.

[4] Hydro resources typically provide RRS in synchronous condenser fast response mode. Under this mode, these Hydro resources provide (full) response within 20 seconds when frequency falls below 59.80 Hz.

The efficacy of ERCOT's AS program with respect to frequency control is demonstrated through ERCOT's NERC Compliance Performance Standard 1 (CPS1) performance; time taken to recover frequency back to pre-event value or 60Hz following a Frequency Measurable Event (FME); and ERCOT's Frequency Response Measure (FRM) performance. ERCOT consistently meets or exceeds NERC requirements for these three measures. Appendix 3 provides further details and statistics on the efficacy of ERCOT's AS program.

Historical Annual Cost for each Ancillary Service

Table 2 presents the total cost of AS and the cost of AS per megawatt-hour (MWh) of Load for the period January 1, 2018 through August 31, 2024. Natural gas prices in ERCOT are also shown for reference.

Table 2 – AS Total Cost ($ Millions), Cost per MWh of Load, and Natural Gas Prices

	2018	2019	2020	2021	2022	2023	2024
Total Cost of AS ($ Millions)							
Regulation	$51.77	$85.77	$51.42	$1,216.72	$110.19	$169.18	$32.52
Responsive	$426.18	$631.37	$272.77	$8,232.24	$508.34	$525.29	$112.91
ECRS	N/A	N/A	N/A	N/A	N/A	$713.69	$134.08
Non-Spin	$126.05	$178.74	$57.39	$2,175.86	$796.51	$465.97	$152.15
All Services	$604.00	$895.88	$381.58	$11,624.82	$1,415.04	$1,874.13	$431.66
Cost of AS ($/MWh of Load)							
Regulation	$0.14	$0.22	$0.13	$3.10	$0.26	$0.38	$0.10
Responsive	$1.13	$1.64	$0.71	$20.96	$1.18	$1.18	$0.36
ECRS	N/A	N/A	N/A	N/A	N/A	$1.60	$0.43
Non-Spin	$0.33	$0.47	$0.15	$5.54	$1.85	$1.05	$0.49
All Services	$1.60	$2.33	$0.99	$29.60	$3.29	$4.21	$1.38
Natural Gas Prices ($/MMBtu)							
ERCOT	$ 3.22	$ 2.47	$ 1.99	$ 7.30	$ 5.84	$ 2.22	$1.80

IMM's Modeling of Required Quantities of Ancillary Services

For this study, the Independent Market Monitor (IMM) developed a probabilistic model to estimate the operational reliability impacts associated with varying levels of 10-minute and 30-minute reserves to inform procurement quantities for ERCOT Contingency Reserve Service (ECRS) and Non-Spinning Reserve Service (Non-Spin). This model does not consider changes to the faster responding AS – Regulation Up/Down and Responsive Reserves (RRS) or to the frequency recovery portion of ECRS.

The basic idea behind this model is to calculate an annual Loss of Load Probability (LOLP), given the stochastic nature of generation outages and forecast errors, while treating reserves as an independent variable. The probability distributions that describe generation outages and forecast errors are accounted for using a Monte Carlo simulation. Each hour is simulated ten thousand times, and the forced outages and forecast error are randomly drawn based on the underlying probability distributions. The simulation is then repeated for a range of reserve levels and the LOLP is calculated as a model output for each reserve level as the percentage of simulations where reserves fell below 1500 MW (and thus ERCOT would be required to declare Energy Emergency Alert Level 3 and to direct Transmission Operators to shed firm load).[5]

The IMM's analysis in this AS Study finds that ERCOT does have sufficient reliability tools, with respect to 10-minute and 30-minute operating reserves, under current conditions. The analysis also concludes that procurement of the non-frequency recovery portion of ECRS and Non-Spinning Reserve can be reduced while maintaining a satisfactory level of expected operational reliability.

Figure 2 shows that the IMM's modeling results suggest that current ECRS levels can be reduced by 50% in all hours while still maintaining an expected annual LOLP below 10%. The analysis of Non-Spin quantities indicate that procurement quantities could be reduced by 35% in all hours while maintaining an expected annual LOLP of 10%.[6]

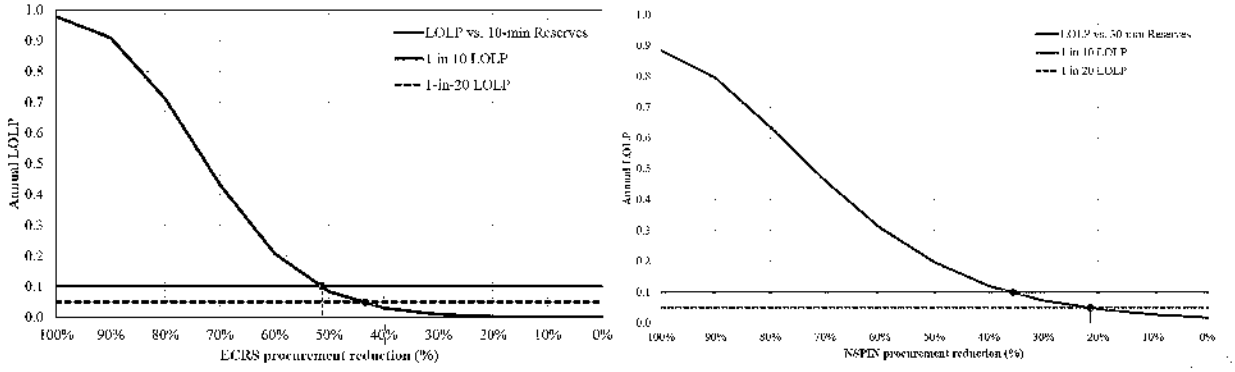

Figure 2 – Modeling Results for ECRS and Non-Spin Required Quantities

[5] Per ERCOT Nodal Protocol § 6.5.9.4.2(3): "…ERCOT will declare an Energy Emergency Alert Level 3 (EEA 3) when PRC cannot be maintained above 1,500 MW [and additionally may declare EEA 3 for other conditions]…."

[6] The study was performed evaluating the impact of changes in the quantities of ECRS and Non-Spin independently. As such, there is not an accurate method to evaluate the impact on reliability of coincident reductions in procurement of both services using the output from the simulations performed for this study without further analysis.

ERCOT and IMM Recommendations[7]

No Additional Ancillary Services Are Recommended by ERCOT or the IMM

Overall, both ERCOT and the IMM find that the existing suite of AS products and the forthcoming Dispatchable Reliability Reserve Service (DRRS) are sufficient for meeting the system's frequency control and uncertainty risk mitigation needs. Neither ERCOT nor the IMM recommends additional AS products at this time.

ERCOT and the IMM Both View Ancillary Services as Operational Tools

Both ERCOT and the IMM have the view that AS are designed and procured to meet real-time (and near-real time) operational reliability needs and are not intended to meet long-term resource adequacy objectives, though the quantities of AS and the structure of the AS program may incrementally impact investments in new resources.

Both ERCOT and the IMM do recommend considering changes to the AS Methodology, as discussed below. However, they differ in the details of their proposals.

ERCOT and the IMM Both Recommend Considering a Fully Probabilistic AS Quantity Methodology

Both ERCOT and the IMM recommend exploring whether to modify the methodology used to calculate the non-frequency responsive portion of ECRS and Non-Spin quantities to use a probabilistic framework for quantifying reliability risks that these reserves are required to cover, rather than the statistical approach used now. A *statistical approach* relies on historical conditions and adjusts for expected future changes, while a *fully probabilistic approach* seeks to build a comprehensive forward-looking probabilistic model to predict expected operational reliability levels based on reserve levels.

According to ERCOT, a fully **probabilistic AS quantity methodology** must carefully consider assumptions such as substitutability of AS, assumptions around available capacity that is not providing AS, **and the appropriate criteria to use for determining quantities of each AS type, i.e., avoiding loss of load, avoiding manual interventions, or avoiding entering into a Watch due to insufficient reserves**. These assumptions directly impact the quantity of reserves procured and operational actions needed to continue operations.

ERCOT and IMM Disagree About Criterion for Determining AS Quantities

Some of the assumptions made by the IMM in its modeling for this study do not match the assumptions within ERCOT's current operating procedures. For example, its recommended reductions in ECRS and Non-Spin procurements are strongly driven by assuming the sole criterion for determining AS procurement quantities is avoiding loss of load, while in practice, ERCOT uses a different criterion – avoiding entering into a Watch due to insufficient reserves.

[7] IMM and ERCOT recommendations are representative of their positions as of the initial draft study report's date, Oct. 1 2024.

Policy decisions about the trade-offs between ERCOT's operational reliability focused view and the IMM's economic efficiency focused view will need to be made to determine the appropriate criterion.

ERCOT and the IMM Both Recommend Potentially Procuring Some Portion of AS Dynamically

Annually, the AS Methodology currently sets the minimum quantities for each AS to be equal to the full quantity that is expected to be needed for each operating hour of the following year. Setting the quantities annually increases the ease of Retail Electric Providers (REPs) hedging of AS costs in advance, at the expense of tending to drive up the required AS quantities, since there is greater uncertainty when making decisions further ahead of an operating day.

Both ERCOT and the IMM recommend that ERCOT should work with stakeholders to reexamine the tradeoffs between the clarity of calculating AS quantities on an annual basis and the efficiency of calculating at least some portion of AS quantities closer to the operating day. A possible framework could involve setting minimum, "expected," and maximum AS quantities in an annual study, and then setting the actual quantity for an Operating Day before the Day Ahead Market (DAM) runs. The actual quantities would be within the minimum and maximum ranges set in advance.

IMM Recommends Reducing the Procurement of ECRS and Non-Spin

The IMM also concludes that procurement of ECRS and Non-Spin can be reduced, while maintaining a satisfactory level of expected operational reliability. These conclusions are based on different assumptions about the key criterion for determining AS quantities – avoiding Watch versus avoiding EEA3. The IMM's quantities modeling in this study did not consider changes to Regulation and RRS.

No Changes to Regulation and RRS Recommended by ERCOT and IMM in This Study

Neither ERCOT nor the IMM recommend changes to Regulation or RRS as part of this study.

IMM Recommends Separately Pricing AS Sub-types

Since the 2019 State of the Market Report, the IMM has recommended pricing ancillary services based on the shadow price of procuring each service, specifically when a sub-type has quantity limitations, such as with RRS. In other words, it recommends pricing each sub-type separately to improve market efficiency and price signals.

Dispatchable Reliability Reserve Service Implementation Update

DRRS is intended to cover risks associated with historical variations in generation variability, including intermittency of non-dispatchable generation resources and forced outages.

At the time of this paper, NPRR1235 is proceeding through the ERCOT stakeholder process to define DRRS and DRRS is expected to be implemented sometime after the Real-Time Co-optimization + Batteries (RTC+B) implementation. The IMM has stated that it supports this NPRR with some qualifications relating to details of deployments, price formation, and quantity determination that it will work on with ERCOT and stakeholders through the process.

Staff's Recommendations

In developing its recommendations, Staff applied the following key principles:

- Complying with the statute and the scope of the study approved by the Commission;
- Satisfying the PUC's mission to protect customers, foster competition, and promote high quality infrastructure;
- Prioritizing market-based solutions over non-market options;
- Providing regulatory certainty by reviewing market design topics holistically and on a predictable schedule;
- Aligning the Commission's goals with increased expectations from the public for a more resilient electric system;
- Improving the transparency of ERCOT's decisions to stakeholders and the public; and
- Minimizing the impact of any recommendations on the implementation of real-time co-optimization plus batteries (RTC+B).

Staff provides further details for each policy topic in the main body of this document as part of the analysis of each issue, along with recommendations and possible next steps.

A summary of Staff's recommendations is also outlined here for reference:

Topic 1: Sufficiency of Current Ancillary Services

- Staff agrees with the Independent Market Monitor (IMM) and ERCOT that ERCOT has sufficient ancillary services (AS) to comply with North American Electric Reliability Corporation (NERC) requirements and provide 10- and 30-minute operational reserves to respond to inherent system variability and uncertainty. The new Dispatchable Reliability Reserve Service (DRRS) being developed to comply with PURA § 39.159(d) (HB1500, 88R) will offer a new ancillary service to address longer horizon inter-hour risks and reduce out of market Reliability Unit Commitment (RUC) actions.
- Staff recommends that ERCOT continue to monitor the need for new AS based on the evolution of the ERCOT system, including changes in system inertia, large load growth, increased energy storage resource (ESR) participation, and other system developments.
- Suggested Next Steps**:** Updates to ERCOT's AS Methodology now require Commission approval, providing an annual opportunity for the Commission to oversee this process. Staff will follow this process and if needed will reevaluate sufficiency of the current AS, particularly after RTC+B and DRRS are implemented.

Topic 2: Providing Adequate Incentives for Dispatchable Generation

- The reliability standard rule (16 TAC § 25.508) has already defined a process for assessing and ensuring resource adequacy. Staff expects all available tools, including AS, will be included when the Commission conducts the reliability assessment in 2026 as required by the rule. Addressing revenue sufficiency for dispatchable generation within that assessment is more likely to be effective because a holistic approach can consider interdependencies of multiple mechanisms and is thus more accurate than a piecemeal approach.

- Suggested Next Steps: Address resource adequacy and sufficiency topics holistically within the periodic assessments required by 16 TAC § 25.508.

Topic 3: Appropriate Criterion for AS Procurement Quantities

- Staff agrees with ERCOT and the IMM that the primary goal of AS is to address real-time risks of system variability, forecast errors (wind, solar, and load), and forced outages. While AS can impact resource adequacy through its role as an important revenue source to retain and incent new generation, this consideration should be made within the broader holistic assessment.
- Staff recommends that it is appropriate to revisit AS procurement levels established after Winter Storm Uri to ensure the proper balance between reliability and cost going forward. Many changes have been made since Uri to improve the resiliency of the ERCOT grid; however, system changes, such as significant expected load growth, including flexible large loads, along with solar and ESR penetration, will continue to increase risks, volatility, and "unknown unknowns." Therefore, Staff does not recommend using the avoidance of load shed as the basis to establish AS procurement levels.
- Staff recommends the Commission clearly articulate an objective criterion for determining AS quantities based on a metric, such as a required confidence level of experiencing no Watches or an acceptable expected number of Watches per year.
- Suggested Next Steps: Ask ERCOT to develop a tool that will be capable of creating current estimates of costs and probability of experiencing a Watch/Emergency Conditions/Load Shed for several potential alternative target reserve levels, as soon as practicable and no later than to support the Commission setting the procurement criteria for the 2027 AS Methodology.

Topic 4: Dynamic Determination of AS Quantities

- Staff recommends that some form of dynamic AS procurement be implemented as soon as practicable due to the potential efficiency gains that could be achieved by this change. Moving from the current annual AS methodology where minimum quantities for each AS are set equal to the full expected quantity for each operating hour to an approach that sets these quantities closer to real time will tend to reduce the quantities needed, since uncertainty tends to decrease closer to the operating day, resulting in a more cost effective AS procurement.
- This approach could be implemented independently from other changes, such as adopting probabilistic modeling (discussed in Topic 5), and it could be implemented while maintaining the current operational risk posture.
- Staff recommends that ERCOT work with stakeholders to develop a dynamic AS methodology that best balances the tradeoffs between the clarity of calculating AS quantities entirely on an annual basis (as is done currently) and the efficiency of calculating some portion of AS quantities closer to the operating day.
- Suggested Next Steps: Ask ERCOT and TAC to develop key principles for implementing dynamic AS quantity determinations for ECRS and Non-Spin using a phased approach that begins no later than the 2028 AS Methodology.

Topic 5: Probabilistic Modeling to Determine AS Quantities

- Staff recommends that ERCOT adopt a probabilistic modeling approach for determining AS quantities, as recommended by both ERCOT and the IMM.

- The criterion for determining AS quantities, discussed above in Topic 3, will be an important, policy driven model input. The Commission should establish this criterion, while all other model inputs and assumptions can be reviewed as part of the annual AS Methodology review.
- While out of scope of this study, Staff notes that implementation of this change should be undertaken deliberately and carefully coordinated with other market changes and should not delay RTC+B go-live.
- Suggested Next Steps: Ask ERCOT to develop a suitable probabilistic model, provide regular updates to TAC, and present options that can be incorporated no later than the 2027 AS Methodology.

Topic 6: Dispatchable Reliability Reserve Service

- Staff recommends that DRRS not be specially designated as a tool for resource adequacy apart from other AS. Staff agrees with ERCOT and the IMM that DRRS should be designed as an ancillary service to mitigate operational risks in real time and reduce the use of RUC.
- Staff agrees that DRRS should be initially targeted to dispatchable generation.
- Revisions to DRRS' design to consider longer or seasonal duration requirements or the need to co-optimize in real-time can be considered in the future versions.
- Suggested Next Steps: Request that ERCOT continue to work on NPRR 1235 with stakeholders and recommend that DRRS should not be granted special status as a resource adequacy tool.

Topic 7: Other Considerations

- Firm Fuel Supply Service (FFSS) is a reliability service which uniquely mitigates risks in the natural gas supply chain. Since this is a separate risk which is not evaluated as part of the annual AS methodology and is not "double-counted" in reserve quantities, Staff does not recommend any change as part of this Study. Changes to FFSS can be taken up in Project No. 56000, *Firm Fuel Supply Service*, and any potential impacts of FFSS on probabilistic modeling assumptions (such as reduced generator outage rates) can be addressed during the annual AS Methodology process.
- Emergency Response Service (ERS): Many commenters recommended reevaluating and expanding ERS. Several commenters proposed creating new demand response (DR) services provided by various customer classes that are procured via the day-ahead market (DAM). Some suggested developing a long-lead time demand response product that would be an additional reliability tool similar to ERS that could cost-effectively reduce the risk of involuntary firm load shed. With more structured DR, most conservation alerts to Texans could be replaced with targeted programs for willing participants with predictable use and market-based compensation. Staff recommends that ERCOT perform a holistic review of all existing emergency and demand response programs and provide resulting recommendations to TAC and the ERCOT Board as soon as practicable.
- Pricing AS subtypes: Since the 2019 State of the Market (SOM) Report, the IMM has recommended pricing AS based on the shadow price of procuring each service, specifically when a subtype has quantity limitations, such as with RRS. In other words, it has recommended creating separate clearing prices for different categories of an AS that are provided by different resource types (e.g. generation, controllable load resources or non-controllable load resources). Staff addressed this recommendation in its response to 2023 SOM filed in Project No. 34677 on September 20, 2024.[8]

[8] *See Reports of the Independent Market Monitor for the ERCOT Region*, Project No. 34677, AIS Item No. 22, (Sept. 20 2024).

Staff agrees that this could improve market efficiency but does not consider it as an urgent issue. It can be revaluated at a later date after RTC+B has achieved steady state.

- Revisiting AS duration requirements for ECRS and Non-Spin: In the draft AS Study report, the IMM recommended revisiting the current duration requirements for Non-Spin (currently 4 hours) and ECRS (currently 2 hours). Staff sees some merit in ERCOT and stakeholders revisiting duration requirements for ECRS and Non-Spin. These changes should only be considered after RTC+B has achieved steady state. This aligns with ERCOT's proposed approach described in NPRR 1096.[9]

Staff Conclusions and Recommended Overall Next Steps

Ancillary Services are vital for ensuring the continued reliable operation of the ERCOT system. AS markets contribute to generator revenue and provide important signals for future investment decisions, while necessarily imposing costs on Texas consumers that the Commission must ensure are economical. It is critical for the Commission to remain engaged with AS after this study has formally concluded, due to both the importance of AS and the increasingly rapidly changing nature of the ERCOT system.

Staff recommends that ERCOT Staff work with TAC and the Board to develop a high-level plan for implementing all Commission-approved study recommendations and present this plan in a timeframe that allows for incorporation of any applicable recommendations into the 2026 AS Methodology.

Staff extends its sincere appreciation to ERCOT and IMM Staff for their effort and collaboration on this study.

[9] *See* NPRR 1096, Require Sustained Two-Hour Capability for ECRS and Four-Hour Capability for Non-Spin, https://www.ercot.com/mktrules/issues/NPRR1096#keydocs.

Introduction

The Ancillary Services Study (Study) was performed to assist the Public Utility Commission of Texas in meeting the requirements of Senate Bill 3 from the 87th regular Texas legislative session, which states, in relevant part, that:

> The commission shall: (1) review the type, volume, and cost of ancillary services to determine whether those services will continue to meet the needs of the electricity market in the ERCOT power region; and (2) evaluate whether additional services are needed for reliability in the ERCOT power region while providing adequate incentives for dispatchable generation.[10]

Ancillary Services (AS) are "services necessary to facilitate the transmission of electric energy including load following, standby power, backup power, reactive power, and any other services as the commission may determine by rule."[11]

AS are an increasingly important mechanism for maintaining the reliability of the ERCOT Interconnection as variability and uncertainty of both supply resources and customer demands on the grid continue to increase. AS are "ancillary" in that they provide *supplemental operational capabilities* that would not otherwise be provided solely by or explicitly incented by the energy market.

Consistent with the approved study scope[12], this paper restricts attention to AS capacity products that are procured in the Day-Ahead Market (DAM).

These AS provide operational capabilities to satisfy two purposes:

1. Meet certain supply and demand balancing related reliability objectives defined in North American Electric Reliability Corporation (NERC) Reliability Standards, and
2. Reduce operational risks associated with the aforementioned variability and uncertainty.

Currently, the ERCOT AS program is not intended to meet long-term resource adequacy objectives, although the quantities of AS products procured and the structure of the AS program may incrementally impact the level and type of investments in new resources by providing additional revenues beyond those earned in the Day-Ahead and Real-Time energy markets and bilateral contracts. AS are specifically designed and procured to meet real-time reliability needs.

AS may be self-arranged[13] by Qualified Scheduling Entities (QSEs) or procured in the DAM by ERCOT on an hourly basis from resources that have the appropriate, defined operating characteristics and offer to sell the AS. The ERCOT Protocols define each type of AS and the capability requirements of resources that may

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[10] Public Utility Regulatory Act (PURA) §35.004(g)

[11] PURA §35.004(e)

[12] Commission approved the study scope at the February 15, 2024 open meeting.

[13] In 2023 approximately 12% of AS were self-arranged, across all hours and AS products.

provide each service[14]. The minimum quantities of each type of AS are determined on an annual basis using a methodology that includes a statistical analysis of the historical drivers for AS and factoring in expected system changes that may impact the needed quantities.

The original framework for AS was designed for the implementation of the single control area in 2001, based on the reserves that each of the 13 control areas in ERCOT had been required to maintain before the market restructuring. In the mid-2010s, ERCOT conducted an extensive evaluation with stakeholders of the AS that would be needed over the next several decades due to the fast-changing resource mix. This evaluation led ERCOT to propose a comprehensive new AS framework in Nodal Protocol Revision Request (NPRR) 667, Ancillary Service Redesign. While NPRR667 was ultimately rejected by stakeholders, most of the fundamental elements of that strategic AS framework, including the recent implementation of the ERCOT Contingency Reserve Service (ECRS), have been implemented in subsequent NPRRs.

Background and Historical Evolution of ERCOT's Ancillary Services

In the early 2000s, electric demand and the mix of resources were much more consistent, with few intermittent resources and little active demand response, and AS consisted of:

- **Regulation Service (Reg-Up and Reg-Down)** (a fast-acting service to balance supply and demand and maintain frequency in between dispatch intervals) varied during certain hours where it had been historically depleted, typically during startup and shutdown times for the then recently added fleets of combined cycle units,
- **Responsive Reserve Service (RRS)** (which provides fast dispatches of resources to arrest frequency deviations, such as occur when a large nuclear generator suddenly trips offline) quantity was a fixed number over the entire year and had been the same quantity since the late 1980s, and
- **Non-Spinning Reserve Service (Non-Spin)** (which provides capacity that can be available within 30 minutes to cover variability in supply and demand and replace deployed reserves) was only procured during high-risk periods when self-committed reserves were less than a fixed number.

[14] See Appendix 1 for further details and protocol references.

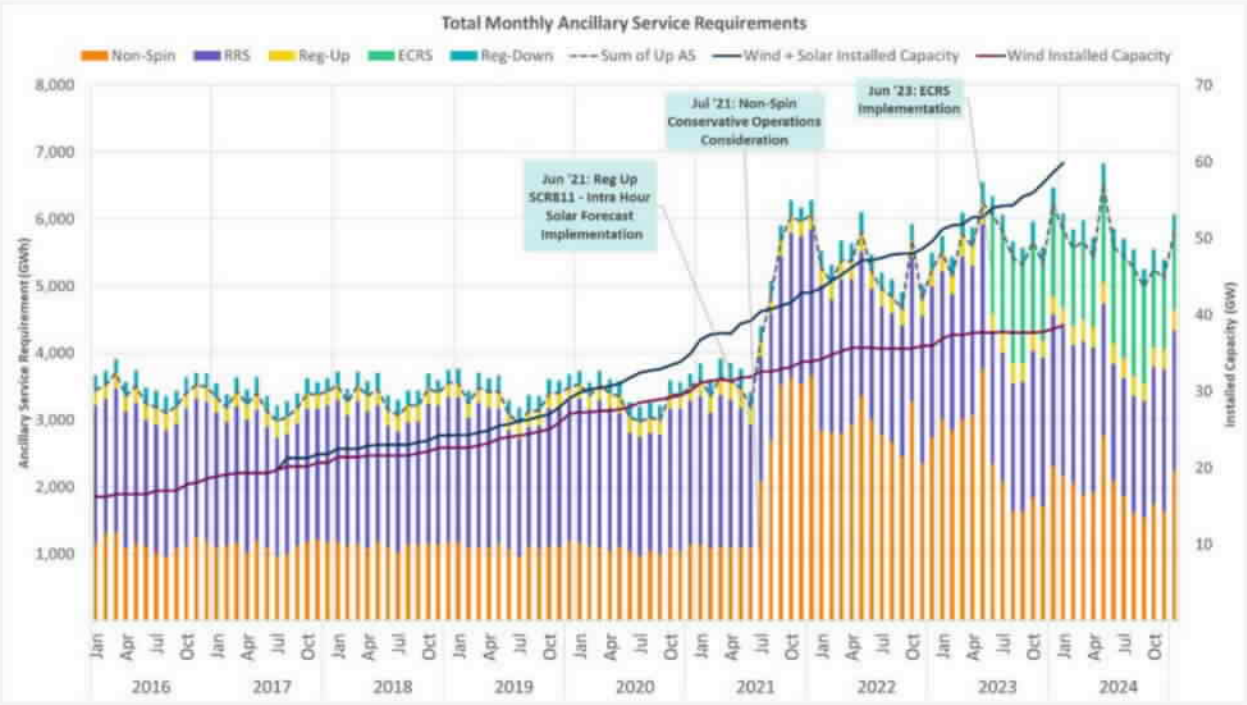


Figure 3 - Historical AS Requirements, Methodology Changes, and Intermittent Resource Capacity

As variability and uncertainty inherent in the grid have evolved over time, the methodology and procurement quantities for AS have also changed (see Figure 3). The historic changes to AS include a discrete increase in the quantities of some types of AS in 2021 intended to better avoid the need to issue a Watch or enter emergency operations.

As ERCOT has sought to meet these requirements efficiently, ERCOT has differentiated the quantity of each AS that is needed in different time periods, based on the variability and risk in each time period. As a result, the complexity of determining AS requirements has increased substantially. For example, ERCOT began to vary the quantity of RRS procured by hour, based on the historic inertia in that hour, so that higher quantities of RRS were procured when most likely to be needed and lower quantities were procured in other hours. For Non-Spin, ERCOT determined that some quantity was needed in all hours, due to increasing uncertainty in both load and generation availability.

ERCOT has also incrementally modified AS to take advantage of new resource types and added a completely new AS,

- **ERCOT Contingency Reserve Service (ECRS) –** Capacity that can respond in 10 minutes and sustain for 2 hours used to recover frequency, cover intra-hour forecast uncertainties, load, wind, and solar variability/ramps, and replace deployed reserves.

With the increasing quantities of intermittent resources, the potential for higher megawatt (MW) forecast errors, faster MW ramps, and the NERC requirement to recover frequency following a disturbance within 15

minutes, this faster-responding service was vital by the time it was implemented in 2023[15]. Figure 4 shows the steady increase in net load ramp (Load – Intermittent Resources) over recent years.

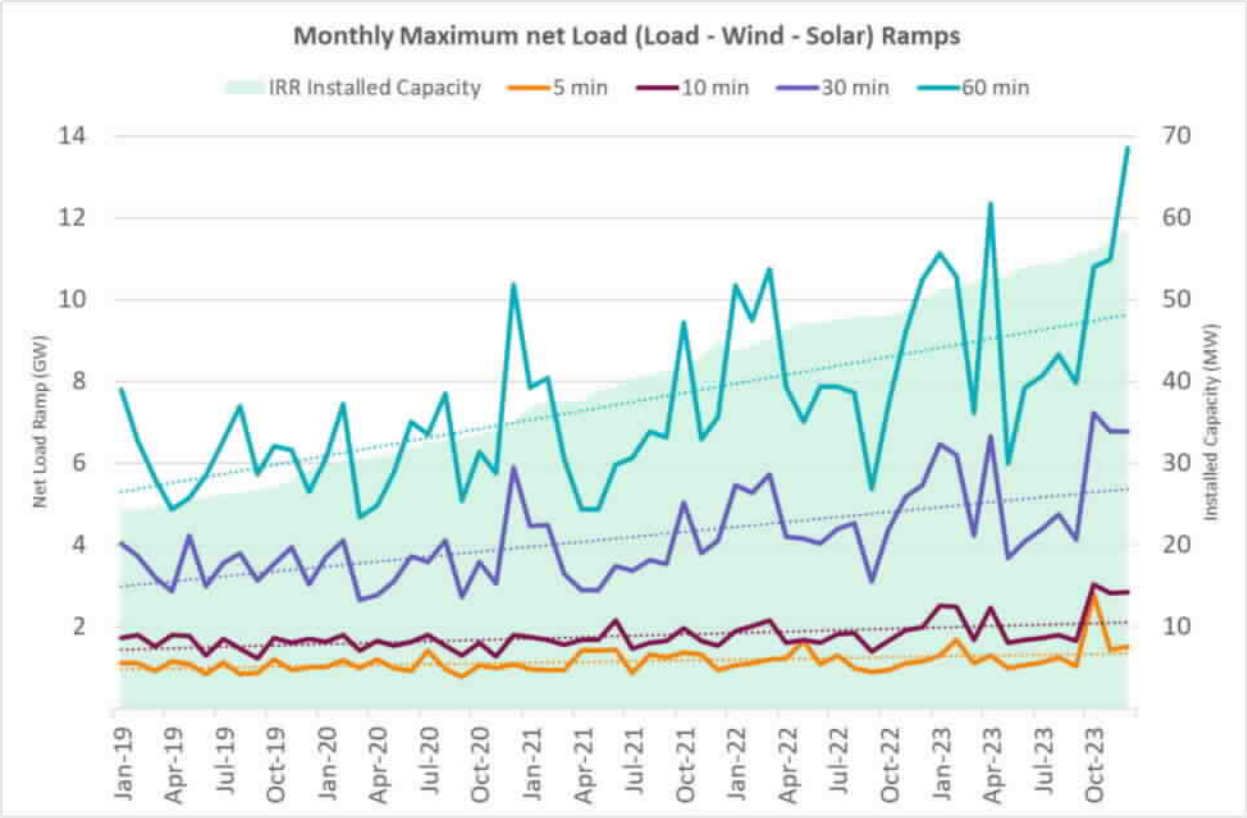


Figure 4 - Historical Monthly Maximum Net Load Ramps

Current Methodology for AS Quantity Requirements

Per Protocols, ERCOT annually reviews the methodology for determining the minimum required quantities for each AS. The *AS Methodology Document*[16] was developed to describe the methodology for calculating the minimum quantity of each type of AS that is needed to meet the defined operational reliability objectives. More detail about the determination of AS quantities is provided starting on page 12.

The increasing complexity in the AS framework and quantification of requirements have been added to the AS Methodology Document during review by numerous stakeholder groups each year. Consequently, this document has grown in detail and serves multiple purposes, including acting as an educational document, technical reference, NERC Reliability Standard compliance record, and a description of reliability risk mitigation.

[15] The requirement is not to have a quantity of AS equal to the ramp, but to cover forecast uncertainties, which are magnified by large net load ramps.

[16] *Available at* https://www.ercot.com/mktinfo/dam/index.html#details-9c502564-95de-4e8d-bfbf-75cd868318f6

Effective August 1, 2024, NPRR 1222 updated the Protocols to require any changes to the AS Methodology document to be reviewed by the ERCOT Board of Directors and approved by the PUCT.

Appendix 4 summarizes changes made to the AS Methodology between 2016 and 2024.

Operational Changes in 2021 to Avoid the Need for Watches

Following multiple days of high net load forecast errors or high generator forced outages, or both, in spring and early summer of 2021, ERCOT began operating with higher real-time reserves. The intent of this change in posture was to achieve a higher operational reliability goal; specifically, *to have enough reserves to decrease the likelihood of issuing a Watch due to insufficient reserve capacity, i.e., available reserves falling below 3000 megawatts (MWs)*[17]. Before this change in posture, if ERCOT issued a Watch but did not shed load, AS quantities would have been considered acceptable.

Initially, ERCOT accomplished this change in operating posture to avoid the need for Watches by committing additional generation through the Reliability Unit Commitment (RUC) process. However, beginning in July 2021, stakeholder feedback led ERCOT to seek the additional reserves through increased procurement of AS quantities. Specifically, ERCOT began procuring a minimum of 2,800 MW of RRS (up from 2,300 MW) during peak hours and increased Non-Spin quantities in all hours.[18]

Figure 5 below depicts the impact of the changes made to avoid the need for Watches on the number of events where Physical Responsive Capability (PRC) fell below 3,000 MW.

[17] Per current ERCOT protocol 6.5.9.4.1 "General Procedures Prior to EEA Operations", ERCOT may issue a Watch when PRC drops below 3,000 MW. Prior to Oct 1 2023, this language was under 6.5.9.3.2 (5) and was referred as Advisory for PRC below 3,000 MW.

[18] Corresponding with the implementation of ECRS in June 2023, ERCOT reduced the quantity of Non-Spin procured. ERCOT also eliminated the additional 500 MW of RRS they had procured since 2021.

Figure 5 - Days with Tight Operating Reserves

Effectively, since 2022, ERCOT's methodology for determining AS procurement quantities has been based on the goal of avoiding the need for issuing Watches. This has resulted in higher AS procurement quantities than a goal of avoiding load shed would have.

IMM's Modeling of Required Quantities of Ancillary Services

To assess the effectiveness and efficiency of the current suite of AS, the Independent Market Monitor (IMM) developed a probabilistic model to assess the reliability benefits of 10-minute and 30-minute reserves. This model does not consider changes to the faster responding AS, Regulation and RRS.

This model and analytical process were used to estimate the reliability impacts associated with varying levels of 10-minute and 30-minute reserves to inform procurement quantities for Non-Spin and ECRS. Further details and results of this analysis are included starting on page 28.

Out of Scope Topics

The following topics are not addressed in this study as they were specifically noted as outside the approved study scope:

- Cost allocation of Ancillary Services,
- Ability of Retail Electric Providers to pass through any Ancillary Service charges, and
- Implementation project timeline or costs of changes recommended by this study.

Ancillary Services in ERCOT Today

AS in ERCOT is an integrated program where different elements that are needed for the program are defined across numerous documents. The AS Program is defined by ERCOT Protocols, ERCOT Operating Procedures, ERCOT AS Methodology Document, and an Other Binding Document (OBD) that describes Non-Spin deployment processes.[19] These documents define and govern the various elements of the AS program:

1. The **definition** of each AS and the **characteristics** that resources must meet to qualify to provide it,
2. The **purposes** for which different types of AS are needed, including to meet NERC requirements and limit the risk of load shed due to insufficient commitment,
3. The **criteria** used to determine the extent to which different types of risks should be mitigated using AS,
4. A description of the **calculations** employed to determine how much of each AS will be procured to meet the criteria described in #2,
5. The **flexibility tradeoff** between the certainty of determining AS quantities in advance (so the AS cost can be hedged by Market Participants) and the efficiency of the quantity (which could be lower in many hours if determined within a time frame where forecasts are more accurate).
6. The criteria and timing for **deployment** of each type of AS.

Many of these elements are comingled in the way the quantities are determined in the AS Methodology document. For example:

- The criteria for determining how much of each type of risk should be mitigated are not defined separately; instead, this is decided implicitly in determining the minimum quantities of each AS.
- The AS Methodology defines some, but not all, of the purposes for which each AS is needed. Each year, ERCOT includes in its methodology document and presentations a discussion of the purpose for each AS, but only to the extent that purpose is the critical factor in determining the minimum quantity of that AS for the year; there may be other purposes for which that AS is needed but in a similar or smaller quantity. For example, ECRS is partially quantified based on replacing RRS following a large unit trip and with net load forecast errors, but it may also be used when multiple units trip even if there is no forecast error.
- Based on input over several years by stakeholders, especially the Retail Electric Providers (REPs), the AS Methodology currently sets the minimum quantities for each AS to be equal to the full quantity that is expected to be needed for each time period. While ERCOT has the authority under the Protocols to procure AS in addition to those minimum quantities, it has increased AS quantities near real time only in a handful of circumstances. Therefore, the AS Methodology currently leans much more on the side of certainty in the tradeoff between efficiency improvements and certainty.

[19] There is currently an initiative at ERCOT to migrate the contents of Other Binding Documents to the ERCOT Protocols and Guides.

Definitions of Each Ancillary Service

Table 3 defines the five current AS products within these four types:

1. Regulation (Up and Down) Services,
2. Responsive Reserve Service (RRS),
3. ERCOT Contingency Reserve Service (ECRS), and
4. Non-Spinning Reserve Service (Non-Spin).

Regulation Up and Regulation Down are two separate Regulation-type products with different quantity requirements and separate clearing prices. In contrast, RRS, ECRS and Non-Spin all have sub-types that have separate quantity constraints but are not priced separately. Separately pricing each sub-type to improve market efficiency, specifically when a sub-type is limited in how much of it can be procured, is a recommendation that the IMM has included in their State of the Market report since 2019.[20]

[20] The recommendations section expands on this topic starting on page 37.

Table 3 – Description of Each Ancillary Service and All Sub-types

Services & Sub-types	Description
Regulation Up Service **(REG-UP)** **Regulation Down Service (REG-DOWN)**	Capacity that can be **automatically deployed by ERCOT systems every 4 seconds to balance supply with demand** in between the 5-min Security-Constrained Economic Dispatch (SCED) intervals and maintain frequency close to 60 Hz. Provided by: • **Generation resources**, • **Batteries** and • **Controllable Load Resources (CLRs).**

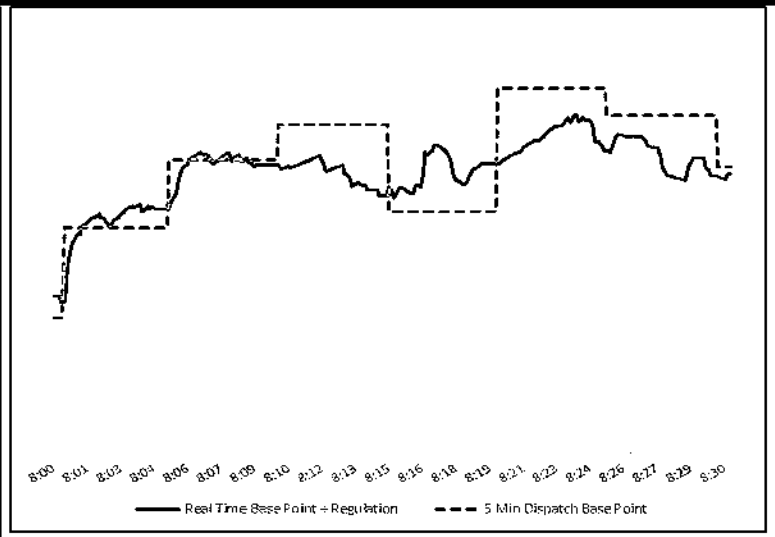
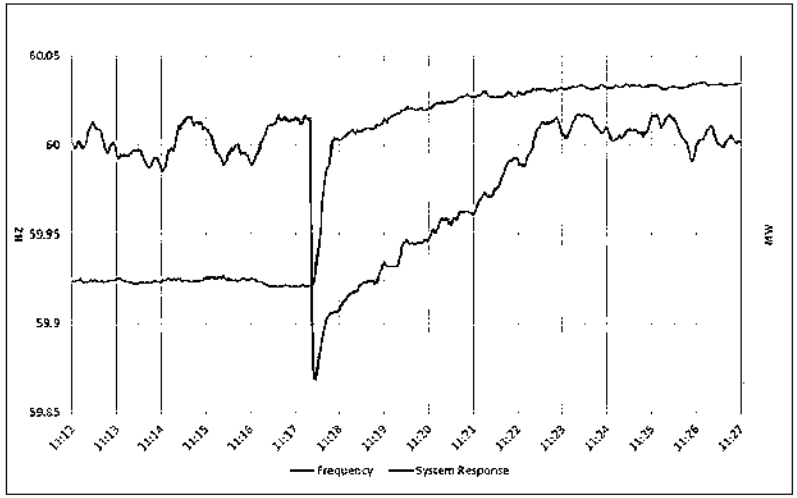
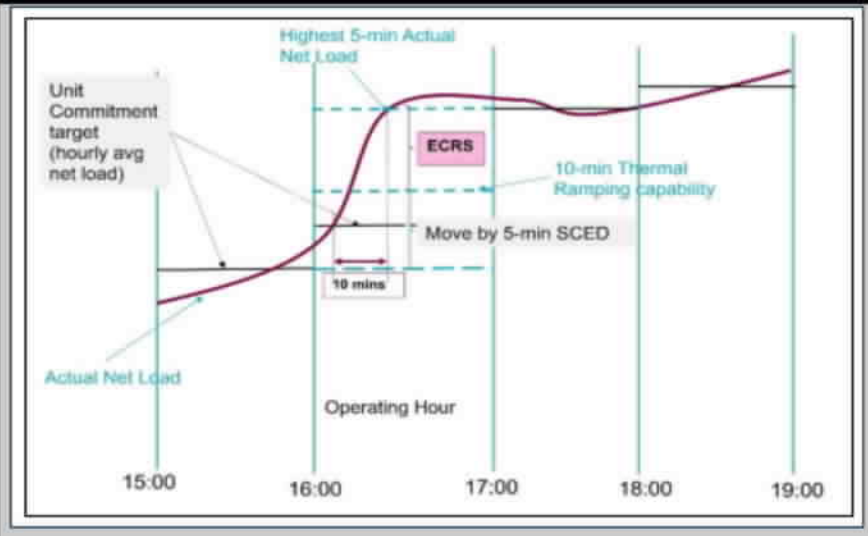


Figure 6 - Example of balancing supply & demand btwn. SCED intervals

Services & Sub-types	Description	
Responsive Reserve Service (RRS) **Subtypes:** **RRS-PFR (Primary Frequency Response)** **RRS-FFR (Fast Frequency Response)** **RRS-UFR (Load with high-set under frequency relays)**	Frequency responsive capacity that can **respond autonomously to low frequency events** typically triggered by generating unit trips. **RRS-PFR** – continuous response to frequency (when it deviates outside a dead-band); provided by **generation resources including hydro resources[21], batteries, and CLRs**. **RRS-FFR** – (full) response within 250 ms when frequency < 59.85 Hz; provided by **batteries and "blocky" Load Resources**. **RRS-UFR** – (full) response when frequency < 59.7 Hz; provided **exclusively by "blocky" Load resources**.	 *Figure 7 - Example of frequency response to a low frequency event*

[21] Hydro resources typically provide RRS in synchronous condenser fast response mode. Under this mode, these Hydro resources provide (full) response within 20 seconds when frequency falls below 59.80 Hz.

Services & Sub-types	Description	
ERCOT Contingency Reserve Service (ECRS) **Subtypes:** **ECRSM (Manually Dispatched)** **ECRSS (SCED Dispatched)**	**Capacity that can respond in 10 minutes** to recover frequency, cover intra-hour forecast uncertainties, load, wind, and solar variability/ramps, and replace deployed reserves. Must be **sustainable for 2 hours**. Provided by: • **Generation resources**, • **Batteries**, and • **Load** (both CLR and blocky).	 *Figure 8 - Example of ECRS*
Non-Spinning Reserve Service (Non-Spin) **Subtypes:** **OFFNS (Off-line Non-Spin)** **ONNS (On-line Non-Spin)**	**Capacity that can be available within 30 minutes** to cover forecast errors, load, wind, and solar variability/ramps, forced outages, and replacement of deployed reserves until additional resources can be committed. Must be **sustainable for 4 hours**. ONNS may be provided by: • **Generation resources**, • **Batteries**, and • **Load** (both CLR and blocky) OFFNS may be provided by Generation resources only.	 *Figure 9 - Example of Non-Spin Deployment to Provide Additional Online Resources*

Required Ancillary Services Quantities

ERCOT determines minimum quantities of each type of AS annually. Their methodology includes a **statistical analysis** of historical AS drivers (such as errors in forecasting net load) and factors in **key expected system changes** (such as continued solar generation growth). Table 4 shows the approved 2024 hourly procurement quantities and a high-level description of how these quantities are calculated.

Table 4 - AS Quantities and Methodology Determination

Hourly Quantity		Service and Sub-types	Method for Determining Required Quantity
Overall: 5,873 to 10,729 MW	55 to 1110 MW (Up) 182 to 1020 MW (Down)	Regulation Up (REG-UP) Regulation Down (REG-DOWN)	Regulation quantities are set using **historic load, wind, and solar variability** and **adjusted for** projected increases in variability due to **growth in utility-scale wind and solar capacity**. Up and Down Regulation are procured as distinct products since directional needs for a given hour are not typically symmetrical.
	2300 to 3178 MW	Responsive Reserve (RRS) Subtypes: • RRS-PFR • RRS-FFR • RRS-UFR	RRS quantities are set for each hour based on historic inertia and the MW quantity needed to arrest frequency drops such that NERC requirements can be met. More RRS is typically procured for periods with lower net load. Per approved methodology, the minimum level of RRS procured from Resources providing RRS-PFR "shall be determined for each month by ERCOT through the use of studies and shall not be less than 1,185 MWs" RRS provided by Resources providing RRS-FFR may not exceed 450 MW. RRS-UFR and Resources providing FFR is limited to 60% of the total RRS procurement. The same 60% limit applies to self-arranged RRS used to fulfill a QSE's RRS requirement.
	889 to 3007 MW	ERCOT Contingency Reserve Service (ECRS) Subtypes: • ECRSM • ECRSS	ECRS quantities are set (for 2024) based on: • 30-minute ahead historic forecast error; • projected utility-scale wind and solar growth; and • capacity needed to recover frequency close to 60 Hz.

			During historic periods with higher reliability risk, such as near-peak load or peak net load[22] when other available capacity is not likely to be available, a higher risk coverage is used when determining ECRS quantities. For example, during sunset hours, the goal is to cover at least 90% of historic observed variation in net load, while a less conservative 85% of coverage is applied to other times of the day when there is more self-committed capacity expected to be available.
	1430 to 4482 MW	Non-Spinning Reserve Service (Non-Spin) Subtypes: OFFNS, ONNS	Non-Spin quantities are set (for 2024) using 6 hours ahead historic forecast error and adjusted for projected over-forecast error increases due to growth in wind and solar capacity. Like ECRS, during periods with a history of higher risk of net load up ramps, a higher risk coverage is used when determining Non-Spin quantities.

When multiple reasons drive a need for a particular AS, the quantity needed to cover the most critical need is often sufficient to cover the other needs. However, in some cases where risks are due to frequent problems, e.g., unit trips and forecast errors, or where there is a significant chance that both problems occur simultaneously, then the different risks may have an additive effect on the AS quantity needed.

For some AS, the criteria are fairly stable over time, e.g. the quantity of Regulation has been based on the same basic formulation, with only updates to the quantities resulting from that formulation, for several years. For other AS, e.g., Non-Spin, the criteria tend to change more frequently as it is driven by changing regulatory and market considerations (such as considering forecast errors further in advance of an operating hour in order to avoid triggering a Watch and reduce the need for RUCs).

Another noteworthy topic in the current AS methodology for ECRS and Non-Spin is in the context of how these use historic net load ramps to identify hours with higher risk of up ramp forecast errors. In these hours, when the risk of insufficient commitment to cover unexpected variations is higher, ECRS and Non-Spin quantities are set based on a higher percentile of applicable net load forecast errors using a sliding scale; hours with lowest risk of up ramps are assigned the lowest percentile (85th in case of ECRS and 68th in case of Non-Spin) and hours with highest risk of up ramp are assigned the highest percentile (95th for both ECRS and Non-Spin). The choices for the start and end values of the sliding scale are based on engineering and operational judgement of "excess" on-line/off-line generation that historically has been available during the relevant timeframe. For example, on a typical summer afternoon, there is not a plethora of excess generation capacity beyond what is committed to serve the forecasted peak demand, so ERCOT procures a quantity of Non-Spin that is based on the 95th percentile of calculated historic risk for those hours. Conversely, in overnight hours, when demand is lower, there may be many generators that are operating below their maximum output or are off-line but with a fast startup time that can help mitigate net load under forecast

[22] Net load is defined as: load – wind – solar

errors, so ERCOT procures a quantity of Non-Spin that is based on the 68th percentile of calculated historic risk for those hours.

AS Quantities are Set Annually, Providing Market Certainty at Cost of Efficiency

The AS methodology document describes the methodology that ERCOT uses, updated annually, to quantify the ***minimum*** requirements for each AS. ERCOT determines the quantity it expects to need to cover the critical need for each AS for each hour, based on system conditions for that hour over some historic period. Based on feedback from stakeholders over many years, once ERCOT determines those expected required hourly quantities, those expected quantities are treated as the minimum quantities for the year and are "locked in" in December as the minimum for each hour of the year. ERCOT has the authority to procure more than the expected quantity if needed based on forecasted conditions closer to real-time, but very rarely does so because the minimum quantities generally tend to be sufficient to cover most conditions that arise. The reason these expected quantities are locked in to be the minimum quantity for each hour is that it allows REPs to hedge against the costs of AS.

Actual system conditions in a particular hour may vary greatly from what was expected based on historic conditions for that hour of the year. In many cases, those actual conditions may result in less AS being required for a particular hour than what was determined in December of the previous year. But because the minimum quantity is already "locked-in," that full quantity will be procured.

There is a tradeoff inherent in this process between certainty and efficiency. When the AS methodology approach was changed to set quantities annually, the difference between the quantities determined in December and the quantities that would be needed based on real-time conditions was relatively small. At that time, the improved ability for REPs to hedge their AS obligations made certainty more important than efficiency.

As the sources of variability and uncertainty on the grid increase with growth in solar, Large Flexible Loads (LFLs), electric vehicles, *et al*, the difference between an AS methodology that determines quantities in December for every hour of the following year and an AS methodology that determines some portion of the quantities that would be needed based on conditions forecasted closer to the operating day is expected to continue to grow.

Technology Types Providing Ancillary Services

Any technology type that can meet the qualification criteria specified in ERCOT Protocols and Operating Guide can provide AS. As installed capacity of batteries has increased, the volumes of Regulation Service, RRS and ECRS being provided by these duration limited resources has also increased. Figure 10 through Figure 14 show the proportion of each AS being provided by different technology types.

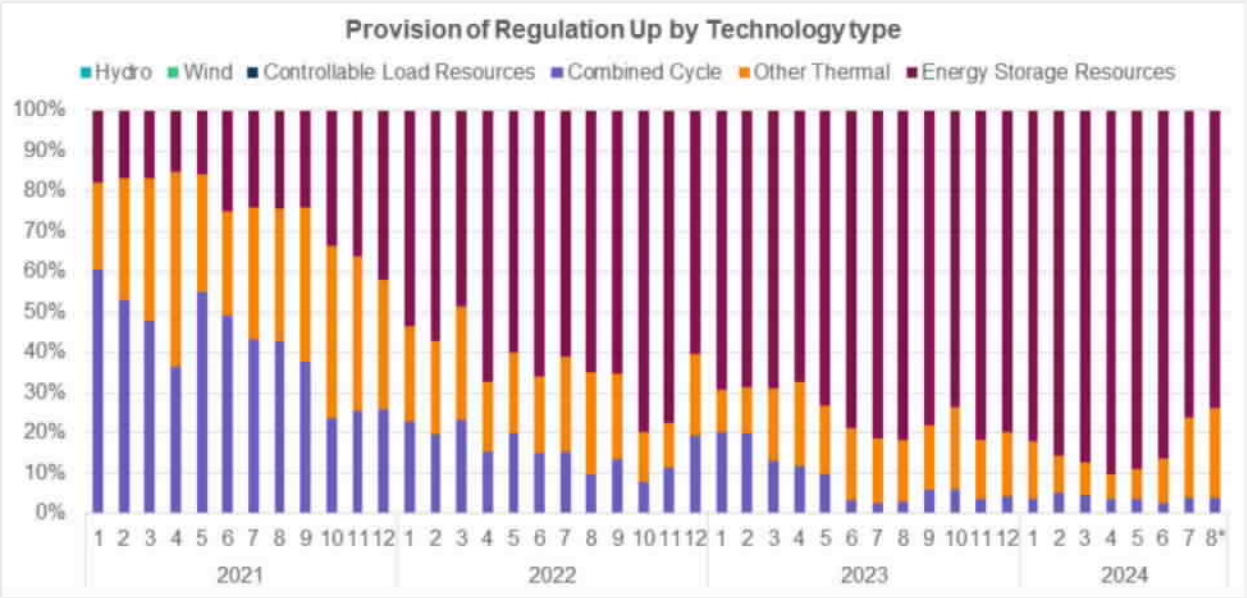


Figure 10 - Technology Types Providing Regulation Up between January 1, 2021 and August 26, 2024

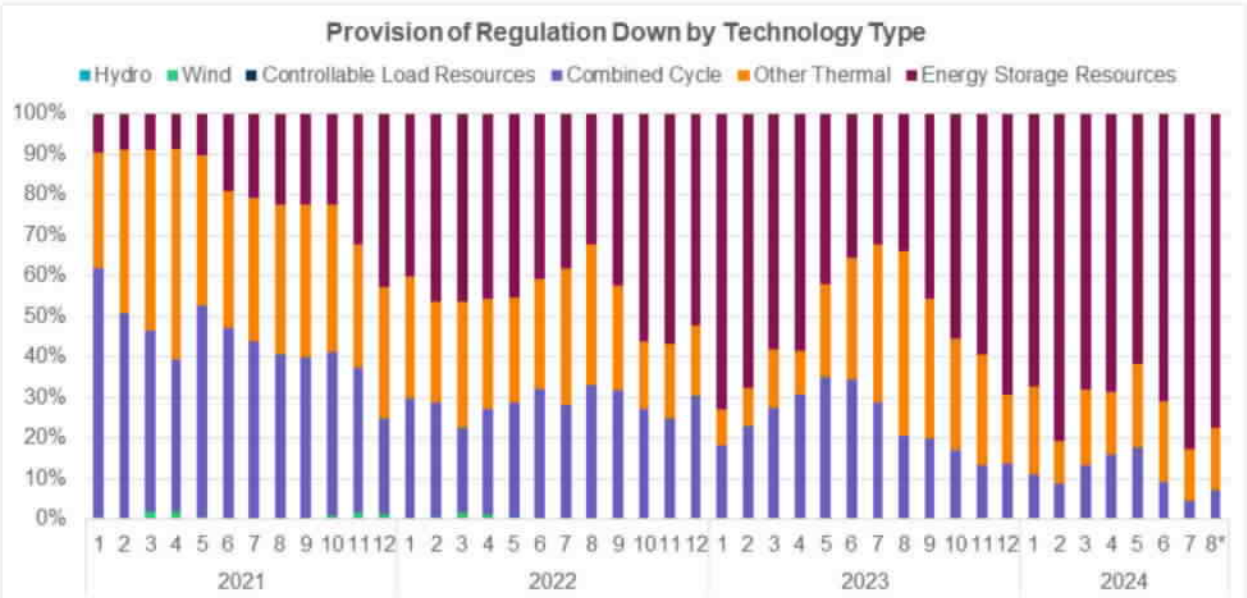


Figure 11 - Technology Types Providing Regulation Down between January 1, 2021 and August 26, 2024

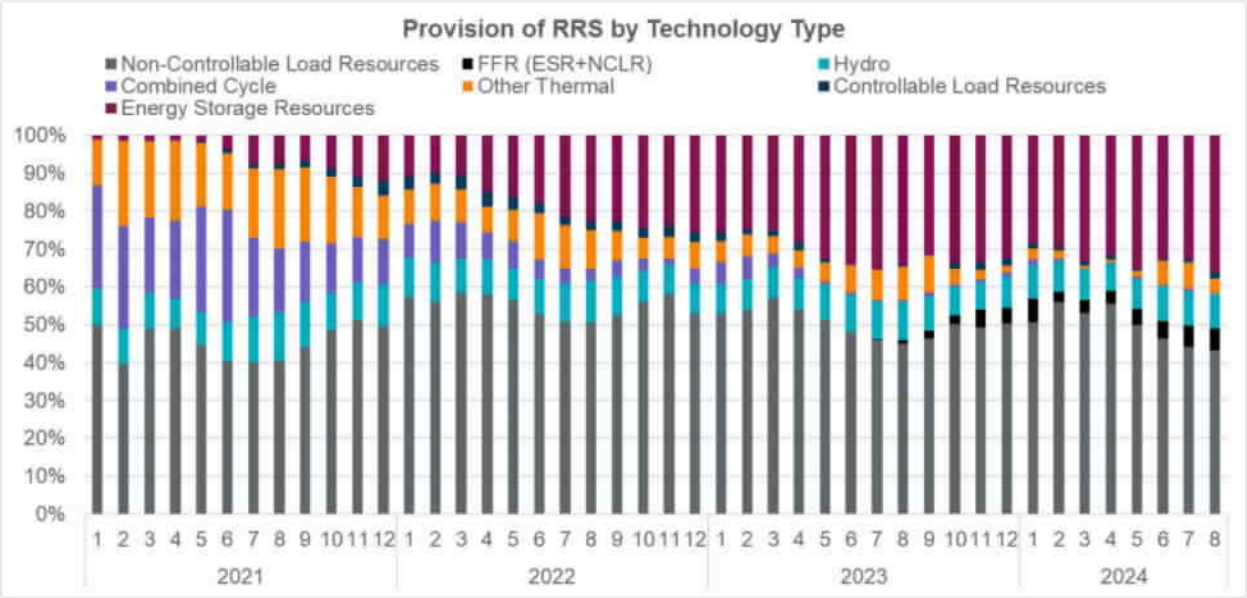


Figure 12 - Technology Types Providing RRS between January 1, 2021 and August 26, 2024

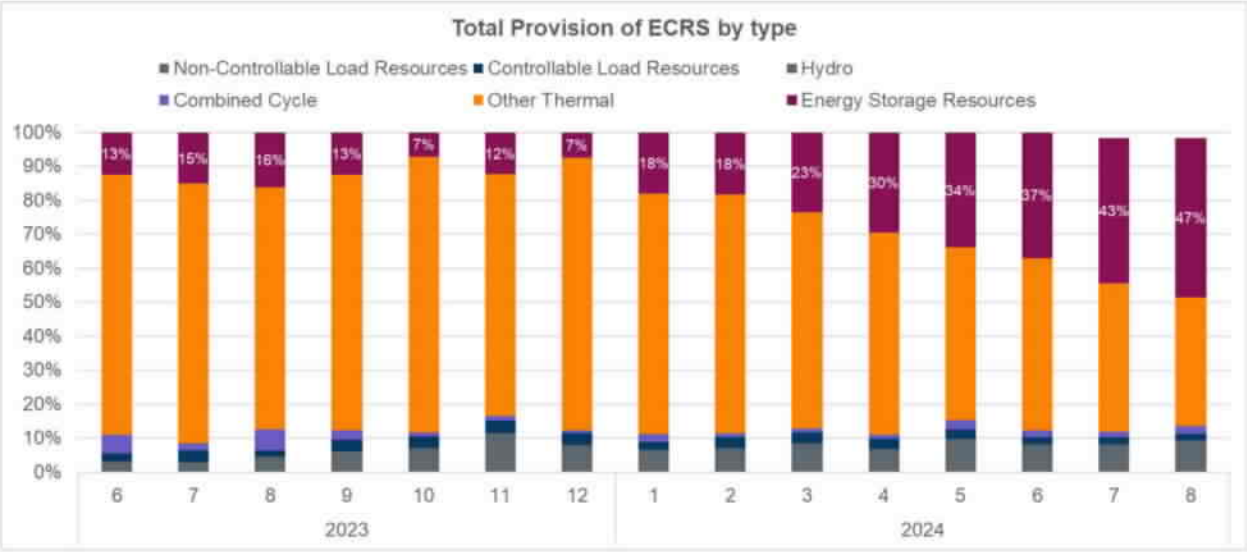


Figure 13 - Technology Types Providing ECRS between January 1, 2021 and August 26, 2024

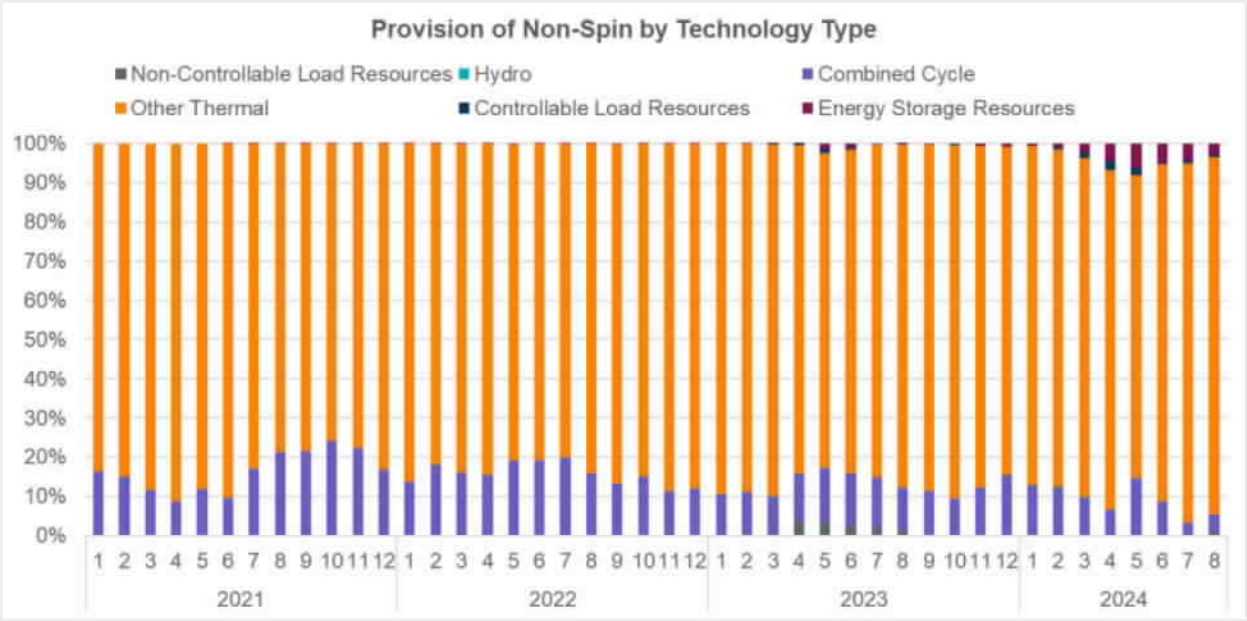


Figure 14 - Technology Types Providing Non-Spin between January 1, 2021 and August 26, 2024

Purposes of Ancillary Services

As stated earlier, AS are required to satisfy two purposes:

1. To meet certain NERC Reliability Standard defined supply and demand balancing related reliability objectives; and
2. To reduce operational risks associated with variability and uncertainty.

Ancillary Services Serve NERC Reliability Standards

ERCOT procures certain types and sufficient quantities of AS to meet balancing, i.e., generation and load must be "balanced", or near equal, at all times, requirements specified in the NERC Resource and Demand Balancing (BAL) Reliability Standards applicable to ERCOT as the sole NERC-registered Balancing Authority (BA) for the ERCOT Region. Compared to other regions in North America, meeting these balancing requirements is more based on the physical characteristics and limitations of the ERCOT Region than equitable reserve sharing, since ERCOT is a single BA interconnection as opposed to one BA within a large, multi-BA interconnection.

ERCOT has developed a compliance program for meeting various BAL standards requirements. NERC Reliability Standards do not specify how a BA's AS program or other reserves must be designed. Instead, the NERC Reliability Standards set several performance requirements that the BA must meet. ERCOT has designed its AS to be used, in addition to the 5-minute dispatch of energy through SCED, to meet those performance requirements. This program must be flexible enough to meet a variety of conditions: unit trips, load/wind/solar/thermal unit ramps, load variations, etc. In some cases, Regulation plus SCED may be sufficient. In other cases, RRS may be autonomously deployed at the same time that ECRS is deployed by the Energy Management System (EMS) to restore frequency, followed by dispatch of energy through SCED.

Fundamental to ERCOT's current approach is the idea that most uses of AS are not "one and done;" for example, when a unit trips and AS are deployed, the risk still exists that another unit could trip, so there is a need to timely restore reserves to prepare for the next possible unit trip without leaving the system exposed without sufficient reserves for an unacceptable period.

Table 5 summarizes ERCOT's NERC balancing requirements and how ERCOT uses SCED, Regulation, RRS, and ECRS (with backup from Non-Spin) to meet these requirements.

Table 5

NERC Reliability Standard	Requirement Summary	Explanation, or more info, if needed	ERCOT Activity to Meet Requirement
BAL-001-2 R1	Maintain 12 month rolling average Compliance Performance Standard 1 (CPS1) score ≥ 100%.	CPS1 is a measure of how close system frequency is maintained relative to 60 Hz.	Frequency control is maintained through Regulation deployment, governor response from RRS resources and from other available on-line resources, and running SCED as often as needed. ERCOT monitors frequency control (both actively and *post hoc*) to ensure compliance with this requirement.
BAL-001-2 R2	Average Area Control Error (ACE) does not exceed BAAL for more than 30 minutes (including during EEA).	Clock-minute average frequency cannot stay below 59.91 Hz or above 60.09 Hz for more than 30 minutes.	ERCOT relies on actions such as deployment of Regulation, governor response from on-line RRS resources and from other available on-line resources, and running SCED as often as necessary. If more on-line resources are needed, ERCOT may deploy Non-Spin and/or ECRS and use DC Ties (increasing import or curtailing export) to recover frequency below ERCOT's BAAL within the timeframes established by this requirement.
BAL-002-3 R2	BA shall have a plan to maintain contingency reserves to cover the most severe single contingency (MSSC).	MSSC for ERCOT is 1,430 MW.	If ERCOT cannot maintain sufficient contingency reserves to withstand the MSSC, it will declare EEA3 and use load shed to restore sufficient contingency reserves, pursuant to EOP-011-2 R2.
BAL-002-3 R1.1	BA must recover frequency to pre-disturbance value within 15 minutes.		Following a low-frequency event, ERCOT meets this requirement by relying on frequency response from resources carrying RRS, deploying Regulation, releasing ECRS, and running SCED as needed to restore frequency within 15 minutes.

NERC Reliability Standard	Requirement Summary	Explanation, or more info, if needed	ERCOT Activity to Meet Requirement
BAL-002-3 R3	BA must restore its contingency reserve to at least its MSSC within 90 minutes		ERCOT will use ECRS, Non-Spin, and load shed to meet this requirement. While the current AS Methodology does not explicitly account for this specific requirement, procurement of ECRS and Non-Spin lessen the likelihood of needing to use load shed to meet the requirement.
BAL-003-2 R1	BA must maintain its annual Frequency Response Measure above its Frequency Response Obligation	Median of frequency response across all events within 12-month period greater than quantity calculated by NERC as necessary to avoid UFLS for loss of two largest units (2,800MW)	ERCOT relies on RRS primarily to meet this requirement. This requirement is directly considered in determining the minimum level of RRS to be procured. At least annually, ERCOT calculates RRS required to meet this frequency response obligation, i.e., not trigger UFLS for the loss of 2,800 MW, at all times. ERCOT also monitors procured RRS in Real Time to ensure these are sufficient to meet ERCOT's obligation under this requirement.

Every AS type and their quantities play a role in meeting ERCOT's obligation under the BAL Reliability Standard requirements listed in the table above. Appendix 3 demonstrates the efficacy of ERCOT's AS program with respect to frequency control.

Ancillary Services Reduce Operational Risks from System Variability

The second purpose of AS is fulfilled by ERCOT procuring certain types and quantities of AS to reduce the necessity of Watches, emergency operations, and load shed due to insufficient resource commitment to cover unexpected variations in system conditions. Most unit-commitment decisions in the ERCOT market are made by Market Participants. In general, each QSE will commit or decommit resources based on their obligations and expected system and market conditions. ERCOT has the authority and tools to commit additional resources through the RUC process if needed to cover the expected net load on the system, to resolve any locational reliability issues, and to preserve the required AS.

Different thermal generation resources take varying periods of time to start up, from less than five minutes for some combustion turbine units to more than 12 hours for some gas steam units. Commitment decisions have to take this lead time into account. Additionally, various thermal generation resources have differing abilities to move from a low output level to a high output level. This is known as ramp capability and is expressed in MWs per minute.

There is significant variability around both the supply and demand sides of system expectations during the timeframe for which commitment decisions must be made:

- Generating units can become unavailable;
- Load can vary from the forecasted values;
- Wind and solar generation can vary from forecasted values; and
- The timing of changes in load, wind, solar, and unit starts can vary from hourly values.

ERCOT must appropriately take these uncertainties into account when determining whether to start additional generation or risk not having sufficient resources available in a timely manner to serve the load if those events occur, in which case Watches, emergency operations, or load shed (to balance the consumer demand with the available resources) might be required. To account for these uncertainties, ECRS and Non-Spin (and in the future Dispatchable Reliability Reserve Service (DRRS))[23], which are provided by reserved on-line resources or off-line resources with relatively short lead times of 10 minutes to 30 minutes (to 2 hours in the future with DRRS in place), are relied upon to mitigate that risk as system conditions vary in real-time from expectations at the time unit commitment decisions were made.

In theory, the risk of insufficient commitment to cover unexpected variations in system conditions can be raised or lowered by increasing or decreasing the quantities reserved through ECRS and Non-Spin beyond the quantities needed to meet NERC BAL Reliability Standards requirements. Currently, there are no objective reliability criteria by which to judge the sufficiency of AS quantities to cover these risks. As such, ERCOT procures quantities of AS to both meet NERC BAL Reliability Standard requirements and to avoid the need to issue a Watch or enter emergency operations considering historic variations/uncertainties in system conditions.

Ancillary Services Deployment

In general, AS capacity is reserved and not used to provide energy unless it is needed to serve the purpose for which it is procured. For some AS, like Regulation, that may happen continuously. For other AS, like ECRS, that may only happen a few times per month.

There is a distinction between the "deployment" of AS and the "release" of AS. A "deployment" happens when resources providing AS are directed – either automatically or through an ERCOT dispatch instruction – to deliver energy through an increase in output or reduction in consumption. A "release" happens when the capacity from resources providing AS is no longer held in reserve and this capacity is allowed to be optimized through dispatch by SCED. Following a release, a resource may or may not change their output or consumption depending on the resource's energy offer price relative to other resources. During scarcity conditions it may become more supportive of reliability to release the AS capacity to be used to serve energy needs rather than to continue to hold it in reserve to cover the potential need for which it was procured (see Nodal Protocols Section 6.5.9.4.1). The deployment or release as applicable in case of each type of AS (or sub-type) will be discussed in the following subsections.

[23] Texas House Bill 1500 includes a requirement for ERCOT to develop and implement an AS to procure dispatchable reliability reserve services on a day-ahead and real-time basis to account for market uncertainty. (H.B. 1500 § 22, 2023, R.S.) ERCOT is in the midst of developing this DRRS product.

Regulation Deployment

As outlined in Nodal Protocol Section 6.5.7.6.2.1, Regulation Service is deployed by the Load Frequency Control (LFC) program within the EMS every 4 seconds as needed to maintain frequency around 60 Hz.

RRS Deployment

RRS from primary frequency response (RRS-PFR) is deployed automatically by resources when the resource senses a frequency deviation greater than the established dead-band (which is defined in NERC Reliability Standard BAL-001-TRE). RRS-PFR may also be released manually during scarcity conditions per Nodal Operating Guide Section 4.8 (more on this below). RRS from Fast Frequency Response resources (RRS-FFR) and RRS from high-set under frequency relays (RRS-UFR) deploy automatically when associated frequency triggers are met. More details on deployment of RRS are in Nodal Protocol Section 6.5.7.6.2.2.

Figure 15 demonstrates response from both RRS-PFR providers (labeled as RRS-Gen) and RRS-UFR providers during a frequency event that was triggered by trip of 2,535 MW of supply. As is visible in this event due to the frequency response available at the time, frequency decline was arrested well above the first stage Under Frequency Load Shed (triggered at 59.3 Hz) and frequency nadir, i.e., the lowest point of frequency, was just above 59.7 Hz.

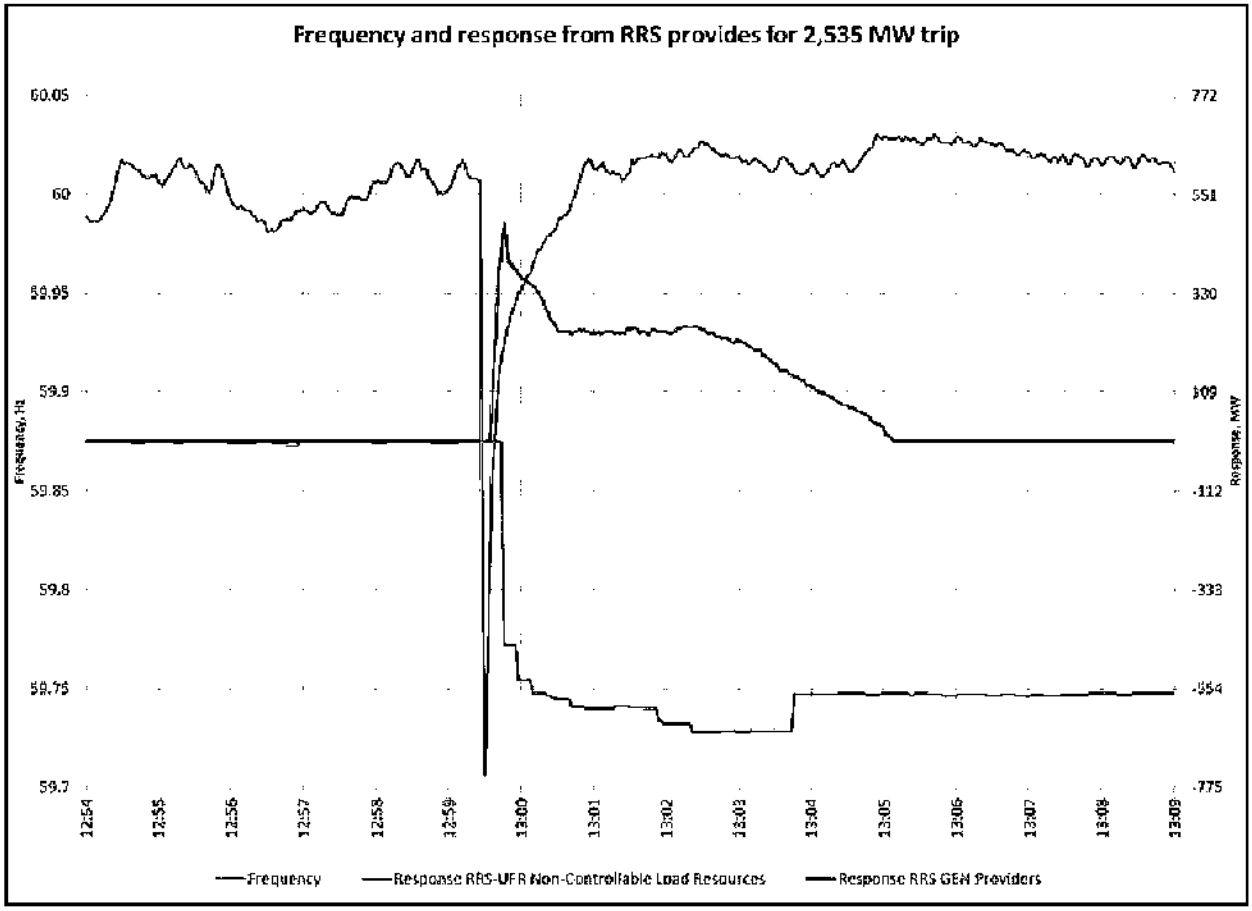


Figure 15 - RRS Deployment Example

Figure 16 demonstrates frequency nadir in Hz during Frequency Measurable Events (FMEs) that occurred between January 1, 2018 and July 31, 2024. In all cases, the lowest point of frequency stayed well above the first stage of Under Frequency Load Shed (triggered at 59.3 Hz). Appendix 2 contains a list of events where RRS was released between January 1, 2018 and July 31, 2024.

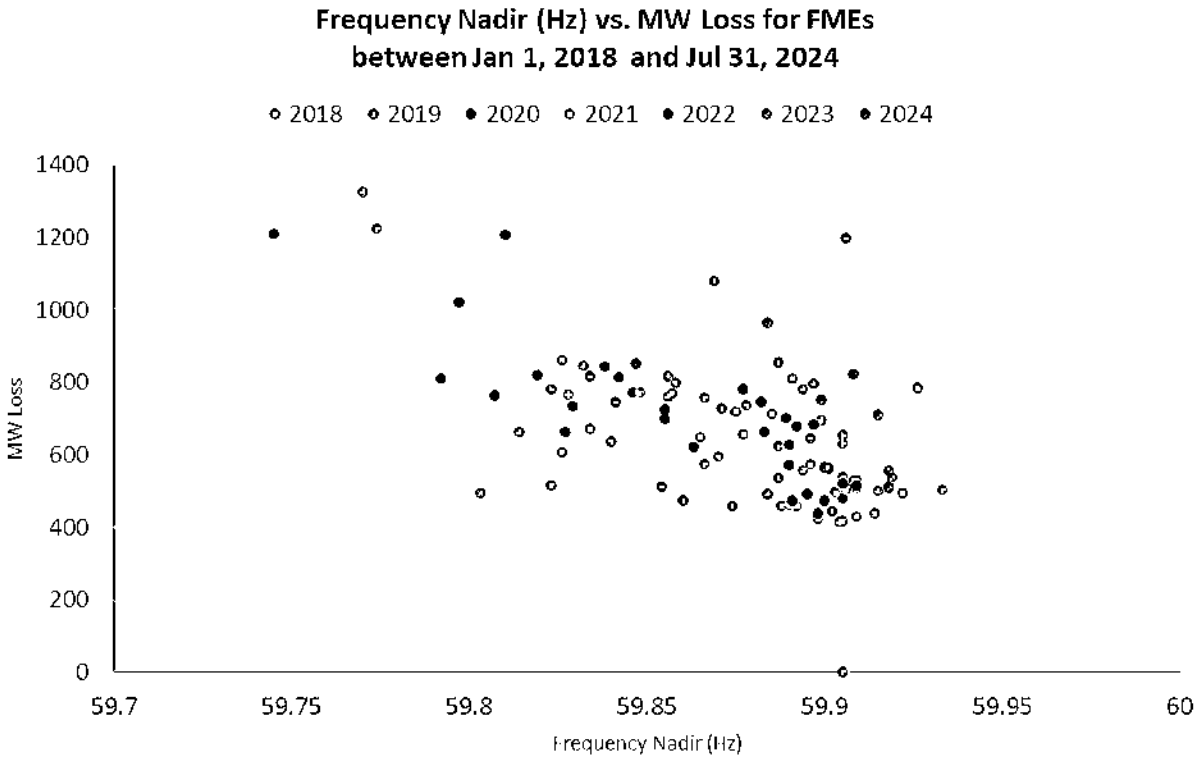


Figure 16 - Frequency Nadir during FMEs between January 1, 2018 and July 31, 2024

ECRS Deployment

As outlined in Nodal Protocol Section 6.5.7.6.2.4, ECRS provided by SCED-dispatchable resources may be released by LFC or manually to restore Regulation and/or RRS. ECRS may also be released when the expected net load ramp exceeds the capability of on-line resources to follow the change in load. ECRS may also be released manually during scarcity conditions (more on this below).

Figure 17 demonstrates an event where a unit started experiencing operational issues and eventually tripped offline. During the event, grid frequency dropped below 59.91 Hz and ECRS was released. Frequency recovered back to 60 Hz within 10 minutes after the release of ECRS. Appendix 2 contains a list of events where ECRS was released between June 10, 2023 and July 31, 2024.

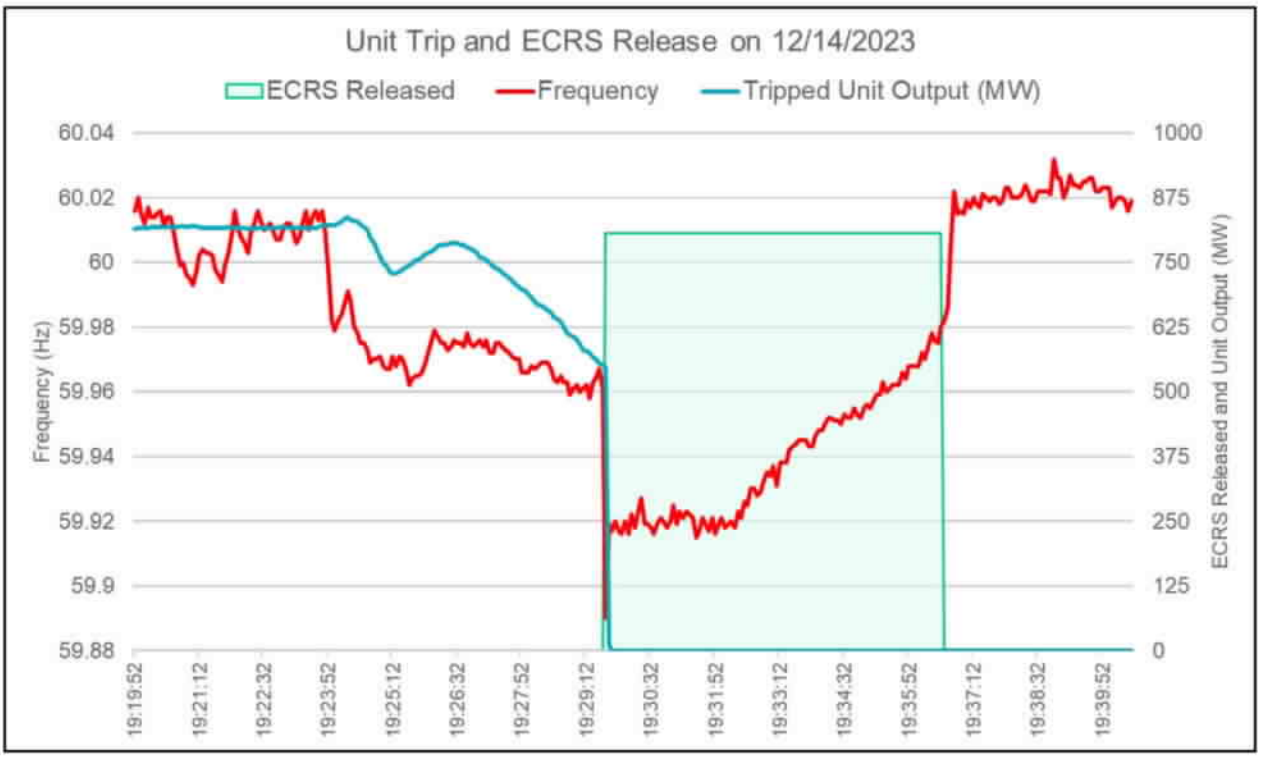


Figure 17 - ECRS Deployment Example

Non-Spin Deployment

For Non-Spin provided by on-line resources, or resources that are considered to be on-line like Quick Start Generation Resources (QSGRs), the capacity reserved for Non-Spin is continuously released to SCED behind a $75 offer floor. The reason that the Non-Spin resources are released behind an offer floor is to allow for a continuous release once a pre-established value threshold is crossed where the market values having the energy now over continuing to hold this capacity in reserve. Thus, Non-Spin is automatically deployed by SCED any time this offer is cleared in the SCED solution (see Nodal Protocols Section 6.4.4.1). The deployment of Non-Spin from off-line resources is governed by Nodal Protocol Section 6.5.7.6.2.3 and the OBD titled, Non-Spinning Reserve Deployment and Recall Procedure. These describe how off-line Generation Resources or Load Resources providing Non-Spin will be deployed to cover ramping needs, mitigate low system operating reserves, or resolve local reliability issues.

Figure 18 demonstrates an event that occurred on May 13, 2022. Entering this Operating Day, ERCOT was already expecting tighter-than-normal operating conditions and had taken actions to bring additional capacity online to avoid issuing a Watch. Between 11:30 a.m. and 2:43 p.m., five generators with a cumulative generation capacity of 2,423 MW tripped offline. ERCOT's PRC dropped to a minimum value of 2,923 MW. RUC instructions and off-line Non-Spin were relied upon to recover PRC and avoid issuing a Watch while continuing reliable grid operations. Appendix 2 contains a list of events where off-line Non-Spin was deployed between January 1, 2018 and July 31, 2024.

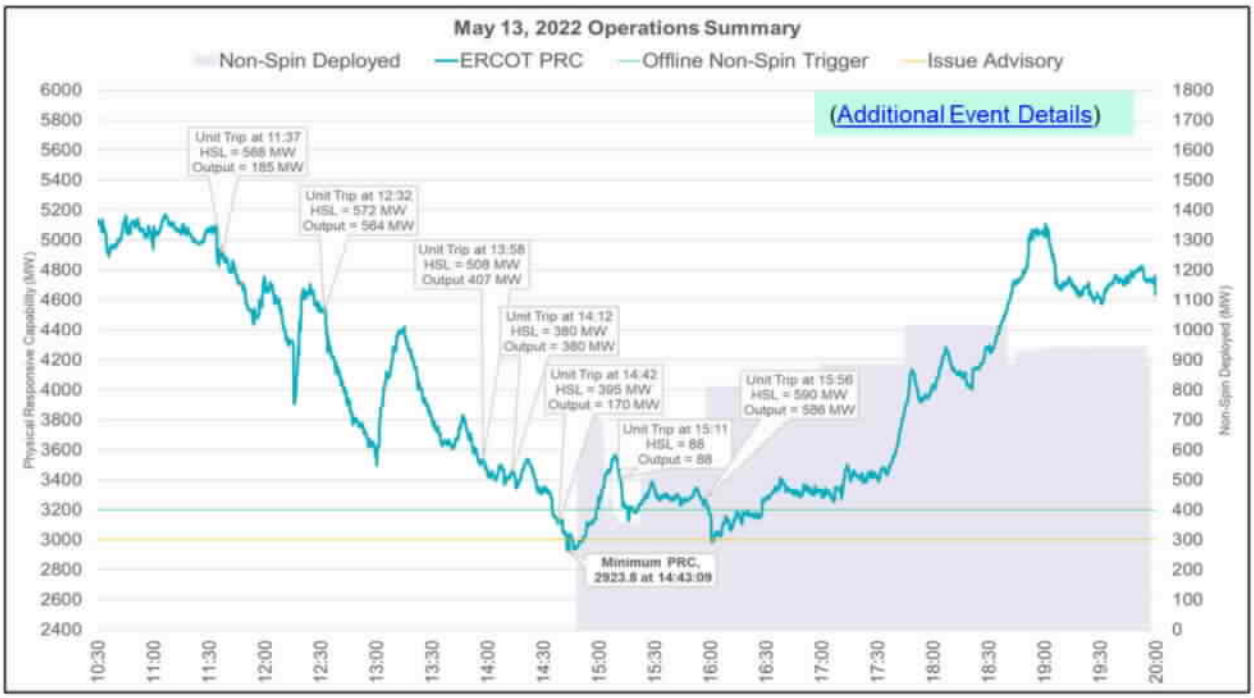


Figure 18 – Non-Spin Deployment Example

AS Deployment During Scarcity

Scarcity conditions occur when demand approaches the available capacity on the system, including the capacity that is held in reserve to provide AS. Other than Regulation, AS are intended to protect the system against future risks, such as unit trips and forecast errors. During scarcity conditions, the immediate need to provide energy to meet demand and avoid load shed becomes a more critical issue than protecting the system against future risks, to the extent that those future risks would not result in a widespread system collapse. Thus, during scarcity conditions, ERCOT procedures include the release of capacity reserved for AS to allow it to be used by SCED to provide energy to avoid, or during, EEAs under Section 3.17.4 of the Protocols.

AS that mitigate relatively longer-term risks are released first during scarcity conditions, with the AS that are used for frequency control released last. If the scarcity becomes severe enough to approach the need for load shed, at least a subset of all AS types other than Regulation are released, and the remaining frequency-responsive capacity on the system is tracked using the calculated PRC.

However, such a release may result in energy being provided by the relatively faster-ramping, frequency responsive resources that were providing the AS and headroom being freed on slower-ramping resources that may not be able to respond to frequency deviations. This would mean that the system is less able to respond to fast-occurring system variations and frequency disturbances. For this reason, per ERCOT, the release of AS capacity to serve energy needs should be done with care to recognize the reliability tradeoffs. This may be less of an issue after implementation of Real-Time Co-optimization + Batteries (RTC+B).

Individual AS are released during scarcity as follows. As noted above, on-line Non-Spin is continuously released to SCED behind a $75/MWh offer floor. If system conditions are tight enough that a resource providing Non-Spin is needed even with an offer of $75/MWh, the capacity from that Non-Spin resource is used to serve load. Resources providing off-line Non-Spin are deployed when available dispatchable

capacity is not sufficient to cover forecasted 30-minute ahead net load or PRC drops below 3,200 MW. ECRS capacity provided by SCED-dispatchable resources is released under scarcity conditions, if not already released due to system ramp limitations when the available dispatchable capacity is not sufficient to cover forecasted 10-minute ahead net load. Following deployment of Non-Spin and SCED dispatchable ECRS, in accordance with Nodal Operating Guide Section 4.8, RRS from resources providing primary frequency response may be released manually during scarcity conditions to avoid EEA. ECRS and RRS capacity from non-controllable load resources is deployed in accordance with Nodal Protocol Section 6.5.9.4, during EEA2.

On August 1, 2024, ERCOT implemented an additional trigger for releasing ECRS during times of high system prices, which may be an indicator of scarcity. The current ERCOT market design (prior to the implementation of the RTC+B project) has a feature whereby SCED will dispatch less generation than load when system prices are high. For example, when system prices reach $1,000/MWh (or higher), SCED will dispatch 40 MW less generation than load. When this "undergen" occurs, it is assumed that Regulation Up will be deployed to balance generation and load so that the frequency is maintained at approximately 60 Hz.

The new ECRS release trigger uses the undergen value as an indicator that the system is nearing scarcity conditions and ECRS should be released. Specifically, when the system has experienced an under-generation of 40 MW for 10 consecutive minutes, ERCOT may release a portion of ECRS reserves.

Historical Annual Costs for each Ancillary Service

Table 6 presents the total cost of AS and the cost of AS per MWh of load for the period January 1, 2018 through August 31, 2024. Natural gas prices are also shown for reference.

Table 6 – AS Total Cost ($ Millions), Cost per MWh of Load, and Natural Gas Prices

	2018	2019	2020	2021	2022	2023	2024
Total Cost of AS ($ Millions)							
Regulation	$51.77	$85.77	$51.42	$1,216.72	$110.19	$169.18	$32.52
Responsive	$426.18	$631.37	$272.77	$8,232.24	$508.34	$525.29	$112.91
ECRS	N/A	N/A	N/A	N/A	N/A	$713.69	$134.08
Non-Spin	$126.05	$178.74	$57.39	$2,175.86	$796.51	$465.97	$152.15
All Services	$604.00	$895.88	$381.58	$11,624.82	$1,415.04	$1,874.13	$431.66
Cost of AS ($/MWh of Load)							
Regulation	$0.14	$0.22	$0.13	$3.10	$0.26	$0.38	$0.10
Responsive	$1.13	$1.64	$0.71	$20.96	$1.18	$1.18	$0.36
ECRS	N/A	N/A	N/A	N/A	N/A	$1.60	$0.43
Non-Spin	$0.33	$0.47	$0.15	$5.54	$1.85	$1.05	$0.49
All Services	$1.60	$2.33	$0.99	$29.60	$3.29	$4.21	$1.38
Natural Gas Prices ($/MMBtu)							
ERCOT	$ 3.22	$ 2.47	$ 1.99	$ 7.30	$ 5.84	$ 2.22	$1.80

IMM Modeling Details and Results

Modeling Methodology

To assess the effectiveness and efficiency of current AS, the Independent Market Monitor (IMM) developed a probabilistic model of 10-minute reserves (ECRS) and 30-minute reserves (Non-Spin). This model focuses on reserves that are responsive within minutes to hours and does not consider changes to the faster responding AS, Regulation and RRS, nor to the frequency control portion of ECRS.

The basic idea behind this model is to calculate an annual Loss of Load Probability (LOLP), given the probabilistic behavior of generation outages and forecast errors, while treating reserves as an independent variable. Mechanically, the probability distributions that describe generation outages and forecast errors are accounted for using a Monte Carlo simulation. Each hour is simulated ten thousand times, and the forced outages and forecast error are randomly drawn based on the underlying probability distributions. For forced outages, the probability of an outage is a function of the average time between outages for each resource:

$$Unit\ Trip = \begin{cases} 1, & if\ random(uniform) < \dfrac{h}{MSTUO} \\ 0, & otherwise \end{cases}$$

Where h refers to the forecast time horizon, and $MSTUO$ is the Mean Service Time to Unplanned Outage, i.e., the mean time between failures. $MSTUO$ is treated on a resource basis to account for the varying outage rates among resource types, vintage, etc. Resource-level derates and outages are based on five years of historical data from ERCOT's Outage Scheduler.

The total capacity of unplanned outages is the sum of capacity from tripped resources, as shown below. Here, the High Sustainable Limit (HSL) is taken as the minimum of the seasonal capacity ratings and the telemetered HSL for each resource.

$$Unit\ Trip\ Capacity = \sum(HSL \times Unit\ Trip)$$

Net load forecast errors are based on the historical distributions of forecast errors, which are themselves a function of the realized output level. The historical output levels and forecast values are input to a regression model which can output a predicted mean and standard deviation as a function of the forecast value. These values are then passed into a random number generator assuming a normal distribution:

$$Forecast\ Error\ (net\ load) = random(normal, predicted\ mean, predicted\ std.\ dev.)$$

Forecast error is based on aggregated system-level data. Data sources include:

- Load - Hourly forecast and actual data; 5 min forecast and actual data
- Wind generation - Hourly forecast and actual data; 5 min forecast and actual data
- Solar generation - Hourly forecast and actual data; 5 min forecast and actual data

The time horizon for the forecast error is an adjustable parameter. The total Forecast Error Impact (FEI) is the net of the wind and solar forecast error and the load forecast error:

$$FEI = FE_{wind} + FE_{solar} - FE_{load}$$

Note that forecast error is defined as the difference between the forecast and the realized value, so a positive forecast error means an over forecast. Under-forecasted net load can result in under-commitment of thermal resources, thus contributing to load at risk of an outage. The load at risk of an outage is the sum of the forecast error impact and the capacity load to unplanned outages:

$$Load\ at\ Risk = -FEI + Unit\ Trip\ Capacity$$

Load at Risk is then compared to Reserves to determine the probability of an outage. Reserves are treated as an independent variable, starting with the level of reserves present in the historical hour and then decrementing the quantity of reserves according to the AS Plan. For example, if the AS Plan is 2000 MW for ECRS, the analysis runs a separate set of simulations for each level of reserves between 0 and 2000 MW, in increments of 200MW.

An Outage is defined as any scenario where the load at risk exceeds the level of reserves by more than the minimum contingency level that would trigger rolling outages, which is 1500 MW[24]:

$$Outage = \begin{cases} 1, & if\ Load\ at\ Risk > Reserves - 1500 \\ 0, & otherwise \end{cases}$$

Thus, for each hour, an hourly outage probability (HOP) is determined based on the number of iterations in the Monte Carlo simulation in which an Outage occurs:

$$HOP = \frac{number\ of\ iterations\ with\ an\ outage}{number\ of\ iterations}$$

An annual LOLP can then be determined from the series of hourly outage probabilities by calculating the probability of having no outages over the whole year as follows:

$$LOLP = 1 - \prod_{h\ \in\ year} [1 - HOP(h)]$$

The simulation is then repeated for the range of reserve levels described above and the LOLP is calculated as a model output for each reserve level.

[24] Per ERCOT Protocols 6.5.9.4.2(3)

Key Modeling Assumptions

Assumptions about Available Reserves

As mentioned in the methodology discussion above, reserves are treated as independent model variables. They are defined as any capacity that can be converted to energy in each time frame – ten minutes for ECRS and thirty minutes for Non-Spin. 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-minute or 30-minutes, respectively, for ECRS and Non-Spin,
- Offline resources providing ECRS and Non-Spin,
- Quick-start units scaled for their start-time,
- Load Resources providing RRS, ECRS, or Non-Spin,
- Large Flexible Loads, which already provide AS and predictably curtail in tight conditions,
- Duration-limited batteries (ESRs) are assumed to provide the quantity of capacity that – if dispatched – could be sustained for one hour[25], and
- Up-configurations for natural gas combined-cycle resources.

Importantly, these definitions and assumptions are not the same assumptions that ERCOT operates under when making AS procurement and deployment decisions. In particular, including all classes of resources that could be utilized to mitigate a potential loss of load assumes a reliance on non-obligated Resources for reliability services, which is not the current practice of ERCOT.

Assumed Use of Reliability Unit Commitment (RUC)

The IMM notes in their August 28, 2024 TAC workshop presentation that "[f]orecast errors becoming (sic) evident over longer time horizons are better addressed by commitment of longer-lead time resources through the RUC [process than Non-Spin]."

Embedded in the model's assumptions is a reliance on reserve availability from quick start units that are not explicitly providing AS, which equates to assuming that ERCOT will freely commit additional generation through the RUC process. However, since July 2021, stakeholder feedback has led ERCOT to seek additional reserves through increased procurement of AS quantities rather than through RUC.

Assumed Criteria for Recommending AS Quantities

As described in the introduction, ERCOT's methodology for determining AS procurement quantities currently uses *avoiding the need for issuing Watches for insufficient capacity* as its goal. In contrast, the IMM's approach assumes that *avoiding load shed* is the sole goal that drives AS quantities.

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[25] ECRS is defined by Protocol to require two hours of sustained deployment. Re-visiting duration requirements for AS is one of the recommendations from the IMM in this Study.

Differing assumptions between the IMM's model and ERCOT's current operational practices do not mean that the model or conclusions drawn using the model are incorrect, rather that interpretation of model results requires keeping the assumptions in front of mind. These assumptions can significantly impact policy decisions informed by this study. These important assumptions, amongst others noted in the Recommendations section below, will need to be carefully considered in any future modeling effort used to inform AS quantities.

Analysis and Results

The IMM's analysis in this AS Study concludes that ERCOT does have sufficient reliability tools, with respect to 10-minute and 30-minute operating reserves, under current conditions. The analysis also concludes that procurement of the non-frequency recovery portion of ECRS and Non-Spinning Reserve can be reduced while maintaining a satisfactory level of expected reliability.[26]

ECRS Results

The model utilizes all capacity that can be accessed in 10 minutes and assumes a required duration for batteries of one hour. The model uses the distribution of 30-minute net load forecast errors and forced outage probabilities to model the reliability risks in each iteration. If these risk cause reserves to fall below 1500 MW, the iteration is tallied as a loss of load event. Figure 19 provides a graphical representation of the results of this analysis.

[26] The study was performed evaluating the impact of changes in the quantities of ECRS and Non-Spin independently. As such, there is not an accurate method to evaluate the impact on reliability of coincident reductions in procurement of both services using the output from the simulations performed for this study without further analysis.

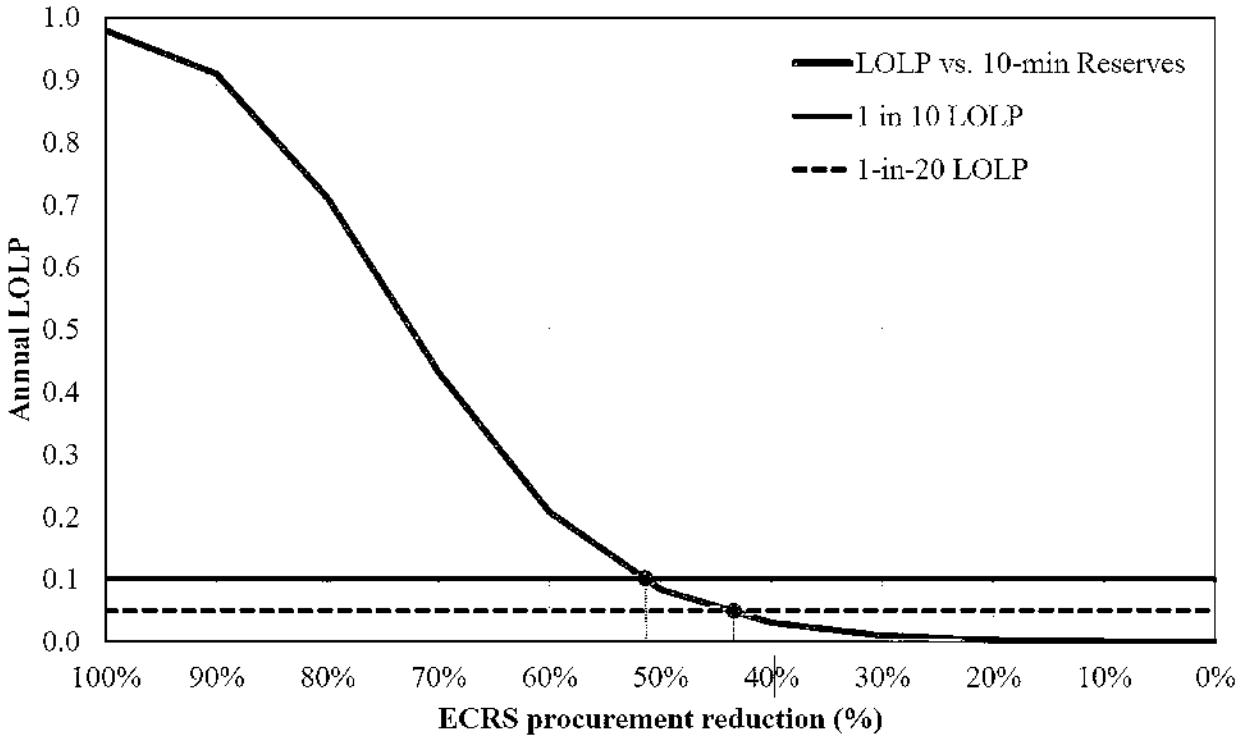

Figure 19 - ECRS Procurement Quantities Modeling Results

These results indicate that ERCOT could reduce the non-frequency recover portion of ECRS procurement by 52% in all hours and achieve a 1-in-10 reliability level (LOLP of 0.1), or by 43% in all hours and achieve a 1-in-20 1reliability level (LOLP of 0.05). However, it is also important to note that the LOLP in each simulation of this analysis is largely driven by a relatively small number of hours with much higher probabilities of load shedding.

Rather than uniformly reducing the AS plan across all hours, larger savings could be achieved by reducing procurements more in low-risk hours and less in high-risk hours. For example, this analysis finds that an annual LOLP of 0.05 can be achieved with an average reduction in ECRS procurements of more than 84% by reducing procurements by 40% from 4 p.m. through 9 p.m. in June through September, by 40% in hours with expected colder weather, and by 90% in all other periods. Further, this analysis suggests that even greater savings could be achieved if procurements were, additionally, dynamically varied based on expected conditions (load and renewable output).

Non-Spin Results

The model utilizes all capacity that can be accessed in 30 minutes and assumes a required duration for batteries of one hour. The model uses the distribution of one-hour net load forecast errors and forced outage probabilities to model the reliability risks in each iteration. If these risks cause reserves to fall below 1500 MW, the iteration is tallied as a load shedding event. Figure 20 provides a graphical representation of the results of this analysis.

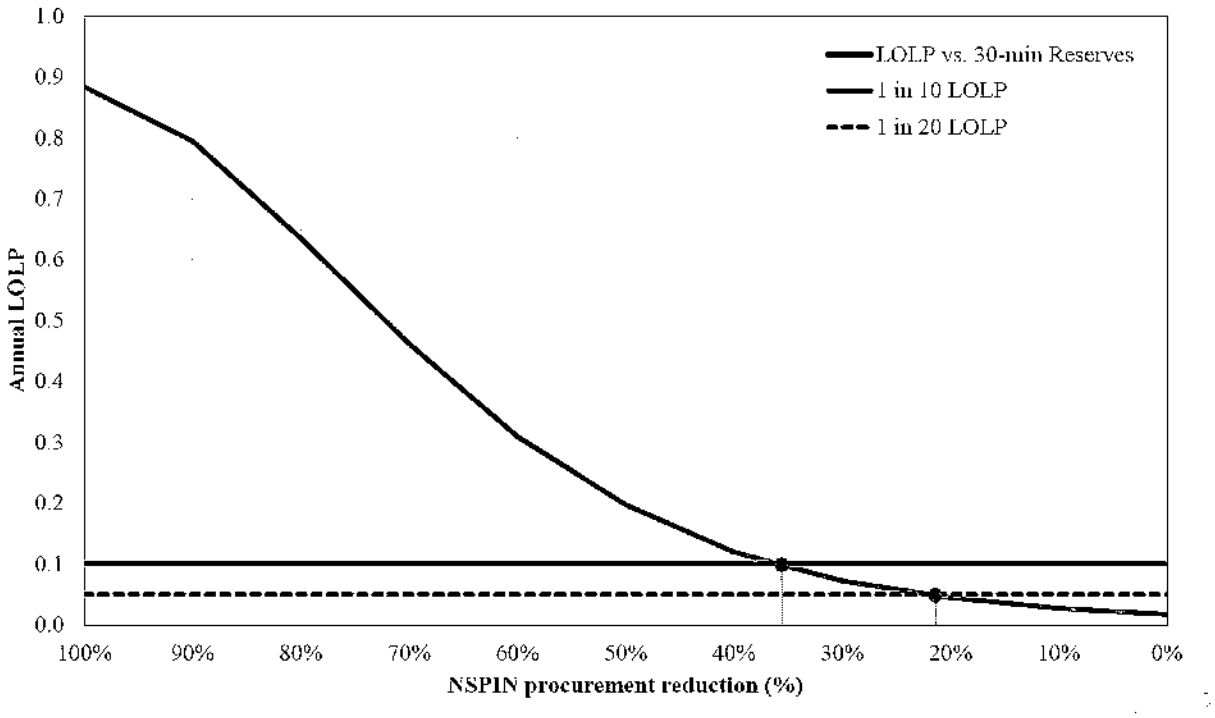

Figure 20 - Non-Spin Procurement Quantities Modeling Results

These results indicate that ERCOT could reduce Non-Spin procurement by 35% in all hours and achieve a 1-in-10 reliability level (LOLP of 0.1), or by 22% in all hours and achieve a 1-in-20 reliability level (LOLP of 0.05). As was the case in the ECRS analysis, the LOLP in the Non-Spin simulations is largely driven by a relatively small number of hours with much higher probabilities of load shedding.

Rather than uniformly reducing the AS plan across all hours, larger savings could be achieved by reducing procurements more in low-risk hours and less in high-risk hours. For example, this analysis finds that an annual LOLP can be achieved with an average reduction in Non-Spin procurements of more than 75% by reducing procurements by 10% from 5 p.m. through 9 p.m. in May through September, by 10% in hours with expected cold weather, and by 80% in all other periods. Further, this analysis suggests that even greater savings could be achieved if procurements were, additionally, dynamically varied based on expected conditions (load and renewable output).

ERCOT and IMM Recommendations Regarding Existing Ancillary Services[27]

ERCOT Recommendations

Current Reliability Tools are Sufficient

Overall, ERCOT finds that the existing AS products and the forthcoming DRRS are sufficient to meet the system's frequency control and uncertainty risk mitigation needs. ERCOT does not recommend additional AS products at this time.

However, as the ERCOT Region continues to transform and as technology continues to evolve, the AS methodology needs to also transform and evolve. Specifically, ERCOT recommends exploring the following two potential improvements in the near term:

1. Revamp the methodology used to calculate the non-frequency responsive portion of ECRS and Non-Spin quantities to use a probabilistic framework for quantifying reliability risks that these reserves are required to cover; and
2. Examine the benefits of determining some portion of AS quantities closer to the operating day based on days-ahead forecast conditions rather than strictly through an annual calculation.

Exploring Building a "Fully Probabilistic" AS Quantity Methodology

The current AS methodology for calculating minimum ECRS and Non-Spin quantities utilizes an approach that considers the historic risk drivers from a statistical perspective. As the ERCOT grid is evolving, the combination of risks that drive the need for Ancillary Services can differ significantly on different days and hours within the same week or month. Furthermore, there are two possible shortcomings of the approach that the current AS methodology uses.

First, the methodology does not incorporate all possible risk factors into a single stochastic calculation. For example, while the Non-Spin methodology accounts for the risk of net load under forecast error and unplanned generation trips, it uses a sliding percentile scale based on risk of net load up ramps to indirectly account for availability of other on-line/off-line capacity. Thus, the methodology does not indicate the true probability that a reserve shortage caused by insufficient Non-Spin quantities will lead to an adverse reliability outcome.

Second, there are not objective criteria by which to determine if the procured quantities of each AS will be sufficient or insufficient. Instead, the quantities are set based on percentiles of risk that are determined by ERCOT operating experience and judgment to prevent the need for issuing Watches or entering emergency operations.

ERCOT recommends that a methodology be developed that will produce statistical reliability indexes that can be measured against objective criteria to determine quantity sufficiency or insufficiency. Recent improvements in data science may make such a methodology possible, whereas it may not have been feasible just a few years ago. However, developing a robust, fully probabilistic framework for AS quantity determination will require substantial work and stakeholder discussion since the analysis of operational

[27] IMM and ERCOT recommendations are representative of their positions as of the initial draft study report's date, Oct. 1 2024.

reserve needs is significantly more complex than the statistical analysis of planning reserve needs, historically performed as part of a loss of load probability (LOLP) study.

To develop a fully statistical AS quantity methodology the following topics should be considered with stakeholders:

- How should the available capacity that is not providing AS be accounted? In other words, should historic available headroom that is not providing AS be counted in the probabilistic risk analysis? For example, during early morning hours there has historically been a number of generators that have headroom but are not carrying AS and could respond to forecast errors, thereby reducing the need for Non-Spin during these hours. That said, historically, ERCOT has set AS quantities based on an estimation of the risks. This approach guarantees that resources with the right operational characteristics will be available to cover these risks and does not rely on past actions/behavior from Market Participants which may not continue.
- How should increases in variability and uncertainty due to wind, solar, and load growth, as well as future changes in generator commitment patterns be accounted for in the statistical methodology?
- What are the appropriate criteria to use for each AS type? Are the criteria simply a matter of avoiding loss of load, or should there be criteria related to avoiding entering into an EEA or a Watch due to insufficient reserves? How should avoiding the need for manual operator actions be included in the criteria?
- How should temporal constraints and cumulative factors be accounted? The possibility of multiple generator trips across multiple hours (as occurred on May 13, 2022, for example) presents a risk that needs to be covered by AS. Increasingly, AS products are being provided by duration limited resources (battery energy storage). There is some risk that battery energy storage resources providing AS deplete their storage during a multi-hour forecast error event, even if they are meeting all applicable requirements. Also, AS is needed until other generators can be started or until the conditions causing the need for the reserves from AS change. All these factors present challenges when calculating the probabilistic need for AS.
- How much can other types of AS reserves be counted on to address risks for a given AS product? For example, should some or all of ECRS be counted towards meeting the reserve needs covered by Non-Spin?

Responses to these questions directly impact the volume of reserves procured and operational actions needed to continue reliable operations. As an example, setting reserves too low could result in lower self-commitment and tools like RUC may be necessary to cover the overall expected operational risk on such days. For proper balance, stakeholder and, potentially, policymaker input on these issues is essential.

Exploring Procuring Some Portion of AS Dynamically

Several of the AS products are used to cover risks associated with load and generation variabilities. Those variabilities are expected to increase substantially in the future and can also differ significantly on different operating days and hours. The quantities of each AS product have increased in recent years to cover the most severe risks and this trend is expected to continue with the anticipated increases in passive response from demand, including LFLs, wind generation, solar generation, and resources on the distribution system, all of which can increase operational variability and uncertainty. Further, the difference between true minimum quantities or typical quantities of some AS products and the quantity needed to meet reliability risk objectives for worst-case or near worst-case conditions may increase in the future.

Based on this, ERCOT should work with stakeholders to reexamine the tradeoffs between the certainty of calculating AS quantities on an annual basis and the efficiency of calculating at least some portion of AS quantities closer to the operating day. A possible framework could involve setting minimum, "expected," and maximum AS quantities in an annual study, and then setting the actual quantity for an Operating Day before the DAM runs. The actual quantity would be within the minimum and maximum range. This recommendation is relevant for the current market design as well as under RTC+B.

IMM Recommendations

Current Reliability Tools are Sufficient

Based on their modeling analysis described above, the IMM concludes that ERCOT has sufficient reliability tools, with respect to 10-minute and 30-minute operating reserves, under current conditions. The IMM does not recommend additional AS products at this time.

Procurement of ECRS and Non-Spin Can be Reduced

The IMM also concludes that procurement of ECRS and Non-Spinning Reserve can be reduced, while maintaining a satisfactory level of expected reliability.[28]

- The analysis results suggest that ECRS procurement can be reduced by 52% across all hours and achieve a 1-in-10 reliability level (LOLP of 0.1) or reduced by 43% across all hours and achieve a 1-in-20 reliability level (LOLP of 0.05).
- The analysis results suggest that Non-Spinning Reserve procurement could be reduced by 35% in all hours and achieve a 1-in-10 reliability level (LOLP of 0.1) or reduced by 22% in all hours and achieve a 1-in-20 reliability level (LOLP of 0.05).
- The LOLP is driven by relatively small number of hours with very high probabilities of load shedding. As such, the analysis results suggest that larger savings could be achieved by reducing procurements more in low-risk hours and by less in high-risk hours.

Recommend Building a "Fully Probabilistic" Analysis of Risks

AS procurement quantities should be informed by a probabilistic analysis of the reliability risks addressed by the AS products. The stochastic model developed by the IMM and used as the basis for these recommendations is a proof-of-concept example of such a probabilistic analysis. This recommendation is relevant for the current market design as well as under RTC+B.

Recommend Procuring Some Portion of AS Dynamically

Additional benefits can be achieved by making the AS procurement quantities dynamically based on the factors that tend to affect the reliability risks, rather than setting future quantities annually. This recommendation is relevant for the current market design as well as under RTC+B.

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[28] The study was performed evaluating the impact of changes in the quantities of ECRS and Non-Spin independently. As such, there is not an accurate method to evaluate the impact on reliability of coincident reductions in procurement of both services using the output from the simulations performed for this study.

Recommend Re-visiting AS Duration Requirements for AS

As more of the system needs are met by batteries, 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, and
- compel gas-fired units to provide reserves when it would be more efficient for them to produce energy.

This lowers reliability by inefficiently reducing batteries' state of charge.

A preliminary analysis of historical events that the reserve products would typically be deployed to address to identify reasonable duration requirements supports a one-hour duration requirement for Non-Spin and ECRS, although a subsequent more stochastic approach would be more definitive.

Recommend Pricing AS Based on Each Sub-type's Shadow Prices

Since the 2019 State of the Market Report, the IMM has recommended pricing ancillary services based on the shadow price of procuring each service. In other words, they recommend pricing each sub-type separately, for sub-types with individual quantity limits.

That report stated:

"Clearing prices should reflect the constraints that are used by ERCOT to purchase ancillary services. However, this is not currently the case with certain ancillary services. ERCOT's procurement requirements for Responsive Reserve Service effectively limit the quantity of under-frequency relay response that can be purchased from load resources. Because these limits are not factored into the clearing prices, there is usually a surplus of relay response offered into the market. However, the surplus does not drive clearing prices down as one would expect in a well-functioning market. Each year the surplus grows, an indicator of the inefficient pricing in this market.... Therefore, the IMM recommends that the clearing price of ancillary services, both current and future, be based on all the constraints used to procure the services."

This recommendation is relevant for the current market design as well as under RTC+B.

ERCOT and IMM Recommendations Regarding Additional Ancillary Services[29]

Additional Ancillary Services

Neither ERCOT nor the IMM recommends developing any additional ancillary services at this time.

Appendix 6 discusses potential future AS needs for the ERCOT Region as the Region continues to transform and as technology continues to evolve.

Dispatchable Reliability Reserve Service Implementation Update (AS OF OCT 1, 2024)

Dispatchable Reliability Reserve Service (DRRS) is a new type of AS introduced in House Bill 1500 from the 88th Texas Legislature. DRRS is intended to cover risks associated with historical variations in generation variability, including intermittency of non-dispatchable generation resources and forced outages. Resources providing DRRS must be capable of being on-line and dispatchable within two hours of being called on for deployment, must have dispatchable flexibility, and must be capable of running for at least four hours at the resource's high sustained limit.

ERCOT filed NPRR1235, Dispatchable Reliability Reserve Service as a Stand-Alone Ancillary Service, to implement the framework and requirements for DRRS in the ERCOT market. At the time of this paper, NPRR1235 is proceeding through the ERCOT stakeholder process. DRRS is expected to be implemented sometime after the RTC+B project. ERCOT will begin discussions with stakeholders regarding the methodology to determine procurement quantities of DRRS after NPRR1235 has been approved by the PUC.

In comments[30] on NPRR1235, the IMM stated:

> *"We are supportive of the NPRR with the following qualifications:*
>
> *The current concept of procuring physical obligations to provide DRRS through DAM and then deploying DRRS through Reliability Unit Commitment (RUC) is likely an improvement compared to over-procuring Non-Spinning Reserve (Non-Spin) or relying on out-of-market RUCs, but a procurement process closer to Real-Time would improve market outcomes and better account for Real-Time system conditions. It may not be feasible to co-optimize DRRS with energy and other Ancillary Services in the Real-Time Market (RTM) because of the different time horizons associated with each product, but DRRS could hypothetically be procured in a separate process closer to Real-Time. This could allow for an efficient rearrangement of DRRS capacity and co-optimized energy / reserve services that reflect changes in conditions since the Day-Ahead Market (DAM) clearing.*
>
> *NPRR1235 currently includes a flat penalty price of $150/MWh for when DAM procures less than the full plan for DRRS. This is preferable to forcing DAM to procure the full volume of DRRS even under tight system conditions, but a sloped demand curve for DRRS would better reflect the marginal reliability value of procuring additional DRRs and will result in more efficient price formation (for reserves and electricity) in the DAM.*
>
> *The effectiveness and efficiency of DRRS implementation is highly dependent on the procurement volumes. While not addressed in this NPRR, it will be important to accurately calibrate the procurement of DRRS to the spot market need identified that motivated the product. DRRS is a spot market product intended to address a*

[29] IMM and ERCOT recommendations are representative of their positions as of the initial draft study report's date, Oct. 1 2024.

[30] https://www.ercot.com/files/docs/2024/09/11/1235NPRR-15%20IMM%20Comments%20091124.docx

narrow need related to forecast uncertainty beyond what is covered by existing products. As such, we do not feel that extending the purpose of this product to cover resource adequacy issues associated with out years is appropriate.

Also critical for effectiveness is the deployment criteria. As noted in other cases, a deployment criteria that is too conservative may result in artificial scarcity in the electricity and other reserve markets, adversely affect price formation, and result in unnecessary excess cost.

DRRS implementation could have adverse effects on price formation in either direction. In addition to artificial scarcity, procuring and deploying DRRS outside of the Real-Time Co-optimization (RTC) framework could result in suppression of Real-Time prices. This NPRR anticipates this with applying the Reliability Deployment Price Adder. This aspect is crucial to avert price suppression in the RTM."

Staff's Analysis, Recommendations, and Next Steps

Topic 1: Sufficiency of Current Ancillary Services

PURA § 35.004 (g) (SB3, 87R) states that Ancillary Services (AS) are "necessary to facilitate the transmission of electric energy including load following, standby power, backup power, reactive power, and any other services as the commission may determine by rule."

Currently there are four major types of AS:

> Regulation Services (Reg-Up and Reg-Down) are provided by resources that can respond to signals from ERCOT to adjust their output or consumption within five seconds to address rapid changes in system frequency.
>
> Responsive Reserve Service (RRS) is provided by resources that can, within the first few seconds, arrest significant frequency deviations on the grid and, ultimately, help restabilize system frequency. One example of an event that would cause such a deviation is a large generation resource tripping offline.
>
> ERCOT Contingency Reserve Service (ECRS) is provided by resources that can be available within 10 minutes and provide the service for at least two consecutive hours to cover errors in forecasting or to replace deployed reserves.
>
> Non-Spinning Reserve Service (Non-Spin) is provided by resources that can be available within 30 minutes and provide the service for at least four consecutive hours to cover errors in forecasting and to replace deployed reserves.

Stakeholder Commentary

In the draft study report, both ERCOT and the Independent Market Monitor (IMM) found that the AS products above, combined with the nascent Dispatchable Reliability Reserve Service (DRRS), are sufficient for meeting the system's frequency control and uncertainty risk mitigation needs.[31] Neither ERCOT nor the IMM recommended additional AS products at this time.

Overall, stakeholders agreed that Regulation and RRS are performing as designed and no change is needed. ERCOT's North American Electric Reliability Corporation (NERC) balancing standard performance scores confirm this, and Staff does not recommend changes to Regulation or RRS at this time. Staff received some comments disagreeing with the IMM's recommendation to reduce quantities for ECRS and Non-Spin.

Staff Analysis and Recommendations

As described in the draft AS Study report, these services provide operational capabilities to satisfy two fundamental purposes:

1. Meet NERC reliability standards[32]

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[31] *See* AS Study Draft Report and Next Steps, AIS Item No. 13 (Oct. 1, 2024).

[32] Table 5 in the draft report describes how each service is used to meet these NERC requirements.

The majority of Regulation and RRS procurement quantities are based on these frequency requirements. In *Appendix 3, Effectiveness of AS* in the draft report, ERCOT provided performance metrics demonstrating the strong effectiveness of AS in meeting these standards.

2. Reduce operational risks associated with variability and uncertainty

   The second function of AS is operational reserve capacity to cover unexpected variations in system conditions and, thus, reduce the necessity of Watches, emergency operations, and load shed due to insufficient resource commitment. The three main sources of variability are: 1) load forecast error, 2) wind and solar forecast error, and 3) forced unit outages. As the ERCOT resource mix has evolved over the years, including increased penetration of intermittent resources and energy storage resources (ESR), determining the quantity and quality of reserves for this second purpose has become increasingly more complex. Additionally, the deployment of AS and the relationship between AS procurement and price signals has become more contentious, with ECRS deployments in the summer of 2023 being one example.

Staff agrees with the IMM and ERCOT that ERCOT has sufficient AS to comply with NERC requirements and provide 10- and 30-minute operational reserves to respond to operational variability and uncertainty. The new Dispatchable Reliability Reserve Service (DRRS) being developed to comply with PURA § 39.159(d) (HB1500, 88R) will offer a useful new ancillary service to address longer horizon inter-hour risks and reduce out of market Reliability Unit Commitment (RUC) actions.

Staff recommends that ERCOT continue to monitor the need for new AS based on the evolution of the ERCOT system, including changes in system inertia, large load growth, increased Energy Storage Resource (ESR) participation, and other system developments. Considerations for the determination of the quantities of these AS are addressed in other parts of the Staff recommendations.

Suggested Next Steps

Updates to ERCOT's AS Methodology now require Commission approval, providing an annual opportunity for the Commission to oversee this process. Staff will follow this process and if needed will reevaluate sufficiency of the current AS, particularly after real-time co-optimization plus batteries (RTC+B) and DRRS are implemented.

Topic 2: Providing Adequate Incentives for Dispatchable Generation

Stakeholder Commentary

Some parties commented that the draft report did not address the statutory requirement in PURA § 35.004(g) to evaluate whether additional AS are needed for reliability while providing adequate incentives for dispatchable generation. Several parties opined that reducing the AS quantities by targeting a less conservative procurement criterion, combined with expected efficiency gains resulting from the implementation of RTC+B and the absolute annual cost cap included in the design of the Performance Credit Mechanism (PCM), would inappropriately reduce long-term investment incentives.

Relatedly, there were also written and verbal comments stating that DRRS procurement quantities should be set at a level high enough to meet the recently adopted reliability standard (16 TAC § 25.508). In opposition to this view, others stated that DRRS quantities should be determined primarily based on operational needs and not based on granting DRRS a special status for resource adequacy purposes.

Multiple parties commented that the RTC Ancillary Service Demand Curves (ASDCs) as currently designed will not meet the needs of the current market. This topic, which is being actively discussed in the stakeholder process, was brought up after the scope for this study was approved and, therefore, was not originally included in the discussion, but Staff has included it here for completeness.

Staff Analysis and Recommendations

The reliability standard rule has already established a process for assessing and ensuring resource adequacy. Staff recommends that AS be considered one of the tools in the toolbox that the Commission can use to address resource adequacy when considering potential market design updates following the reliability assessment in 2026 as required by the rule. However, AS product design and procurement methodologies should first focus on the operational reliability needs the service is intended to address. Moreover, the holistic reliability standard assessment and resulting changes are more likely to achieve the desired resource adequacy results than a piecemeal approach.

In accordance with the new reliability standard rule, beginning January 1, 2026, ERCOT is expected to initiate an assessment *to determine whether the bulk power system for the ERCOT region is meeting the reliability standard and is likely to continue to meet the reliability standard for the three years following the date of assessment.* This assessment will be conducted at least once every three years, will include opportunities for stakeholder comments and will give the Commission the opportunity to address resource adequacy holistically and compare the cost and reliability benefits of potential market design changes, including changes to real-time and ancillary services markets (including ASDCs and criteria for determining AS quantities).

Staff will continue actively monitoring RTC+B stakeholder meetings and recommends that non-resource adequacy related changes to ASDCs be addressed in that venue and codified via a Protocol Revision Request. There are two types of changes to the ASDCs currently being discussed: 1) changes that increase the area under the curve of the aggregate ORDC and 2) changes to how the aggregate ORDC is disaggregated to formulate individual demand curves for each AS. The area under the curve of the aggregate ORDC is set formulaically based on Commission direction in *Review of Real-Time Co-Optimization in the ERCOT Market,* Project No. 48540. Therefore, Staff recommends that changes to ASDC process be limited to those changes that affect the disaggregation of the aggregated curve only and not the area under the curve. Changes to the shape of the aggregate curve can be included in the reliability standard assessment.

As noted in Topic 3, Staff also recommends targeting DRRS for dispatchable generation, at least initially, in order to provide an additional market-based revenue source and help incentivize dispatchable generation.

Suggested Next Steps

Address resource adequacy topics holistically within the periodic reliability assessments as required by 16 TAC § 25.508.

Topic 3: Appropriate Criterion for AS Procurement Quantities

Stakeholder Commentary

There was disagreement among commenters on the proper criterion for establishing AS procurement quantities. Some supported ERCOT's recommendation to continue the current operating posture,

implemented following Winter Storm Uri, of operating with a goal of *avoiding Watches*. Others recommended adopting a less conservative approach target of only *avoiding involuntary load shed*, as suggested by the IMM.

Some commenters suggested that *avoiding Energy Emergency Alerts (EEAs)* would be a reasonable compromise between these two positions. During the October 31, 2024 workshop, ERCOT noted that when the first EEA level is reached today, conditions are significantly closer to load shed than would have been before changes were made to EEA levels and procedures in October 2021. Specifically:

- Before these changes, the system was 3100 MW away from load shed when an Advisory for PRC<3000 MW was called and 2600 MW away from load shed when EEA1 was called.
- Currently, the system is 3100 MW away from load shed when a Watch for PRC<3000 MW is called and 1000 MW away from load shed when EEA1 is called.[33]

Staff Analysis and Recommendations

There is value in avoiding emergency operations and Watches, over and above the value of not shedding load. This includes intangibles such as the value of positive public perception as it relates to Texas's ability to attract new business and the value of meeting expectations from public for a more resilient electric system.

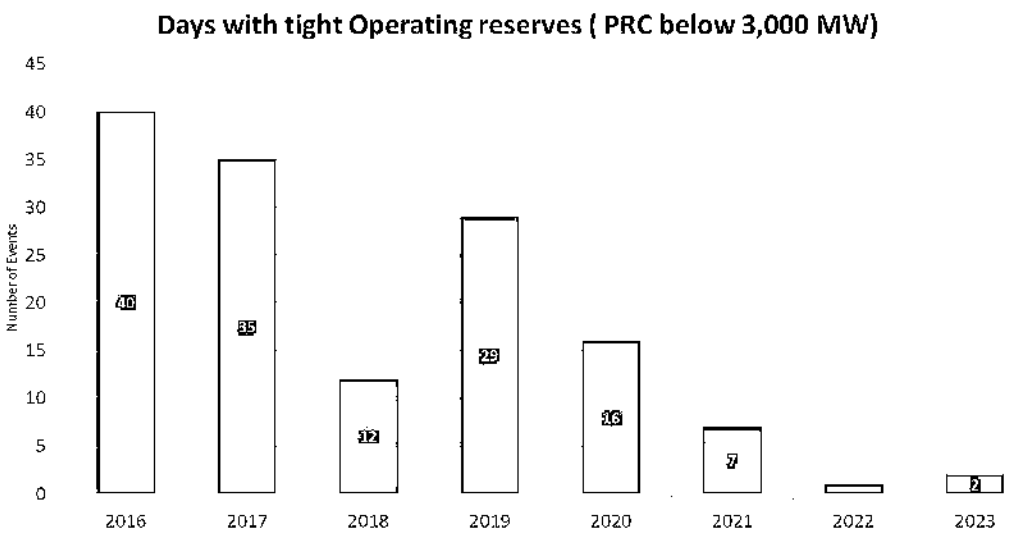
Staff agrees with ERCOT and the IMM that the primary goal of AS is to address real-time risks of system variability, forecast errors (wind, solar, and load), and forced outages. While AS can impact resource adequacy through its role as an important revenue source to retain and incent new generation, this consideration should be made within the broader holistic assessment.

Increased reliability through increasing procurement of AS comes with tangible and intangible benefits but necessarily also comes with increased costs. Staff recommends that this is an appropriate time to revisit AS procurement levels established after Uri to ensure that the proper balance between reliability and cost is maintained.

In order to achieve this balance and to provide market stability and transparency, Staff recommends the Commission clearly articulate an objective criterion for determining AS quantities. "Avoiding Watches" and "Avoiding emergency operations" are not objective criteria.

As the below chart shows, the number of days where Watch conditions for PRC<3000MW have occurred has dramatically declined over time. However, even this data does not confirm or refute whether the goal of "Avoiding Watches" has been met, since it is not defined in measurable terms.

[33] *See* materials filed in support of ERCOT's presentation during the October 30, 2024 AS workshop, filed in Project No. 55845: https://interchange.puc.texas.gov/search/documents/?controlNumber=55845&itemNumber=40.



Examples of potential objective criteria are:

- A specified confidence that no Watches due to low reserves will occur. (i.e., "There is an X% chance that no Watches due to low reserves will occur each year."
- A specified confidence in experiencing no more than a maximum tolerable number of Watches. (i.e., "There is a Y% chance that no more than Z Watches will occur each year.")

ERCOT can support the Commission's decision-making by developing a tool that will be capable of providing the type of data described in the table below.

Here, each scenario corresponds to a quantity of upward reserves. Based on any such criterion, an analysis could be conducted to determine the associated probability of experiencing a Watch, the probability of experiencing more than Z Watches (for any desired value of Z), the expected number of Watches, the probability of entering emergency conditions (EEA1), and the probability of experiencing load shed (EEA3). Given the relationship between PRC and the various system conditions, for any given scenario, we would expect that the probability of a watch will exceed the probability of EEA1, which in turn will exceed the probability of EEA3. Comparing across the criteria, as the reserve quantity decreases, we would expect the probability of any event to increase.

Collectively, this data could be used to compare the estimated costs of different criteria against their corresponding risks and allow for a quantitative determination of a criterion that strikes the best balance between cost and risk.

Scenario	Total Upward Reserve Quantity	Probability of a Watch due to low reserves (PRC <3000)	Probability of Experiencing more than Z Watches due to low reserves (PRC<3000)	Expected Number of Watches due to low reserves	Probability of EEA1 (PRC<2500) due to low reserves	Probability of Load Shed (EEA3) (PRC <1500) due to low reserves
Current Policy	**AT LEAST 6500 MW**	**$Prob_{Watch,0}$**	**$Prob_{Z,0}$**	**$N_{Watch,0}$**	**$Prob_{EEA1,0}$**	**$Prob_{EEA3,0}$**
Potential Criterion 1	Q_1	$Prob_{Watch,1}$	$Prob_{Z,1}$	$N_{Watch,1}$	$Prob_{EEA1,1}$	$Prob_{EEA3,1}$
Potential Criterion 2	Q_2	$Prob_{Watch,2}$	$Prob_{Z,2}$	$N_{Watch,2}$	$Prob_{EEA1,2}$	$Prob_{EEA3,2}$
…	…	…	…	…	…	…
Potential Criterion n	Q_N	$Prob_{Watch,n}$	$Prob_{Z,n}$	$N_{Watch,n}$	$Prob_{EEA1,n}$	$Prob_{EEA3,n}$

Suggested Next Steps

Ask ERCOT to develop a tool that will be capable of creating current estimates of costs and probability of experiencing a Watch/Emergency Conditions/Load Shed for several potential alternative target reserve levels as soon as practicable and no later than to support the Commission setting the procurement criteria for 2027 AS Methodology.

Topic 4: Dynamic Determination of AS Quantities

Stakeholder Commentary

ERCOT and the IMM both recommended potentially procuring some portion of AS dynamically, i.e., moving from the current approach where minimum quantities for each AS are set equal to the full quantity expected to be needed for each operating hour to an approach that sets these quantities closer to real time. Commenters on the draft AS study broadly agreed that dynamic procurement may be more efficient and will tend to reduce the quantities needed to maintain the same target operational reliability level, since uncertainty tends to decrease closer to the operating day. However, there were concerns raised regarding how this may impact hedging practices for loads and generators. Some suggested it would be beneficial for ERCOT to produce expected and maximum quantities in addition to minimum quantities as part of the annual assessment.

Staff Analysis and Recommendations

Staff recommends that some form of dynamic AS procurement be implemented as soon as practicable due to the potential efficiency gains that could be achieved by this change. The current annual AS methodology

sets the minimum quantities for each AS equal to the full quantity that is expected to be needed for each operating hour of the following year. Since there is greater uncertainty when making decisions further ahead of time, this will tend to increase costs by driving up the required AS quantities. Determining at least some portion of AS on a more dynamic basis will tend to reduce the quantities needed, thereby resulting in more efficient procurement and reduced costs for consumers. This recommendation is particularly relevant for certain types of AS (e.g., ECRS, Non-Spin), but even other AS (e.g., Reg, RRS), for which quantities are more constrained, may be dynamically adjustable to some extent.

Staff recommends that ERCOT work with stakeholders to develop a dynamic AS methodology that best balances the tradeoffs between the clarity of calculating AS quantities entirely on an annual basis (as is done currently) and the efficiency of calculating some portion of AS quantities closer to the operating day. Setting AS quantities entirely on an annual basis provides clarity for load serving entities (LSE) and improves their ability to hedge AS costs in advance. To mitigate the impact that a dynamic AS procurement would have on an LSE's ability to hedge costs, the dynamic methodology could involve an annual assessment that establishes both minimum and expected quantities, with actual quantities determined closer to the operating day. Minimum quantities could, for example, be set as a fixed percentage of the expected quantities. Or, in the event a probabilistic AS methodology is adopted at a future date, minimum quantities could be set annually based on a less conservative criterion (e.g., avoiding load shed, avoiding emergency operations), while expected and actual quantities are set, closer to the operating day, based on a more conservative criterion.

Staff also notes that, while this new approach would not necessitate a change in the risk tolerance associated with AS procurement quantities, it is likely to result in reduced procurement quantities at any level of risk. Additionally, a dynamic procurement methodology has the additional benefit of allowing for the incorporation of newly identified risks that were unforeseen further in advance of the operating day.

Suggested Next Steps

Ask ERCOT and TAC to develop key principles for implementing dynamic AS quantity determinations for ECRS and Non-Spin using a phased approach that begins no later than with the 2028 AS Methodology.

Topic 5: Probabilistic Modeling to Determine AS Quantities

Stakeholder Commentary

Both ERCOT and the IMM recommend considering a fully probabilistic AS quantity determination methodology. Commenters on the draft AS study broadly agreed that a probabilistic modeling approach may be superior to a historical statistical approach due to the potential for improved accuracy and the natural ability to incorporate objective reliability targets into such an approach. Additionally, ERCOT noted that recent advances in data science have made this approach more feasible than in the past.

There was also broad agreement on the importance of carefully and transparently establishing modeling assumptions. Faulty model assumptions leading to over- or under-stating AS quantity requirements was noted as a potential shortcoming of this approach. Clearly identifying appropriate assumptions and inputs is a critical step in developing a suitable probabilistic model that will yield consistent and accurate outputs.

Staff Analysis and Recommendations

Staff recommends that ERCOT adopt a probabilistic modeling approach for determining AS quantities. This will allow for an AS methodology that can be based on an established, objective reliability criterion and that is better able to account for all possible risk factors.

As discussed in Topic 3, Staff recommends that the Commission should establish an AS procurement criterion that can be incorporated into a probabilistic AS methodology. Going forward, Staff would recommend that the Commission review this criterion in concert with any potential market design updates considered following each regular reliability standard assessment. Staff also recommends that modeling assumptions should be reviewed as part of the annual AS Methodology review.

While out of scope of this study, Staff notes that implementation of this change should be undertaken deliberately and carefully coordinated with other market changes, and this should not delay the implementation of RTC+B.

Suggested Next Steps

Ask ERCOT to develop a suitable probabilistic model, provide regular updates to TAC, and present options that can be incorporated no later than the 2027 AS Methodology.

Topic 6: Dispatchable Reliability Reserve Service (DRRS)

Stakeholder Commentary

Both ERCOT and the IMM recommend considering DRRS as primarily an Ancillary Service as opposed to a tool for resource adequacy. Commenters were split on the topic of whether DRRS was intended to be a resource adequacy tool and the consequences thereof.

Staff Analysis and Recommendations

As an initial matter, Staff recognizes that, other than the requirements specified in PURA § 39.159(d) and (e), DRRS is still being designed in the stakeholder process.[34] Accordingly, this recommendation is based on assumptions about the ultimate design. In particular, Staff understands that DRRS will be implemented after RTC+B and that, initially, it will not be co-optimized with energy and other Ancillary Services in real-time. Furthermore, Staff understands that the initial implementation will only include dispatchable generation capable of "running for at least four hours at the resource's high sustained limit".[35] With that understanding, Staff makes the following observations and recommendations.

Staff has reviewed the comments regarding the role of DRRS as a resource adequacy tool and recommends that the Commission not grant it a special status for this purpose. While the arguments both for and against the role of DRRS as a resource adequacy tool are well-taken, it is important to recognize two key points. First, PURA defines DRRS as an ancillary service, and, as noted above, these are products designed to

[34] NPRR 1235, *Dispatchable Reliability Reserve Service as a Stand-Alone Ancillary Service*.

[35] PURA § 39.159(d)(2)(A).

address explicit risks to reliable operations of the bulk power system. Second, designating DRRS as a resource adequacy tool is not necessary to use it for resource adequacy purposes, though, making such a designation could lead to misunderstandings. Designating DRRS as a resource adequacy tool might create the impression that the Commission must use the procurement of DRRS for that purpose. Moreover, as DRRS would be the first and only service with such a designation, it might create the impression that other services, including other Ancillary Services, cannot be used for resource adequacy purposes. To the extent that the Commission seeks to further incentivize dispatchable generation, changes to DRSS procurement design could be one of the many options available.

Because DRRS is an AS intended to serve a reliability purpose and has been mandated with specific operational requirements, the primary focus of DRRS design should be on meeting its reliability objectives and statutory requirements. Staff recommends that present design efforts not be diverted to also design DRRS to meet some resource adequacy goal. Changes to the design are always available for future consideration.

Staff is also aware of stakeholder discussions concerning the use of energy storage resources (ESR) to provide DRRS. Staff understands that DRRS was initially targeted towards dispatchable generation but should not ultimately exclude other resources, such as ESRs. Accordingly, Staff concurs with ERCOT's plan for the first implementation of DRRS to only support the use of dispatchable generation. If later deemed appropriate, other resources, like ESRs, could be included in subsequent versions provided that any eligible resource is technically capable of meeting the service's dispatch requirements.

Based on the current status of DRRS design and the comments received on this topic, Staff does not have any recommendations regarding the effect of DRRS on pricing outcomes at this time. While it is known that DRRS may have an effect on energy price formation based on the procurement and deployment criteria, it is not possible at this time to accurately predict those impacts without a more thorough understanding of the market after the implementation and stabilization of RTC.

Staff will continue to monitor the development of NPRR 1235 consistent with any guidance provided by the Commission.

Suggested Next Steps

Request that ERCOT continue to work on NPRR 1235 with stakeholders and recommend that DRRS should not be granted special status as a resource adequacy tool.

Topic 7: Other Considerations

Other Reliability Services not Procured in DAM

Staff asked for stakeholder feedback regarding how other reliability services not procured in DAM, such as Firm Fuel Supply Service (FFSS) and Emergency Response Service (ERS), should be considered within this review. Unlike AS, both FFSS and ERS are procured seasonally for future months through an RFP process. There was overall agreement that, if the risks these services are procured to mitigate are not the same risks considered in the annual AS methodology, then there would be no overlap. However, some opined that if there are any overlaps during certain weather events, then ERCOT's modeling should take it into account and prevent double counting and over procuring.

FFSS

Currently, FFSS is designed to address weather-driven risks in the natural gas supply chain. Generators are compensated for having on site secondary fuel sources or having direct access to natural gas inventory. There is no energy held out of RTM market like the AS procured in DAM. It is a very specific program to insure for a very specific risk. Staff agrees with commenters that FFSS provides longer duration (48 hour) support to grid reliability that is not considered in the AS methodology. Therefore, Staff does not recommend any change to FFSS as part of this study. Changes to FFSS can be taken up in Project No. 56000, *Firm Fuel Supply Service*, and any potential impacts of FFSS on probabilistic modeling assumptions (such as reduced generator outage rates) can be addressed during the annual AS Methodology process.

ERS

As currently designed, ERCOT can deploy ERS as an operational tool prior to or during an Energy Emergency Alert (EEA). ERS is used to decrease the likelihood of depleting operating reserves and the need for ERCOT to order shedding of firm load, which occurs at EEA3 ERCOT may also deploy ERS resources during EEA3. Capacity procured can be from loads with backup generation, and the total amount of ERS is historically less than 1500 MW. ERS provides another layer of insurance. However, there were comments requesting that the Commission reevaluate the requirements for ERS to allow for more demand response participation. Some stakeholders have suggested developing a long-lead time demand response product. This would not be an ancillary service but would be an additional reliability tool similar to ERS that could cost-effectively reduce the risk of involuntary firm load shed. There was also a recommendation for ERCOT to create new day-ahead products focused on demand response for different customer classes in the retail market, such as (1) large commercial and industrial customers, (2) small to mid-sized commercial and industrial customers or aggregations, and (3) residential aggregations.

Staff recommends ERCOT perform a holistic review of all existing demand response programs, including ERS, and provide recommendations to TAC and the ERCOT Board. This is consistent with the Phase 1 market blueprint that required "Adopt[ing] changes that allow for more targeted demand response to increase utilization of load resources for grid reliability."[36]

Duration Requirements for ECRS and Non-Spin

In the draft report, the IMM recommended revisiting the duration requirements for ECRS and Non-Spin. According to the IMM, as more of the system needs are met by batteries, duration requirements for the AS products becomes an increasingly important design decision. Therefore, the IMM stated that duration requirements that are overly aggressive may result in inefficiently reducing batteries' state of charge and reducing reliability. Based on the IMM's preliminary analysis, historical data supports a one-hour duration requirement for Non-Spin and ECRS, although the IMM recommended a more in-depth analysis before any change.

ERCOT filed NPRR 1096 on September 28, 2021, which was approved by the Commission on May 12, 2022. This NPRR required resources that provide ECRS to limit their responsibility to a quantity of capacity that is capable of being sustained for two consecutive hours, and for resources that provide Non-Spin to limit their

[36] *See* Approval of Blueprint for Wholesale Electric Market Design and Directives to ERCOT, Project No. 52373, AIS Item No. 336, (January 13, 2022).

responsibility to a quantity of capacity that is capable of being sustained for four consecutive hours. At that time, ECRS was yet to be implemented and those durations requirements were more aligned with the reliability requirements of those services. However, in the business case of the NPRR, ERCOT stated that when RTC is implemented, it would reassess if the duration requirements for ECRS and Non-Spin can be lowered. In addition, based on stakeholder discussions, future design changes to the DAM, Reliability Unit Commitment (RUC), and RTC clearing engines to consider state of charge for ESRs will also lead to a reassessment of the duration requirements for ECRS and Non-Spin.

Staff sees merit in ERCOT reevaluating the ECRS and Non-Spin duration requirements as recommended by IMM based on a more stochastic approach. However, this evaluation should only be started after RTC+B implementation, in alignment with ERCOT's proposed approach described in NPRR 1096.

Separately Pricing AS Subtypes

Ancillary Services can be provided by controllable and non-controllable load resources, ESRs, and generation resources. ERCOT's AS procurement process limits the quantities it procures from certain type of load resources. However, there is a single market clearing price for the same main ancillary service regardless of the different procurement characteristics of any sub-types. For some sub-types, this results in a surplus being offered into the market. In a well-functioning market, a surplus of any service is expected to drive clearing prices down, which has not been observed. Therefore, the IMM concluded, in 2019, that the clearing price of all ancillary services should incorporate all constraints affecting the procurement of the service.

Staff agrees that more homogenously defining each separate service is likely to result in more efficient pricing because resources with similar characteristics will compete against each other to provide the requested service. Staff is aware that this topic has been discussed previously in the stakeholder process and rejected due to concerns about reduced participation of load resources. However, the long-term efficiency of the market products should be the overarching goal. Staff does not believe this issue rises to a level of significance that necessitates recommending specific next steps in this report. It can be addressed at a later date.

Staff Conclusions

Ancillary Services are vital for ensuring the continued reliable operation of the ERCOT system. AS markets contribute to generator revenue and provide important signals for future investment decisions, while necessarily imposing costs on Texas consumers that the Commission must ensure are economical. To safeguard the continued effectiveness and efficiency of AS in the context of an increasingly rapidly changing ERCOT system, it is critical the Commission remain engaged with AS after this study has formally concluded.

Staff views the AS Methodology update process as a valuable tool for continuous process improvement, particularly now that annual Commission approval is required. Each year, ERCOT develops proposed updates to AS quantities, based on their expert analysis of current and future needs, and brings proposals and supporting analyses to multiple TAC subcommittees or task forces for vetting before seeking approval by TAC, the ERCOT Board, and finally the Commission. ERCOT has provided a very transparent process that allows multiple opportunities to review changes before they are finalized so that any stakeholder concerns and questions can be resolved. Staff will follow this process each year and, if needed, will reevaluate the sufficiency of current AS, particularly after RTC+B and DRRS are implemented.

Amongst other recommendations previously discussed, Staff highlights its recommendations that the Commission address resource adequacy topics holistically within the periodic reliability assessments as

required by 16 TAC § 25.508; and that ERCOT perform a comprehensive review of all existing demand response programs and provide resulting recommendations to TAC and the ERCOT Board as soon as practicable.

It may be difficult for some market participants to adapt to the market changes associated with RTC+B at the same time as major modifications to the AS procurement methodology. While Staff does not recommend that improvements to the AS procurement methodology necessarily wait for market participant availability, Staff recognizes that RTC will represent a significant operational shift for many. Staff recommends that ERCOT Staff work with TAC and the Board to develop a high-level plan for implementing all Commission-approved study recommendations and present this plan in a timeframe that allows for incorporation of any applicable recommendations into the 2026 AS Methodology.

APPENDICES

Appendix 1: Nodal Protocol 3.17, Ancillary Service Capacity Products (Summarized by ERCOT)

Regulation Service

1. Regulation Up Service (Reg-Up) is a service that provides capacity that can respond to signals from ERCOT within five seconds to respond to changes from scheduled system frequency. The quantity of Reg-Up capacity is the quantity of capacity available from a Resource that may be called on to change output as necessary to maintain proper system frequency. A Generation Resource providing Reg-Up must be able to increase energy output when deployed and decrease energy output when recalled. A Load Resource providing Reg-Up must be able to decrease Load when deployed and increase Load when recalled. Fast Responding Regulation Up Service (FRRS-Up) is a subset of Reg-Up Service in which the participating Resource provides Reg-Up capacity to ERCOT within 60 cycles of either its receipt of an ERCOT Dispatch Instruction or the detection of a trigger frequency independent of an ERCOT Dispatch Instruction. ERCOT dispatches Reg-Up by a Load Frequency Control (LFC) signal. The LFC signal for FRRS-Up is separate from the LFC signal for other Reg-Up.
2. Regulation Down Service (Reg-Down) is a service that provides capacity that can respond to signals from ERCOT within five seconds to respond to changes from scheduled system frequency. The quantity of Reg-Down capacity is the quantity of capacity available from a Resource that may be called on to change output as necessary to maintain proper system frequency. A Generation Resource providing Reg-Down must be able to decrease energy output when deployed and increase energy output when recalled. A Load Resource providing Reg-Down must be able to increase Load when deployed and decrease Load when recalled. Fast Responding Regulation Down Service (FRRS-Down) is a subset of Reg-Down Service in which a participating Resource provides Reg-Down capacity to ERCOT within 60 cycles of either its receipt of an ERCOT Dispatch Instruction or the detection of a trigger frequency independent of an ERCOT Dispatch Instruction. ERCOT dispatches Reg-Down by an LFC signal. The LFC signal for FRRS-Down is separate from the LFC signal for other Reg-Down.

Responsive Reserve Service

1. Responsive Reserve (RRS) is a service used to restore or maintain the frequency of the ERCOT System in response to a significant frequency deviation.
2. RRS is automatically self-deployed by Resources in a manner that results in real power increases or decreases.
3. RRS may be provided by:
    a. On-Line Generation Resource capable of providing Primary Frequency Response with the capacity excluding Non-Frequency Responsive Capacity (NFRC);
    b. Resources capable of providing Fast Frequency Response (FFR) and sustaining their response for up to 15 minutes;
    c. Load Resources controlled by high-set under-frequency relays; and

d. Generation Resources operating in synchronous condenser fast-response mode as defined in the Operating Guides.

Non-Spinning Reserve Service

1. Non-Spinning Reserve (Non-Spin) is provided by using:
    a. Generation Resources, whether On-Line or Off-Line, capable of:
        i. Being synchronized and ramped to a specified output level within 30 minutes; and
        ii. Running at a specified output level for at least four consecutive hours;
    b. Controllable Load Resources qualified for Dispatch by Security-Constrained Economic Dispatch (SCED) and capable of:
        i. Ramping to an ERCOT-instructed consumption level within 30 minutes; and
        ii. Consuming at the ERCOT-instructed level for at least four consecutive hours; or
    c. Load Resources that are not Controllable Load Resources and are qualified for deployment by the operator using the Ancillary Service Deployment Manager and capable of:
        i. Reducing consumption based on an ERCOT Extensible Markup Language (XML) instruction within 30 minutes; and
        ii. Maintaining that deployment until recalled.
2. The Non-Spin may be deployed by ERCOT to increase available reserves in Real-Time Operations.

ERCOT Contingency Reserve Service

1. ERCOT Contingency Reserve Service (ECRS) is a service that is provided using capacity that can be sustained at a specified level for two consecutive hours and is used to restore or maintain the frequency of the ERCOT System:
    a. In response to significant depletion of RRS;
    b. As backup Regulation Service; and
    c. By providing energy to avoid getting into or during an Energy Emergency Alert (EEA).
2. ECRS may be provided through one or more of the following means:
    a. From On-Line or Off-Line Resources as prescribed in the Operating Guides following a significant frequency deviation in the ERCOT System; and
    b. Either manually or by using a four-second signal to provide energy on deployment by ERCOT.
3. ECRS may be used to provide energy prior to or during the implementation of an EEA. ECRS provides Resource capacity, or capacity from interruptible Load available for deployment on ten minutes' notice.
4. ECRS may be provided by:
    a. Unloaded, On-Line Generation Resource capacity;
    b. Quick Start Generation Resources (QSGRs);
    c. Load Resources that may or may not be controlled by high-set, under-frequency relays;

d. Controllable Load Resources; and

e. Generation Resources operating in synchronous condenser fast-response mode as defined in the Operating Guides.

Appendix 2: Historical Use of AS (As Provided by ERCOT)

Figure 21 summarizes the number of events when RRS was released between January 1, 2018 and July 31, 2024; the table below this figure contains further details of each such event.

It is worth noting that prior to implementation of ECRS (around June 10, 2023), RRS was manually released both during FMEs and during scarcity conditions using the approach outlined in Nodal Operating Guide Section 4.8. After implementation of ECRS, RRS is only released during scarcity conditions, hence there is a stark reduction in RRS release events, post Jun 10, 2023.

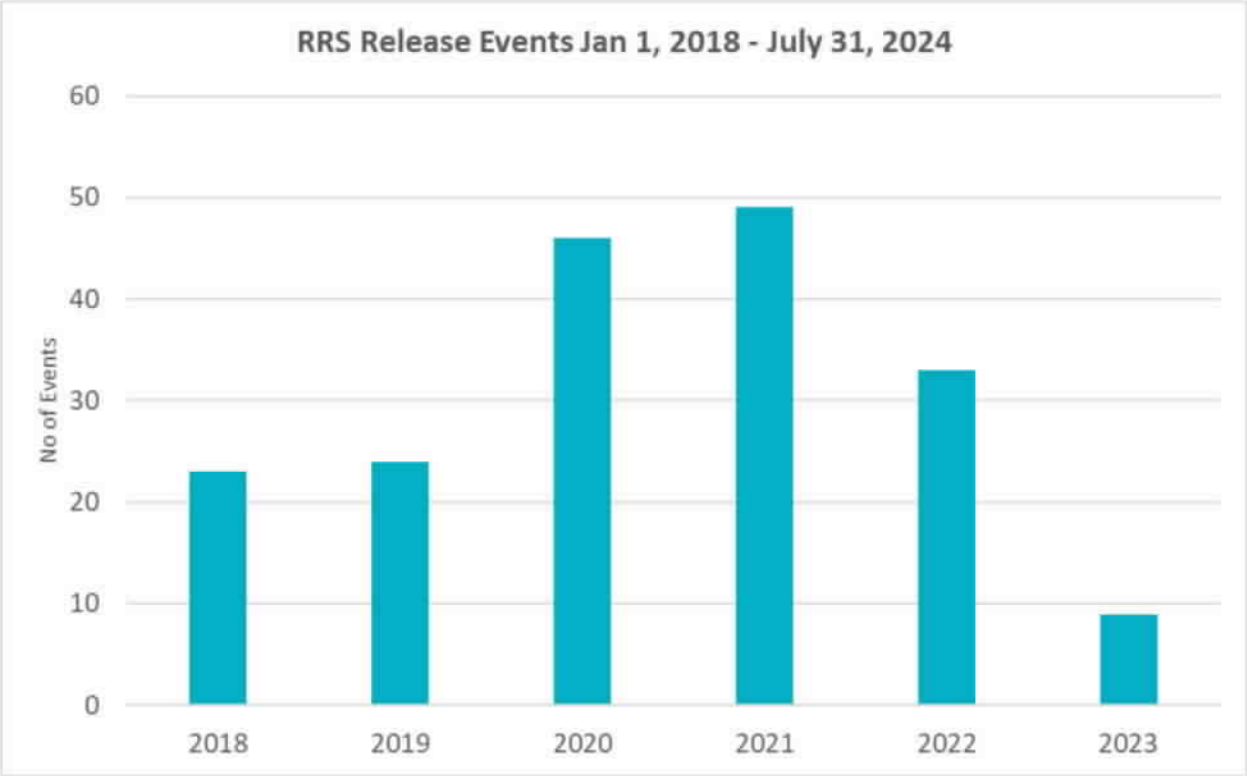


Figure 21 - RRS Release Events Jan 1 2028 - July 31, 2024

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
2/2/2018 23:46	2/2/2018 23:49	0:03:16	680
2/5/2018 14:04	2/5/2018 14:10	0:05:04	939
2/6/2018 18:19	2/6/2018 18:21	0:01:32	271
2/14/2018 6:30	2/14/2018 6:33	0:02:44	273
4/15/2018 1:11	4/15/2018 1:14	0:02:44	308

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
4/21/2018 17:11	4/21/2018 17:15	0:03:40	1548
4/28/2018 9:50	4/28/2018 9:51	0:00:56	287
8/4/2018 8:20	8/4/2018 8:24	0:03:24	554
8/13/2018 23:00	8/13/2018 23:03	0:03:36	1103
8/15/2018 18:10	8/15/2018 18:14	0:03:36	745
8/16/2018 12:44	8/16/2018 12:48	0:04:08	393
8/18/2018 16:12	8/18/2018 16:16	0:03:32	896
8/31/2018 12:04	8/31/2018 12:09	0:05:36	215
9/1/2018 10:38	9/1/2018 10:43	0:04:44	228
9/4/2018 19:30	9/4/2018 19:34	0:03:43	756
9/19/2018 20:43	9/19/2018 20:47	0:04:15	1011
9/24/2018 1:39	9/24/2018 1:42	0:03:32	641
9/26/2018 13:54	9/26/2018 13:59	0:05:32	579
9/28/2018 1:12	9/28/2018 1:17	0:05:00	727
9/28/2018 12:00	9/28/2018 12:03	0:03:12	747
10/6/2018 1:30	10/6/2018 1:36	0:05:44	1039
10/15/2018 6:29	10/15/2018 6:32	0:02:40	228
10/19/2018 15:23	10/19/2018 15:27	0:04:00	756
3/2/2019 3:19	3/2/2019 3:24	0:05:36	1211
3/11/2019 21:24	3/11/2019 21:28	0:04:16	955
3/21/2019 13:40	3/21/2019 13:44	0:04:03	513
4/11/2019 3:38	4/11/2019 3:42	0:04:48	1034
4/18/2019 17:04	4/18/2019 17:09	0:04:24	775

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
4/19/2019 8:01	4/19/2019 8:05	0:04:36	638
4/25/2019 11:20	4/25/2019 11:23	0:03:04	1011
4/30/2019 9:37	4/30/2019 9:40	0:03:36	741
4/30/2019 21:11	4/30/2019 21:15	0:03:19	715
5/1/2019 10:17	5/1/2019 10:20	0:02:28	144
5/12/2019 8:57	5/12/2019 8:58	0:01:16	180
5/18/2019 15:25	5/18/2019 15:27	0:02:28	593
5/23/2019 16:41	5/23/2019 16:45	0:03:47	664
5/30/2019 2:56	5/30/2019 3:00	0:04:24	723
5/31/2019 11:56	5/31/2019 12:00	0:03:08	733
5/31/2019 21:06	5/31/2019 21:12	0:05:24	1138
7/15/2019 14:37	7/15/2019 14:41	0:04:36	564
7/22/2019 10:34	7/22/2019 10:38	0:03:44	332
7/23/2019 9:10	7/23/2019 9:14	0:04:00	271
7/29/2019 17:59	7/29/2019 18:04	0:05:47	1157
10/14/2019 15:31	10/14/2019 15:35	0:03:52	457
10/30/2019 21:29	10/30/2019 21:33	0:03:28	933
11/18/2019 16:20	11/18/2019 16:26	0:06:08	486
12/29/2019 22:27	12/29/2019 22:31	0:04:12	689
1/1/2020 12:53	1/1/2020 12:58	0:05:01	1150
1/10/2020 20:54	1/10/2020 20:58	0:04:12	1002
1/16/2020 18:04	1/16/2020 18:09	0:04:55	600
1/17/2020 10:01	1/17/2020 10:05	0:03:54	1099

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
2/6/2020 1:16	2/6/2020 1:20	0:03:52	429
2/6/2020 21:22	2/6/2020 21:29	0:06:32	845
2/10/2020 16:07	2/10/2020 16:13	0:06:32	854
3/1/2020 17:43	3/1/2020 17:47	0:03:52	520
3/2/2020 13:13	3/2/2020 13:18	0:05:08	506
3/18/2020 19:15	3/18/2020 19:20	0:04:32	958
3/22/2020 8:10	3/22/2020 8:14	0:04:12	852
3/26/2020 13:05	3/26/2020 13:10	0:05:16	671
4/8/2020 15:37	4/8/2020 15:42	0:05:39	635
4/22/2020 12:44	4/22/2020 12:49	0:05:29	679
5/6/2020 5:57	5/6/2020 6:01	0:03:32	423
5/7/2020 23:29	5/7/2020 23:33	0:03:32	595
5/12/2020 1:14	5/12/2020 1:20	0:06:12	707
5/31/2020 10:45	5/31/2020 10:53	0:07:52	1153
6/1/2020 9:48	6/1/2020 9:51	0:03:00	214
6/13/2020 12:00	6/13/2020 12:05	0:04:44	396
6/15/2020 17:22	6/15/2020 17:29	0:06:52	529
6/23/2020 16:54	6/23/2020 16:58	0:04:44	665
7/1/2020 18:28	7/1/2020 18:33	0:05:28	1162
7/6/2020 15:09	7/6/2020 15:15	0:06:08	1164
7/9/2020 20:14	7/9/2020 20:20	0:05:43	1163
7/16/2020 15:13	7/16/2020 15:20	0:06:44	794
7/20/2020 11:47	7/20/2020 11:54	0:06:08	1163

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
8/2/2020 15:17	8/2/2020 15:22	0:04:23	725
8/22/2020 23:47	8/22/2020 23:51	0:04:28	587
9/19/2020 16:02	9/19/2020 16:08	0:05:50	559
9/22/2020 21:04	9/22/2020 21:09	0:04:48	779
10/10/2020 14:18	10/10/2020 14:25	0:06:36	975
10/10/2020 16:44	10/10/2020 16:50	0:05:24	1150
10/13/2020 17:13	10/13/2020 17:20	0:06:24	620
10/19/2020 14:30	10/19/2020 14:36	0:05:24	598
10/26/2020 13:23	10/26/2020 13:26	0:03:20	606
10/27/2020 8:41	10/27/2020 8:46	0:04:44	1151
11/7/2020 18:05	11/7/2020 18:08	0:03:24	596
11/16/2020 9:51	11/16/2020 9:57	0:05:28	1163
11/21/2020 0:20	11/21/2020 0:25	0:05:12	1235
11/22/2020 1:22	11/22/2020 1:26	0:04:04	626
11/22/2020 12:35	11/22/2020 12:39	0:04:12	506
12/4/2020 7:44	12/4/2020 7:50	0:05:24	753
12/10/2020 14:34	12/10/2020 14:39	0:04:28	582
12/22/2020 15:46	12/22/2020 15:51	0:05:08	564
12/26/2020 20:49	12/26/2020 20:51	0:01:08	662
1/3/2021 11:34	1/3/2021 11:38	0:04:13	999
1/6/2021 18:20	1/6/2021 18:25	0:04:50	796
1/11/2021 13:03	1/11/2021 13:08	0:04:31	756
1/16/2021 21:35	1/16/2021 21:39	0:04:17	568

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
1/28/2021 14:21	1/28/2021 14:25	0:04:18	656
2/13/2021 8:36	2/13/2021 8:44	0:08:00	725
2/14/2021 23:19	2/15/2021 2:03	2:43:48	2000
2/15/2021 3:43	2/15/2021 11:56	8:13:08	1879
2/15/2021 17:08	2/15/2021 17:42	0:34:40	1000
2/15/2021 18:16	2/15/2021 19:28	1:12:20	1000
2/15/2021 21:42	2/15/2021 22:35	0:53:04	1000
2/16/2021 3:23	2/16/2021 9:31	6:08:04	1560
2/16/2021 12:49	2/16/2021 13:01	0:12:04	400
2/16/2021 14:27	2/16/2021 15:09	0:41:16	300
2/16/2021 17:29	2/16/2021 18:23	0:54:20	500
2/17/2021 6:05	2/17/2021 9:18	3:12:32	650
2/22/2021 5:39	2/22/2021 5:41	0:02:56	338
3/9/2021 16:33	3/9/2021 16:52	0:18:50	716
3/25/2021 0:59	3/25/2021 1:06	0:06:29	644
3/26/2021 23:10	3/26/2021 23:15	0:04:44	662
3/30/2021 18:01	3/30/2021 18:04	0:03:24	821
4/11/2021 19:20	4/11/2021 19:35	0:14:51	1350
4/11/2021 19:56	4/11/2021 20:20	0:23:13	500
4/13/2021 15:58	4/13/2021 18:40	2:42:40	1000
4/30/2021 22:14	4/30/2021 22:18	0:03:20	1277
5/9/2021 11:21	5/9/2021 11:24	0:02:26	859
5/19/2021 12:06	5/19/2021 12:10	0:03:32	514

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
5/24/2021 20:03	5/24/2021 20:08	0:05:08	913
5/25/2021 7:02	5/25/2021 7:06	0:04:40	1146
5/26/2021 23:14	5/26/2021 23:17	0:03:04	955
6/7/2021 15:26	6/7/2021 15:32	0:05:25	1420
6/20/2021 22:53	6/20/2021 22:58	0:05:19	588
7/20/2021 8:46	7/20/2021 8:50	0:04:22	696
8/10/2021 13:34	8/10/2021 13:37	0:02:53	624
8/16/2021 13:37	8/16/2021 13:44	0:07:12	797
9/9/2021 17:11	9/9/2021 17:18	0:06:44	644
9/12/2021 23:17	9/12/2021 23:21	0:03:44	1187
9/22/2021 9:15	9/22/2021 9:17	0:02:44	359
9/25/2021 15:39	9/25/2021 15:42	0:02:52	374
10/1/2021 11:11	10/1/2021 11:15	0:04:52	809
10/2/2021 5:51	10/2/2021 5:56	0:04:48	908
10/27/2021 1:11	10/27/2021 1:18	0:06:34	650
11/1/2021 4:57	11/1/2021 5:05	0:07:43	403
11/10/2021 11:23	11/10/2021 11:38	0:15:00	70
11/15/2021 17:53	11/15/2021 17:56	0:02:44	722
11/17/2021 14:32	11/17/2021 14:35	0:03:00	768
12/23/2021 9:33	12/23/2021 9:37	0:04:16	823
12/27/2021 9:57	12/27/2021 10:00	0:02:44	653
12/30/2021 12:41	12/30/2021 12:44	0:03:00	635
1/11/2022 9:15	1/11/2022 9:18	0:03:08	635

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
1/13/2022 18:06	1/13/2022 18:10	0:03:28	742
1/16/2022 19:03	1/16/2022 19:09	0:06:04	619
1/26/2022 2:28	1/26/2022 2:33	0:05:48	1053
2/4/2022 18:21	2/4/2022 18:27	0:05:52	822
2/22/2022 6:18	2/22/2022 6:20	0:01:48	786
3/12/2022 10:21	3/12/2022 10:25	0:04:12	469
3/14/2022 21:41	3/14/2022 21:45	0:03:56	543
3/21/2022 13:50	3/21/2022 13:52	0:01:25	620
3/22/2022 4:16	3/22/2022 4:19	0:02:44	524
3/29/2022 23:58	3/30/2022 0:01	0:02:33	743
4/13/2022 7:28	4/13/2022 7:34	0:05:12	1040
4/19/2022 15:16	4/19/2022 15:20	0:04:28	1159
4/20/2022 19:31	4/20/2022 19:36	0:05:04	671
5/8/2022 23:37	5/8/2022 23:42	0:04:20	555
5/13/2022 12:32	5/13/2022 12:36	0:04:16	553
5/24/2022 7:05	5/24/2022 7:07	0:02:48	662
6/4/2022 12:59	6/4/2022 13:00	0:01:19	1227
6/20/2022 19:26	6/20/2022 19:30	0:04:28	671
6/28/2022 16:18	6/28/2022 16:23	0:04:20	680
7/13/2022 15:16	7/13/2022 16:42	1:26:00	500
8/21/2022 19:27	8/21/2022 19:31	0:04:44	763
9/5/2022 23:48	9/5/2022 23:52	0:04:28	1219
10/6/2022 2:24	10/6/2022 2:30	0:06:12	941

RRS Event Start	RRS Event End	RRS Event Duration	Max RRS Released (MW)
10/6/2022 11:54	10/6/2022 11:57	0:02:24	558
10/8/2022 6:47	10/8/2022 6:51	0:04:08	252
10/16/2022 18:41	10/16/2022 18:45	0:03:36	576
10/20/2022 5:05	10/20/2022 5:11	0:06:36	849
10/21/2022 16:45	10/21/2022 16:49	0:03:04	769
10/26/2022 0:21	10/26/2022 0:25	0:04:04	540
10/27/2022 23:15	10/27/2022 23:20	0:04:48	704
12/8/2022 3:39	12/8/2022 3:43	0:03:32	484
12/17/2022 18:54	12/17/2022 18:59	0:04:56	648
1/24/2023 14:27	1/24/2023 14:31	0:04:16	570
4/12/2023 20:46	4/12/2023 20:49	0:02:38	382
5/1/2023 13:32	5/1/2023 13:35	0:02:56	664
5/23/2023 11:21	5/23/2023 11:24	0:03:20	263
5/24/2023 20:39	5/24/2023 20:42	0:03:32	455
8/17/2023 19:09	8/17/2023 20:06	0:57:00	893
8/25/2023 19:21	8/25/2023 20:11	0:50:00	1000
8/30/2023 19:25	8/30/2023 20:24	0:59:00	700
9/6/2023 18:59	9/6/2023 19:55	0:55:52	1100

Figure 22 summarizes the events when ECRS was released between June 10, 2023 and July 31, 2024; the table below this figure contains further details of each event.

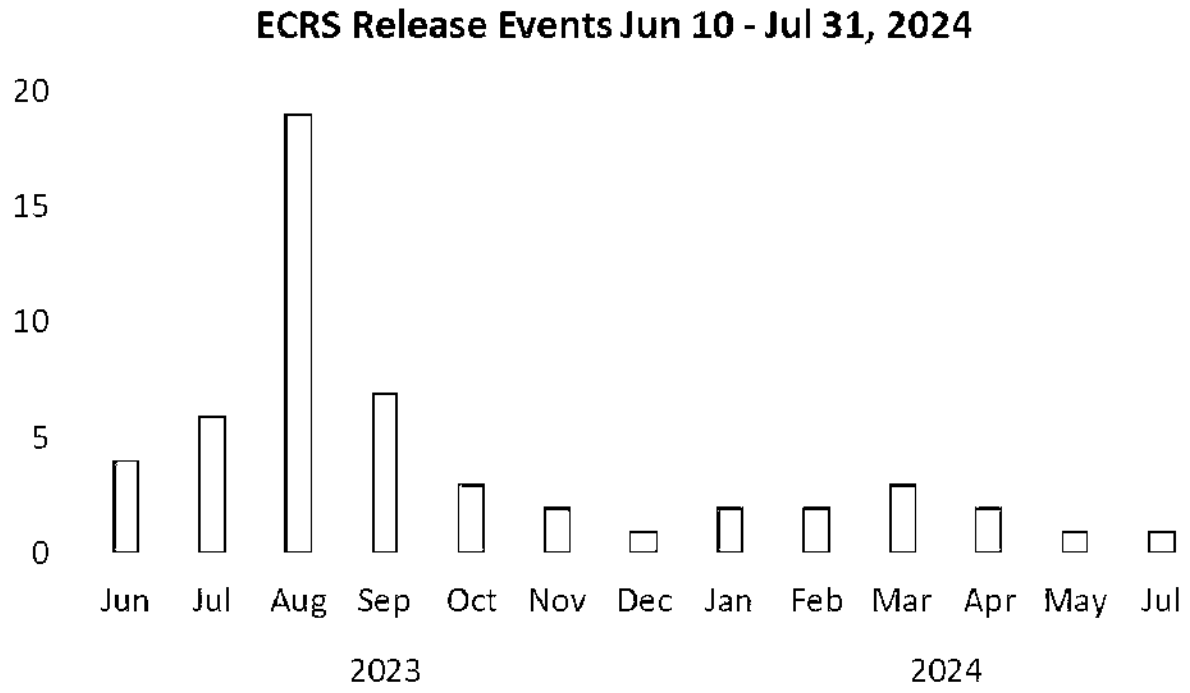


Figure 22 - ECRS Release Events through July 31, 2024

ECRS Event Start	ECRS Event End	ECRS Event Duration	Max ECRS Released (MW)
6/14/2023 19:20	6/14/2023 19:33	0:13:00	600
6/16/2023 18:31	6/16/2023 18:36	0:05:00	430
6/18/2023 19:20	6/18/2023 19:45	0:25:00	200
6/20/2023 16:21	6/20/2023 21:01	4:40:00	1900
7/6/2023 21:05	7/6/2023 21:12	0:07:00	724
7/8/2023 19:57	7/8/2023 20:04	0:07:00	500
7/10/2023 19:21	7/10/2023 19:43	0:22:00	700
7/16/2023 10:41	7/16/2023 10:45	0:04:00	133
7/31/2023 18:35	7/31/2023 18:44	0:09:00	809

ECRS Event Start	ECRS Event End	ECRS Event Duration	Max ECRS Released (MW)
7/31/2023 19:35	7/31/2023 20:32	0:57:00	400
8/4/2023 17:03	8/4/2023 18:14	1:10:48	800
8/4/2023 18:52	8/4/2023 20:41	1:49:12	2472
8/6/2023 19:46	8/6/2023 20:26	0:39:20	1500
8/7/2023 16:42	8/7/2023 18:06	1:24:32	500
8/7/2023 18:57	8/7/2023 20:16	1:19:36	1500
8/8/2023 19:31	8/8/2023 20:27	0:56:16	1500
8/10/2023 15:29	8/10/2023 17:19	1:49:52	1500
8/10/2023 17:20	8/10/2023 20:18	2:58:32	1250
8/11/2023 18:31	8/11/2023 20:06	1:34:56	1750
8/12/2023 19:37	8/12/2023 20:12	0:34:40	500
8/15/2023 19:25	8/15/2023 20:31	1:05:44	500
8/17/2023 14:41	8/17/2023 20:46	6:04:40	2620
8/20/2023 19:11	8/20/2023 21:11	1:59:44	2000
8/22/2023 1:27	8/22/2023 1:35	0:08:00	674
8/24/2023 15:55	8/24/2023 20:41	4:45:48	2342
8/25/2023 18:21	8/25/2023 20:44	2:23:04	2579
8/26/2023 19:38	8/26/2023 20:46	1:07:56	500
8/29/2023 19:26	8/29/2023 20:01	0:35:08	700
8/30/2023 18:27	8/30/2023 20:41	2:13:32	2749
9/5/2023 19:20	9/5/2023 20:02	0:42:08	500
9/6/2023 14:57	9/6/2023 20:56	5:58:48	2600
9/7/2023 18:34	9/7/2023 20:03	1:29:04	1964

ECRS Event Start	ECRS Event End	ECRS Event Duration	Max ECRS Released (MW)
9/8/2023 16:06	9/8/2023 17:44	1:37:12	1000
9/8/2023 18:56	9/8/2023 19:32	0:36:00	750
9/17/2023 18:56	9/17/2023 19:27	0:31:00	500
9/22/2023 10:09	9/22/2023 10:13	0:04:00	232
10/5/2023 19:50	10/5/2023 19:56	0:06:12	498
10/19/2023 18:17	10/19/2023 18:44	0:27:08	500
10/25/2023 22:30	10/25/2023 22:31	0:00:12	651
11/13/2023 6:21	11/13/2023 6:25	0:03:36	149
11/13/2023 10:28	11/13/2023 10:33	0:04:56	546
12/14/2023 19:29	12/14/2023 19:36	0:07:00	805
1/1/2024 20:13	1/1/2024 20:19	0:06:00	549
1/16/2024 18:25	1/16/2024 19:07	0:42:00	400
2/27/2024 9:21	2/27/2024 9:28	0:07:00	779
2/28/2024 10:16	2/28/2024 10:19	0:03:00	329
3/4/2024 18:31	3/4/2024 19:20	0:49:00	550
3/12/2024 8:16	3/12/2024 8:24	0:08:00	852
3/17/2024 15:16	3/17/2024 15:19	0:03:00	820
4/16/2024 19:58	4/16/2024 20:32	0:34:00	200
4/28/2024 19:47	4/28/2024 21:10	1:23:00	1200
5/8/2024 19:07	5/8/2024 20:48	1:41:00	1827
7/24/2024 7:02	7/24/2024 7:08	0:06:00	884

Figure 23 summarizes the events when off-line Non-Spin Reserve Service (Non-Spin) was deployed between January 1, 2018 and July 31, 2024; the table below this figure contains further details of each event.

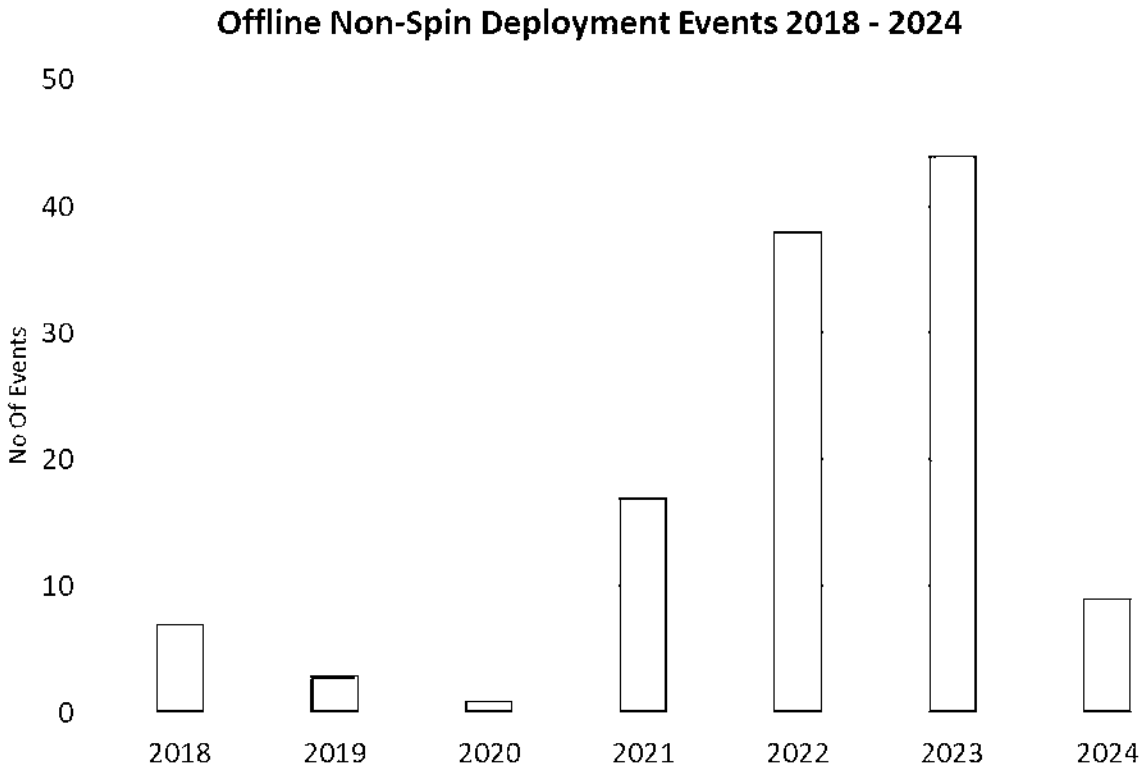


Figure 23 - Offline Non-Spin Deployments 2018-2024

Non-Spin Event Start	Non-Spin Event End	Non-Spin Event Duration	Max Off-Line Non-Spin Deployed (MW)
1/23/2018 6:43	1/23/2018 7:29	00:46:52	1005
4/11/2018 15:16	4/11/2018 23:59	08:42:04	50
4/12/2018 13:25	4/12/2018 23:59	10:33:43	203
4/25/2018 12:11	4/25/2018 17:18	05:06:56	140
5/1/2018 17:46	5/2/2018 8:00	14:13:46	86
5/2/2018 9:41	5/2/2018 22:00	12:19:43	66
5/3/2018 1:33	5/3/2018 16:01	14:28:09	14

Non-Spin Event Start	Non-Spin Event End	Non-Spin Event Duration	Max Off-Line Non-Spin Deployed (MW)
9/22/2019 16:33	9/22/2019 16:35	00:01:49	74
10/5/2019 15:52	10/5/2019 17:05	01:12:55	305
12/22/2019 8:27	12/22/2019 12:00	03:32:37	115
2/3/2020 8:55	2/3/2020 13:58	05:02:46	145
2/13/2021 8:46	2/13/2021 12:35	03:48:50	324
2/14/2021 23:17	2/19/2021 10:08	10:51:53	537
4/11/2021 19:21	4/11/2021 20:35	01:13:56	497
4/13/2021 15:47	4/13/2021 19:20	03:32:53	375
6/13/2021 15:37	6/13/2021 20:15	04:38:00	696
6/14/2021 14:13	6/14/2021 16:17	02:03:52	512
9/13/2021 19:07	9/13/2021 20:34	01:26:35	295
9/24/2021 16:18	9/24/2021 19:44	03:26:12	400
9/25/2021 15:46	9/25/2021 19:14	03:27:58	433
9/26/2021 19:06	9/26/2021 20:05	00:58:58	424
10/20/2021 12:57	10/20/2021 15:00	02:02:39	53
10/22/2021 14:00	10/22/2021 18:39	04:39:29	49
10/24/2021 18:44	10/24/2021 21:23	02:39:15	140
10/30/2021 17:51	10/30/2021 18:50	00:59:08	582
12/22/2021 7:14	12/22/2021 8:12	00:58:15	493
12/28/2021 17:53	12/28/2021 20:00	02:06:03	494
12/29/2021 7:54	12/29/2021 9:12	01:17:37	504
4/2/2022 16:05	4/2/2022 20:51	04:46:00	529

Non-Spin Event Start	Non-Spin Event End	Non-Spin Event Duration	Max Off-Line Non-Spin Deployed (MW)
4/5/2022 15:48	4/5/2022 19:26	03:38:00	50
4/15/2022 15:18	4/15/2022 19:55	04:37:00	49
5/3/2022 1:03	5/3/2022 6:59	05:56:59	47
5/9/2022 13:23	5/10/2022 0:00	10:37:00	568
5/10/2022 14:32	5/11/2022 0:00	09:28:00	253
5/11/2022 14:45	5/11/2022 18:28	03:43:00	46
5/11/2022 14:45	5/11/2022 18:28	03:43:00	46
5/13/2022 14:48	5/13/2022 19:56	05:08:00	1018
5/26/2022 16:34	5/26/2022 20:08	03:34:00	840
6/14/2022 11:35	6/14/2022 20:31	08:56:00	158
6/15/2022 12:25	6/15/2022 20:08	07:43:00	157
7/8/2022 13:06	7/8/2022 18:24	05:18:00	939
7/9/2022 13:56	7/9/2022 21:16	07:20:00	891
7/10/2022 13:47	7/10/2022 20:23	06:36:00	897
7/11/2022 12:49	7/11/2022 16:38	03:49:00	611
7/13/2022 12:39	7/13/2022 19:01	06:22:00	877
8/9/2022 12:33	8/9/2022 16:43	04:10:00	592
8/23/2022 13:15	8/23/2022 22:15	09:00:00	617
8/28/2022 13:01	8/28/2022 18:28	05:27:00	2745
8/31/2022 10:46	8/31/2022 16:16	05:30:00	1157
9/3/2022 12:37	9/3/2022 21:52	09:15:00	1592
9/4/2022 13:38	9/4/2022 15:18	01:40:00	941

Non-Spin Event Start	Non-Spin Event End	Non-Spin Event Duration	Max Off-Line Non-Spin Deployed (MW)
9/5/2022 13:40	9/5/2022 21:35	07:55:00	1869
9/9/2022 13:33	9/9/2022 20:13	06:40:00	722
9/11/2022 18:42	9/11/2022 21:15	02:33:00	784
9/13/2022 16:11	9/13/2022 19:55	03:44:00	905
9/28/2022 18:46	9/28/2022 21:04	02:18:00	1049
10/1/2022 18:55	10/1/2022 19:56	01:01:00	574
10/2/2022 16:46	10/2/2022 19:55	03:09:00	1726
10/4/2022 17:39	10/4/2022 19:47	02:08:00	1118
10/5/2022 15:50	10/5/2022 18:56	03:06:00	612
10/6/2022 18:01	10/6/2022 19:05	01:04:00	557
11/26/2022 16:45	11/26/2022 18:12	01:27:00	3988
12/13/2022 17:40	12/13/2022 19:30	01:50:00	2965
12/14/2022 18:43	12/14/2022 19:01	00:18:00	485
12/16/2022 17:42	12/16/2022 19:17	01:35:00	967
12/23/2022 6:52	12/23/2022 10:01	03:09:00	3222
1/3/2023 17:21	1/3/2023 18:30	01:09:00	1135
1/6/2023 16:53	1/6/2023 18:15	01:22:00	1215
1/9/2023 17:26	1/9/2023 17:56	00:30:00	514
1/17/2023 5:46	1/17/2023 7:25	01:39:00	468
2/8/2023 18:07	2/8/2023 18:40	00:33:00	544
3/21/2023 19:01	3/21/2023 19:50	00:49:00	545
3/22/2023 19:01	3/22/2023 19:51	00:50:00	525

Non-Spin Event Start	Non-Spin Event End	Non-Spin Event Duration	Max Off-Line Non-Spin Deployed (MW)
3/24/2023 5:55	3/24/2023 7:19	01:24:00	1832
3/24/2023 18:55	3/24/2023 19:33	00:38:00	976
3/25/2023 18:44	3/25/2023 20:48	02:04:00	1829
3/26/2023 18:35	3/26/2023 20:03	01:28:00	2241
3/27/2023 18:32	3/27/2023 21:05	02:33:00	731
4/14/2023 19:15	4/14/2023 20:14	00:59:00	622
4/21/2023 18:54	4/21/2023 20:56	02:02:00	690
4/29/2023 19:39	4/29/2023 21:11	01:32:00	1183
5/4/2023 19:50	5/4/2023 20:25	00:35:00	447
5/11/2023 19:18	5/11/2023 21:18	02:00:00	1049
6/10/2023 19:16	6/10/2023 20:32	01:16:00	328
6/18/2023 19:36	6/18/2023 20:22	00:46:00	448
6/20/2023 16:24	6/20/2023 21:09	04:45:00	379
7/10/2023 19:21	7/10/2023 20:23	01:02:00	1081
8/4/2023 17:04	8/4/2023 20:43	03:39:22	123
8/7/2023 16:58	8/7/2023 20:19	03:21:27	129
8/10/2023 15:29	8/10/2023 20:23	04:53:33	117
8/11/2023 18:34	8/11/2023 20:09	01:34:37	112
8/12/2023 18:57	8/12/2023 20:13	01:16:18	244
8/13/2023 19:02	8/13/2023 20:06	01:03:24	199

Appendix 3: Effectiveness of AS (As Provided by ERCOT)

The efficacy of ERCOT's AS program with respect to frequency control is demonstrated through ERCOT's CPS1 performance, time taken to recover frequency back to pre-event value or 60Hz following a Frequency Measurable Event (FME) and ERCOT's Frequency Response Measure (FRM) performance. Figure 24 - ERCOT's 12-month Rolling Average CPS1 Performance shows ERCOT's 12-month rolling average CPS1 score. ERCOT's CPS1 performance is one of the best in North America and is well above 100%, the minimum threshold for performance under NERC Reliability Standard requirements.

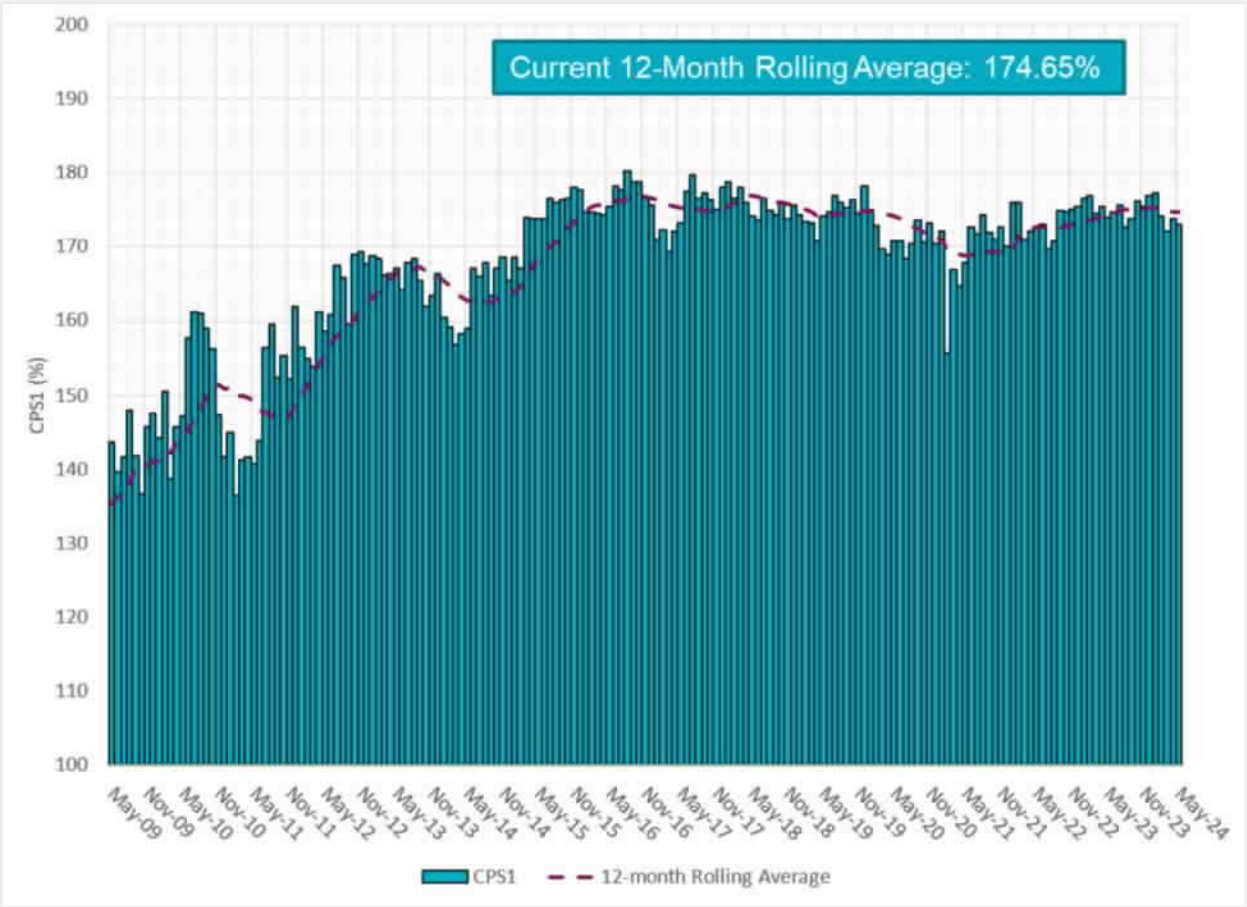


Figure 24 - ERCOT's 12-month Rolling Average CPS1 Performance

Figure 25 demonstrates the time taken to recover frequency during FMEs that occurred between January 1, 2018 and July 31, 2024. ERCOT was able to recover frequency in under 15 minutes in all events during this timeframe.

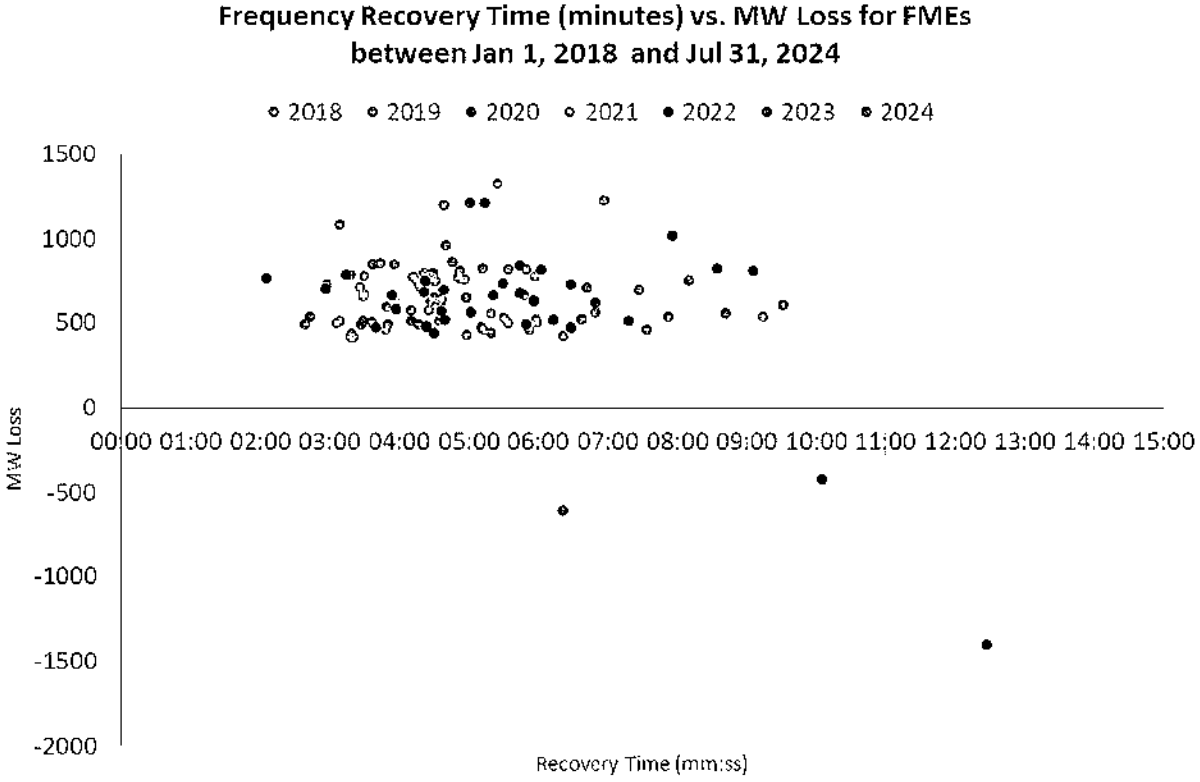


Figure 25 - Frequency Recovery Time for FMEs between January 1, 2018 and July 31, 2024

Figure 26 demonstrates measured frequency response (FRM) during FMEs that occurred between April 1, 2015 and July 31, 2024. ERCOT's FRM stayed well above ERCOT's Interconnection Minimum Frequency Response (IMFR) obligation.

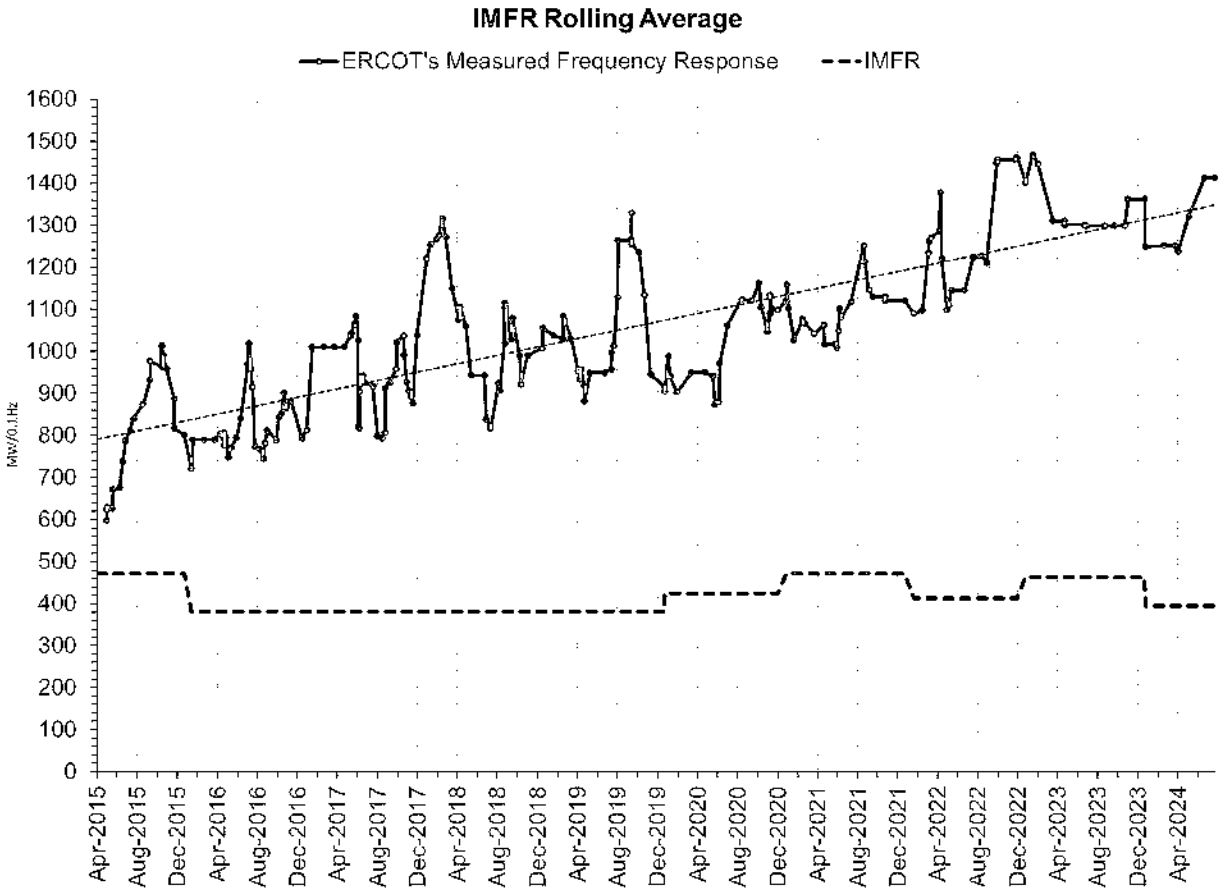


Figure 26 - Measured Frequency Response (FRM) during FMEs between April 1, 2015 and July 31, 2024

Appendix 4: Changes to AS Methodology between 2016 and 2024 (As Provided by ERCOT)

The table below summarizes the modifications made to the AS Methodology between 2016 and 2024 to account for changes in the reliability risks for which these AS quantities were being procured.

Year	AS Methodology Change Description
2016	Remove consideration of the last 30 days from Regulation analysis and instead use the Regulation data using same month of the previous two years; Use 95th percentile of 5-minute netload/deployments instead of 98.8th percentile in Regulation methodology. Remove last 30 days from Non-Spin analysis and instead use the same month for previous three years; Use the 3-hour ahead net forecast error instead of 6-hour ahead; Use net forecast error only on the under-forecast; and use dynamic percentile between 70th and 95th percentile based on the risk of net load ramp in Non-Spin methodology
2017	Remove Regulation exhaustion feedback and include solar into net load variability calculation in Regulation methodology
2018	Include effects of solar in Net Load Forecast error & Net Load up-ramp risk calculations and include an adjustment to account for additional over-forecast uncertainty from projected increase in installed wind capacity in Non-Spin methodology
2019	Remove 1,375 MW floor on Non-Spin quantities during On-Peak Hours (HE 7 thru 22)
2020	No Changes.
2021	Create and incorporate Solar adjustment tables into the Regulation Service methodology, similar to the Wind adjustment tables. Create and incorporate a Solar over-forecast error adjustment table in Non-Spin methodology.
2022	A floor of 2800 MW applied to RRS quantities during the peak hours. Use the highest 5-min net load within the hour and 6-HA netload forecast to calculate netload forecast uncertainty; change percentile coverage to vary between 85th and 95th; build a table that tracks historical intra-day variations in thermal resource availabilities due to Forced Outages to compute Non-Spin quantities.

Year	AS Methodology Change Description
2023	Introduced ECRS beginning June 10, 2023. Non-Spin methodology was changed such that prior to ECRS implementation, update the hourly net load forecast uncertainty calculation to use ten hours ahead net load forecast. Upon ECRS implementation, update the hourly net load forecast uncertainty calculation to use six hours ahead net load forecast and the average net load. Change in the percentile coverage for off-peak hours such that Non-Spin requirements for these hours is determined using 75th percentile of historical hourly net load forecast uncertainty.
2024	Remove 2,800 MW floor for RRS during the peak hours. A floor on the percentile coverage for sunset hours such that the ECRS requirements for these hours are determined using at least 90th percentile of historical intra-hour net load uncertainty. Change the frequency recovery related computations such that ECRS requirements are determined using 2 years of historic information, cover 60% of historic net load and inertia conditions and account for Regulation requirement in the hour. Change the percentile coverage for HE23 to HE02 in Winter and HE23 to HE06 rest of the year such that Non-Spin requirements for these hours is determined using 68th percentile of historical hourly net load forecast uncertainty. Change approval process for the AS Methodology so that the PUC is the final approver rather than the ERCOT Board of Directors.