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Public Utility Commission of Texas
Memorandum

TO: Interested parties

FROM: Julie Gauldin, Market Analysis Division

DATE: October 1, 2024

RE: **Project No. 55845** – *Review of Ancillary Services in the ERCOT Market*
Draft report and next steps

Senate Bill 3, 87th Leg, R.S. (2021), directed the Commission to "(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."

To assist the Commission with meeting these requirements, staff from the Commission, Electric Reliability Council of Texas, Inc. (ERCOT), and the Independent Market Monitor (IMM) collaborated on developing a scope for this review, and the Commission approved the study scope at the February 15, 2024 open meeting.[1]

ERCOT and IMM conducted a comprehensive review of the current suite of ancillary services, covering the purpose of each service; the reliability requirements and risks for which each ancillary service is procured to mitigate; the effectiveness of ancillary services in managing these risks; the qualification criteria for providing each ancillary service; required quantities of each ancillary service and the methodology used to compute these required quantities; and operational deployment procedures. The historic evolution of the ERCOT system and associated changes in ancillary services were also reviewed.

Over the course of the past several months, ERCOT and IMM have presented interim results at several presentations to ERCOT's Technical Advisory Committee (TAC), including a special workshop on August 28, 2024 where stakeholder-submitted questions were answered and discussed in detail.

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[1] See *Review of Ancillary Services in the ERCOT Market*, Project No. 55845, AIS Item No. 12 (Feb. 8, 24).

The attached draft report contains the results of ERCOT's and the IMM's reviews. Staff's analysis and recommendations are intentionally left out of this draft. Staff will add its analysis and recommendations to the report after gathering additional stakeholder comments on the draft report and conducting a public workshop on October 31, 2024. Staff will present a final draft of the report for the commissioners' consideration later this fall.

To complete the last phase of the ancillary service review, Staff will:

- File questions on the report by October 7th.
- Review responses to questions, which will be due on October 21st.
- Publish an agenda for the workshop by October 28th.
- Hold the workshop on October 31st starting at 1:30 pm.
- File draft analysis and recommendation memo by November 14th.
- Commission considers Staff's recommendations at the November 21st open meeting.
- Commission considers Staff's recommendations at the December 12th open meeting.
- Commission finalizes AS Study recommendations to be added to the Agency report on December 19 open meeting.

Staff would like to extend its sincere gratitude to ERCOT and IMM Staff for their hard work and dedicated collaboration.

Attachment: AS Study Draft Report

REVIEW OF ANCILLARY SERVICES IN THE ERCOT MARKET

PUBLIC UTILITY COMMISSION OF TEXAS

PROJECT NO. 55845 – OCTOBER 1, 2024 - DRAFT

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.

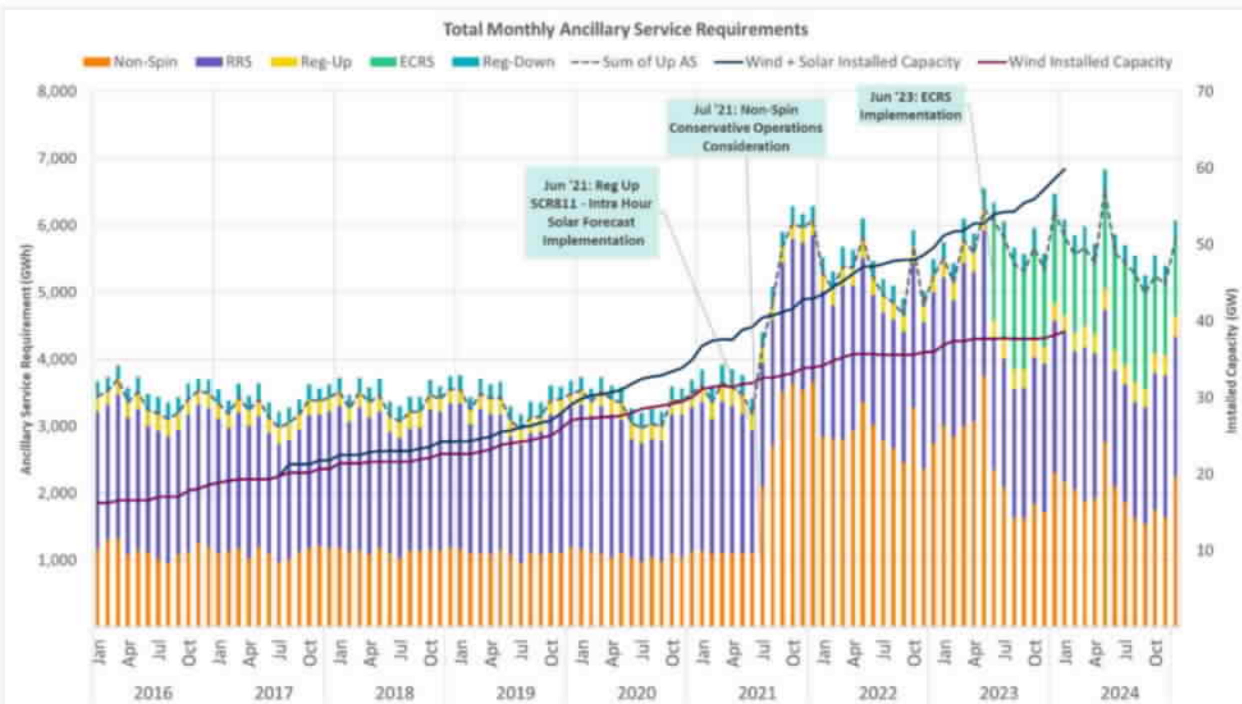

Figure 1 - Historical AS Requirements, Methodology Changes, and Intermittent Resource Capacity

[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]

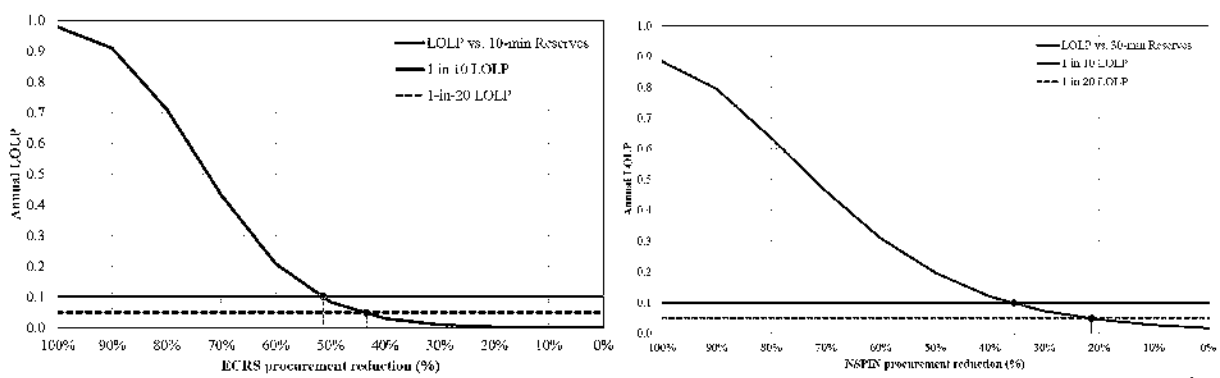

Figure 2 – Modeling Results for ECRS and Non-Spin Required Quantities

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[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

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.

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.

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.[7]

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."[8]

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[9], 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[10] 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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[7] Public Utility Regulatory Act (PURA) §35.004(g)

[8] PURA §35.004(e)

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

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

provide each service[11]. 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.

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

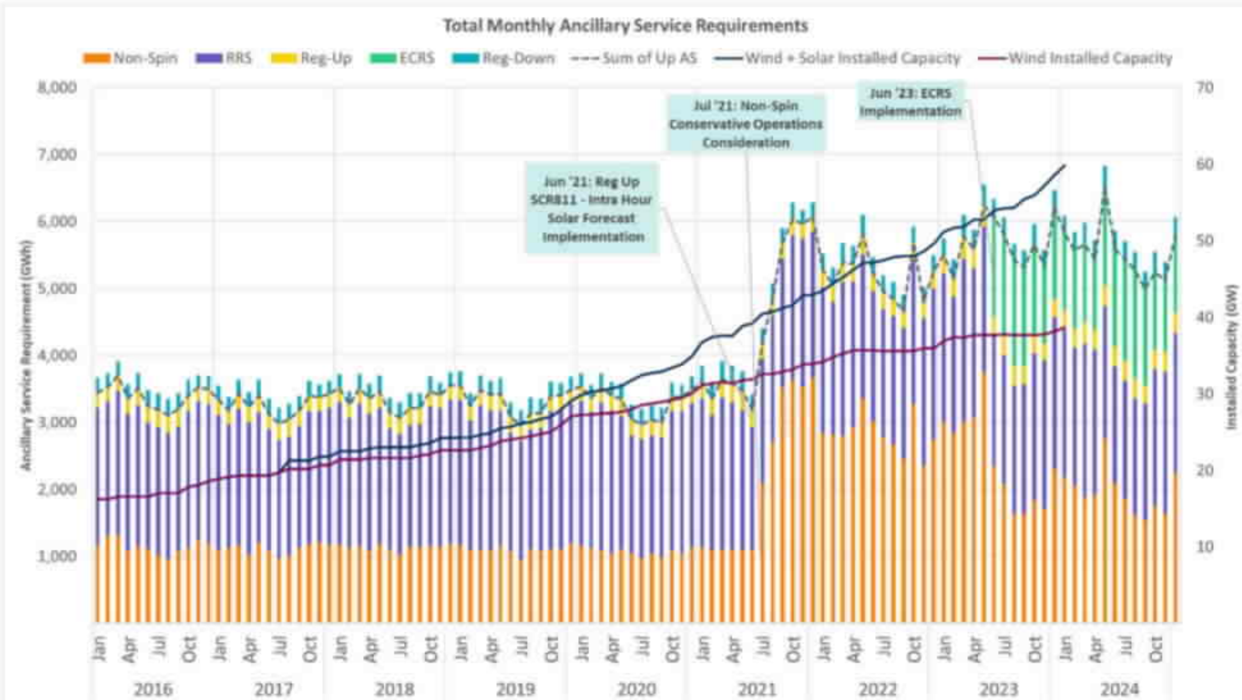


Figure 3 - Historical AS Requirements, Methodology Changes, and Intermittent Resource Capacity

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[12]. Figure 4 shows the steady increase in net load ramp (Load – Intermittent Resources) over recent years.

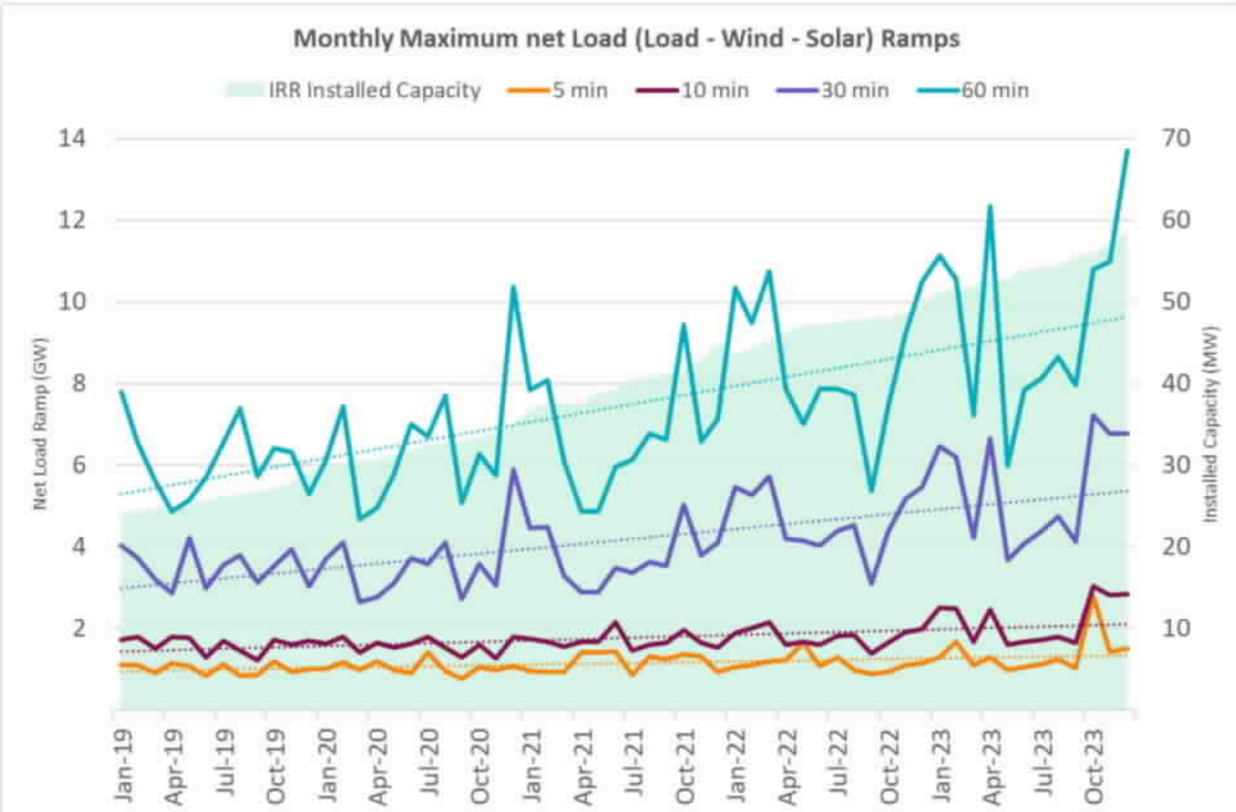


Figure 4 - Historical Monthly Maximum Net Load Ramps

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*[13] 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.

[12] 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.

[13] *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)*[14]. 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.[15]

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.

[14] 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.

[15] 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.

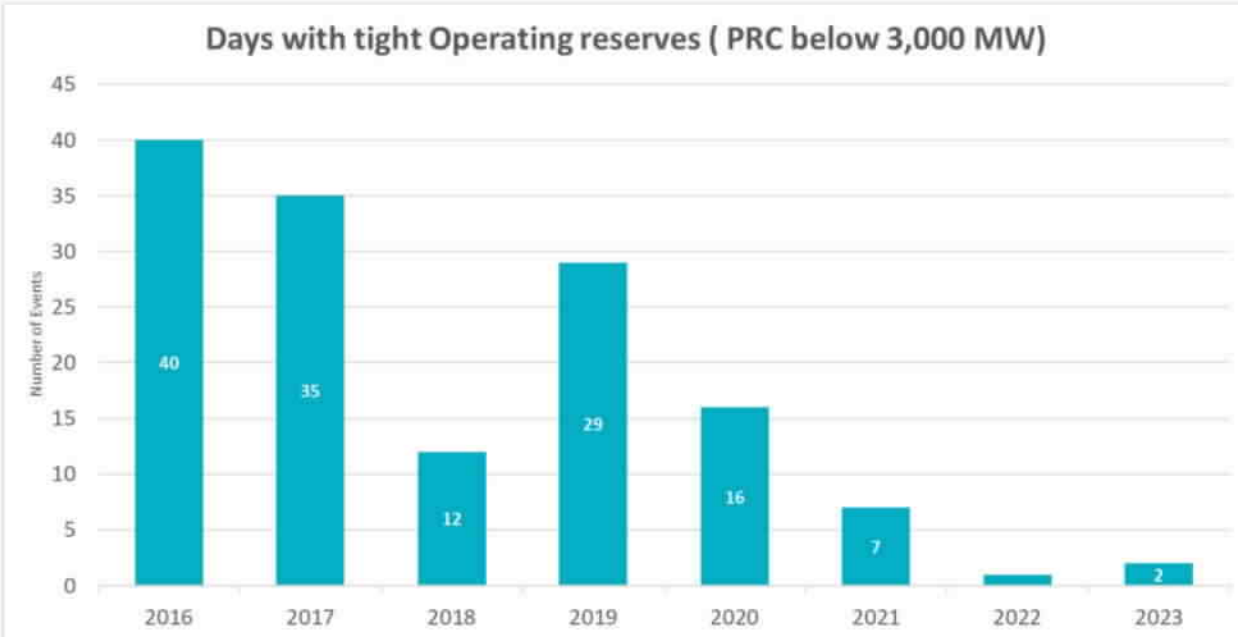


Figure 5 - Days with Tight Operating Reserves

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.[16] 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.

[16] 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

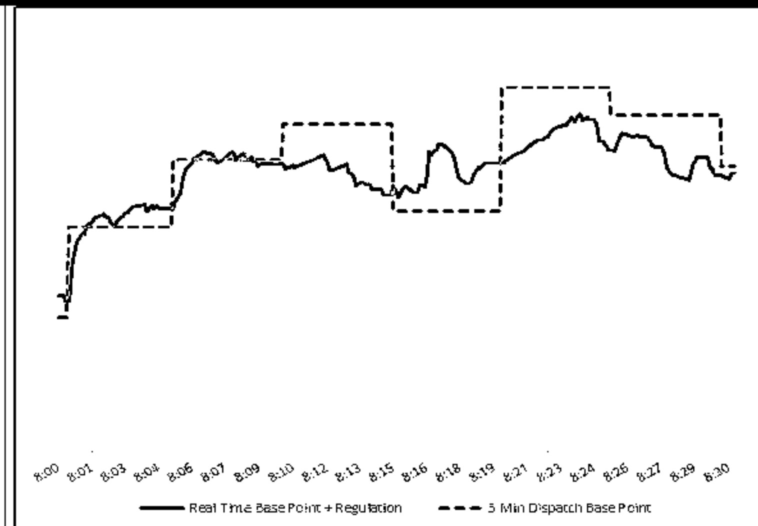
Table 3 defines the five current AS products within these four types:

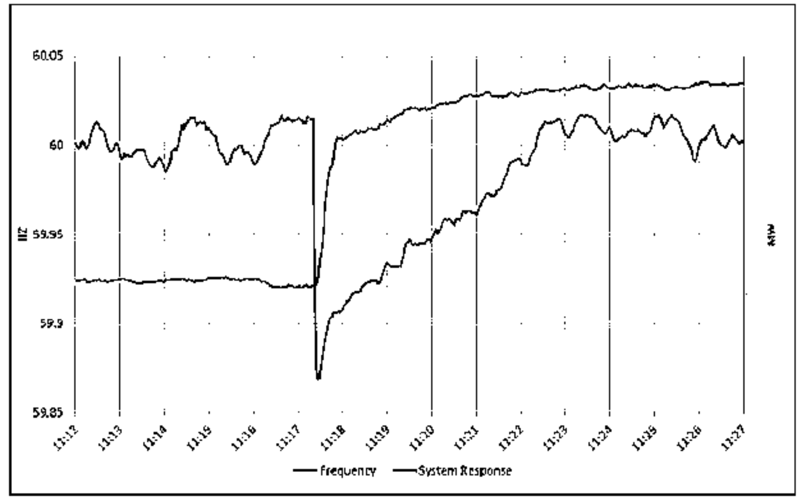
1. Regulation (Up and Down) Services,
2. Responsive Reserve Service (RRS),
3. ERCOT Contingency Reserve Service (ECRS), and
4. Non-Spinning Reserve Service (Non-Spin).

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.[17]

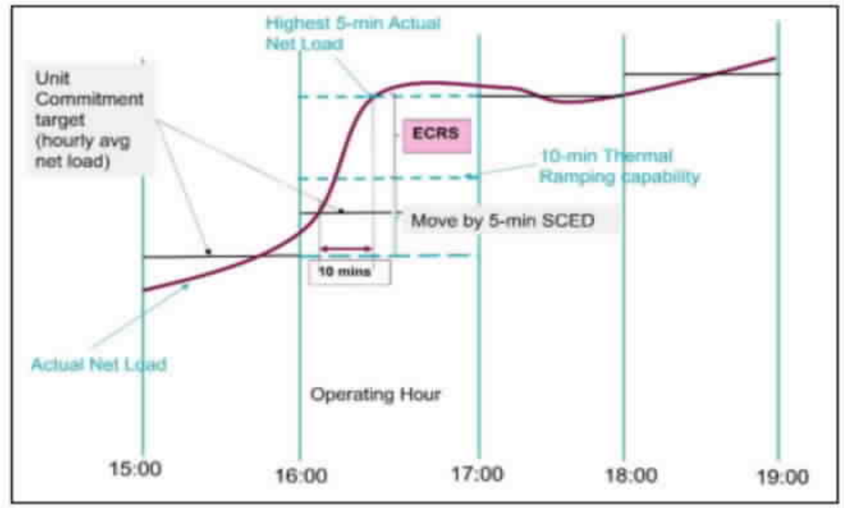
[17] The recommendations section expands on this topic starting on page 37.

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[18], 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*

[18] 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[19] when other available

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

Hourly Quantity		Service and Sub-types	Method for Determining Required Quantity
			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 (85^{th} in case of ECRS and 68^{th} in case of Non-Spin) and hours with highest risk of up ramp are assigned the highest percentile (95^{th} 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 95^{th} 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 errors, so ERCOT procures a quantity of Non-Spin that is based on the 68^{th} 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.

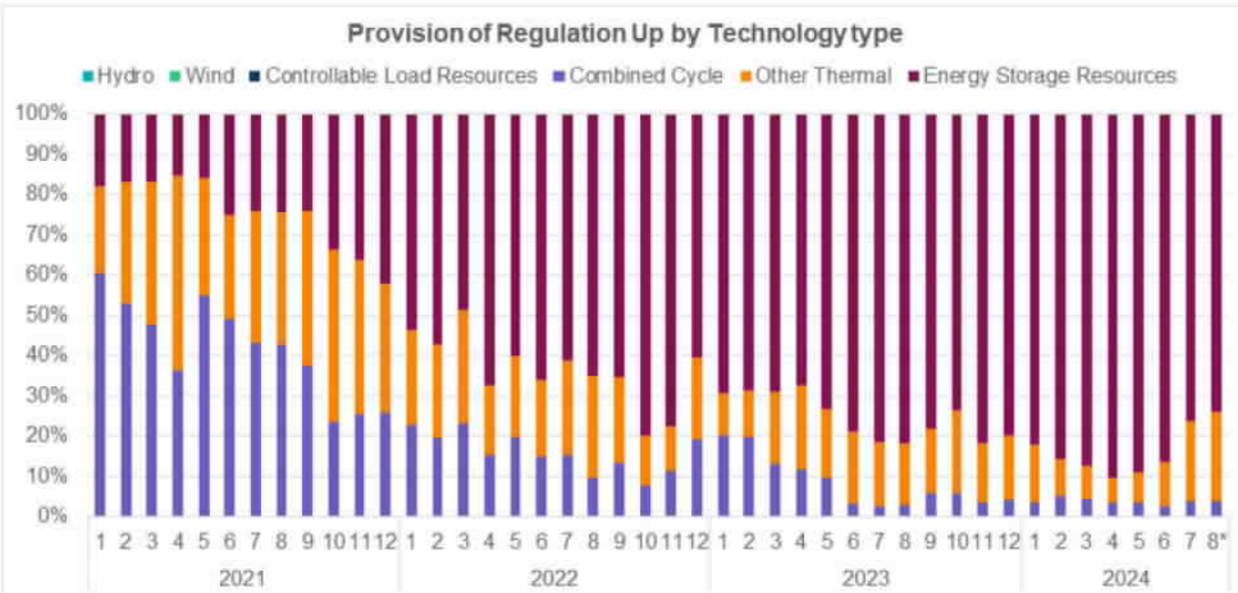


Figure 10 - Technology Types Providing Regulation Up between January 1, 2021 and August 26, 2024

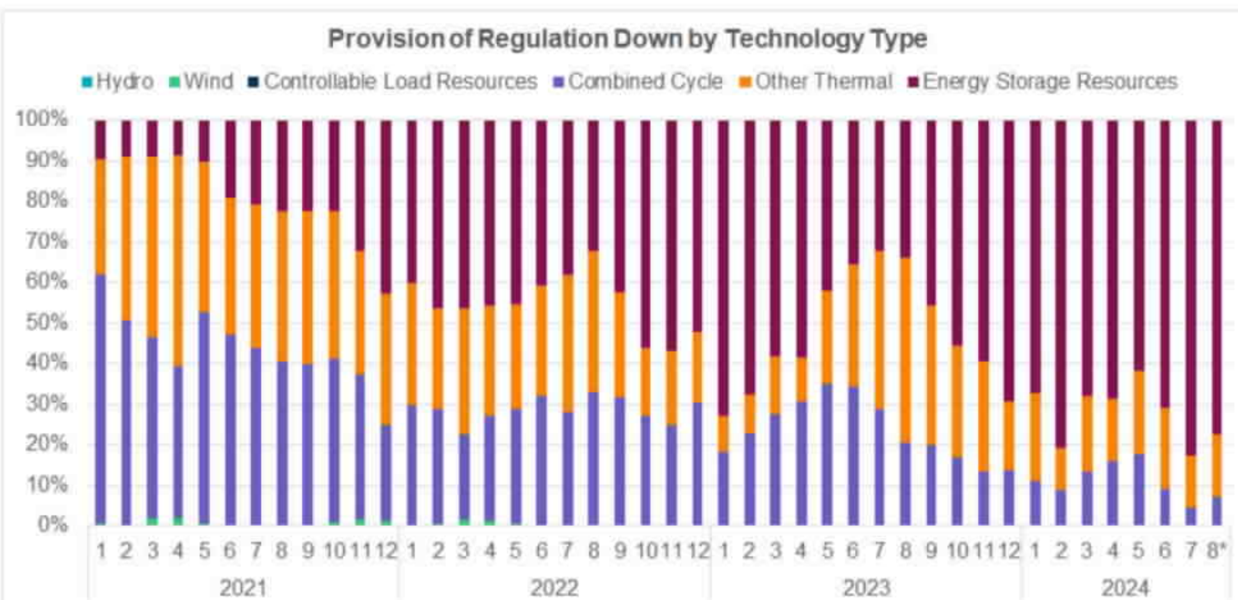


Figure 11 - Technology Types Providing Regulation Down between January 1, 2021 and August 26, 2024

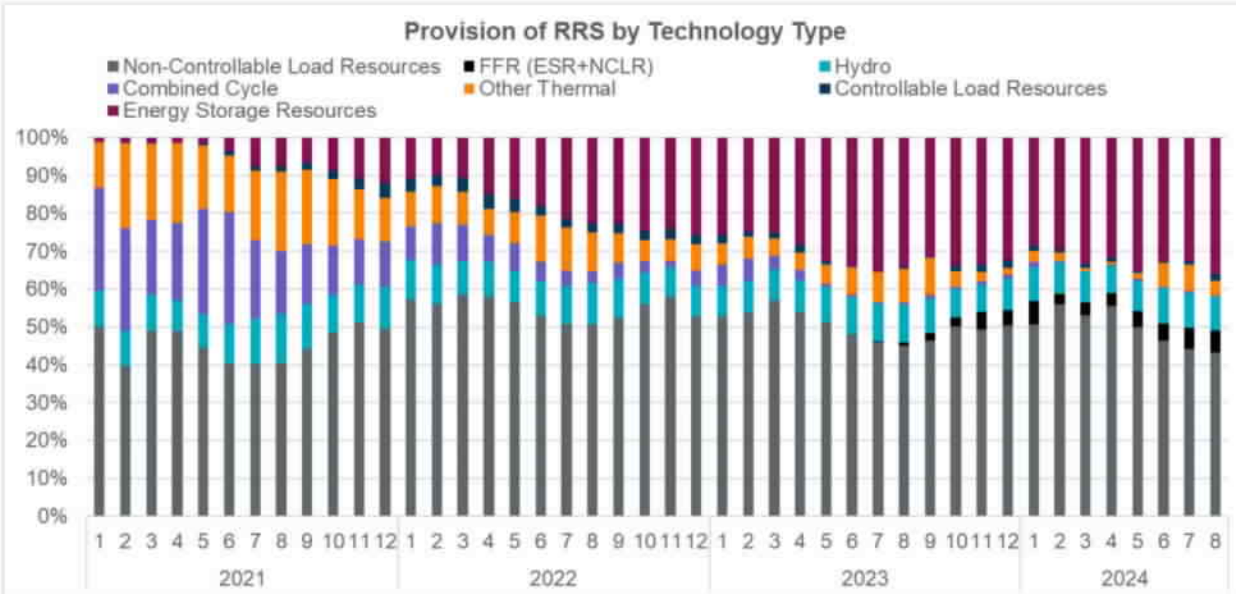


Figure 12 - Technology Types Providing RRS between January 1, 2021 and August 26, 2024

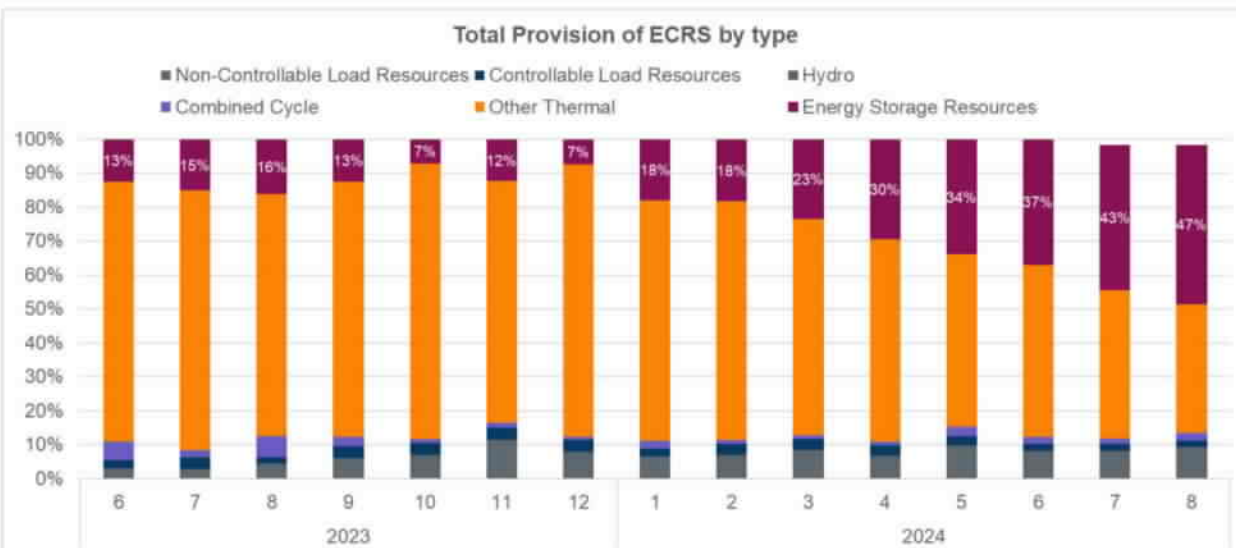


Figure 13 - Technology Types Providing ECRS between January 1, 2021 and August 26, 2024

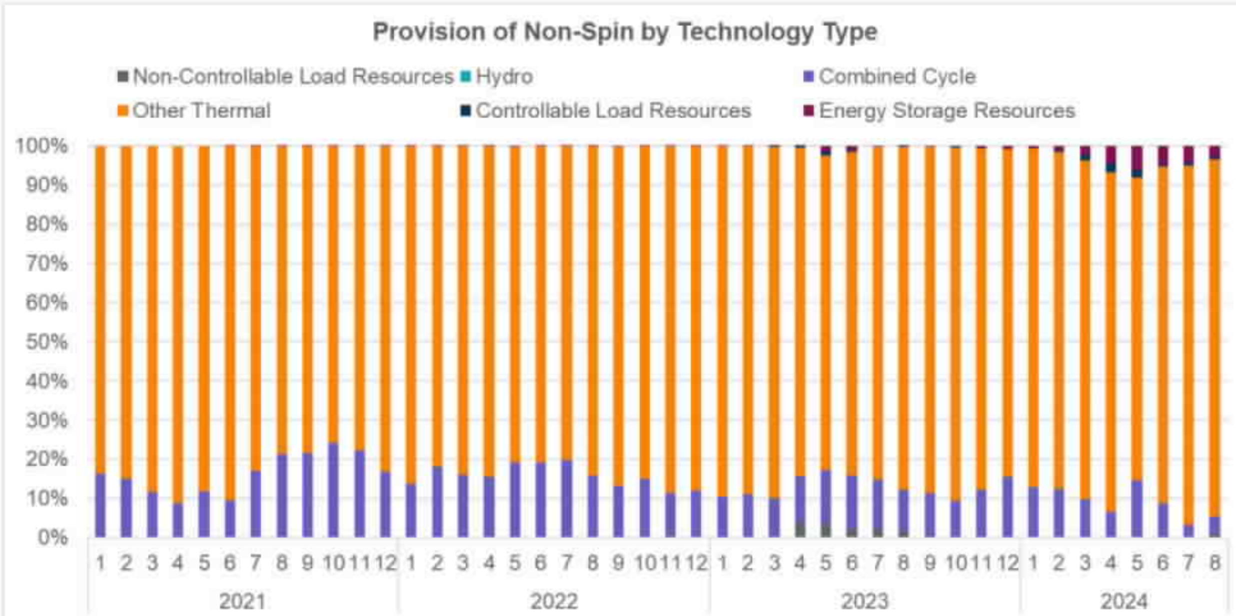


Figure 14 - Technology Types Providing Non-Spin between January 1, 2021 and August 26, 2024

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))[20], 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.

[20] 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.

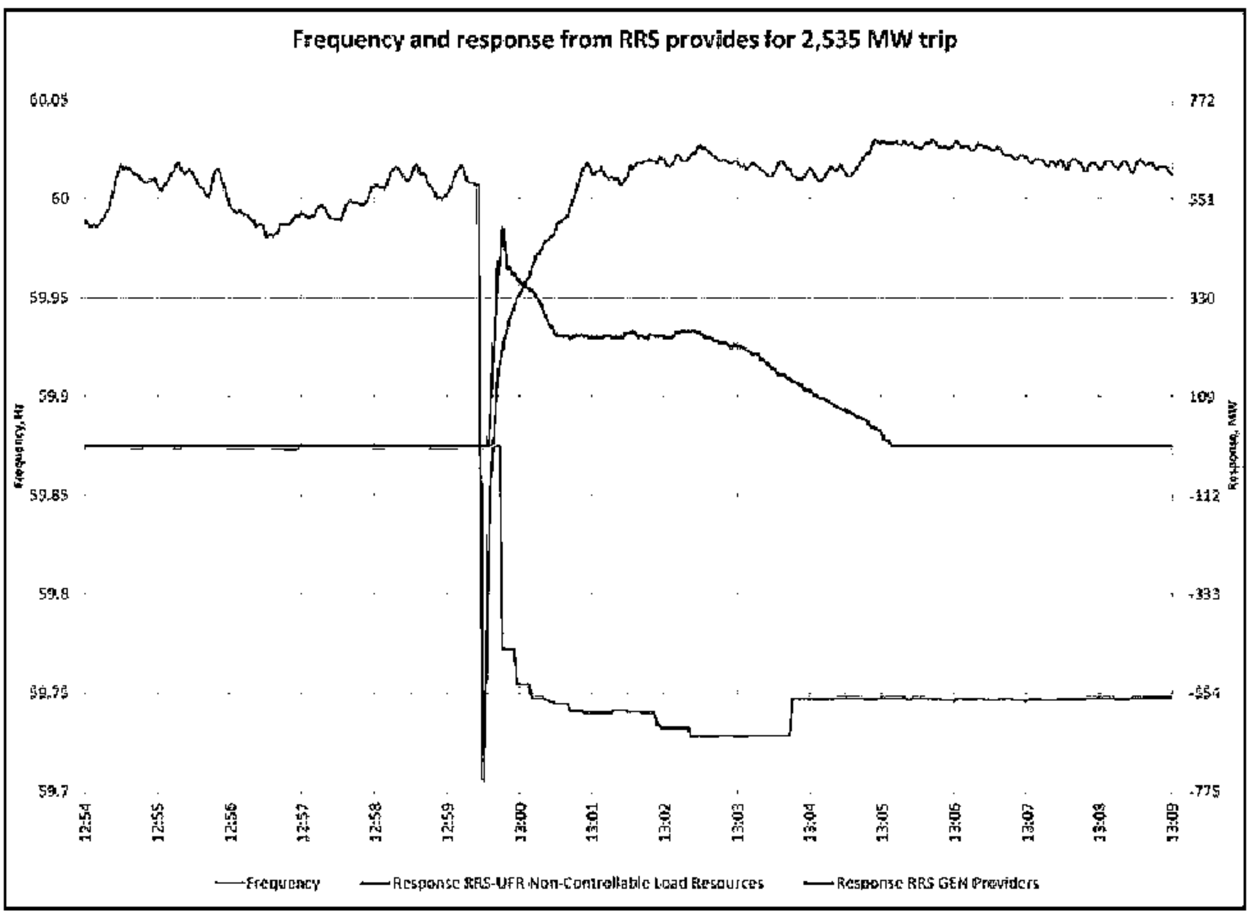


Figure 15 - RRS Deployment Example

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.

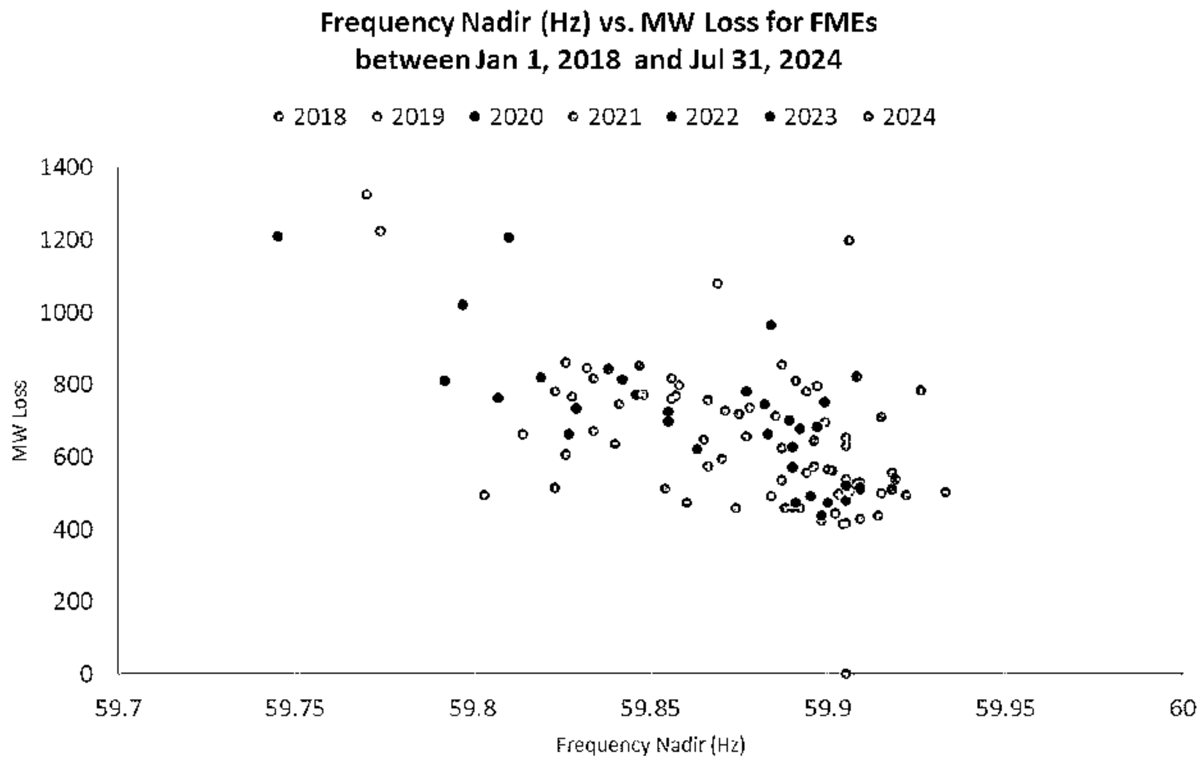


Figure 16 - Frequency Nadir during FMEs between January 1, 2018 and July 31, 2024

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.

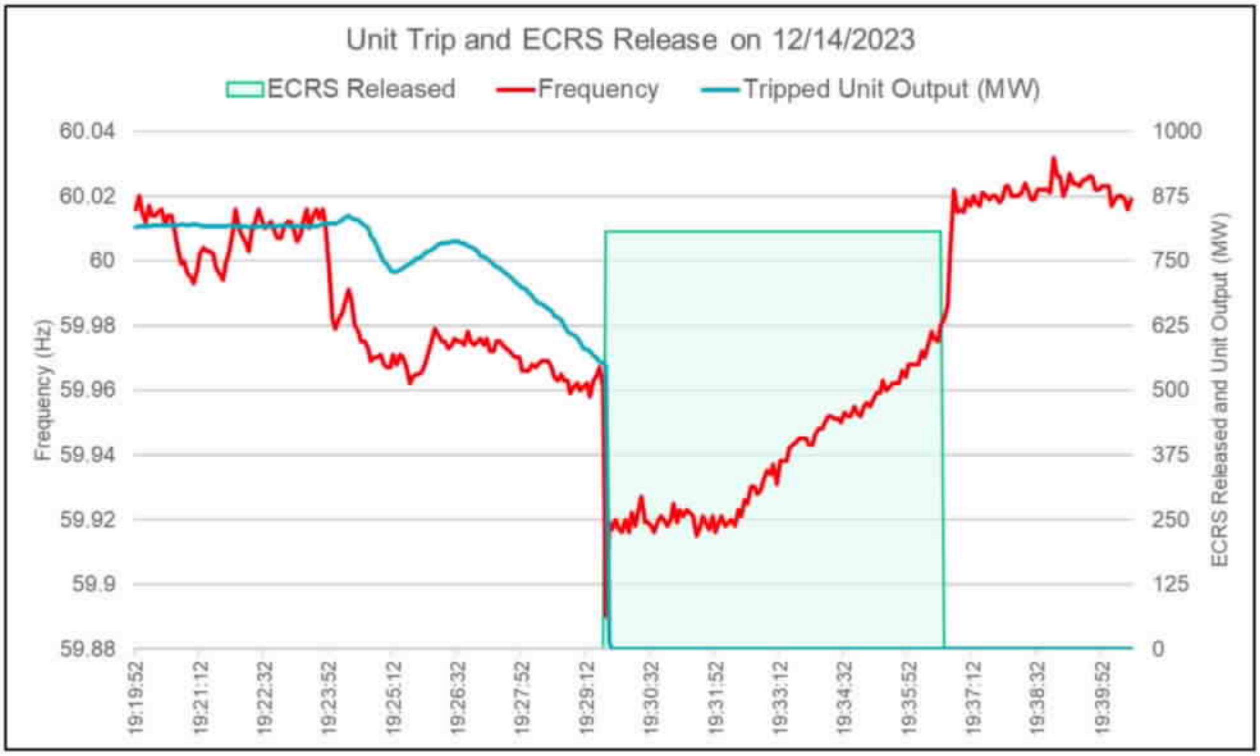


Figure 17 - ECRS Deployment Example

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.

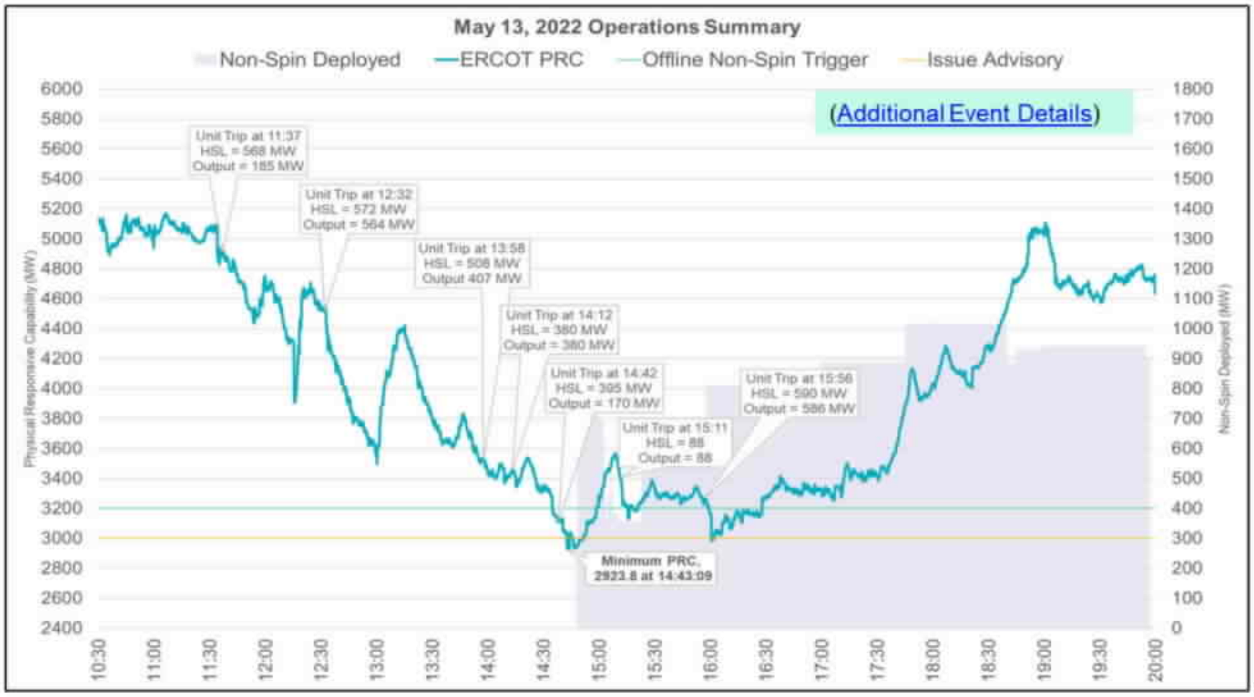


Figure 18 – Non-Spin Deployment Example

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[21]:

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

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.

[21] 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[22], 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.

[22] 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.[23]

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.

[23] 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.

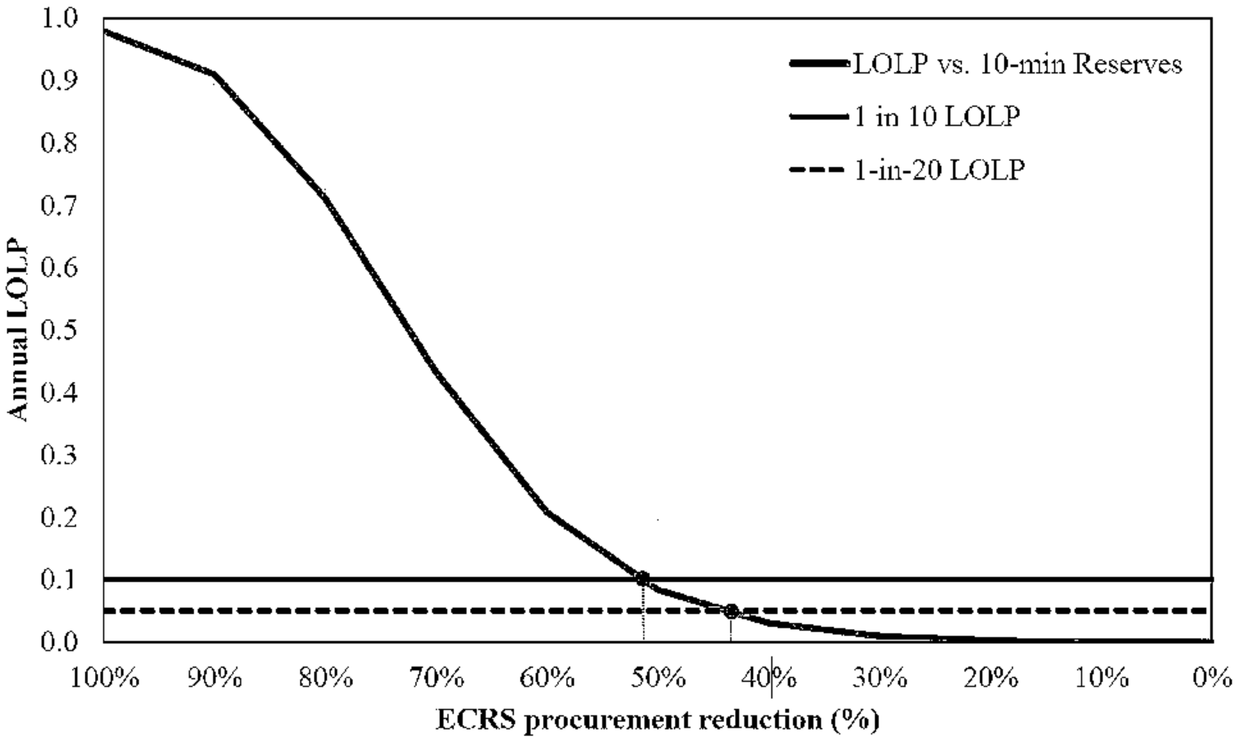


Figure 19 - ECRS Procurement Quantities Modeling Results

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.

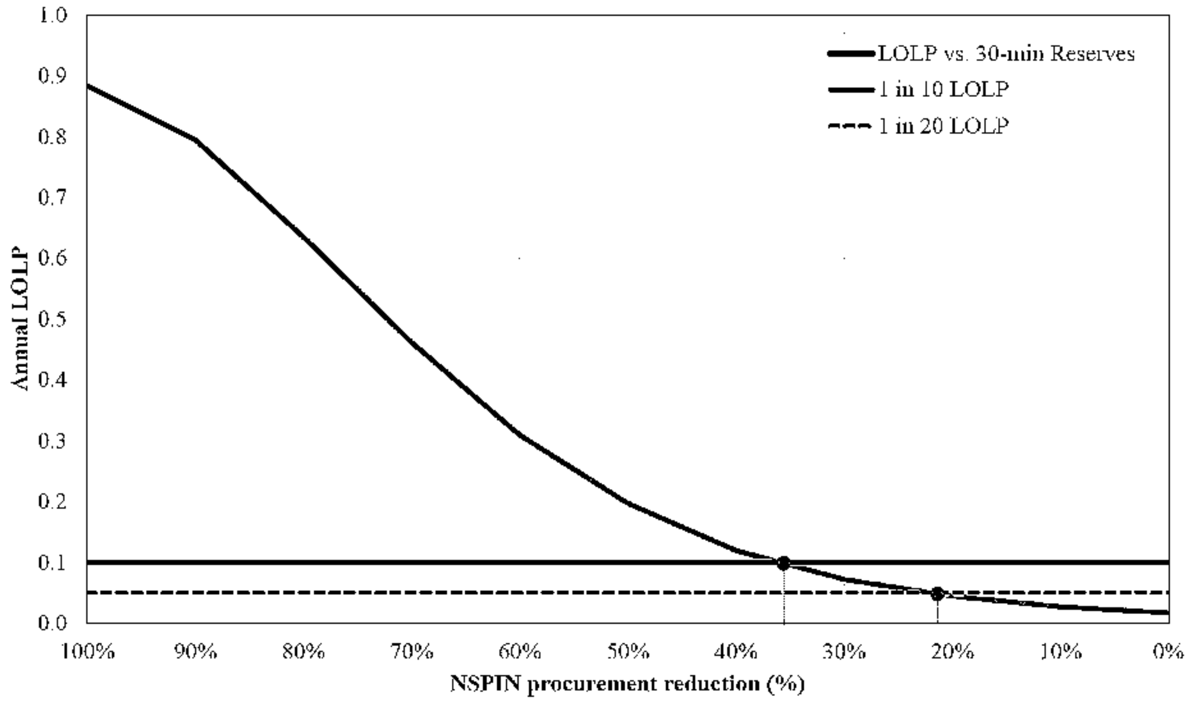


Figure 20 - Non-Spin Procurement Quantities Modeling Results

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).

Recommended Changes to Existing Ancillary Services

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 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.[24]

- 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.

[24] 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.

Recommendations for Additional Ancillary Services

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

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[25] 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 narrow need related to forecast uncertainty beyond what is covered by existing products. As such, we do not*

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

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."

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.

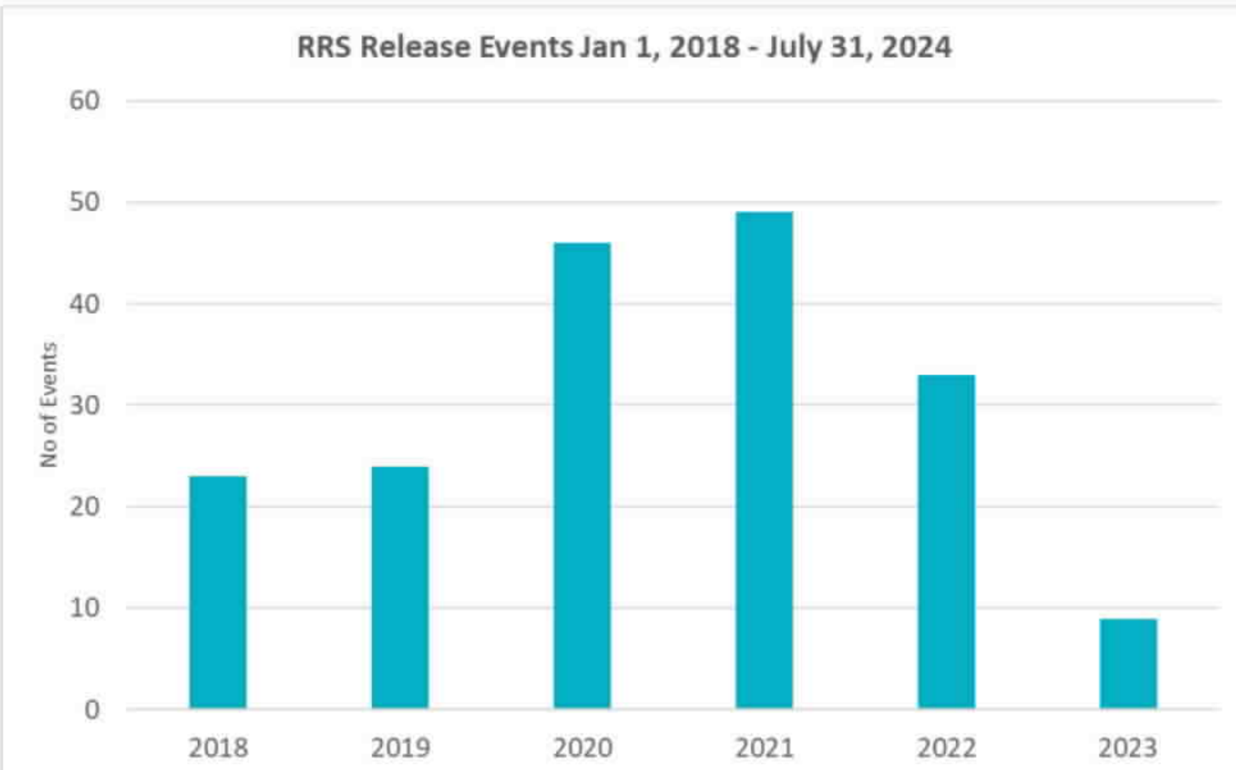


Figure 21 - RRS Release Events Jan 1 2028 - July 31, 2024

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.

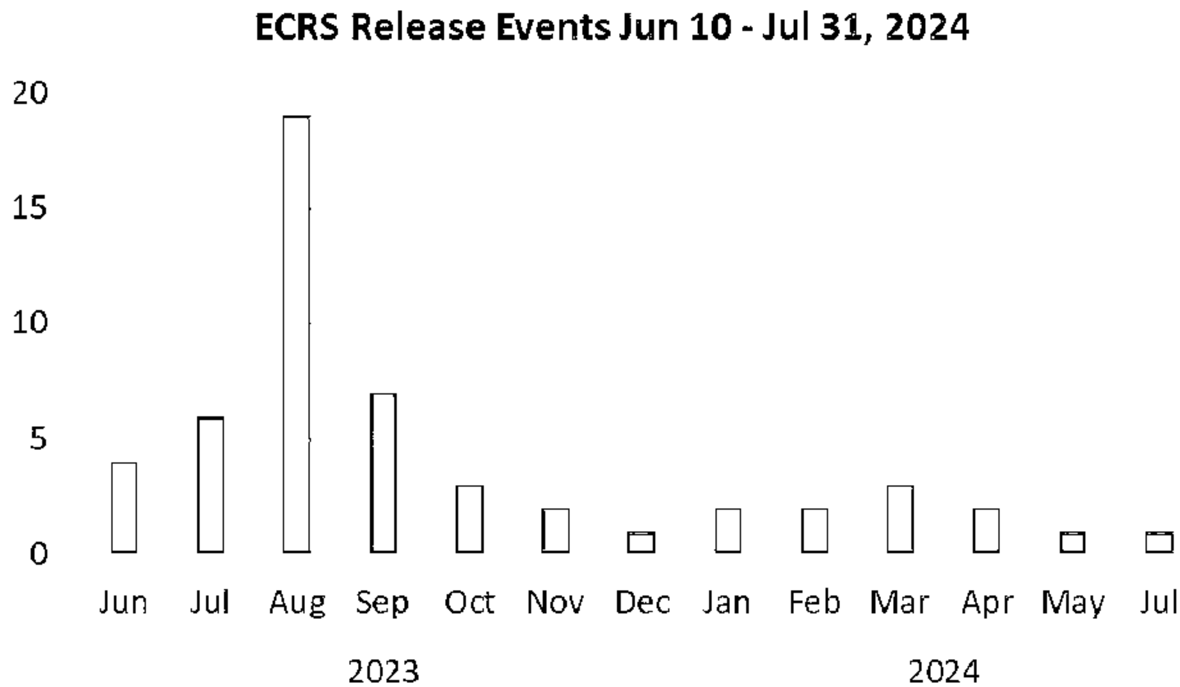


Figure 22 - ECRS Release Events through July 31, 2024

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.

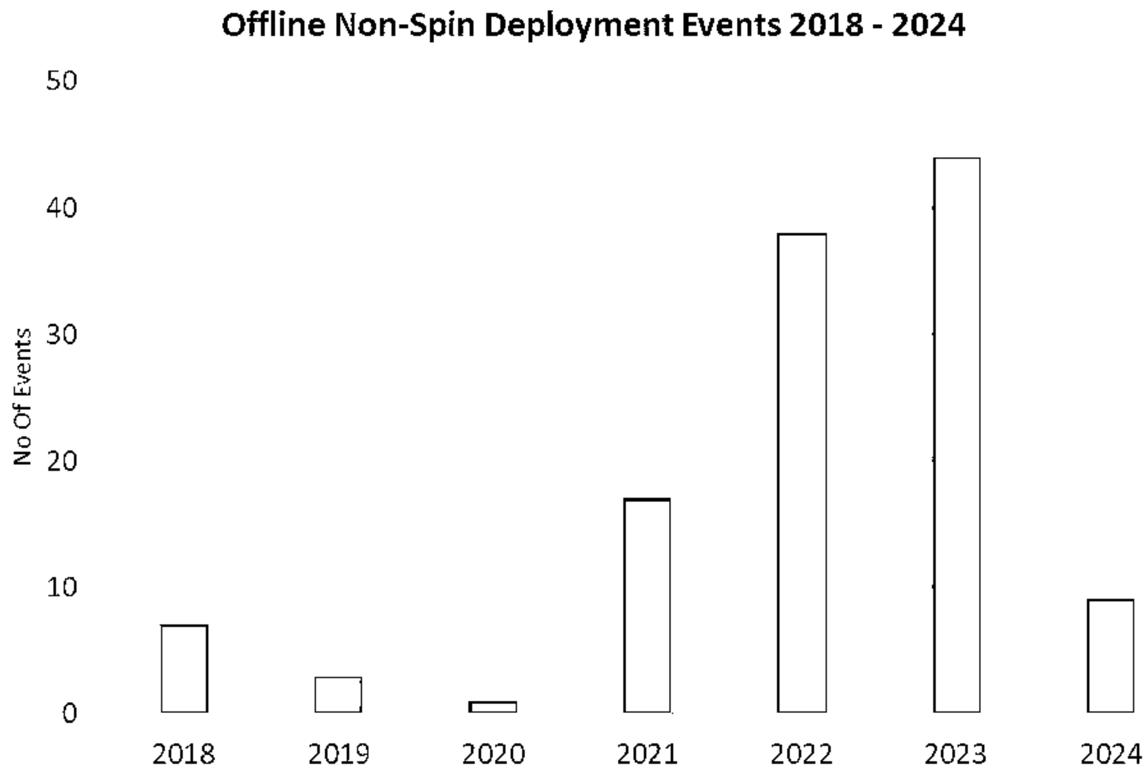


Figure 23 - Offline Non-Spin Deployments 2018-2024

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.

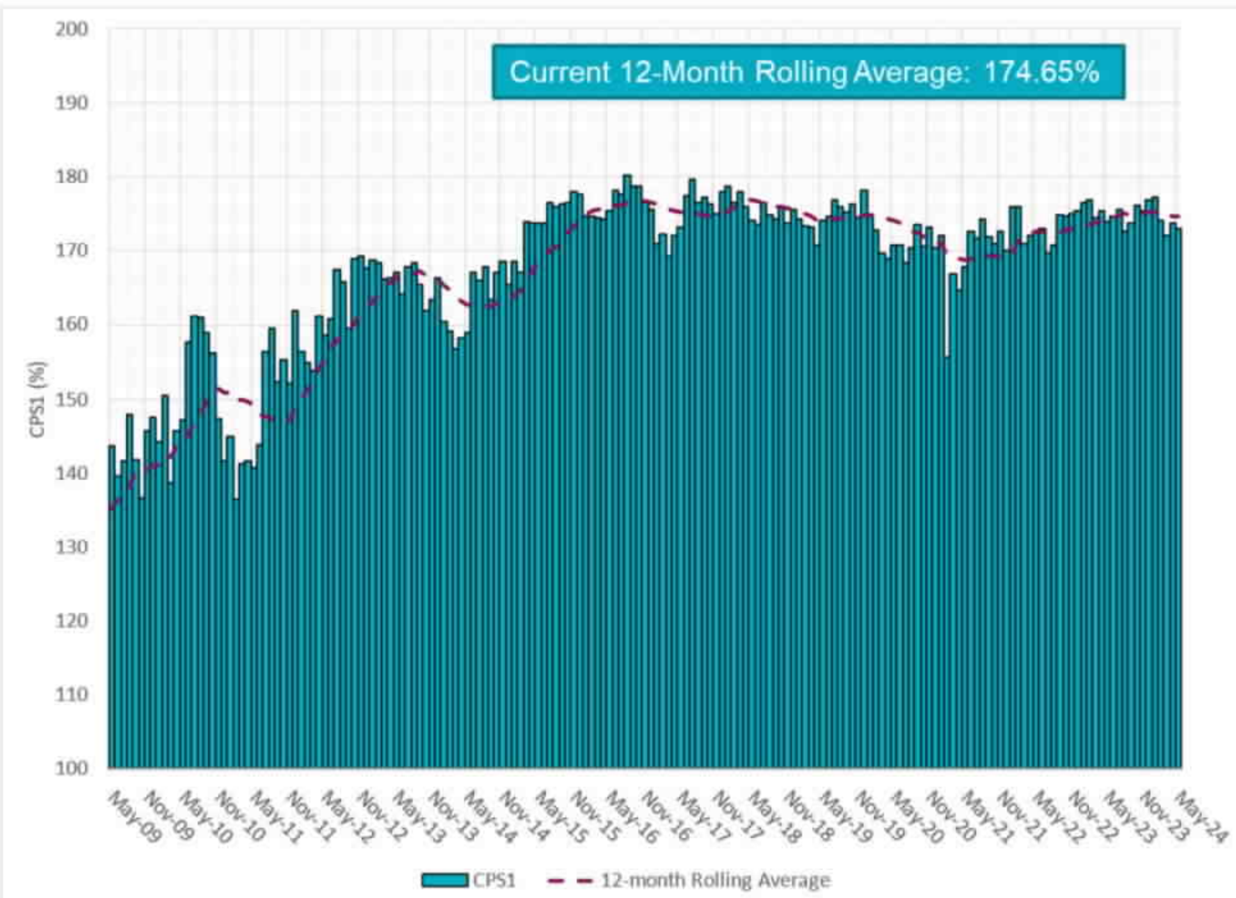


Figure 24 - ERCOT's 12-month Rolling Average CPS1 Performance

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.

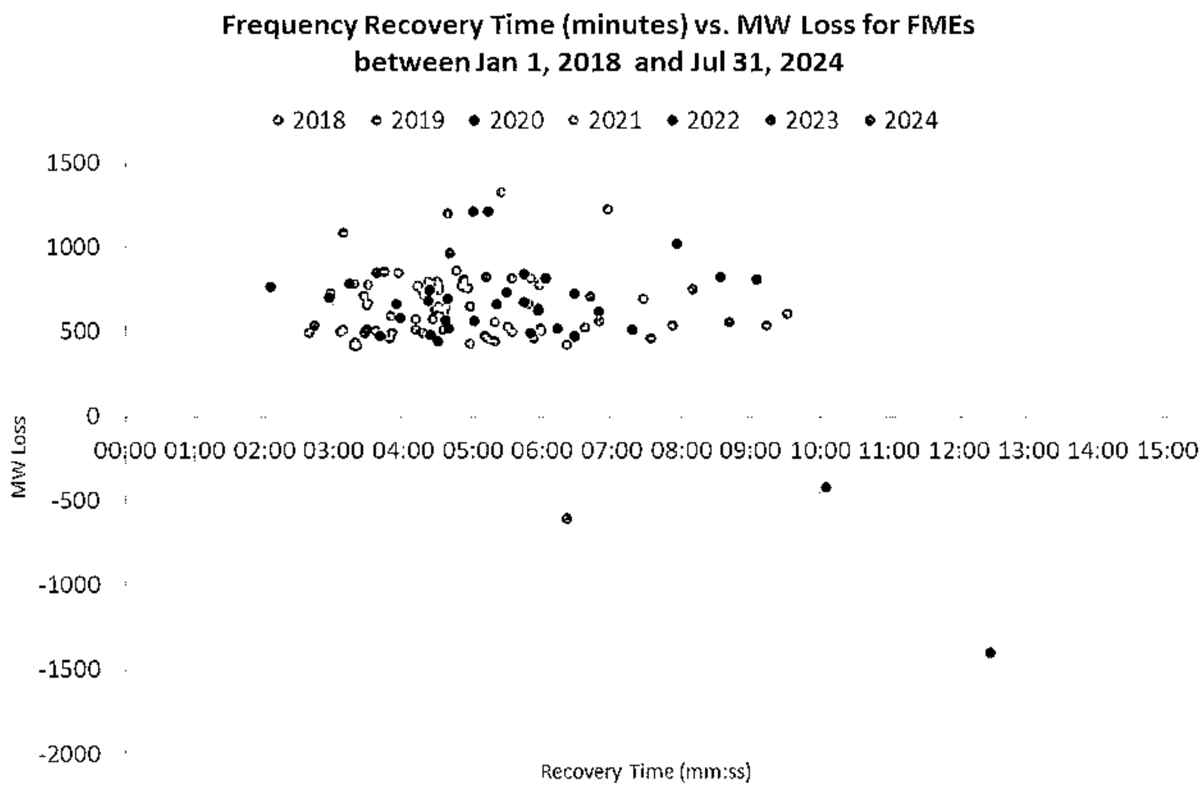


Figure 25 - Frequency Recovery Time for FMEs between January 1, 2018 and July 31, 2024

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.

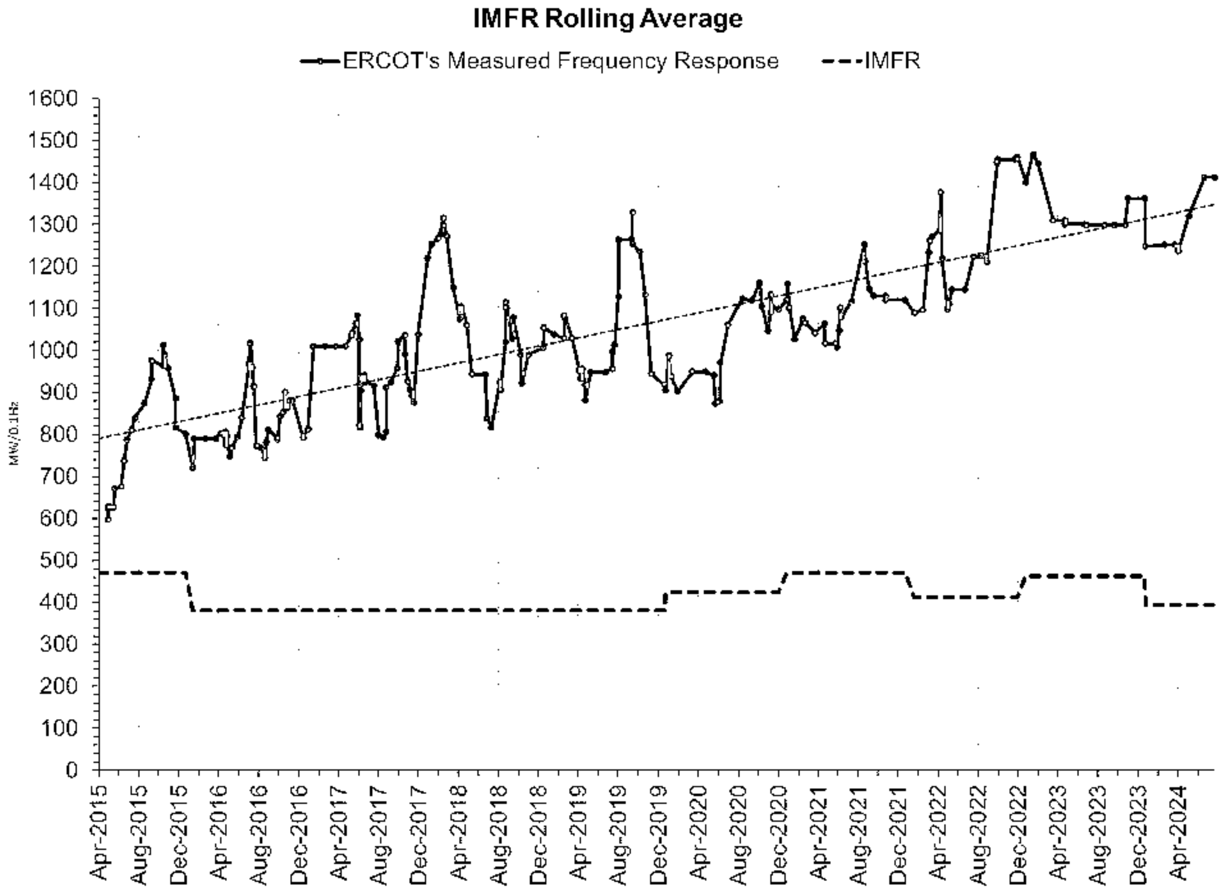


Figure 26 - Measured Frequency Response (FRM) during FMEs between April 1, 2015 and July 31, 2024

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.

Appendix 5: Reserve Products in Electric Markets Around the World (As Provided by ERCOT)

Product Type / Comparison Element	Outside of U.S.			United States						
	AEMO	Eirgrid (Ireland)	National Grid (United Kingdom)	ISO-NE	NYISO	PJM	MISO	SPP	ERCOT	CAISO
Region Facts	Max Demand 35,796 MW Min Demand 11,892 MW Wind Capacity 11,392 MW Solar Capacity 9,644 MW Rooftop Solar Capacity 19,642 MW	Max Demand 5,577 MW	Max Demand 55 Gigawatts (GW) Min Demand 15 GW Wind and Solar Capacity 35 GW (Includes 2.9 GW of Rooftop solar capacity)	Max Demand 28,130 MW (Aug 2006) Wind Capacity as of Dec 2023: 1,400 MW Solar Capacity mostly Rooftop as of Dec 2023: 6,500 MW	Max Demand 33,956 MW (July 2013) Wind Capacity as of Dec 2023: 2,736 MW Solar Capacity as of Dec 2023: 194.4 MW Rooftop Solar Capacity as of Dec 2023: 5,227 MW	Max Demand 165,563 MW (Summer 2006) Wind Capacity as of Jun 2022: 1,570 MW Solar Capacity as of Jun 2022: 2,665 MW	Max Demand 127.1 GW (7/20/2011) Wind Capacity as of Dec 2023: 30.56 GW Solar Capacity as of Dec 2023: 7.6 GW	Max Demand 56,184 MW (8/21/2023) Wind Capacity as of Jun 2024: 5.4 GW Solar Capacity as of Jun 2024: 396 MW	Max Demand 85,559 MW (8/20/2024) Wind Capacity as of Jun 2024: 39,450 MW Solar Capacity as of Jun 2024: 25,333 MW	Max Demand 44,534 MW (8/16/2023) Wind Capacity as of Aug 2024: 8,352 MW Solar Capacity as of Aug 2024: 19,638 MW Rooftop Solar Capacity as of Aug 2024: 10,000 MW

Product Type / Comparison Element	Outside of U.S.			United States						
	AEMO	Eirgrid (Ireland)	National Grid (United Kingdom)	ISO-NE	NYISO	PJM	MISO	SPP	ERCOT	CAISO
Total AS Products Procured Using Pre-Day Ahead or Day Ahead or Real Time Markets	10[26]	(Current) 10 (AS product suite is in active transition. Products and counts may change in future)	(Current) 20 (AS product suite is in active transition. Products and counts may change in future)	4	3	4	5 or 6	6	5	6 or 7
Regulation Service	Regulation raise and Regulation lower	Primary Frequency Control Secondary Frequency Control	Regulating Reserve changing to Dynamic Regulation and Dynamic Moderation	Regulation	Regulation	Regulation	Regulation	Regulation Up Regulation Down	Regulation Up Regulation Down	Regulation Up Regulation Down

[26] For AEMO, SPP, ERCOT, and CAISO, it's relevant to note that these numbers include the fact that these markets have separate Regulation Up and Regulation Down AS products. The other regions also have Regulation Up and Regulation Down, i.e., Regulation to address frequency deviations in either direction, but they are part of one singular Regulation product.

Product Type / Comparison Element	Outside of U.S.			United States							
	AEMO	Eirgrid (Ireland)	National Grid (United Kingdom)	ISO-NE	NYISO	PJM	MISO	SPP	ERCOT	CAISO
Frequency Response		Fast Frequency Response Primary Operating Reserve Secondary Operating Reserve	Dynamic Containment, Static Firm Frequency Response and Dynamic Firm Frequency Response	-	-	-	-	-	Responsive Reserve Service	-

Product Type / Comparison Element		Outside of U.S.			United States						
		AEMO	Eirgrid (Ireland)	National Grid (United Kingdom)	ISO-NE	NYISO	PJM	MISO	SPP	ERCOT	CAISO
Contingency Reserve	Spinning	Very fast raise & lower (1 second raise & lower) Fast raise & lower (6 second raise & lower) Slow raise & lower (60 second raise & lower) Delayed raise & lower (5-minute raise & lower)		(Proposed) Quick Reserve (Proposed) Slow Reserve	Ten-Minute Spinning Reserve (TMSR)	Spinning Reserve	Synchronized Reserve (SR)	Spinning Reserve	Spinning Reserve	ECRS	Spinning Reserve

Product Type / Comparison Element		Outside of U.S.			United States						
		AEMO	Eirgrid (Ireland)	National Grid (United Kingdom)	ISO-NE	NYISO	PJM	MISO	SPP	ERCOT	CAISO
	Non-Spinning reserves and supplemental reserves	-	Tertiary Primary Operating Reserve Band 1 Tertiary Operating Reserve Band 2 Replacement Reserve Substitute Reserve Contingency Reserve	Short term operating reserve	Ten-Minute Non-Spinning Reserve (TMNSR) Thirty-Minute Operating Reserve (TMOR)	Non-Spinning reserve	Non-Synchronized Reserve (NSR) Secondary Reserve	Supplemental reserve	Supplemental Reserves	Non-Spin reserve	Non-Spinning Reserve
Ramp Products	Short Horizon	-	(Proposed) Ramping Margin 1 Hour (Proposed) Ramping Margin 3 Hour (Proposed) Ramping Margin 8 Hour	Start up and Hot standby	-	-	-	Up and down Ramp Capability	Ramp Capability Product	ECRS	Flexible Ramping Product– upward and downward reserves
	Longer Horizon							Short-Term Reserve	Uncertainty Product	Non-Spin Reserve	Imbalance Reserve

Appendix 6: Potential Future AS Needs (As Provided by ERCOT)

As the ERCOT Region continues to transform and technology continues to evolve, Ancillary Services are expected to also transform and evolve. *Appendix 4: Changes to AS Methodology between 2016 and 2024* lists the significant changes to the AS Methodology since 2016. Going forward, stakeholders should expect similar advancements to be implemented as needed to meet evolving system needs.

Two topics that have elicited stakeholder discussions regarding possible changes to AS but have not yet been deemed to require new AS products are inertia and the impacts of the addition of new large loads.

Inertia

Inertia is the physical measurement of a power system's potential energy that is stored in the mass of rotating machines, primarily generators. Inertia levels, typically expressed in terms of gigawatt-seconds (GW-s), indicate a power system's ability to resist a change in frequency due to an imbalance in generation and load. As an example, when a generator trips offline suddenly, the inertia in a system prevents the frequency from dropping below 60 Hz too much and too quickly.

Inertia is inherently provided by synchronous generators, such as gas, coal, nuclear, and hydro resources which contain large synchronous rotating masses. Inverter-based resources (IBRs), namely wind, solar, and battery resources, do not have the inherent capability to provide inertia. It has been generally understood that as the resource mix changes to include a greater portion of IBRs and lesser quantities of synchronous generators, inertia will decrease.

ERCOT has calculated a minimum inertia level (known as "critical inertia") of 100 GW-s, which is the quantity of inertia needed to maintain stability. In ERCOT, inertia is typically between 200 GW-s and 400 GW-s depending on the number and size of synchronous generators that are online. Low inertia levels occur during times of low net load when the load is low, IBR generation is relatively high, and very few synchronous generators are online. These conditions usually occur in the spring and fall. The lowest inertia that ERCOT has experienced in the last ten years has been 115 GW-s, which occurred in March 2022.

ERCOT monitors inertia in real-time, and if inertia levels were to approach the critical inertia level, operators would use the RUC process to commit additional synchronous generation, thereby increasing inertia. This process ensures that reliability is maintained, but if ERCOT were to take this action on a regular basis, it may be more efficient to procure the inertia through a new or modified AS product.

ERCOT has not yet needed to use the RUC process to maintain inertia. Additionally, there are several developments that may lessen the chance that ERCOT would experience inertia levels near the critical inertia threshold. These developments include:

1. Minimum load levels have been and are expected to continue to increase due to increasing quantities of data center and oil and gas loads. The higher the minimum load levels, the more likely it is for synchronous generators to remain online, which results in higher inertia on the system. Figure 27 shows that minimum load levels rose significantly over the study period.

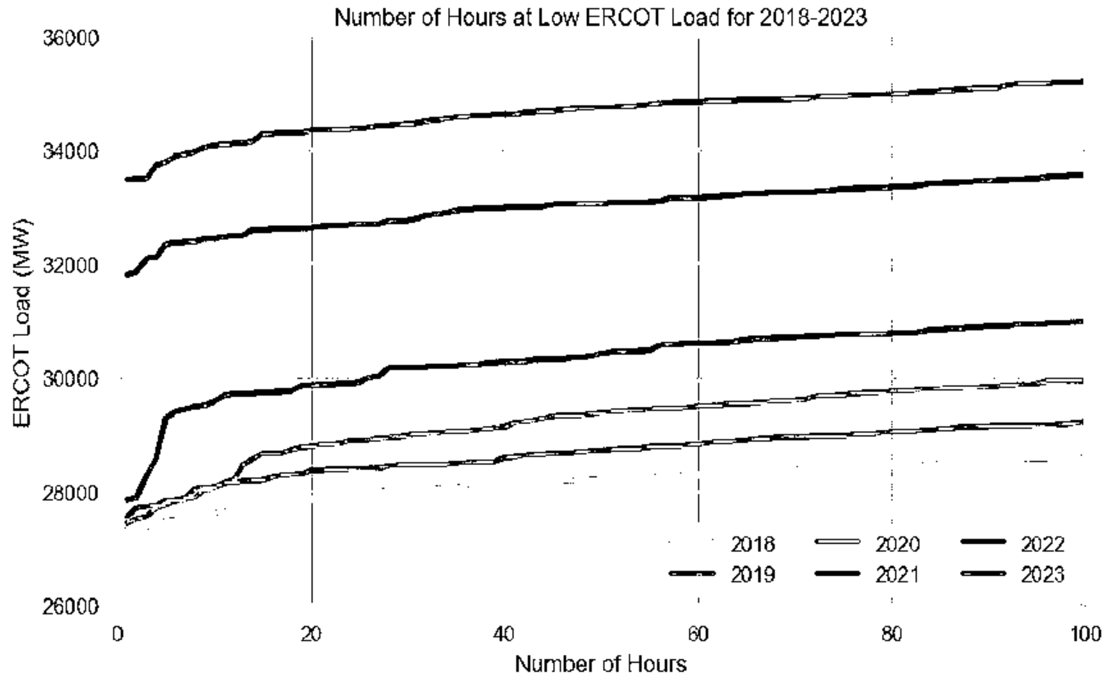


Figure 27 - Number of Hours of Low ERCOT Load for 2018-2023

2. The expected adoption of grid forming inverters is expected to lower the critical inertia level required by synchronous generators in ERCOT. Grid forming inverters are a new type of inverter that has advanced capabilities compared to the inverters on existing IBRs. While grid forming inverters do not provide inertia, they do provide stability when there is an imbalance between load and generation when a generator trips. Grid forming inverters are commercially available for battery energy storage resources, and ERCOT plans to propose grid forming inverter grid code specifications by the end of 2024 to provide guidance to stakeholders.

3. The planned addition of synchronous condensers in ERCOT will increase inertia on the system. Like synchronous generators, synchronous condensers inherently provide inertia. Synchronous condensers are planned to be added at six locations in west Texas by 2027. These synchronous condensers are expected to provide a total of at least 12 GW-s of inertia and are planned to be operated continuously, except for maintenance periods.

Because of these developments, at this time, ERCOT does not see a need to pursue AS product changes to address low inertia levels.

Large Load Related AS Changes

Recently, ERCOT has experienced a notable increase in new loads that are greater than 75 MW in size. These "large loads" present some unique challenges that may need to be addressed by changes to AS. Specifically, there are two challenges that could potentially be mitigated by AS changes and that, if not addressed, may cause reliability issues on the ERCOT system.

1. Some large loads, for example crypto-mining data centers, can quickly change consumption based on changes in ERCOT wholesale prices. If many large loads change their consumption at the same time and in a manner not coordinated with ERCOT, it could cause a significant imbalance between load and generation, which could cause frequency instability on the ERCOT system. This issue could be addressed by mandating those that are able to follow SCED must register as Controllable Load Resources (CLRs) and by establishing ramp rate limitations for large loads that cannot be CLRs, i.e., how fast a large load can change their consumption, or by increasing the quantities of AS that are procured to cover consumption changes by large loads. However, through mid-2024, ERCOT has not observed reliability problems due to large load consumption ramps. Based on this, ERCOT is not currently planning to make any related changes but will continue to monitor the issue.

2. The second challenge is related to how large load equipment responds to system faults, such as lightning strikes. When a fault occurs somewhere on the transmission system, the voltage of the equipment in the immediate vicinity of the fault will spike below normal levels. When this happens, certain voltage sensitive equipment, such as the power supplies of data center servers, will temporarily cease consuming power. This sudden reduction in consumption can cause an imbalance between load and generation, which could cause sudden frequency instability on the ERCOT system. Such an event occurred on the ERCOT system in December 2022 when multiple faults in west Texas caused the loss of 1,600 MW of consumption. In this case, frequency rose to 60.235 Hz, which is relatively high, but it did not cause any significant reliability problems on the ERCOT system. There are several ways this issue could be mitigated, including limiting the quantity of load that can be connected to the transmission system at any single location, constructing transmission system improvements, establishing "voltage ride-through" requirements for large loads, or by creating a new type of AS to preserve "floor room" on generators so that the generators can respond to sudden load-generation imbalances and maintain frequency stability. At this time, ERCOT is not pursing a new type of AS but is proposing to create a planning criterion that could help limit the maximum load loss that occurs during system faults. As the system and ERCOT Market Rules evolve, the need for a new type of AS should be assessed based on ERCOT's ability to maintain frequency below the levels that trigger NERC compliance issues or generation trips during actual system faults.

Appendix 7: Current Proposed Changes for 2025 Ancillary Services Methodology

Table 7 summarizes ERCOT's proposed changes for the 2025 AS Methodology. These changes are proceeding through the Protocol-defined annual update process and are expected to be considered at the October ERCOT Board meeting.

Table 7 – Summary of Proposed Changes for 2025 Ancillary Services Methodology

AS	Proposed Changes
Regulation	Change methodology for Regulation Service, to the error in forecasting net load that is used to set dispatch target for SCED (i.e. Generation to be Dispatched (GTBD). This aligns the required quantity more closely to the forecast error that drives the need.
RRS	To align with ERCOT's new IFRO from NERC, the minimum RRS-PFR limit for 2025 will change to 1,365 MW. NERC's preliminary BAL-003 Interconnection Frequency Response Obligation (IFRO) for Operating Year (OY) 2025 assessment for ERCOT shows a decrease in ERCOT's IFRO.
ECRS	Change methodology for ERCOT Contingency Reserve Service (ECRS) to (1) Remove the adjustment for risk coverage during sunset hours to be at least 90th percentile, (2) Adjust the frequency recovery portion such that it covers 70% of historic net load and inertia conditions and (3) compute the minimum ECRS requirements as the larger of the capacity needed to recover frequency and capacity needed to support net load forecast errors.
Non-Spin	Change Non-Spin quantities specifically for nighttime (HE23 to HE06) to be computed using 4 Hours Ahead (HA) hourly average net load forecast error. Non-Spin quantities during rest of the hours will be based on 6 HA hourly average net load forecast error (as in 2024). Based on analysis of committed resources and ability to meet forecast errors over past 3.5 yrs.