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ERCOT Methodologies for Determining Ancillary Service Requirements

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Executive Summary

Introduction

ERCOT Protocol 6.4.1(2) requires that methodologies for determining the amounts of Ancillary Services to be required by ERCOT must be developed at least annually. Protocol 6.4.1(4) requires approval of this methodology by the ERCOT Board of Directors.

This document discusses the various Ancillary Services for which requirements are to be developed. Further, detailed methodologies for determining those requirements are attached as part of this document.

The approach taken is to summarize the details that are built into the operations systems purchased for the purpose of implementing the operations requirements of ERCOT Protocols and to provide the individual procedures that ERCOT will use for those services whose quantity requirements are not determined within the operations systems.

Overview of ERCOT AS Methodology

Methodologies are required for the determination of the quantities of Regulation Service (RGS) and Non Spinning Reserve Service (NSRS) required to maintain system reliability. Those procedures are discussed below.

The ERCOT Operating Guides establish a minimum requirement of 2300 MW of Responsive Reserve Service (RRS). This quantity will be increased for hour ending 0700 to hour ending 2200 by linking the amount of RRS to a day-ahead forecast of the Reserve Discount Factor (RDF) until it is determined that a change is appropriate. At that time, the changed methodology will be developed and presented to ERCOT TAC and the ERCOT Board for approval.

Regulation Service (RGS) Requirement

ERCOT has developed a procedure for determination of the base requirement for Regulation Service. The base requirement will be calculated as follows:

Calculate the 98.8 percentile for the up and down Regulation Service deployed ~~in the previous~~during the 30 days prior to the time of the stu~~t~~dy ~~month,~~ and for the same month of the previous year by hour.[1] For each of these months calculate the amount of Regulation Service required by hour to provide an adequate supply of Regulation Service capability 98.8% of the time.

ERCOT will calculate the increased amount of wind penetration each month and utilize tables provided by GE in their final report to ERCOT in the computation of Regulation Service requirements. The tables indicate additional MWs to add to the regulation requirements per 1000 MWs of increase in wind generation.

If it is determined that during the course of the 30 days prior to the time of the study that the ERCOT average CPS1 score was less than 100%, additional Regulation Up and Down will be procured for hours in which the CPS1 score was less than 100% in the previous month.

Experience has shown that, although the total amount of Regulation Service appears to be sufficient for most hours using the methodology described above, the maximum ramp rate of deployment [defined by protocols as the amount procured divided by 10] appears to be insufficient during the 0600 and 2200 time periods each day. For this reason, ERCOT will examine these time periods each month for maximum ramp rate requirements and; if greater than the amount calculated above, will set a higher RGRS requirement for these periods.

Each month ERCOT will perform a back-cast of last month's actual exhaustion rate. If the exhaustion rate exceeded 1.2% in any given hour, ERCOT will determine the amount of increase necessary to achieve an exhaustion rate of 1.2 % for that hour.

Non-Spinning Reserve Service (NSRS) Requirements

The GE final report to ERCOT indicated that wind generation could be treated as negative load. The report went on to describe Load minus wind generation as Net Load. The impact of Net Load on the system was the basis for the analysis performed by GE. Net Load can not be forecasted but Load and wind generation can be forecasted independently and then combined. The combination of Load forecast error and Wind forecast error on the system, creates operational risks that have to be mitigated through ancillary services and/or manual instructions taken by the ERCOT operators. ERCOT will calculate the historical Net Load by subtracting the actual wind generation from the actual Load. The historical Net Load will then be compared to the Load and wind generation forecasts to determine the historical accuracy observed in

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[1] ERCOT has the option to use only the current year's data if its analysis indicates a significant change in market behavior since the previous year.

forecasting. ERCOT will then compute the amount of NSRS required to ensure that the combination of NSRS procured plus the average amount of Regulation Up procured, will result in a total capacity that is larger than 95 percent of the errors observed in the Net Load accuracy evaluation.

has developed a heuristic procedure for determining of the requirement for Non Spinning Reserve Service. The plan is described in detail in the attached sections. In simple terms, ERCOT will plan to purchase NSRS equal to or greater than the largest unit planned to be in operation for periods of projected higher risk. This is intended to cover the exposure to loss of the largest unit and also to provide for load forecast error. ERCOT will monitor the continued need for NSRS as the RPRS market matures.

Replacement Reserve (RPRS) and Balancing Energy Requirements

ERCOT operations systems develop internally the requirements for Replacement Reserve Service and Balancing Energy Service as part of the on-line real-time market operations and power operations activities. These quantities may vary, depending upon the parameters described in the attached descriptions.

Minimum Balancing Energy Down Requirement

The balancing energy down requirement will be determined by examining the previous month and the same month of the previous year to determine how much balancing energy down will be required for ERCOT 99.9% of the time. The procedure for estimating this requirement is described in the attached sections.

Responsive Reserve (RRS) Requirement

Responsive Reserves are resources ERCOT maintains to restore the frequency of the ERCOT System within the first few minutes of an event that causes a significant deviation from the standard frequency. The ERCOT Operating Guides set the minimum RRS requirement at 2300 MW for all hours under normal conditions. The Operating Guides allow ERCOT to increase that requirement under extreme conditions.

Regulation Service (RGS) Requirement Details

Introduction

Regulation Service consists of resources that can be deployed by ERCOT in response to changes in ERCOT System frequency to maintain the target ERCOT System frequency within predetermined limits according to the Operating Guides. ERCOT is required to evaluate normal requirements for Regulation Service – Up (regulation up) and Regulation Service – Down (regulation down) on an annual basis. It is ERCOT's intent to use historical rates of Regulation Service usage to perform this evaluation. Regulation Service is deployed in order to correct actual frequency to scheduled frequency.

This normal Regulation Service requirement may be increased by a multiple of two (2) during projected severe stress conditions such as forecasted extreme weather days.

Summary

To evaluate Regulation Service requirements, ERCOT collects monthly historic deployed Regulation Service data. This data is used to calculate average historically deployed Regulation Service for one-minute periods. By calculating the 98.8 percentile of the amounts of deployed regulation up and deployed regulation down by hour, ERCOT will estimate the expected needs for similar months.

ERCOT provides the mathematical expectation that sufficient Regulation Service will be available 98.8% of all periods. This implies that 1.2% of every month, or 35 intervals/month; ERCOT expects to exhaust available Regulation Service and will perform a back-cast of last month's actual exhaustion rate. If the exhaustion rate exceeded 1.2% in any given hour, ERCOT will determine the amount of increase necessary to achieve an exhaustion rate of 1.2 % for that hour.

Procedure

Using archived data, ERCOT will calculate the 98.8 percentile of actual Regulation Service deployed hourly for the 30 days prior to the time of the study~~previous month~~ and the same month of the previous year. In order to consider the increased amount of wind penetration, ERCOT will calculate the increase in installed wind generation capacity and then, depending on the month of the year and the hour of the day, will add incremental MWs to the 98.8^{th} value. The tables of Incremental MWs for Regulation Up and Down ~~tables~~ come from the Appendix of GE's final report to ERCOT~~. The tables~~ and contain additional MWs for every 1000 MW increase in wind capacity. The increase in wind capacity will be calculated by taken the total nameplate capacity of wind resources in the ERCOT network model at the time of the procurement study and subtracting out the total nameplate capacity of wind resources in the ERCOT model at the end of the month being studied from the previous year.

Incremental MW Adjustment to Prior-Year Up-Regulation 98.8 Percentile Deployment Value, per 1000 MW of Incremental Wind Generation Capacity, to Account for Wind Capacity Growth

Month	Hour Ending																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan.	2.8	4.2	3.1	3.7	2.5	0.4	2.3	2.2	4.2	5.9	7.6	5.7	4.7	3.3	2.8	2.3	4.0	8.6	4.2	2.7	1.6	2.7	1.4	1.6
Feb.	3.6	4.0	2.9	2.9	1.5	1.8	5.2	3.5	4.9	6.0	5.1	5.2	5.3	4.2	4.3	3.5	3.8	8.6	5.5	1.9	1.4	3.1	1.9	2.2
Mar.	5.5	5.3	4.6	4.2	2.6	3.3	7.1	7.9	6.8	5.7	4.2	3.4	2.8	2.6	2.7	2.3	2.9	7.7	6.8	2.1	1.1	3.0	1.5	2.8
Apr.	3.1	3.6	5.0	4.0	2.4	2.5	8.5	11.6	10.0	5.6	4.2	3.4	3.2	2.5	2.1	2.1	3.5	9.2	8.2	4.1	1.0	0.8	0.0	1.4
May	3.6	3.3	4.3	4.3	4.2	3.3	8.7	8.8	8.1	5.7	6.0	4.4	3.6	3.8	3.9	4.2	4.7	11.6	5.9	0.6	0.0	1.0	1.4	2.5
Jun.	2.3	2.6	3.3	3.7	3.9	2.4	8.5	8.2	6.6	4.5	4.2	3.1	2.5	2.5	0.7	0.2	1.3	7.5	3.3	1.7	0.7	0.3	0.6	1.3
Jul.	1.0	2.8	4.4	3.7	3.0	3.2	11.2	10.2	6.5	5.3	3.3	2.2	1.4	0.4	-0.9	-1.3	0.3	3.4	0.9	1.1	0.1	0.0	1.0	1.2
Aug.	1.4	3.8	4.5	4.5	2.2	0.9	6.3	6.8	6.6	6.6	3.2	2.6	2.1	1.2	1.4	1.3	1.3	4.6	1.2	0.9	0.7	0.8	1.1	1.3
Sep.	3.2	4.0	3.7	3.5	1.8	1.9	6.9	7.7	8.3	6.9	3.5	4.8	3.8	2.3	1.6	1.2	3.0	9.2	3.1	0.9	0.1	0.4	0.8	1.9
Oct.	3.4	2.8	2.4	2.2	1.7	1.8	5.0	5.8	6.1	5.9	4.0	5.4	3.2	2.2	1.2	1.7	3.1	6.8	0.8	2.1	0.0	0.2	1.8	2.5
Nov.	2.7	3.2	3.6	3.0	2.2	2.3	4.6	5.3	6.9	6.8	5.1	5.6	4.1	3.7	1.8	1.7	5.8	12.8	4.8	3.8	1.0	1.6	2.2	1.4
Dec.	2.8	2.4	1.4	2.1	1.2	0.4	2.8	2.7	3.8	4.6	6.8	7.0	6.0	4.4	3.3	3.0	5.0	9.9	4.3	2.6	2.1	4.3	2.0	1.5

Incremental MW Adjustment to Prior-Year Down-Regulation 98.8 Percentile Deployment Value, per 1000 MW of Incremental Wind Generation Capacity, to Account for Wind Capacity Growth																							
Month											**Hour Ending**												
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Jan.	1.2	1.7	2.2	2.9	2.5	1.0	0.8	2.5	-0.2	-0.5	-0.2	2.4	4.0	3.6	4.0	3.5	2.7	5.1	7.8	10.4	8.4	5.2	5.2	3.6
Feb.	2.7	3.6	3.8	4.4	3.3	1.7	0.5	2.5	2.0	2.3	2.1	2.3	2.8	3.7	3.7	2.6	2.3	6.9	7.2	10.0	11.0	7.3	7.1	4.7
Mar.	2.9	3.8	3.1	2.3	2.2	2.2	1.9	0.9	0.4	3.7	4.0	2.1	1.6	2.3	3.2	3.9	3.2	6.1	6.1	8.3	9.5	6.5	5.2	3.6
Apr.	4.3	4.5	3.4	3.0	4.1	2.8	2.4	1.3	0.6	2.9	4.5	3.3	1.4	2.5	4.1	4.5	4.5	7.3	7.3	10.7	9.5	7.4	5.1	3.0
May	3.0	1.6	2.3	1.7	0.4	-0.2	0.4	0.5	1.1	2.4	3.5	3.1	1.8	2.7	2.6	2.5	3.8	8.7	7.5	11.1	9.7	8.2	5.8	3.7
Jun.	1.4	0.1	1.7	2.0	0.5	-0.7	-1.2	-0.7	-0.2	0.0	0.7	0.9	1.9	2.8	2.9	2.8	3.6	11.0	8.4	7.7	6.5	5.8	4.2	2.7
Jul.	2.6	1.5	0.7	-0.3	-0.6	-0.7	-1.0	-0.5	-0.5	-0.7	0.0	0.7	1.7	2.3	2.7	3.1	2.7	8.0	9.2	8.7	6.1	5.5	4.7	2.6
Aug.	2.0	1.7	1.0	0.6	0.3	-0.9	0.0	0.3	-0.2	-0.1	0.7	1.0	1.5	1.9	2.7	4.1	3.6	4.7	5.6	7.2	5.0	5.4	5.1	2.7
Sep.	1.5	2.2	0.8	-0.4	-0.6	-1.4	-0.8	-0.4	-0.6	0.4	1.0	0.9	1.4	1.5	2.4	2.7	3.3	7.2	5.2	7.2	6.9	6.5	6.3	4.1
Oct.	2.4	4.0	2.0	0.6	0.1	-0.3	-0.2	0.3	0.0	1.5	2.6	2.4	2.6	2.0	2.3	3.0	4.3	9.0	6.8	8.6	6.8	4.6	4.2	2.3
Nov.	1.8	2.7	2.6	1.9	0.7	1.0	1.5	1.2	-0.6	1.5	2.1	2.0	2.2	1.5	1.8	3.5	4.7	6.8	10.4	14.1	9.5	5.7	4.1	1.7
Dec.	2.9	3.2	2.8	2.6	2.2	1.9	2.6	2.9	-0.8	-0.6	-0.4	1.3	1.8	1.4	2.6	3.5	3.2	3.1	7.9	11.8	7.9	4.2	3.9	3.4

During the 0600 & 2200 time periods, large schedule changes typically occur, related to 16 hour block energy sale products. Because of these large energy swings, ERCOT often finds its maximum deployment rate of Regulation Service insufficient to control frequency.[2]. During these times, ERCOT may see the need for extra Regulation Service to be available to cover the amount needed to respond to such large schedule changes. ERCOT may also include historic deployment of Responsive Reserve as a part of Regulation Service deployment in this analysis.

Additionally, if it is determined that during the course of the 30 days prior to the time of the study that the ERCOT average CPS1 score was less than 100%, ERCOT will procure an extra 10% of both Regulation Up and Down for all hours of the day during the upcoming month in which the CPS1 score was less than 100. This value will increase to 20% if the CPS1 score for the previous month falls below 90%. These additional reserves will assist ERCOT in ensuring that NERC requirements are met.

ERCOT will calculate and post this requirement by the 20th of each month for the succeeding month as required by the protocols.

ERCOT will post this requirement for each day of the month as required by the Protocols.

Non-Spinning Reserve Service (NSRS) Requirement Detailss

Introduction

Non-Spinning Reserve Service (NSRS) consists of resources capable of being ramped to a specified output level within thirty (30) minutes or Loads acting as a Resource that are capable of being interrupted within thirty (30) minutes and that are capable of running (or being interrupted) at a specified output level for at least one (1) hour. NSRS may be deployed to replace loss of generating capacity, to compensate for load forecast and/or wind forecast errors on days in which large amounts of reserve are not available online or when 95% or more of Balancing Energy bid into the market is projected to be used.

Summary

ERCOT will determine the 95th percentile of the observed hourly Net Load Error from the previous 90 days from when the study is performed. Net Load is defined as the difference between the ERCOT load minus the total output from WGRs plus the down balancing instructions for wind-only QSEs. The forecast of Net Load is computed by subtracting the Total ERCOT Wind Power Forecast (TEWPF) from the Mid-term Load Forecast (MTLF). The TEWPF and MTLF used are the updated forecasts as of 1600 in the day-ahead. The Net Load Error is then defined as the difference between the Net Load and the forecasteds Nnet Lload.

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[2] ERCOTs maximum deployment of RRS is defined as the amount procured, divided by 10 multiplied by 1.25. This restrictions is specified in protocol section 6.10.5.3 which states "ERCOT shall limit the deployment of RGS Services to QSEs for each control cycle equal to one hundred twenty five percent (125%) of the total amount of RGS Service in ERCOT divided by the number of control cycles in ten (10) minutes. "

ERCOT will subtract the Regulation Up requirement from the calculated 95th percentile value to determine the amount NSRS to purchase during each hour of the day for the upcoming month.

ERCOT will purchase NSRS such that the combination of NSRS and Regulation Up Services cover 95% of the calculate error from the Net Load error analysis of the prior ~~month~~90 days.. ~~when projected risk of insufficiency is higher than normal~~.

Procedure

For the purpose of determining the amount of NSRS to purchase for each hour of the day during the upcoming month, each hour will be placed in one of two categories: off-peak hours (hours ending 1 through 6 and 23 through 24) and on-peak hours (hours ending 7 through 22). The 95th percentile of the Net Load Error for the last 90 days for all hours which are considered off-peak will be calculated. The same calculation will be done for all hours considered on-peak. ERCOT will then calculate the average Regulation Up requirement for off- and on-peak, separately, for the upcoming month. The NSRS requirement for the upcoming month for all off-peak hours is calculated as the 95th percentile calculation for off-peak hours minus the average Regulation Up requirement during off-peak hours. The same is done for on-peak hours.

ERCOT will calculate and post this requirement by the 20th of each month for the succeeding month.

~~Using this methodology ERCOT procures NSRS when hot weather, cold weather, or uncertain weather is expected.~~

Discussion

Historically, the need for NSRS has occurred during hot weather, during cold weather, during unexpected changes in weather, or during large unit trips when large amounts of spinning reserve have not been on line (spinning reserve in this document represents un-deployed online generation capacity). The increasing level of wind penetration has resulted in an increased level of operational risk. Wind output tends to be higher during off-peak hours when the system load is less and introduces a risk of decreasing output while the load demand is increasing. The periods when load is increasing and wind generation is decreasing requires other generation resources to increase output or come online quickly to compensate for the sudden Net Load increase. The risk of Net Load increases that are not forecasted exists for all hours of the day.

Examples of circumstances when NSRS has been used are:

- Across peak hours during spring and fall months when hotter than expected weather with large amounts of capacity offline resulted in EECP events.
- Afternoons during Summer seasons when high loads and unit outages outstripped the capability of base load and normal cyclic units.
- Cold weather events when early morning load pickup outpaced the ability of generation to follow.

- Major unit trips when large amounts of spinning reserve were not online.
- During periods when the wind generation is decreasing and load demand is increasing.

Currently NSRS can be provided from on-line or off-line generation resources that can be started and ramped up in 30 minutes or less.

The April May and October transition months are not considered "normal" due to the larger than normal probability of significant load forecast error.
Extreme weather days are defined as days in which the forecast peak temperature for ERCOT is projected to be higher than 95 degrees, or the forecast high temperature is lower than 30 degrees, or days in which ERCOT has issued a Security Notice. On extreme weather days, ERCOT will purchase an amount of NSRS no less than the largest unit online for on peak hours, and may purchase amounts of NSRS greater than this amount in extreme circumstances.

ERCOT will use the following in determining the amount of NSRS needed:

1. Review the weather forecast for the next day and see if it differs significantly from the current day.
2. If the next day forecast is "similar" to the current day forecast, and the current day forecast high temperature is <95 degrees in Dallas/Ft. Worth or Houston, and the current day low temperature is greater than 30 degrees and the current month is not April, May, or October, THEN no NSRS is considered to be required all day for the next day.
3. Else: Purchase NSRS using the following:

- If the current month is April, May or October, then purchase NSRS in amounts no less than the largest unit online for the hours projected within 85% of peak hour.
- If today's and tomorrow's ERCOT high temperature is projected above 95 degrees in Dallas/Ft. Worth or Houston, then purchase NSRS in amounts no less than the largest unit online for the hours projected warmer than 95 degrees.
- If tomorrow's low temperature forecast is projected below 30 degrees in Dallas/Ft. Worth or Houston, then purchase NSRS in amounts no less than the largest unit online for the projected morning load pickup hours and hours projected within 85% of peak hour.
- Review the next day Resource Plans after the 1800 RPRS run and open a supplemental NSRS market for hours in which the Market Analyst Interface indicates less than 3300 MW of spinning reserve.

Replacement Reserve Service (RPRS) Requirement Details

Replacement Reserve Service (RPRS) is procured by ERCOT if resources are needed to provide additional Zonal or Local Balancing Energy Service. The RPRS analysis performs look-ahead analysis of the physical system for each of the hourly time intervals in either the Day Ahead or Adjustment Period Time frame. Based on the study, RPRS procurements are made if the

submitted resource plans indicate capacity inadequacy or potential zonal congestion requiring additional resources or local congestion requiring specific resources. The procured capacity from these resources must be bid into the Balancing Energy Service market, which clears during the Operating Period.

The purpose of RPRS is to insure the availability of capacity from resources such that the energy from those resources would be available to solve the following system security violations:

a) Local congestion
b) ERCOT system capacity insufficiency
c) Zonal Congestion

Also, the procurement mechanism for resolving local congestion needs to be separate from the mechanism for resolving capacity insufficiency/ zonal congestion. The procurement for resolving local congestion is based on a minimal cost approach that uses generic costs for resources and the procurement for capacity insufficiency and zonal congestion is based on a minimal cost approach that uses resource bids or generic costs from the participants. Hence, the objective of the proposed RPRS market clearing is to minimize the total cost of procuring the RPRS bids for the whole duration of the Replacement market (i.e. the whole day for Day Ahead Market and the specified time duration for the Adjustment Period) subject to the unit specific temporal constraints and ERCOT transmission security constraints not being violated.

Figure - Flow diagram for the RPRS market clearing engine
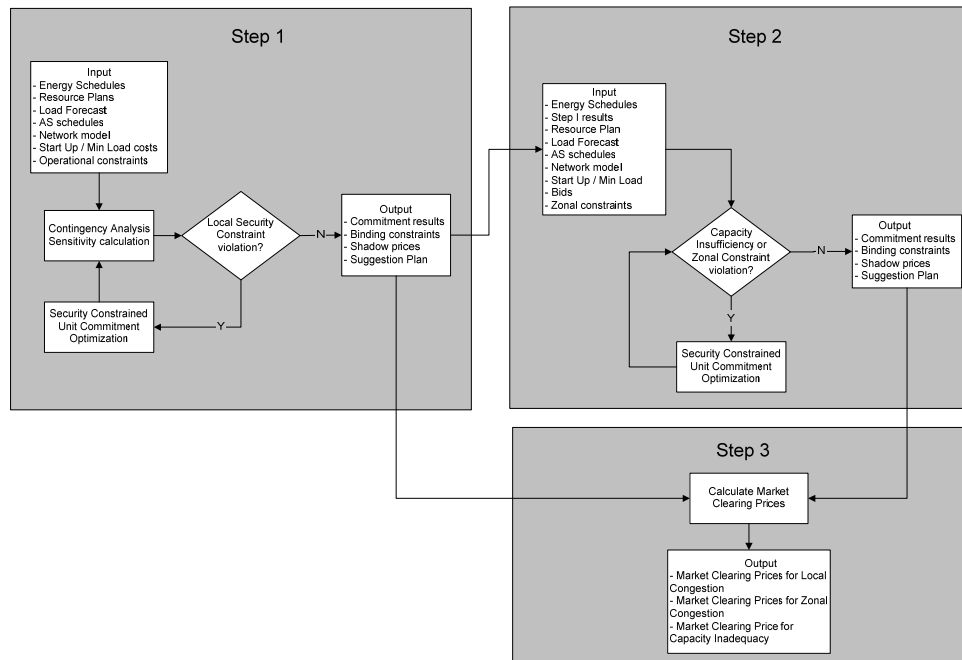
Balancing Energy Requirement *Details*

Balancing Energy is incremental or decremental energy dispatched by ERCOT for each by 15-minute Settlement Interval to meet the difference between generation scheduled by the market and ERCOT System load. Local Balancing Energy Service is also used to resolve local transmission congestion. Balancing Energy is deployed by ERCOT with the goals that (1) Regulation Service in either direction not be depleted during the interval, (2) Regulation Service up and down energy is deployed in each Settlement Interval such that the net energy in Regulation Service is minimized, and (3) to provide for frequency control when frequency is high, especially during minimum load intervals. The latter will be included in the determination of BES Down Bid Percentage Requirements. ERCOT will estimate Balancing Energy needs based on the actual Load, the difference in forecasted Loads and bilateral schedules, deployed Regulation Service, and forecasted Congestion.

The following three-step approach is used to determine amount and location of BES needed in each Settlement Interval.

Step 1 is to determine balancing energy service needs to resolve generation-load balance and Zonal Congestion. Balancing Energy Service is procured with Local Congestion ignored, i.e., only recognizing Zonal Congestion.

The output of the application will be zonal MCPE, shadow prices of Zonal Congestion and Portfolio Incremental/Decremental balancing service MW needed by QSE and CM zone. An

estimate will be made of Resource-specific MW outputs (this is intermediate solution and does not indicate resource-specific dispatch instructions).

Step 2 is to determine balancing energy service needs to resolve Local Congestion as well as generation-load balance and Zonal Congestion.

1) The transmission security analysis is performed using the Resource Plan for both the starting with the dispatch and each unit's minimum/maximum capabilities MW solutions from Step 1 for checking operational security.

3)2)If no operational constraint violation is detected, the solution from Step 1 is the final solution to the balancing energy service market.

5)3)When any Local Congestion is violated, the solution proceeds as follows:

    3.1) The resource-specific incremental premium is taken as the prices for resource-specific incremental bids.

    3.2) The resource-specific decremental premium is taken as the prices for resource-specific decremental bids.

    3.3) The portfolio balancing service MW solutions by QSE and CM zone obtained in Step 1 are kept the same at the portfolio level.

    3.4) The amount and location of balancing energy service is recalculated with the sum of the incremental and decremental bids cleared due to relieve Local Congestion across all zones. All constraints, including Zonal Congestion and OC, are observed. The objective of Step 1 solution is to minimize the cost of Local Congestion. The output of the application will be as follows:

- Portfolio Incremental/Decremental balancing service MW solutions by QSE and CM zone
- Resource-specific MW outputs (resources that are identified to receive premiums will be sent resource-specific dispatch instructions.)
- Shadow prices of Local Congestion

Step 2 is to determine balancing energy service needs to resolve generation-load balance and Zonal Congestion. Balancing Energy Service is procured while maintaining Local Congestion constraints

- The output of Step 2 will be zonal MCPE, shadow prices of Zonal Congestion and Portfolio Incremental/Decremental balancing service MW needed by QSE and CM zone. An estimate will be made of Resource-specific MW outputs (this is intermediate solution and does not indicate resource-specific dispatch instructions).
- A complete list of all RPRS unit commitment with the ability for the Operator to de-select any individual unit/hour.

Step 3 is to determine balancing energy service needs to resolve generation-load balance and Zonal Congestion subject to the local constraint deployments made in step 2. The market clearing prices from Step 3 will represent the marginal cost for the solution of each constraint and will be produced as an output of the mathematical optimization application. The output of the application will be as follows:

- zonal MCPE
- shadow prices of Zonal Congestion

- Portfolio Incremental/Decremental balancing service MW needed by QSE and CM zone
- Resource-specific MW outputs (this is intermediate solution and does not indicate resource-specific dispatch instructions).
- A final RPRS unit commitment for all study hours

Minimum Balancing Energy Service (BES) Down Bid Percentage Requirement Details

For Frequency Control (to correct high frequency)

Minimum Balancing Energy Service (BES) Down Bid Percentage Requirement will be set for all intervals of each day. A down bid percentage requirement will be determined to allow for correcting for high frequency. This is a potential need for all intervals, but is especially needed during minimum load periods.

ERCOT will normally calculate the minimum down balancing requirement for QSE's as follows.

> ERCOT will collect the amount of BES (up and down) deployed and the sum of schedules for each operating period for the two time frames described below:

1) The monthly data one year previous to the month to be posted.

2) The month to date data on the current month (month previous to the month being analyzed). This interval will generally end on the 19th of the month previous to the month to be posted as the requirements will be posted on the 20th of the preceding month.

From this data ERCOT will calculate the mean balancing energy deployed and a standard deviation An amount of down balancing service expected to be sufficient to avoid exhausting the down balancing stack 99.9% of intervals will then be calculated. This amount of down balancing service, expressed as a percentage, will normally be posted as the down balancing percentage requirement. (Note – single outlying historic deployments may be selected in place of this statistical analysis if review indicates such a requirement is justified.)

ERCOT may post this value to be the continuous requirement, or may further analyze the needs to provide a varying requirement by:

- Zone

- On Peak and Off Peak hours

ERCOT may change this requirement during the month if experience shows that the initially proposed requirement is insufficient.

For Congestion Management

If a need for additional down balancing is required in a single zone, or zones for congestion management, it is expected by ERCOT that zonal assessment of the data discussed above will allow detection and posting of the need in advance. If this expectation is not correct, ERCOT may adjust the zonal down balancing requirement to address specific congestion events

observed.

Responsive Reserve Service (RRS) Requirement Details

The ERCOT Operating Guides set the minimum RRS requirement at 2300 MW for all hours under normal conditions. The Operating Guides allow ERCOT to increase that requirement under extreme conditions. ERCOT will increase the amount of RRS purchased for Hour Ending 0700 through Hour Ending 2200 by linking the amount of RRS to a day-ahead forecast of the RDF. ERCOT will use the higher of the hourly forecast temperature for North Central or the Coastal weather zone to predict the amount of RDF to apply in real-time. For each hour in which the RDF is projected to be greater than 2%, ERCOT will adjust the Day-Ahead hourly RRS obligation upward by 100 MW per percentage point. ERCOT will not adjust the RRS requirement below the minimum RRS requirement set forth in the ERCOT Operating Guides nor greater than 500 MW more than the minimum RRS requirement in the ERCOT Operating Guides. The 2300 MW requirement was derived based on studies done in the past to determine the amount of Responsive Reserve that might be required to prevent the shedding of firm load upon the simultaneous loss of the two largest Generation Resources in the ERCOT Region.

One type of Responsive Reserve is Interruptible Responsive Reserve. Interruptible Responsive Reserve is Load Acting as a Resource (LaaR) that is automatically interrupted when system frequency decreases to 59.7 Hz. The ERCOT Protocols state, "[t]he amount of Resources on high-set under-frequency relays providing RRS will be limited to 50% of the total ERCOT RRS requirement. ERCOT may reduce this limit if it believes that this amount will have a negative impact on reliability or if this limit would require additional Regulation Service to be deployed as prescribed in section 6.4.1, Standards for Determining Ancillary Services Quantities." The total amount of LaaR procured in any hour will be limited to 1150 MW until additional studies are performed and a determination is made that the ERCOT System will remain reliable using increased amounts of LaaR.

Self arranged RRS used to fulfill a QSE's RRS requirement will be limited to 50% from LAARs for hours in which the total RRS obligation is 2300 MW. For hours in which the RRS requirement exceeds 2300 MW, the LaaR portion of RRS shall be limited to a proportionate weighting of the total RRS obligation such that the total amount of LaaR procured in any hour does not exceed 1150 MW. ERCOT procured RRS to provide the difference between the RRS system requirement and the amount of RRS self-arranged by all QSEs must also be limited to no more than 1150 MW from LaaRs.

If the minimum LAAR % level specified in the Protocols is changed, that change will be reflected in these requirements.

Responsive Reserve % LAAR

Protocols allow ERCOT to set the percentage of Responsive Reserve that may be served by LAARs. ERCOT calculates the maximum secure RRS that can be provided by LAARS by performing stability analysis of several power flow cases modeling the ERCOT

transmission/generation system at different states. ERCOT will examine these models response to generator trip events and the response of LAARS/Generation to recover frequency using different generation/LAAR amounts. Unless indicated otherwise by these studies or adverse operating experience, LAARs will be allowed to provide up to 50% of the minimum ERCOT Responsive Requirement of 2300 MW.