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| NOGRR Number | [278](https://www.ercot.com/mktrules/issues/NOGRR278) | NOGRR Title | Related to NPRR1290, Gap Resolutions and Clarifications for the Implementation of RTC+B |
| Date of Decision | | August 27, 2025 | |
| Action | | Recommended Approval | |
| Timeline | | Urgent – to align with Nodal Protocol Revision Request (NPRR) 1290’s timeline and allow for ERCOT Board of Directors (Board) consideration in September 2025 and Public Utility Commission of Texas (PUCT) consideration in November 2025, so that these changes can go live with Real-Time Co-optimization (RTC) | |
| Estimated Impacts | | Cost/Budgetary: None  Project Duration: No project required | |
| Proposed Effective Date | | Upon system implementation of NPRR1290, Gap Resolutions and Clarifications for the Implementation of RTC+B | |
| Priority and Rank Assigned | | Not applicable | |
| Nodal Operating Guide Sections Requiring Revision | | 2.3.1.2.1, Limit on Resources Providing RRS Using Primary Frequency Response  4.8, Responsive Reserve Service During Scarcity Conditions  4.8.1, Responsive Reserve Service Manual Deployment (delete)  4.8.2, Responsive Reserve Service Manual Recall  8, Attachment C, Turbine Governor Speed Tests  8, Attachment N, Procedure for Calculating RRS MW Limits for Individual Resources to Provide RRS Using Primary Frequency Response | |
| Related Documents Requiring Revision/Related Revision Requests | | NPRR1290 | |
| Revision Description | | This Nodal Operating Guide Revision Request (NOGRR):  1. Aligns the relevant Nodal Operating Guide language with Protocol revisions from NPRR1290; and  2. Updates the manual deployment of Responsive Reserve (RRS) during scarcity conditions to:  (a) Remove deployment via the release of High Ancillary Service Limit (HASL); and  (b) Update the threshold for manual deployment of Load Resources that are not Controllable Load Resources (CLRs). | |
| Reason for Revision | | [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 1 – Be an industry leader for grid reliability and resilience  [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 2 - Enhance the ERCOT region’s economic competitiveness with respect to trends in wholesale power rates and retail electricity prices to consumers  [Strategic Plan](https://www.ercot.com/files/docs/2023/08/25/ERCOT-Strategic-Plan-2024-2028.pdf) Objective 3 - Advance ERCOT, Inc. as an independent leading industry expert and an employer of choice by fostering innovation, investing in our people, and emphasizing the importance of our mission  General system and/or process improvement(s)  Regulatory requirements  ERCOT Board/PUCT Directive  *(please select ONLY ONE – if more than one apply, please select the ONE that is most relevant)* | |
| Justification of Reason for Revision and Market Impacts | | Under RTC, the Security-Constrained Economic Dispatch (SCED) process will automatically deploy RRS from dispatchable Resources based on system conditions and the provision to manually deploy RRS from dispatchable Resources will be removed. Hence removing the Nodal Operating Guide language regarding manual deployment of RRS from dispatchable Resources is appropriate. Under RTC, ERCOT will continue to have the ability to manually deploy RRS from Load Resources that are not CLRs to maintain at least 500 MW of Physical Responsive Capability (PRC) on SCED-dispatchable Resources. ERCOT has updated the threshold for this deployment to align with the Energy Emergency Alert (EEA) Level 2. | |
| ROS Decision | | On 8/7/25, ROS voted unanimously to grant NOGRR278 Urgent status, to recommend approval of NOGRR278 as submitted, and to forward to TAC NOGRR278 and the 7/16/25 Impact Analysis. All Market Segments participated in the vote. | |
| Summary of ROS Discussion | | On 8/7/25, the sponsor provided an overview of NOGRR278 and the request for urgency. | |
| **TAC Decision** | | On 8/27/25, TAC voted unanimously to recommend approval of NOGRR278 as recommended by ROS in the 8/7/25 ROS Report. All Market Segments participated in the vote. | |
| **Summary of TAC Discussion** | | On 8/27/25, there was no additional discussion beyond TAC review of the items below. | |
| **TAC Review/Justification of Recommendation** | | Revision Request ties to Reason for Revision as explained in Justification  Impact Analysis reviewed and impacts are justified as explained in Justification  Opinions were reviewed and discussed  Comments were reviewed and discussed (if applicable)  Other: (explain) | |

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| **Opinions** | |
| **Credit Review** | Not applicable |
| **Independent Market Monitor Opinion** | IMM has no opinion on NOGRR278. |
| **ERCOT Opinion** | ERCOT supports approval of NOGRR278. |
| **ERCOT Market Impact Statement** | ERCOT Staff has reviewed NOGRR278 and believes the market impact for NOGRR278 provides clarification and addresses gaps ahead of the implementation of RTC+B. |

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| Sponsor | |
| Name | Abhi Masanna Gari |
| E-mail Address | [abhilash.masannagari@ercot.com](mailto:abhilash.masannagari@ercot.com) |
| Company | ERCOT |
| Phone Number | 512-248-4445 |
| Cell Number |  |
| Market Segment | Not applicable |

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| --- | --- |
| **Market Rules Staff Contact** | |
| **Name** | Cory Phillips |
| **E-Mail Address** | [cory.phillips@ercot.com](mailto:cory.phillips@ercot.com) |
| **Phone Number** | 512-248-6464 |

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| **Comments Received** | |
| **Comment Author** | **Comment Summary** |
| None |  |

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| --- |
| Market Rules Notes |

Please note the baseline Nodal Operating Guide language in the following sections(s) has been updated to reflect the incorporation of the following NOGRR(s) into the Nodal Operating Guides:

* NOGRR271, Related to NPRR1257, Limit on Amount of RRS a Resource can Provide Using Primary Frequency Response (incorporated 4/1/25)
  + Section 8, Attachment N

|  |
| --- |
| Proposed Guide Language Revision |

2.3.1.2.1 Limit on Resources Providing RRS Using Primary Frequency Response

(1) ERCOT shall establish MW limits on individual Resource’s ability to provide RRS using Primary Frequency Response. The MW limit shall be based on Resource performance during Frequency Measurable Events (FMEs) and actual tests.

(2) The default maximum MW limit of Primary Frequency Response shall be set to 20% of its Maximum Droop Response Range (MDRR) for any newly qualified Resource not yet evaluated per Section 8, Attachment N, Procedure for Calculating RRS MW Limits for Individual Resources to Provide RRS Using Primary Frequency Response, for measuring actual performance.

(3) A Private Use Network with a registered Resource may use the gross HSL for qualification and establishing a limit on the amount of RRS capacity that the Resource within the Private Use Network can provide.

4.8 Responsive Reserve Service and ERCOT Contingency Reserve Service During Scarcity Conditions

(1) This Section details how Responsive Reserve (RRS) service may be manually deployed, during scarcity conditions, pursuant to Protocol Section 6.5.7.6.2.2, Deployment of Responsive Reserve (RRS). The existing measure of scarcity is Physical Responsive Capability (PRC). If PRC drops below 3,000 MW, and all available Non-Spinning Reserve (Non-Spin) has been deployed, this process may be used. Scarcity conditions may occur during the Peak Load Season when ERCOT System Load is above 60,000 MW. For all other months, they could occur when ERCOT System Load is above 50,000 MW.

(a) When HSL – (Gen + 5-minute load ramp) <= 2000 MW, ERCOT may deploy Load Resources that are not Controllable Load Resources (CLRs) and that are providing ERCOT Contingency Reserve Service (ECRS) or RRS.

4.8.1 Responsive Reserve Service and ERCOT Contingency Reserve Service Manual Recall

(1) The operator will consider system conditions and Ancillary Services in releasing or recalling RRS. System frequency, load ramp, and factors such as Regulation Up Service (Reg-Up) versus Regulation Down Service (Reg-Down) deployment status will be considered.

(2) The manual deployment of RRS or ECRS for capacity from Load Resources that are not CLRs may be recalled pursuant to Protocol Section 6.5.9, Emergency Operations.

**ERCOT Nodal Operating Guides**

**Section 8**

**Attachment C**

**Turbine Governor Speed Tests**

**TBD**

Turbine Governor Speed Regulation Test for Mechanical-Hydraulic Governor

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of test:

QSE: Resource Entity:

***Steady State Speed Regulation at High-Speed Stop***



Where:

A = Speed with speed changer set at high-speed stop and with throttle (or stop) valves open and machine running idle on the Governor.

B = Speed with speed changer set at high-speed stop and when governing valves just reach wide-open position.

***Steady State Speed Regulation at Synchronous Speed*** *[[1]](#footnote-1)*



Where:

C = Speed with speed changer set for synchronous speed and with throttle (or stop) valves open and machine running idle on the Governor.

D = Speed with speed changer set at the same position as in C above and when governing valves just reach wide open position.

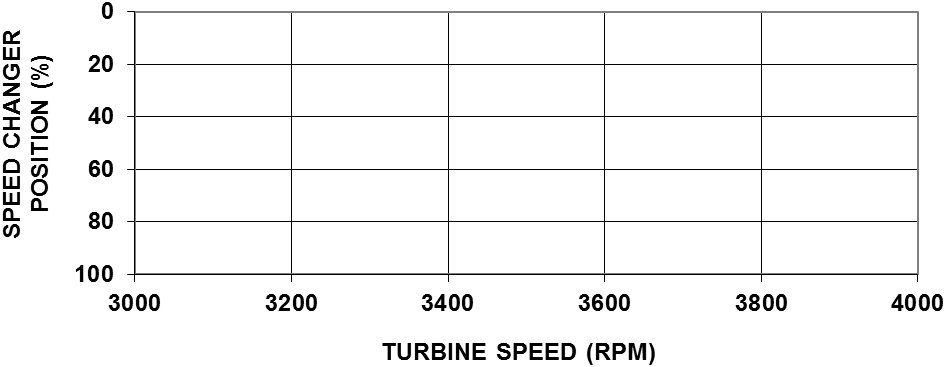
***Steady State Speed Regulation at Low-Speed Stop***



Where:

E = Speed with speed changer set at low-speed stop and with throttle (or stop) valves open and machine running idle on the Governor.

F = Speed with speed changer set at low-speed stop and when governing valves just reach wide-open position.



E, F @ Low Speed Stop

C, D @ Sync. Speed

A, B @ High Speed Stop

**Test Data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Point** | **A** | **B** | **C** | **D** | **E** | **F** |
| Speed, RPM |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Frequency Hz |  |  |  |  |  |  |

**Speed Changer Travel Time:**

(a) From Low-Speed Stop to High-Speed Stop in \_\_\_\_\_\_\_\_\_seconds.

(b) From High-Speed Stop to Low-Speed Stop in \_\_\_\_\_\_\_\_\_seconds.

Over-speed Trip Test Speed at \_\_\_\_\_\_\_\_\_rpm.

Comments:

***Submittal***

Resource Entity Representative:

QSE Representative:

Date submitted to ERCOT Representative:

Example of a Turbine Governor Speed Regulation Test for Mechanical-Hydraulic Governor

***Steady State Speed Regulation at High-Speed Stop***



Where:

A = Speed with speed changer set at high-speed stop and with throttle (or stop) valves open and machine running idle on the Governor.

B = Speed with speed changer set at high-speed stop and when governing valves just reach wide-open position.

***Steady State Speed Regulation at Synchronous Speed [[2]](#footnote-2)***



Where:

C = Speed with speed changer set for synchronous speed and with throttle (or stop) valves open and machine running idle on the Governor.

D = Speed with speed changer set at the same position as in C above and when governing valves just reach wide open position.

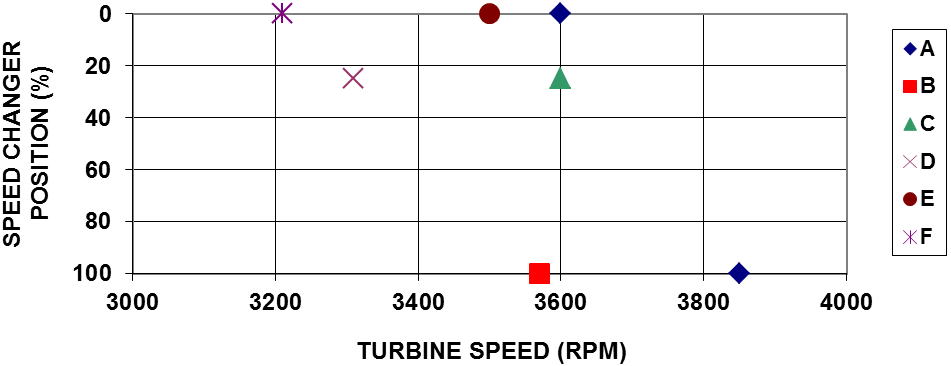
***Steady State Speed Regulation at Low-Speed Stop***



Where:

E = Speed with speed changer set at low-speed stop and with throttle (or stop) valves open and machine running idle on the Governor.

F = Speed with speed changer set at low-speed stop and when governing valves just reach wide-open position.



E, F @ Low Speed Stop

C, D @ Sync. Speed

A, B @ High Speed Stop

**Test Data**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Point** | **A** | **B** | **C** | **D** | **E** | **F** |
| Speed, RPM | 3850 | 3570 | 3600 | 3310 | 3500 | 3210 |
|  |  |  |  |  |  |  |
| Frequency Hz | 64.2 | 59.5 | 60.0 | 55.0 | 58.3 | 53.5 |

**Speed Changer Travel Time:**

(a) From low-speed stop to high-speed stop in 73 seconds.

(b) From high-speed stop to low-speed stop in 74 seconds.

Over-speed trip test speed at 3965 rpm.

Comments:

**Turbine Governor Speed Regulation Test for Electro-Hydraulic Governor**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of test:

QSE: Resource Entity:

***Turbine Governor Speed Regulation Test Procedures***

(a) Simulate unit On-Line and turbine speed at 3600 RPM.

(b) Set Load reference at minimum value.

(c) Monitor valve demand signal and record as value “A” (in %).

(d) Reduce speed until valve demand just reaches maximum value.  
Record valve demand as value “B” (in %) and speed as value “C” (in RPM).

(e) Set speed at 3600 and Load reference at maximum value.

(f) Monitor valve demand signal and record as value “D” (in %).

(g) Increase speed until valve demand just reaches minimum value.  
Record valve demand as value “E” (in %) and speed as value “F” (in RPM).

***Turbine Governor Speed Regulation Test Results***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **A** | **B** | **C** | **D** | **E** | **F** |
| Valve Demand (%) |  |  |  |  |  |  |
| **Speed (rpm)** |  |  |  |  |  |  |

***Speed Regulation With Decreasing Speed***



***Speed Regulation With Increasing Speed***



Comments:

***Submittal***

Resource Entity Representative:

QSE Representative:

Date submitted to ERCOT Representative:

**Definitions**

|  |  |
| --- | --- |
| **System Frequency Response** | This response is a function of two key variables: the Primary Frequency Response from Governors and Load dampening of the connected Load. |
| **Percent Droop Settings** | Also known as Frequency Regulation, Speed Regulation, Speed Sensitivity, Speed Error and others. Percent droop is the percent change in nominal frequency that will cause generator output to change from no Load to full Load. For synchronous Resources, it is the change in steady state rotor speed, expressed in percent of rated speed, when power output is gradually reduced from rated to zero power. A common percent droop setting is 5% for both high and low frequency excursions. |
| **Dead-Band** | The range of deviations of system frequency (+/-) that produces no Governor response, and therefore, no frequency (speed) regulation. It is expressed in percent of rated speed, Hz, or RPM. |
| **Valve Position Limiter** | A device that acts on the speed and Load governing system to prevent the Governor-controlled valves from opening beyond a pre-set limit. |
| **Blocked Governor Operation** | Operating the generating unit with the control system adjusted to prevent the turbine governor from responding to system frequency (speed) variations. In an effort to reduce speed Governor operation in some generating units, turbine control systems can be adjusted to block the operation of the Governor after the unit is in parallel with the system and is running at its desired output. Selection of a high percent droop characteristic or a large Governor Dead-Band constitutes a form of blocked Governor action. |
| **Variable Pressure Operation** | Varying the boiler pressure to improve turbine efficiency at lower Loads. Two methods are normally used. The first method, the turbine control (G.E.) or Governor (Westinghouse) valves are positioned in the wide-open position and the generator is changed by changing the boiler pressure. With this method, there is very little, if any response to frequency excursions. The second method, the valves are positioned at approximately 50% open. The valves are still able to respond to system disturbances. Normal changes in generation requirements are made by varying the boiler pressure until the unit is at rated pressure. After full pressure is reached, the turbine valves are used to make the required generation changes. |

1. Generation Resource Frequency Response Test Procedure

***Description of the Test***

1. The frequency response function of the Generation Resource is tested On-Line at a Load level that allows the Generation Resource to increase or decrease Load without reaching low operating limits or high operating limits. If the Generation Resource cannot be tested On-Line then it will notify ERCOT that it will be conducting an Off-Line test. The recommended level is 92% Base Load or below.

2. The test is performed by adding a frequency offset signal that exceeds the Governor Dead-Band value to the measured frequency signal. This should create immediate step change in the measured frequency signal.

3. The test starts at time t0 when the frequency Dead-Band is exceeded and signal “Generation Resource Frequency Response On” becomes active.

4. The following signals should be recorded at least two seconds: Unit MW Output, “Generation Resource Frequency Response On.”

5. The duration of the test is 100 seconds. After 100 seconds, the offset signal should be removed and the Generation Resource should return to pretest power output.

6. The test should be conducted both with positive and negative frequency offsets.

7. The test is considered successful after the signal becomes active if at least 70% of the calculated MW contribution is delivered within 16 seconds and the response is maintained for an additional 30 seconds.

8. Governor droop and Governor Dead-Band settings shall be set in accordance with Section 2.2.7, Turbine Speed Governors.

***Definitions***

**Generation Resource Base Load =** Maximum Droop Response Range (MDRR)

**Gain MW for 0.1Hz** = 

Where:

*P* = Generation Resource Base Load (MW)

*Droop* = droop (%)

**Frequency Offset** = +0.2 Hz and -0.2 Hz (+12 rpm and -12 rpm, for 3600 sync speed machines), outside Governor Dead-Band

**Test frequency** = Measured Frequency + Frequency Offset

**MW Contribution** = Gain MW to 0.1 Hz \*10\*Frequency Offset

**Calculated droop** = - 

Where:

P = Generation Resource Base Load (MW)

ΔHz = Change in frequency (Hz), taking into account Governor Dead-Band

ΔMW = Change in power output (MW)

***Example***

Generation Resource Base Load = 150 MW

Droop = 0.05 or 5% (use 0.05 for calculation)

Governor Dead-Band = 0.034

Gain MW to 0.1 Hz =  = +/- 5.06 MW/0.1 Hz

MW Contribution = 5.06\*10\*+/- (0.2) = +/-10.12 MW

Expected under-frequency response: +10.12 MW in 16 sec. for -0.2 Hz offset

Expected over-frequency response: -10.12 MW in 16 sec. for +0.2 Hz offset

Minimum accepted under-frequency response: +7.08 MW in 15 sec. for -0.2 Hz offset

Minimum accepted over-frequency response: -7.08 MW in 15 sec. for +0.2 Hz offset

Calculated droop for 8 MW increase in power output in 16 sec. for -0.2 Hz offset:

Calculated droop = - = 0.0625 or 6.25%

**Generation Resource FREQUENCY RESPONSE TEST FORM**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of Test:

QSE: Resource Entity:

***Test Results***

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Test with +0.2 Hz** | **Test with -0.2 Hz** |
| **1** | **Generation Resource Base Load** |  |  |
| **2** | **GAIN MW to 0.1Hz** |  |  |
| **3** | **Calculated**  **MW Contribution** |  |  |
| **4** | **MW at test start (t0)** |  |  |
| **5** | **MW at t0 + 16 sec** |  |  |
| **6** | **MW Contribution**  **at t0 + 16 sec** |  |  |
| **7** | **MW at t0 + 46 sec** |  |  |
| **8** | **Calculated droop** |  |  |
| **9** | **CONCLUSION**  **(PASSED/FAILED)** |  |  |

***Comments***: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Submittal***

Resource Entity Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QSE Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date submitted to ERCOT Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Energy Storage resource Frequency Response Test Procedure

***Description of the Test***

1. An Energy Storage Resource (ESR) is tested On-Line in both maximum charging and discharging modes at a level that allows the ESR to increase or decrease Load without reaching its operating limits. If the ESR cannot be tested On-Line then it will notify ERCOT that it will be conducting an Off-Line test.

2. The test is performed by adding a frequency offset signal that exceeds the Governor Dead-Band value to the measured frequency signal. This should create an immediate step-change in the measured frequency signal.

3. The test starts at time t0 when the frequency dead-band is exceeded.

4. The following signals should be recorded for at least two seconds: unit MW level and frequency offset signal.

5. The duration of the test is 100 seconds. After 100 seconds, the offset signal should be removed and the Energy Storage Resource should return to the pretest MW level.

6. The test should be conducted with both positive and negative frequency offsets.

7. The test is considered successful after the signal becomes active if at least 70% of the calculated MW contribution is delivered within 16 seconds and the response is maintained for an additional 30 seconds.

8. Governor droop and Governor Dead-Band settings shall be set in accordance with Section 2.2.7, Turbine Speed Governors.

***Definitions***

**Energy Storage Resource Base Load =** MDRR for low frequency test and for high frequency test

**Gain MW for 0.1Hz** =

10

\*

)

60

\*

(

*Band*

*GovernorDead*

*Droop*

*P*





Where:

*P* = Energy Storage Resource Base Load (MW)

*Droop* = droop (%)

**Frequency Offset** = +0.2 Hz and -0.2 Hz (+12 rpm and -12 rpm, for 3600 sync speed machines), outside Governor Dead-Band

**Test frequency** = Measured Frequency + Frequency Offset

**MW Contribution** = Gain MW to 0.1 Hz \*10\*Frequency Offset

**Calculated droop** = - 

Where:

P = Energy Storage Resource Base Load (MW)

ΔHz = Change in frequency (Hz), taking into account Governor Dead-Band

ΔMW = Change in power level (MW)

***Example***

Energy Storage Resource Base Load = 150 MW, when discharging

Droop = 0.05 or 5% (use 0.05 for calculation)

Governor Dead-Band = 0.017

Gain MW to 0.1 Hz = = +/- 5.03 MW/0.1 Hz

MW Contribution (injection) = 5.03\*10\*+/- (0.2) = +/-10.06 MW

Expected under-frequency response (injection): +10.06 MW in 16 sec. for -0.2 Hz offset

Expected over-frequency response (withdrawal): -10.06 MW in 16 sec. for +0.2 Hz offset

Minimum accepted under-frequency response (injection): +7.04 MW in 15 sec. for -0.2 Hz offset

Minimum accepted over-frequency response (withdrawal): -7.04 MW in 15 sec. for +0.2 Hz offset

Calculated droop for 8 MW increase in power output in 16 sec. for -0.2 Hz offset:

Calculated droop = - = 0.0625 or 6.25%

**Energy Storage Resource FREQUENCY RESPONSE TEST FORM**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of Test:

QSE: Resource Entity:

***Test Results***

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Test with +0.2 Hz** | **Test with -0.2 Hz** |
| **1** | **Energy Storage Resource (ESR) Base Load** |  |  |
| **2** | **GAIN MW to 0.1Hz** |  |  |
| **3** | **Calculated**  **MW Contribution** |  |  |
| **4** | **MW at test start (t0)** |  |  |
| **5** | **MW at t0 + 16 sec** |  |  |
| **6** | **MW Contribution**  **at t0 + 16 sec** |  |  |
| **7** | **MW at t0 + 46 sec** |  |  |
| **8** | **Calculated droop** |  |  |
| **9** | **CONCLUSION**  **(PASSED/FAILED)** |  |  |

***Comments***: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Submittal***

Resource Entity Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QSE Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date submitted to ERCOT Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Generation Resource, Energy Storage Resource, and Controllable Load Resource Primary Frequency Response test Procedures Based on Historical Data**

***Description of Historical Verification***

The purpose of this template is to allow the Entity that operates a Generation Resource, Energy Storage Resource (ESR) or a Controllable Load Resource (CLR) to demonstrate acceptable frequency response of its Generation Resource(s), ESR(s) or CLR(s) based on historical data in order to minimize testing costs, scheduling conflicts and the risk of damage to equipment or Forced Outage.

1. All verifications will be based on at least one of the events from the published list of Frequency Measurable Events (FMEs).

2. Governor droop and Governor Dead-Band settings shall be set in accordance with Section 2.2.7, Turbine Speed Governors.

3. For clarification purposes, the time of FME (t(0)), pre-perturbation average frequency and post-perturbation average frequency, as defined in Section 8, Attachment J, Initial and Sustained Measurements for Primary Frequency Response, will be used for the verification process. The values of these metrics will be identified in the FME Report.

4. The test is considered successful if the Generation Resource, ESR, or the CLR is able to meet a minimum of 75% of its initial Primary Frequency Response and 75% of its sustained Primary Frequency Response as calculated in the FMEs report posted on the Market Information System (MIS) Certified Area. Any Generation Resource, ESR, or CLR may use the FME report in lieu of testing.

a. The calculation of Generation Resources, ESRs, or CLRs initial and sustained Primary Frequency Response is detailed in Section 8, Attachment J.

b. ERCOT shall evaluate initial and sustained Primary Frequency Response using an expected performance Governor droop of 5.78% for combined-cycle Resources.

5. Intermittent Renewable Resources (IRRs) located behind one Point of Interconnection (POI), metered by one ERCOT-Polled Settlement (EPS) Meter, and operated as an integrated Facility may combine IRRs for the purposes of this test.

***Definitions***

Generation Resource, ESR, or CLR Base Load = MDRR (this value is not reduced for temporary output limitations of the Generation Resource, ESR, or CLR due to auxiliary equipment outages, weather conditions, or fuel limitations, it is the “nameplate” rating of the Generation Resource, ESR, or CLR). For the IRR, the Base Load for purposes of this test shall be their MDRR. The IRR shall use only a FME in which the IRR’s HSL is greater than 50% of the IRR’s total design output capability.

1. HISTORICAL GENERATION RESOURCE, Energy Storage Resource, OR CONTROLLABLE LOAD RESOURCE **FREQUENCY RESPONSE TEST FORM**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of FME:

QSE: Resource Entity:

***Historical Results***

|  |  |
| --- | --- |
| ***Evaluation Point*** | ***Frequency*** |
| ***Time (sec) of FME (t(0))*** |  |
| ***Pre-Perturbation Average Frequency (t(-2) to t(-16))*** |  |
| ***Post-Perturbation Average Frequency (t(20) to t(52))*** |  |

|  |  |  |
| --- | --- | --- |
| **1** | **Pre-Perturbation Average MW [T(-2 ) to T(-16)]** |  |
| **2** | **Post-Perturbation Average MW [T(+20 to T(+52)]** |  |
| **3** | **Expected Initial Primary Frequency Response (MW)** |  |
| **4** | **Expected Sustained Primary Frequency Response (MW)** |  |
| **5** | **Adjusted Actual Initial Primary Frequency Response (MW)** |  |
| **6** | **Adjusted Actual Sustained Primary Frequency Response (MW)** |  |
| **7** | **Initial Response P.U. Performance** |  |
| **8** | **Sustained Response P.U. Performance** |  |

***Comments:*** \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Submittal***

Resource Entity Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QSE Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date submitted to ERCOT Representative:

Intermittent renewable resource (IRR) Frequency Response Test Procedure

***Description of the Test***

1. The frequency response function of the Intermittent Renewable Resource (IRR) is tested On-Line at a Load level that allows the IRRs to increase or decrease Load without reaching low operating limits or high operating limits.

2. The test is performed by adding a frequency offset signal that exceeds the Governor Dead-Band value to the measured frequency signal. This should create immediate step change in the measured frequency signal.

3. The test starts at time t0 when the frequency Dead-Band is exceeded.

4. The MW output signal should be recorded at least every two seconds.

5. The duration of the test is 100 seconds. After 100 seconds, the offset signal should be removed and the IRR should return to pretest power output.

6. The test should be conducted both with positive and negative frequency offsets.

7. The test is considered successful after the signal becomes active if at least 70% of the calculated MW contribution is delivered within 16 seconds and the response is maintained for an additional 30 seconds.

8. Governor droop and Governor Dead-Band settings shall be set in accordance with Section 2.2.7.

9. IRRs located behind one POI, metered by one ERCOT-Polled Settlement (EPS) Meter, and operated as an integrated Facility may combine IRRs for the purposes of this test.

***Definitions***

**IRR Base Load =** MDRR. The test shall be performed at an output level which is greater than 50% of IRR’s total design output capability.

**Gain MW for 0.1Hz** consistent with a selected droop percentage =



Where:

*P* = IRR telemetered HSL (MW)

*Droop* = droop (%)

**Frequency Offset** = +0.2 Hz and -0.2 Hz, outside Governor Dead-Band

**Test frequency** = Measured Frequency + Frequency Offset

**MW Contribution** = Gain MW to 0.1 Hz \* 10 \* Frequency Offset

**Calculated droop** = - 

Where:

*P* = IRR telemetered HSL (MW)

*ΔHz* = Change in frequency (Hz), taking into account Governor Dead-Band

*ΔMW* = Change in power output (MW)

***Example***

IRR telemetered HSL = 150 MW

Droop = 0.05 or 5% (use 0.05 for calculation)

Governor Dead-Band = 0.017 Hz

Gain MW for 0.1 Hz =  = +/- 5.03 MW/0.1 Hz

∆MW Contribution = 5.03 \* 10\* +/-0.2 = +/-10.06 MW

Expected under-frequency response: +10.06 MW in 16 sec. for -0.2 Hz offset

Expected over-frequency response: -10.06 MW in 16 sec. for +0.2 Hz offset

Minimum accepted under-frequency response: +7.04 MW in 16 sec. for -0.2 Hz offset

Minimum accepted over-frequency response: -7.04 MW in 16 sec. for +0.2 Hz offset

Calculated droop for 8MW increase in power output in 16 sec. for -0.2 Hz offset:

Calculated percent droop = - \*100 = 6.25%

**Intermittent renewable resource (IRR) FREQUENCY RESPONSE TEST FORM**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of Test:

QSE: Resource Entity:

***Test Results***

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Test with +0.2 Hz** | **Test with -0.2 Hz** |
| **1** | **IRR Base Load** |  |  |
| **2** | **GAIN MW to 0.1Hz** |  |  |
| **3** | **Calculated Minimum**  **MW Contribution** |  |  |
| **4** | **MW at test start (t0)** |  |  |
| **5** | **MW at t0 + 16 sec** |  |  |
| **6** | **MW Contribution**  **at t0 + 16 sec** |  |  |
| **7** | **MW at t0 + 46 sec** |  |  |
| **8** | **Calculated droop** |  |  |
| **9** | **CONCLUSION**  **(PASSED/FAILED)** |  |  |

***Comments***: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Submittal***

Resource Entity Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QSE Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date submitted to ERCOT Control Area Authority Rep.: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Controllable load resource Frequency Response Test Procedure

***Description of the Test***

1. The frequency response function of the Controllable Load Resource (CLR) is tested On-Line at a Load level that allows CLRs to increase or decrease Load without reaching Low Power Consumption (LPC) or Maximum Power Consumption (MPC).

2. The test is performed by adding a frequency offset signal that exceeds the Governor Dead-Band value to the measured frequency signal. This should create an immediate step change in the measured frequency signal.

3. The test starts at time t0 when the frequency Dead-Band is exceeded.

4. The MW output signal should be recorded at least every two seconds.

5. The duration of the test is 100 seconds. After 100 seconds, the offset signal should be removed and the CLR should return to pretest power output.

6. The test should be conducted both with positive and negative frequency offsets.

7. The test is considered successful after the signal becomes active if at least 70% of the calculated MW contribution is delivered within 16 seconds and the response is maintained for an additional 30 seconds.

8. Governor droop and Governor Dead-Band settings shall be set in accordance with Section 2.2.7, Turbine Speed Governors.

***Definitions***

**Controllable Load Resource Base Load =** MDRR. The test shall be performed at an output level that allows the CLR to increase or decrease Load without reaching LPC or MPC.

**Gain MW for 0.1Hz** consistent with a selected droop percentage =



Where:

*P* = CLR telemetered MPC (MW)

*Droop* = droop (%)

**Frequency Offset** = +0.2 Hz and -0.2 Hz, outside Governor Dead-Band

**Test frequency** = Measured Frequency + Frequency Offset

**MW Contribution** = Gain MW to 0.1 Hz \* 10 \* Frequency Offset

**Calculated droop** = - 

Where:

*P* = CLR telemetered MPC

*ΔHz* = Change in frequency (Hz), taking into account Governor Dead-Band

*ΔMW* = Change in power output (MW)

***Example***

CLR telemetered MPC = 150 MW

Droop = 5%

Governor Dead-Band = 0.036 Hz

Gain MW to 0.1 Hz =  = +/- 5.06 MW/0.1 Hz

∆MW Contribution = 5 \* 10\* +/-0.2 = +/-10.12 MW

Expected under-frequency response: -10.12 MW in 16 sec. for -0.2 Hz offset

Expected over-frequency response: +10.12 MW in 16 sec. for +0.2 Hz offset

Minimum accepted under-frequency response: -7.08 MW in 16 sec. for -0.2 Hz offset

Minimum accepted over-frequency response: +7.08 MW in 16 sec. for +0.2 Hz offset

Note: The negative sign in expected under-frequency response and minimum accepted under-frequency response denotes the required reduction in power consumption. Similarly the positive sign in expected over-frequency response and minimum accepted over-frequency response denotes the required increase in power consumption.

Calculated droop for 8 MW increase in power output in 16 sec. for -0.2 Hz offset:

Calculated percent droop = - = 6.25%

**Controllable load resource (CLR) FREQUENCY RESPONSE TEST FORM**

***General Information***

Unit Code (16 characters): Location (County):

Unit Name: Date of Test:

QSE: Resource Entity:

***Test Results***

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | **Test with +0.2 Hz** | **Test with -0.2 Hz** |
| **1** | **CLR Base Load** |  |  |
| **2** | **GAIN MW to 0.1 Hz** |  |  |
| **3** | **Calculated Minimum**  **MW Contribution** |  |  |
| **4** | **MW at test start (t0)** |  |  |
| **5** | **MW at t0 + 16 sec** |  |  |
| **6** | **MW Contribution**  **at t0 + 16 sec** |  |  |
| **7** | **MW at t0 + 46 sec** |  |  |
| **8** | **Calculated droop** |  |  |
| **9** | **CONCLUSION**  **(PASSED/FAILED)** |  |  |

***Comments***: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

***Submittal***

Resource Entity Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

QSE Representative: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date submitted to ERCOT Control Area Authority Rep.:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**ERCOT Nodal Operating Guides**

**Section 8**

**Attachment N**

**Procedure for Calculating RRS MW Limits for Individual Resources to Provide RRS Using Primary Frequency Response**

**TBD**

1. Introduction

Changes to this attachment shall be reviewed by the Performance, Disturbance, Compliance Working Group (PDCWG).

2. Responsive Reserve Service Using Primary Frequency Response

Responsive Reserve (RRS) using Primary Frequency Response is an operating reserve on Generation Resources, Controllable Load Resources (CLRs), and Energy Storage Resources (ESRs) maintained by ERCOT to help control the frequency of the system. RRS on Resources providing Primary Frequency Response can be released to Security-Constrained Economic Dispatch (SCED) during scarcity conditions as outlined in Section 4.8, Responsive Reserve Service During Scarcity Conditions.

# 3. RRS MW Limits for Individual Resources

Generation Resources, ESRs, and CLRs that do not meet the 12 months or the last eight Frequency Measurable Events (FMEs) (applicable if a minimum threshold of eight FMEs within the 12 month period is not met) rolling average criteria, or have failed to score greater than or equal to 0.75 for Primary Frequency Response initial or Primary Frequency Response sustained measures (computed per Section 8, Attachment J, Initial and Sustained Measurements for Primary Frequency Response) for three consecutive FMEs, where the unit was evaluated, over a minimum period of two calendar months, will be subject to review of their respective RRS MW limit for Primary Frequency Response (“RRS MW Limit”) using the process outlined in Section 4 below. All other Generation Resources, ESRs, and CLRs shall continue to be limited to their respective RRS MW Limit established as follows.

1. The default RRS MW Limit for any Generation Resource, ESR, or CLR providing RRS shall be set to 20% of its Maximum Droop Response Range (MDRR). A Private Use Network with a registered Resource may use its gross HSL for qualifying and establishing a limit on the amount of RRS capacity that the Resources within the Private Use Network can provide.

2. RRS MW Limits for non-thermal Generation Resources, Generation Resources with a Resource Category of either (i) aeroderivative simple cycle commissioned after 1996, or (ii) Reciprocating Engines, ESRs, or CLRs may be updated to be higher or lower than the default threshold based on their droop performance characteristics and actual tests.

3. In order to ensure that the frequency responsive capability is distributed across multiple Resources, the RRS MW Limit for all Generation Resources, ESRs, or CLRs may be further adjusted based on the maximum amount of RRS that an individual Resource can provide using Primary Frequency Response established per paragraph (3) of Protocol Section 3.16, Standards for Determining Ancillary Service Quantities.

Based on Protocol Section 3.18, Resource Limits in Providing Ancillary Service, (i) Generation Resources operating in synchronous condenser fast-response mode may provide RRS up to the Generation Resource’s ERCOT-validated 20-second response capability (which may be 100% of their HSL).

# 4. Calculating RRS MW Limits for Individual Resources

For Resources that fail the Primary Frequency Response initial or Primary Frequency Response sustained measures for three consecutive FMEs, where the unit was evaluated, over a minimum period of two calendar months or are failing the 12 months or the last eight FMEs (applicable if a minimum threshold of eight FMEs within the 12 month period is not met) rolling average criteria, ERCOT shall establish RRS MW Limit for providing RRS using Primary Frequency Response based on their respective performance during FMEs, any limitations exhibited within its dynamic models, or through droop performance tests on an as needed basis.

If the RRS MW Limit is to be determined based upon the Resource’s performance during an FME, then such RRS MW Limit shall be calculated as follows,

1. The RRS MW Limit for each Generation Resource, ESR, and CLR will be calculated using the droop performance during an FME. The Calculated Droop Performance and RRS MW Limit for an FME is calculated as follows:

**Delta Hertz (∆Hz):** The pre-perturbation [the 16-second period of time before t(0)] average frequency minus the post-perturbation [the 32-second period of time starting 20 seconds after t(0)] average frequency

**Delta MW (∆MW):** The pre-perturbation average MW of the Resource minus the post-perturbation average MW of the Resource

**Scheduled Frequency:** The frequency value to be maintained on the system, always 60 Hz

**Power Augmentation (PA) Capacity:** The telemetered portion of a Generation Resource’s HSL that represents the sustainable non-Dispatched power augmentation capability from duct firing, inlet air cooling, auxiliary boilers, or other methods which does not immediately respond, arrest, or stabilize frequency excursions during the first minutes following a disturbance without secondary frequency response or instructions from ERCOT

**Deadband (Deadbandmax):** The range of deviations of system frequency (+/-) that produces no Primary Frequency Response

2. The median of the calculated RRS MW Limits in the last five FMEs where the unit was evaluated will be computed for each individual Generation Resource, ESR, and CLR. If a Resource hasn’t participated in five FMEs, proceed to Step 3.

3. The median of all FMEs during the previous three months where the unit was evaluated will be computed for each individual Generation Resource, ESR, and CLR.

4. RRS MW Limit will be established based on the lower of the values computed in Steps 2 and 3.

If a Generation Resource’s, ESR’s, or CLR’s performance during an FME is excluded per the current process (NERC Reliability Standard BAL-TRE-001) from the rolling average calculation, the Resource’s performance will also be excluded from the RRS MW Limit calculation. Also note that all members of a Combined Cycle Generation Resource will be evaluated as one Generation Resource for the purposes of this evaluation.

# 5. Timeline to Establish RRS MW Limits

ERCOT will recalculate the RRS MW Limit on each individual Generation Resource, ESR, and CLR on a monthly basis. ERCOT shall post on the Market Information System (MIS) Certified area the RRS MW Limit for each Resource qualified to provide RRS by the 10th day of each month. These RRS MW Limits will be effective in ERCOT systems coincident with the first Network Model Database Load[[3]](#footnote-3) two months later. For example, ERCOT shall post the RRS MW Limit for each Resource by January 10, 2020. These RRS MW Limits will be effective in ERCOT systems beginning March 4, 2020. These recalculated values will follow any threshold limitations as expressed in Section 3 above.

If at the time of recalculation, a Generation Resource, ESR, or CLR was previously limited due to any failure mentioned in Section 4 above, then the established RRS MW Limit will continue to apply. In order to reset the RRS MW Limit, a Generation Resource, ESR, or CLR may use dynamic models, droop performance tests, or documentation of an implemented corrective action plan to demonstrate that it is capable of carrying the standard RRS limit as mentioned in Section 3 above. A Generation Resource, ESR, or CLR that requests its RRS MW Limit to be reset must have a current 12 months or the last eight FMEs rolling average of at least 0.75 for Primary Frequency Response initial or sustained measures.

# Appendix: RRS MW Limit Decision Tree

The diagram below describes at a high level the decision tree procedure to compute a RRS MW Limit for every Generation Resource, ESR, and CLR. In the event there is a conflict between the diagram below and text stated in the sections above, the language stated in text above takes precedence.

Monthly RRS MW Limit Calculation for a Resource

Is the Resource currently limited due to previous failure?

Entry criteria\* met?

Compute new RRS MW Limit and post

Corrective Actions Complete?

Set RRS MW Limit to default based on Section 3 above and post

RRS MW Limit remains unchanged at prior limited value and post

Y

Y

Y

N

N

N

\*(1) failed rolling average or (2) score in last three evaluated events in two consecutive months is less than 0.75

1. Westinghouse recommends using only this test. [↑](#footnote-ref-1)
2. Westinghouse recommends using only this test. [↑](#footnote-ref-2)
3. The most recent Network Model Database Load Schedules can be accessed at the following link.

   <http://www.ercot.com/gridinfo/transmission/opsys-change-schedule.html> [↑](#footnote-ref-3)