

ERCOT Protocols & Operating Guides on Reactive Testing

P 3.15

Voltage Support

- (1) ERCOT in coordination with the Transmission Service Providers (TSPs) shall establish and update, as necessary, the ERCOT System Voltage Profile for all Electrical Buses used for Voltage Support in the ERCOT System and shall post all Voltage Profiles on the Market Information System (MIS) Secure Area. ERCOT may temporarily modify its requirements based on current system conditions.
- (2) All Generation Resources (including self-serve generating units) that have a gross generating unit rating greater than 20 MVA or those units connected at the same Point of Interconnection (POI) that have gross generating unit ratings aggregating to greater than 20 MVA, that supply power to the ERCOT Transmission Grid, shall provide Voltage Support Service (VSS).
- (3) Generation Resources required to provide VSS shall comply with the following Reactive Power Requirements:
 - (a) An over-excited (lagging or producing) power factor capability of 0.95 or less determined at the generating unit's maximum net power to be supplied to the ERCOT Transmission Grid and at the transmission system Voltage Profile established by ERCOT, both measured at the POI;
"the rectangle"
<-- Test #1 (Net MVAR @ POI) Pass if >= .328 x Defined GEN MW
 - (b) An under-excited (leading or absorbing) power factor capability of 0.95 or less, determined at the generating unit's maximum net power to be supplied to the ERCOT Transmission Grid and at the transmission system Voltage Profile established by ERCOT, both measured at the POI;
Lagging: Conv >95% SUM HSL, IRR >60% SUM HSL
 - (c) Reactive Power capability shall be available at all MW output levels and may be met through a combination of the Generation Resource's Unit Reactive Limit (URL), which is the generating unit's dynamic leading and lagging operating capability, and/or dynamic VAr capable devices. This Reactive Power profile is depicted graphically as a rectangle. For Intermittent Renewable Resources (IRRs), the Reactive Power requirements shall be available at all MW output levels at or above 10% of the IRR's nameplate capacity. When an IRR is operating below 10% of its nameplate capacity and is unable to support voltage at the POI, ERCOT may require an IRR to disconnect from the ERCOT System for purposes of maintaining reliability; and
Leading: Conv= "typ. MW that time of year", IRR= <60% Fall HSL
 - (d) As part of the technical Resource requirements to begin commercial operations, all Generation Resources must conduct an engineering study, or demonstrate through performance testing, compliance with the Reactive Power capability requirements of this Section 3.15. Any study or testing results must be accepted by ERCOT prior to commercial operations.
- (4) Wind-powered Generation Resources (WGRs) that commenced operation on or after February 17, 2004, and have a signed Standard Generation Interconnection Agreement (SGIA) on or before December 1, 2009 ("Existing Non-Exempt WGRs"), must be capable of producing a defined quantity of Reactive Power to maintain a Voltage Profile established by ERCOT in accordance with the Reactive Power requirements established in paragraph (3) above, except in the circumstances described in paragraph (a) below.
- (3) (a) Existing Non-Exempt WGRs whose current design does not allow them to meet the Reactive Power requirements established in paragraph (3) above must conduct an engineering study using the Summer/Fall 2010 on-peak/off-peak Voltage Profiles, or conduct performance testing to determine their actual Reactive Power capability. Any study or testing results must be accepted by ERCOT. The Reactive Power requirements applicable to these Existing Non-Exempt WGRs will be the greater of: the leading and lagging Reactive Power capabilities established by the Existing Non-Exempt WGR's engineering study or testing results; or Reactive Power proportional to the real power output of the Existing Non-Exempt WGR (this Reactive Power profile is depicted graphically as a triangle) sufficient to provide an over-excited (lagging) power factor capability of 0.95 or less and an under-excited (leading) power factor capability of 0.95 or less, both determined at the transmission system Voltage Profile established by ERCOT, and both measured at the POI.
 - (i) Existing Non-Exempt WGRs shall submit the engineering study results or testing results to ERCOT no later than five Business Days after its completion.
 - (ii) Existing Non-Exempt WGRs shall update any and all Resource Registration data regarding their Reactive Power capability documented by the engineering study results or testing results.
 - (iii) If the Existing Non-Exempt WGR's engineering study results or testing results indicate that the WGR is not able to provide Reactive Power capability that meets the triangle profile described in paragraph (4)(a) above, then the Existing Non-Exempt WGR will take steps necessary to meet that Reactive Power requirement depicted graphically as a triangle by a date mutually agreed upon by the Existing Non-Exempt WGR and ERCOT. The Existing Non-Exempt WGR may meet the Reactive Power requirement through a combination of the WGR's URL and/or automatically switchable static VAr capable devices and/or dynamic VAr capable devices. No later than five Business Days after completion of the steps to meet that Reactive Power requirement, the Existing Non-Exempt WGR will update any and all Resource Registration data regarding its Reactive Power and provide written notice to ERCOT that it has completed the steps necessary to meet its Reactive Power requirement.
 - (iv) For purposes of measuring future compliance with Reactive Power requirements for Existing Non-Exempt WGRs, results from performance testing or the Summer/Fall 2010 on-peak/off-peak Voltage Profiles utilized in the Existing Non-Exempt WGR's engineering study shall be the basis for measuring compliance, even if the Voltage Profiles provided to the Existing Non-Exempt WGR are revised for other purposes.
- (b) Existing Non-Exempt WGRs whose current design allows them to meet the Reactive Power requirements established in paragraph (3) above (depicted graphically as a rectangle) shall continue to comply with that requirement. ERCOT, with cause, may request that these Existing Non-Exempt WGRs provide further evidence, including an engineering study, or performance testing, to confirm accuracy of Resource Registration data supporting their Reactive Power capability.

- (5) Qualified Renewable Generation Resources (as described in Section 14, State of Texas Renewable Energy Credit Trading Program) in operation before February 17, 2004, required to provide VSS and all other Generation Resources required to provide VSS that were in operation prior to September 1, 1999, whose current design does not allow them to meet the Reactive Power requirements established in paragraph (3) above, will be required to maintain a Reactive Power requirement as defined by the Generation Resource's URL that was submitted to ERCOT and established per the criteria in the ERCOT Operating Guides.
- (6) New generating units connected before May 17, 2005, whose owners demonstrate to ERCOT's satisfaction that design and/or equipment procurement decisions were made prior to February 17, 2004, based upon previous standards, whose design does not allow them to meet the Reactive Power requirements established in paragraph (3) above, will be required to maintain a Reactive Power requirement as defined by the Generation Resource's URL that was submitted to ERCOT and established per the criteria in the Operating Guides.
- (7) For purposes of meeting the Reactive Power requirements in paragraphs (3) through (6) above, multiple generation units including IRRs shall, at a Generation Entity's option, be treated as a single Generation Resource if the units are connected to the same transmission bus.
- (8) Generation Entities may submit to ERCOT specific proposals to meet the Reactive Power requirements established in paragraph (3) above by employing a combination of the URL and added VAr capability, provided that the added VAr capability shall be automatically switchable static and/or dynamic VAr devices. A Generation Resource and TSP may enter into an agreement in which the proposed static VAr devices can be switchable using Supervisory Control and Data Acquisition (SCADA). ERCOT may, at its sole discretion, either approve or deny a specific proposal, provided that in either case, ERCOT shall provide the submitter an explanation of its decision.
- (9) A Generation Resource and TSP may enter into an agreement in which the Generation Resource compensates the TSP to provide VSS to meet the Reactive Power requirements of paragraph (3) above in part or in whole. The TSP shall certify to ERCOT that the agreement complies with the Reactive Power requirements of paragraph (3).
- (10) Unless specifically approved by ERCOT, no unit equipment replacement or modification at a Generation Resource shall reduce the capability of the unit below the Reactive Power requirements that applied prior to the replacement or modification.
- (11) Generation Resources shall not reduce high reactive loading on individual units during abnormal conditions without the consent of ERCOT unless equipment damage is imminent.
- (12) All WGRs must provide a Real-Time SCADA point that communicates to ERCOT the number of wind turbines that are available for real power and/or Reactive Power injection into the ERCOT Transmission Grid. WGRs must also provide two other Real-Time SCADA points that communicate to ERCOT the following:
 - (a) The number of wind turbines that are not able to communicate and whose status is unknown; and
 - (b) The number of wind turbines out of service and not available for operation.
- (13) All PhotoVoltaic Generation Resources (PVGRs) must provide a Real-Time SCADA point that communicates to ERCOT the capacity of PhotoVoltaic (PV) equipment that is available for real power and/or Reactive Power injection into the ERCOT Transmission Grid. PVGRs must also provide two other Real-Time SCADA points that communicate to ERCOT the following:
 - (a) The capacity of PV equipment that is not able to communicate and whose status is unknown; and
 - (b) The capacity of PV equipment that is out of service and not available for operation.
- (14) fm. (13) For the purpose of complying with the Reactive Power requirements under this Section 3.15, Reactive Power losses that occur on privately-owned transmission lines behind the POI may be compensated by automatically switchable static VAr capable devices.

P 8.1.1.2.1.4 Voltage Support Service Qualification

- (1) The Resource Entity must verify and maintain its stated Reactive Power capability for each of its Generation Resources providing Voltage Support Service (VSS), as required by the Operating Guides. Generation Resources providing VSS reactive capability limits shall be specified considering nominal substation voltage.
- (2) The Resource Entity shall conduct reactive capacity qualification tests to verify the maximum leading and lagging reactive capability of all Generation Resources required to provide VSS. Reactive capability tests are performed on initial qualification and at a minimum of once every two years. ERCOT may require additional testing if it has information indicating that current data is inaccurate. The Resource Entity is not obligated to place Generation Resources On-Line solely for the purposes of testing. The reactive capability tests must be conducted at a time agreed to in advance by the Resource Entity, its QSE, the applicable TSP, and ERCOT.
- (3) Maximum lagging power factor reactive operating limit must be demonstrated during peak Load season, at or above 95% of the current Seasonal HSL, insofar as system voltage conditions and other factors will allow. Generation Resources that are classified as Intermittent Renewable Resources (IRRs) shall be tested when generating at or above 60% of their Seasonal HSL. The Generation Resource providing VSS is required to maintain this level of Reactive Power for 15 minutes.
- (4) Maximum leading power factor reactive operating limit must be demonstrated during light Load conditions, with the Generation Resource operating at a typical output for that condition, or the normal expected output level for solid fuel Generation Resources during light Load conditions, insofar as system voltage conditions and other factors will allow. Generation Resources that are classified as IRRs shall be tested when generating below 60% of their Seasonal HSL. The Generation Resource is required to maintain this level of Reactive Power for 15 minutes.

OG 3.3.2.1 Corrected Unit Reactive Limits (CURL)

The reactive capability curve for each unit on the ERCOT System shall be submitted to ERCOT through the Market Information System (MIS) Certified Area and must contain the most limiting elements for the leading and lagging reactive output. The limiting factors such as under-excitation limiters, over-excitation limiters, ambient temperature limitations across the MW range of the unit at the unit terminals or any other factor that limits the reactive output of the unit and is verifiable through engineering calculations or testing may be produced on the corrected reactive capability curve. The corrected reactive capability curve establishes the Corrected Unit Reactive Limits (CURL) at the unit terminals that ERCOT Planning and ERCOT Operations will use for their studies. ERCOT Operations, after reviewing the updated curves and checking them for reasonableness, will forward copies to the Steady State Working Group (SSWG). The SSWG members shall have ten Business Days to provide ERCOT Operations any comments regarding updated curves. If appropriate, the SSWG shall use the updated curves in modeling such capability in the ERCOT transmission planning cases. If ERCOT finds the submitted CURL unreasonable, ERCOT will follow Section 3.5, ERCOT Implementation.

OG 3.3.2.2 Non-Coordinated Reactive Testing

- (1) The QSE representing the Generation Resource shall give ERCOT at least two hours advance Notice prior to the start of the test. ERCOT shall Notify the host TO prior to the test. ERCOT retains the right to cancel the reactive test if ERCOT believes, in its sole judgment, that conducting the test at the requested time could jeopardize the reliability of the ERCOT System. For example, ERCOT can cancel a requested leading capability test during a time when system voltages are low or expected to be low due to factors such as high import power levels, transmission line Outages, capacitor bank Outages, or Generation Resource Outages or exciter limitations.
- (2) It is recommended, but not required, that tests to verify maximum lagging reactive capability shall be conducted during times when ERCOT System Loads are typically high, such as during the months of May through September, but not necessarily at the time of system peak. ERCOT has the authority to not allow a reactive capability test to be conducted if it believes system conditions at the requested time of the test are unfavorable. Generation Resources being tested shall be operating at or above 95% of net dependable real power (MW) output. Generation Resources that are classified as Intermittent Renewable Resources (IRRs) shall be tested when generating at or above 60% of their seasonal High Sustained Limit (HSL). If the Generation Resource being tested is unable to achieve adequate lagging reactive capability per the CURL, the Generation Resource, at its discretion, may utilize the capability of another Generation Resource in the same plant to offset (take in VARs) the lagging test that is under way. This circulation of VARs must leave the high side of the GSU of the unit being tested and flow through the GSU of the Generation Resource taking in the VARs. Under no circumstances shall VARs be circulated between Generation Resources on the same low side bus.
- (3) It is recommended, but not required, that tests to verify maximum leading reactive capability be conducted during times when ERCOT System Loads are typically low, during the months of October through April. Generation Resources being tested shall be operating at a real power (MW) output representative of its usual loading during such light Load periods. Generation Resources that are classified as IRRs shall be tested when generating below 60% of their seasonal HSL. ERCOT has the authority to not allow a reactive capability test to be conducted if it believes system conditions at the requested time of the test are unfavorable.
- (4) The Resource Entity shall measure the tested reactive capability on the Generation Resource output terminals. The value recorded shall represent the gross MVAR output of the Generation Resource. This value shall have the Generation Resource's auxiliary reactive consumption deducted from the Generation Resource's gross reactive output. Additionally, the net reactive capability shall be measured at the high side of the GSU transformer if metering is available. If metering is not available at the high side, the Resource Entity shall calculate the reactive capability at the high side. Both high side of the GSU transformer and Generation Resource output terminal values are required and must be submitted through the MIS Certified Area. CURLs shall be attached to the test results submitted, and shall be clearly defined. All fields shown on the form in the MIS Certified Area shall be completed in order for a submittal to be considered complete by ERCOT.
- (5) The QSE representing a Generation Resource shall be responsible for scheduling reactive verification tests in accordance with the conditions outlined above. If ERCOT does not issue an alternative reactive testing interval, the Generation Resource shall complete a reactive qualification test at least every two years.
- (6) ERCOT shall have the option to waive the requirement to test and verify the maximum leading reactive capability of any Generation Resource that seldom runs during such light Load periods. The granting of such a waiver shall be effective for two years. Initial test results and the two-year reactive test results beginning December 1, 2008, as provided to ERCOT, shall be posted to the MIS Certified Area. Initial test results and two-year reactive test results conducted prior to December 1, 2008 do not need to be resubmitted to the MIS Certified Area and will remain on file with ERCOT in the original hard copy format.
- (7) The minimum duration for any reactive verification test, leading or lagging, is 15 minutes. The CURL should be posted in the Resource Entities control room, where the tests are conducted, at the QSE's Real-Time/generation dispatch desk, and copies should be provided to ERCOT Operations. During any test, the Generation Resource must maintain its generator cooling system at normal operating level. Tests will be conducted to produce MVARs at a level not less than 90% of the amount indicated by the existing reactive capability curve (original manufacturer's unit reactive capability curve, or the most recent CURL).

<-- Test #2 (Gross MVAR - Aux Load MVAR) Pass if - >= 90% latest CURL

(8) The QSE representing a Generation Resource shall be responsible for the timely and accurate reporting of test results to ERCOT. The QSE representing a Generation Resource shall be responsible for the timely submittal to ERCOT of an updated CURL reflecting any known changes in the reactive output of the Generation Resource. A QSE must properly complete all required data fields on the MIS Certified Area for a test to be considered valid.

Lagging: Conv >95% SUM HSL, IRR >60% SUM HSL

OG 3.3.2.3 Coordinated Reactive Testing

Leading: Conv= "typ. MW that time of year", IRR= <60% Fall HSL

- (1) "Coordinated Testing" is the testing of a Generation Resource's reactive capability to verify the Generation Resource's most current CURL. The verification test will be a coordinated effort between the Resource Entity, the Resource Entity's QSE, the TO which the Resource Entity is connected, and ERCOT Operations. Coordinated Testing is at the option of the Resource Entity. Coordinated Testing can be ordered by ERCOT if a retest is required.
- (2) The Resource Entity requesting to perform a Coordinated Test will provide ERCOT Operations and the TO with notice of the proposed test date before 1500 on the day prior to the day of the test. Requests shall be made between 0800 and 1700 on Business Days. Upon receipt of a request for test, ERCOT Operations and the TO will evaluate the expected conditions and determine whether ERCOT System conditions conducive to a valid test can be created through coordinated network switching, modification of the generation reactive dispatch of nearby Generation Resources, or by some other means. Having established that suitable ERCOT System conditions exist or can be created, ERCOT Operations, and the TO shall confirm with the Resource Entity and the QSE the agreed upon test time and date or a rejection of the test time and date before 1700 on the day prior to the day of the test.
- (3) The Coordinated Test shall begin and end within the standard work day (nominally 0800 to 1700). Since leading tests will often occur in off-peak periods, the coordinated leading test shall begin and end at times agreed to by ERCOT, the TO, QSE and Resource Entity. The minimum duration for any reactive verification test, leading or lagging, is 15 minutes. The CURL should be provided to ERCOT Operations and posted in the Resource Entity's control room and at the QSE's Real-Time/generation dispatch desk. The testing period shall be scheduled such that sufficient time is given for any transmission switching. During the test, the QSE shall be in communication with the TO in order to coordinate the reactive output of adjacent Generation Resources, capacitor switching, reactor switching, and any other activity needed to perform the scheduled reactive test accurately.
- (4) Lagging Reactive Tests - Generation Resources shall be tested to verify lagging reactive capability at or above 95% of net dependable real power output as indicated on the CURL. Generation Resources that are classified as IRRs shall be tested when generating at or above 60% of their seasonal HSL. Maximum lagging capability is most likely to be needed during times when ERCOT System Loads are typically high, and transmission system voltages are relatively low, such as during the months of May through September. ERCOT has the authority to not allow a reactive capability test to be conducted if it believes ERCOT System conditions at the requested time of the test are unfavorable. The transmission voltage at the switchyard to which the Generation Resource is connected should be at or below the ERCOT currently scheduled voltage prior to starting the test. If the Generation Resource being tested is unable to achieve adequate lagging reactive capability per the CURL, the Generation Resource, at its discretion, may utilize the capability of another Generation Resource in the same plant to offset (take in VARs) the lagging test that is under way. This circulation of VARs must leave the high side of the GSU of the Generation Resource being tested and flow through the GSU of the Generation Resource taking in the VARs. Under no circumstances shall VARs be circulated between Generation Resources on the same low side bus.
- (5) Leading Reactive Tests - Generation Resources shall be tested to verify leading reactive capability at a MW loading level representative of expected Generation Resource MW loading during minimum Load conditions as indicated on the CURL. Generation Resources that are classified as IRRs shall be tested when generating below 60% of their seasonal HSL. Maximum leading capability is most likely to be needed when ERCOT System Loads are typically light and transmission system voltages are relatively high, such as during the months of October through April. ERCOT has the authority to not allow a reactive capability test to be conducted if it believes the system conditions at the requested time of the test are unfavorable. The transmission voltage at the switchyard to which the Generation Resource is connected should be at or above the ERCOT currently scheduled voltage prior to starting the test. At ERCOT's sole discretion, the requirement to test leading capability may be waived for peaking Generation Resources which seldom, if ever, run during light Load conditions.
- (6) The Resource Entity shall measure the tested reactive capability at the Generation Resource terminals. The reading recorded shall represent the net MVAR output of the generator and shall have the Generation Resource's auxiliary reactive consumption deducted from the Generation Resource's gross reactive output at the machine's terminals. Additionally, the tested reactive capability shall be measured at the high side of the GSU transformer if metering is available. If metering is not available at the high side, the Resource Entity shall calculate the reactive capability at the high side. Both high side and generator terminal values are required for proper submittal of the test results.
- (7) The QSE representing a Generation Resource shall be responsible for scheduling reactive tests in accordance with the conditions outlined above, and for the timely and accurate reporting of test results to ERCOT. All test documents (the CURL and the CURL with the test point indicated) shall be submitted by the Resource Entity's QSE. The Resource Entity must properly complete all required data fields on the MIS Certified Area for a test to be considered complete.
- (8) The minimum duration for any reactive verification test, leading or lagging, is 15 minutes. The CURL should be posted in the Resource Entities control room, where the tests are conducted, at the QSE's Real-Time/generation dispatch desk, and copies should be provided to ERCOT Operations. During any test, the Generation Resource must maintain its generator cooling system at normal operating level. Tests will be conducted to produce MVARs at a level not less than 90% of the amount indicated by the existing reactive capability curve (original manufacturer's unit reactive capability curve, or the most recent CURL).

Lagging: Conv >95% SUM HSL, IRR >60% SUM HSL

Leading: Conv= "typ. MW that time of year", IRR= <60% Fall HSL

<-- Test #2 (Gross MVAR - Aux Load MVAR) Pass if ->= 90% latest CURL

- (9) The QSE representing a Generation Resource shall be responsible for the timely and accurate reporting of test results to ERCOT. The QSE representing a Generation Resource shall be responsible for the timely submittal to ERCOT of an updated CURL reflecting any known changes in the reactive output of the Generation Resource. A QSE must properly complete all required data fields on the MIS Certified Area for a test to be considered valid.

OG 3.5 ERCOT Implementation

- (1) Reactive test results shall be reviewed by ERCOT to determine the accuracy and consistency of the test data provided, and to determine the appropriateness of unit loading and system conditions during the test. ERCOT shall have the right to order a re-test of the unit, if it determines there are significant discrepancies with the test data.
- (2) Reactive test results shall be reviewed by ERCOT to determine if test results fall within 90% of Corrected Unit Reactive Limit (CURL) expectation. If test results are less than 90% of CURL expectation, ERCOT shall have the right to either order the Resource Entity to produce a new CURL, or to order a re-test of the unit.
- (3) Reactive test results shall be reviewed by ERCOT against the most recent CURL for the unit. If unit reactive capability appears to be limited to less than 90% of CURL by unit controls or relays, ERCOT shall contact the Resource Entity and attempt to resolve the limitation. ERCOT shall have the right to order the Resource Entity to produce a new CURL that reflects current operating limits.
- (4) CURL data validated by test, or any new CURL produced by a Resource Entity in response to new operating limits, shall be implemented by ERCOT in its operational model within two weeks of receipt and resolution of the data. ERCOT will provide such data to the Steady State Working Group (SSWG) after validation by ERCOT.