###### ERCOT VOLTAGE PROFILE WORKING GROUP

###### PROCEDURE MANUAL

*March 2025*

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# Introduction

## Background

ERCOT Nodal Protocols, Section 3.15 (1) dictates that ERCOT, in coordination with the TSPs, shall establish, update as necessary and post on the Market Information System (MIS) Secure Area the ERCOT System Voltage Profiles for all Electrical Buses used for Voltage Support in the ERCOT System.

ERCOT staff in coordination with the TSPs establishes the ERCOT System Voltage Profiles at the Point of Interconnection Bus (POIB) of Generation Resources biannually. These voltage profiles are posted on the MIS Secure Area by June 1st for Summer and Fall voltage profiles and by December 1st for Winter and Spring voltage profiles.

This published voltage set point in the Voltage Profile is to be used for general guidance. In real-time, Generation Resources and ESRs are required to follow the current real-time voltage set point KVT (the KV target at the POIB) which, along with real-time measured voltage KVM (measured KV at the POIB) are telemetered from the TSP, through ERCOT, to their QSE for voltage control. The KVT is considered to be a voltage operating instruction and ERCOT expects Generation Resources and ESRs to stay on or as close to the real-time voltage set point as possible.

To ensure this, ERCOT has a tolerance band requirement around the set point and checks to see whether a Generation Resource’s or ESR’s measured voltage is within the tolerance band of the set point. For example, for a plant whose nominal voltage is 138 kV at the POIB, ERCOT would require the plant to keep KVM within ±2 kV of the current KVT (e.g., if KVT is 139 kV, tolerance band would be 139±2 kV which gives the range 137-141 kV, then if KVT changed to 141 kV, tolerance band would change to 139-143 kV). The voltage profile process also verifies that the resource can stay within the tolerance band which is set for compliance purposes.

## Purpose & Scope

The purpose of the Voltage Profile Working Group (VPWG) is to formalize a framework of requirements and criteria associated with the coordination necessary to produce Voltage Profiles for the ERCOT System. This coordination may include appropriate Protocol and Guide changes necessary to support development and implementation of the Voltage Profiles. The VPWG’s scope of work should include consideration of the following issues:

* Improving the Voltage Profile Study process
* Develop and update the VPWG Procedure Manual to reflect current need and practices
* Establishing the system voltage profiles for generator or ESR buses and POIBs used for voltage support in the ERCOT system
* Establishing a preferred voltage profile at the POIB for any future generating units in the study cases
* Establishing the basis of the need for constraint management plans to mitigate future post contingency voltage violations
* Providing feedback to the appropriate group for issues identified in the Voltage Profile Study process
* Recommend Guide and Protocol changes to clarify definitions, provide guidelines, address conflicts with NERC Reliability Standards, and modify rules to account for emerging reliability needs, as necessary, relative to the ERCOT system Voltage Profiles
* Request QSEs and REs input bi-annually prior to the new voltage profile kick-off for comments on existing voltage set points or process improvement.
* Support technical workshops and training efforts related to the obligations of entities in the development and implementation of the Voltage Profiles

In addition, ERCOT staff will publish a monthly Generator Voltage Performance Report with the top 20 worst performing Generation Resources or ESRs that failed to meet their set point bandwidth while staying within the power factor requirement in ERCOT Protocol 3.15. The expectation is that TSPs will reach out to entities reported within their service territory to discuss remediating actions regarding their voltage control performance. The TSPs are expected to have procedures in place for switching static reactive compensation to maintain the dynamic capability of resources within their area and making voltage set point changes via ICCP and contacting Resources. These top 20 worst performing entities are to be turned over to Reliability Monitor for enforcement.

# Voltage Profile Study Procedure

## Study Setup

* + 1. Study Cases: Steady State Working Group (SSWG) cases are used as a starting point for the voltage profile study
			1. The Summer study cases are SUM1 year, FAL2 year. The winter study cases are WIN1 year+1, SPG2 year+1
			2. TSPs will check control bus numbers for each of the generators and ESRs and verify that the correct transmission POIBs are modelled in all study cases. All generator and ESR control bus numbers should be TSP-assigned bus numbers and not ERCOT generator bus numbers which are typically in the 100,000-range
			3. TSPs will submit updates (in IDEV format) which will add the appropriate voltage profile for the upcoming study season, the generation plant controlled bus (which shall be the same as the transmission POIB), update reactive device status for equipment under their control, update any operational bus voltage limits (normal and emergency) which may differ from the limits modeled in the Network Operations Model, and add any transmission configuration changes that may not be represented in the case
			4. ERCOT, in conjunction with the TSPs, shall review typical Private User Network (PUN) load/generation injection for the season to be studied and determine the appropriate load/generation ratio to be modeled for each PUN.
		2. Study Case Conditioning
			1. Off-line or New Generation Resources: The treatment of off-line (and/or mothballed) units and new generators is coordinated with the TSP for the area where the generators are located
			2. Generator Reactive Capabilities: ERCOT will check generator reactive capabilities in the case and make any necessary corrections
			3. Incorporate any long-term outages expected to last a significant portion of the study period (generally greater than 45 days). ERCOT will add generator outages and derates as per the Outage Scheduler and redispatch the case accordingly. TSPs will add transmission outages and check the study case for any lines incorrectly modeled out of service
			4. Incorporate any known operational issues or limitations into the case. Documentation of these operational issues to be provided as feedback to the SSWG
			5. VPWG will consider input provided by the QSEs and REs regarding their current voltage profiles.
		3. Contingency List

A contingency list for the planning horizon topology representation is created & maintained by the SSWG and posted on the MIS Secure Area. The following contingencies are selected from the latest contingency set that matches the selected study cases used in the voltage profile study:

* + - 1. NERC P1 Contingencies: Single Contingency (includes loss of a generator, breaker-to-breaker transmission circuit, transformer, and shunt device)
			2. NERC P7 Contingencies: Loss of a double-circuit on a common tower sharing more than half a mile
			3. Automatically generated single element contingencies (includes loss of individual segments within a breaker-to-breaker line segment).

## Study Process

* + 1. Study Pass 0 (Study Kickoff):
			1. The study is kicked off via an e-mail to the Voltage Profile Group using the e-mail address: voltageprofilegroup@lists.ercot.com

This email must include the base cases and contingency files that will be used as a starting point for the study. ERCOT and the TSPs must perform the checks listed under Study Case Conditioning, Section 2.1 b. TSPs must review the information in the modified SSWG cases for accuracy and to correct any base case or contingency voltage abnormalities:

* Check study case voltage limits, against Voltage Criteria below
* Adjust Capacitors and Reactors (including wind farm devices)
* Check dynamic voltage control devices (SVC, STATCOM, Synchronous Condensers, etc,) voltage control settings
* Check Autotransformer LTCs. If changes are needed, the TSPs are requested to submit corrections in an acceptable format (such as an IDEV or CON file).

This email may also include a proposed calendar of activities to be performed during the review & the expected start/stop dates.

* + - 1. Voltage Criteria

The following ranges are considered to be the default steady-state system voltage limits in ERCOT for Operations purposes:

* + - 0.95 Per unit to 1.05 per unit in the pre-contingency state
		- 0.90 Per unit to 1.10 per unit in the post-contingency state.

As per the [ERCOT SOL Methodology for the Operations Time Horizon](https://www.ercot.com/mp/data-products/data-product-details?id=pg7-225-m), Section 4.2, if a Facility owner communicates alternate voltage limits that are more restrictive than the default, these voltage exceptions shall be considered the steady-state voltage limit for their Facilities.

* + 1. Study Pass 1 (Base Case Adjustments):
			1. Upon completion of the initial case review, ERCOT will incorporate the suggested updates and revisions into the base cases & contingency definitions as needed
			2. TSPs will check for case solution conflicts or base case violations
			3. ERCOT will check for conflicting set points at a common control bus and will report back to the TSPs
			4. TSPs shall use their procedures for the operation of transmission-controlled reactive Resources in order to minimize the dependence on generation-supplied reactive Resources.
		2. Review Pass 1: Each TSP submits IDEVs for any necessary base case corrections.
		3. Study Pass 2 (Run Contingencies):
			1. ERCOT staff will verify the suggested resolutions
			2. ERCOT staff will then run Contingency Analysis using the updated base cases and contingency definitions and identify voltage violations based on the voltage criteria. Contingency analysis will be run assuming a Full Newton-Raphson solution method with tap adjustments locked, switched shunt adjustments locked, phase shift and DC taps locked
			3. The list of voltage violations resulting from the Contingency Analysis study is sent out to the VPWG. Each TSP is requested to review the violations for their system/area and provide suggestions to resolve the voltage violation.
		4. Study Pass 3: ERCOT staff will create a preliminary voltage profile report for all units in the case. The voltage profile will be based on the scheduled voltage in the case. For all online units, the resulting POIB voltage is expected to be within approved tolerance band (ERCOT Nodal Operating Guide 2.7.3.5 (4)) of the voltage set point assigned to that unit. Any deviations from the tolerance band shall be identified. If a unit is out-of-service in the study case, then its scheduled voltage shall be used as its voltage profile.
			1. Documentation will be requested for any deviations greater than the tolerance band below or for any online unit that shows its reactive power output to have reached a Qmin/ Qmax limit

|  |  |
| --- | --- |
| NominalVoltage (kV) | ToleranceBand (kV) |
| 345 | +/- 4 |
| 230 | +/- 3 |
| 138 | +/- 2 |
| 115 | +/- 2 |
| 69 | +/- 1 |

* + - 1. The voltage profile shallbe rounded to the nearest 0.5 kV
			2. The updated voltage violation list and preliminary voltage profile spreadsheet is sent to the VPWG. Each TSP is requested to review these for their system/area and provide documented suggestions to resolve any voltage violations as specified above.
			3. Each TSP shall review the Resources included in the preliminary spreadsheet and remove any Energy Storage Resource (ESR) that do not meet the Protocol 3.15 minimum size that’s required to provide Voltage Support Service (<20 MVA). However, ESRs of any size that aggregate with other Resources at the same POIB to greater than or equal to 20 MVA, the ESRs must be kept in the voltage profile.
		1. Review Pass 3: Each TSP provides solutions to resolve voltage violations and/or changes to the draft voltage profile spreadsheet sent by ERCOT.
		2. Steps subsequent to Pass 3 are iterative in nature, and are repeated until all voltage violations have been resolved and all applicable voltage set points have been established.

## Finalizing Study Results

* + 1. Before finalizing the voltage profile, the VPWG shall meet to discuss voltage violations, suggested solutions, the voltage profile, and any deviations from the approved tolerance band
			1. ERCOT staff will document the suggested solutions and/or any exemptions (granted in the Nodal Protocols) that allow a unit’s voltage profile to deviate from the tolerance band requirementand then implement these in the base case of the study. If necessary, contingency analysis shall then be re-run, and the results evaluated
			2. The contingency analysis results will be sent out to the VPWG. If any of the suggested solutions do not resolve the intended violations, these results will be communicated to the specific TSPs
			3. If a TSP is unable to resolve any of the voltage violations, the TSP is requested to develop an Operational solution, Remedial Action Scheme (RAS) or Congestion Management Plan (CMP) for the associated contingency or contingencies. Any new RAS or CMPs shall be coordinated with ERCOT.
		2. The finalized Voltage Profile is posted on the MIS Secure Area. A Market Notice will be issued informing the ERCOT Market Participants (QSEs and TSPs) of the study completion and new voltage profile postings
			1. To be compliant with NERC Reliability Standard VAR-001-4.1, ERCOT Staff shall ensure a column is provided that will note an equivalent Voltage Profile at the bus representing the high-side of the Main Power Transformer (MPT) for every generator. In most instances this is the same bus as the transmission POIB. If the low-side of the MPT must be used for some reason, identify it as such
			2. When the POIB is electrically separated from the high-side of the MPT, the following formula shall be used to estimate the equivalent Voltage Profile at the high side of the MPT:

$$HS MPT V\_{S}=\frac{HSMPT V\_{A}× POIB V\_{S}}{POIB V\_{A}}$$

* + - 1. The Market Notice shall include a presentation explaining the Voltage Support Service (VSS) responsibilities and the format of the Voltage Profile spreadsheet

## Study Feedback to Other Working Groups

* + 1. At the end of each study period, VPWG shall provide the following feedback to other ERCOT Working Groups
			1. Any modeling or contingency issues discovered while reviewing the SSWG cases will be documented and provided as feedback to the SSWG
			2. Any operational issues or limitations discovered in the course of the voltage profile study shall be documented and provided as feedback to the SSWG, including suggested solutions
			3. Request QSE/RE feedback on previous profile and/or study issues
			4. Any generating plant which reaches its maximum reactive capability during the course of the study, shall be documented and provided as feedback to the SSWG. This list may indicate the need for additional study to determine if reactive devices under TSP control (Capacitor banks, SVCs, STATCOMs, Auto Transformer LTCs and Reactors) are required in order to maintain adequate dynamic reserve
			5. VPWG shall report its progress to ROS.