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Reactive Capability at Zero MW

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Nodal Operating Guides

Section 2: System Operations and Control Requirements

2.9.1 Voltage Ride-Through Requirements for Transmission-Connected Inverter-Based Resources (IBRs), Type 1 Wind-powered Generation Resources (WGRs), Type 2 WGRs and Type 3 WGRs

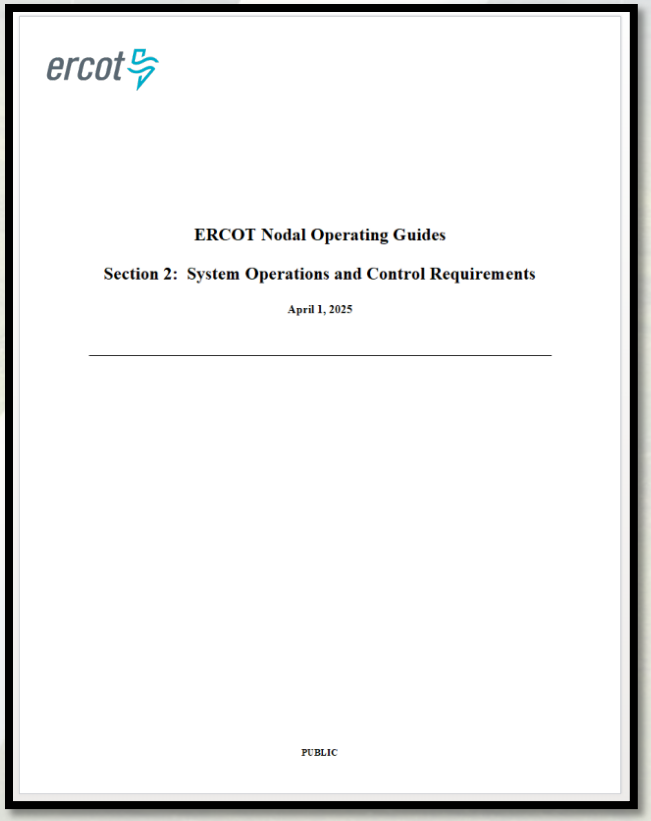
…

An IBR with an SGIA executed on or after August 1, 2024 or that implements a modification, as described in paragraph (1)(c) of Planning Guide Section 5.2.1 for which a GIM was initiated on or after August 1, 2024, shall meet or exceed the capability and performance requirements in the following sections of Institute **of Electrical and Electronics Engineers (IEEE) 2800-2022**, Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems ("IEEE 2800-2022 standard"), including any intra-standard cross references or definitions, unless otherwise clarified, modified, or exempted in the Protocols, these Operating Guides, or the Planning Guide:

(a) Section 5, Reactive power-voltage control requirements within the continuous operation region;

(b) Section 7, Response to TS abnormal conditions; and

(c) Section 9, Protection.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ERCOT Nodal Operating Guides

Section 2: System Operations and Control Requirements

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IEEE 2800 – 5. Reactive power-voltage control req. within the cont. operation region

5.1 Reactive power capability

The minimum reactive power capability shall have following characteristics within the *continuous operation region* as specified in 7.2 and 7.3:

- An *IBR plant* shall have the capability to inject and absorb a minimum reactive power defined by $|Q\text{min}| \geq 0.3287 \times \text{ICR}$ at the RPA when injecting active power into the TS
- An IBR plant shall have the capability to inject and absorb minimum reactive power defined by $|Q\text{min}| \geq 0.3287 \times \text{ICAR}$ at the RPA when absorbing active power from the TS. The ICAR of an IBR plant may be less than ICR.
- Where an *IBR plant*'s minimum reactive power capability *Q*min may be temporarily reduced due to *IBR units* and/or *supplemental IBR devices* that are out of service, the coordination requirements set forth in 4.1.3 shall apply.
- The minimum reactive power capability shall be met at the RPA **for all active power output levels (including at zero)** of the *IBR plant* as shown in Figure 6 and Figure 7 with the following exceptions:
  - For an *IBR plant* consisting of type III WTGs that are not connected to the TS via a VSCHVDC line, the minimum reactive power capability requirement when the active power output is less than 0.1 × ICR is reduced to as shown by the dashed line due to limitations of the technology.
  - b) For an ac-connected *offshore IBR plant* ...
- The minimum reactive power capability for non-nominal voltage conditions is shown in Figure 8.
- **IBR units shall have the capability to provide reactive power support when the primary energy source is available and not available**, and during the transition between these two resource availability states. *IBR units* shall have the capability to remain *in service* while not exporting or importing active power, except for importation of active power to cover losses, and **to have the reactive power capability as defined as shown in Figure 6 and Figure 7**. Note that the *type III WTGs* may have a reduced reactive power capability when the *primary energy source* is not available due to the size of the line-side converter. The utilization of this capability shall be under mutual agreement between the *IBR owner* and the *TS owner*.

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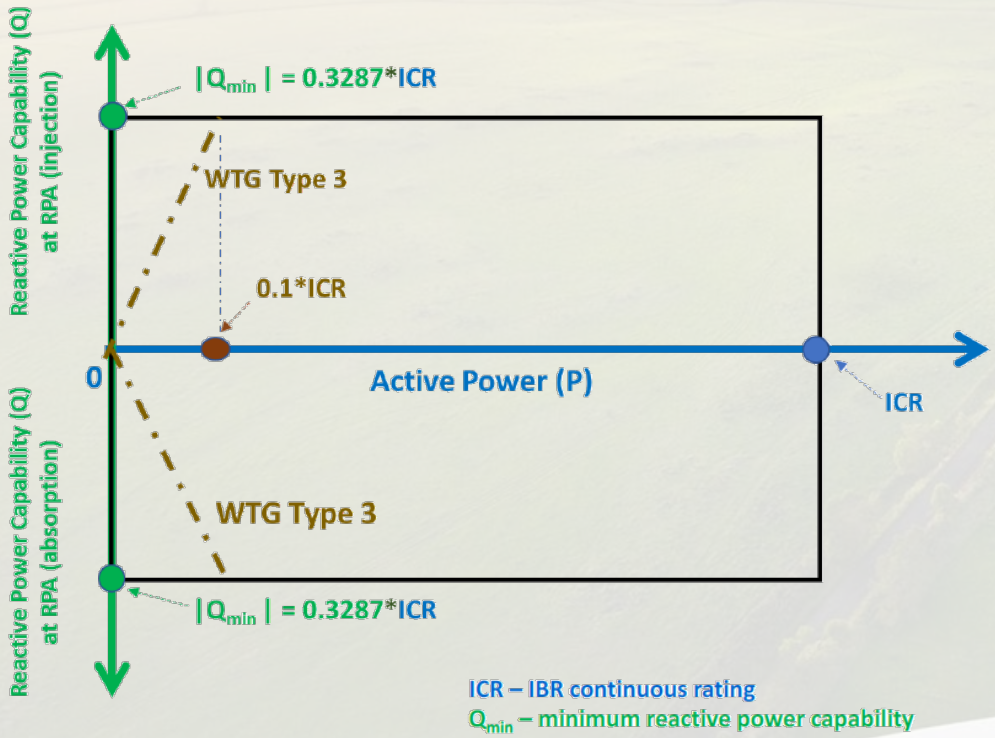
IEEE 2800 – 5. Reactive power-voltage control req. within the cont. operation region

5.1 Reactive power capability

IEEE Std 2800-2022
IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems



NOTE 1—Exchange of reactive power may require the *IBR plant* to consume active power from the grid due to losses when there is no available *primary energy source*.

NOTE 2—The figure shows the minimum range for the reactive power capability required by this standard. The *IBR plant*'s actual capability may be outside of the black box.

Figure 6—Minimum range for reactive power capability—Q versus P for active power injection capability at the RPA (generator sign convention)

IEEE Std 2800-2022
IEEE Standard for Interconnection and Interoperability of Inverter-Based Resources (IBRs) Interconnecting with Associated Transmission Electric Power Systems

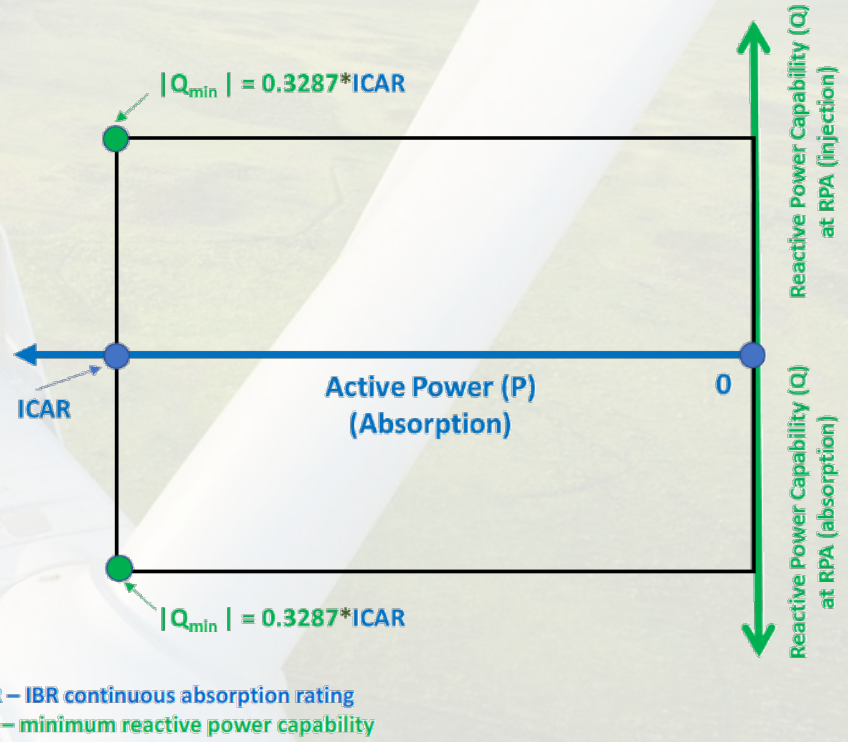


Figure 7—Minimum range for reactive power capability—Q versus P for active power absorption capability at the RPA (generator sign convention)

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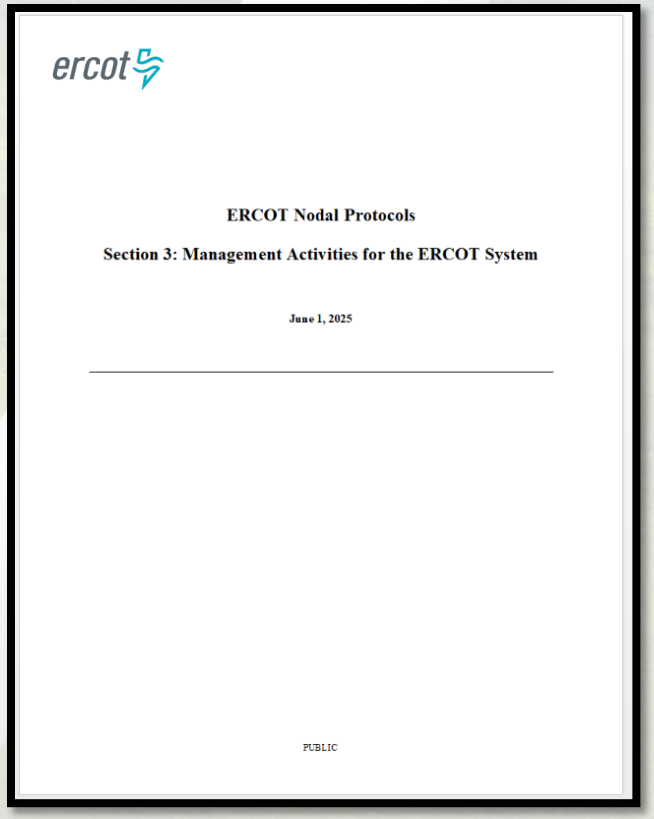
Nodal Protocols

Section 3: Management Activities for the ERCOT System

3.15 Voltage Support

For Generation Resources, the Reactive Power capability shall be available at all MW output levels and may be met through a combination of the Generation Resource's Corrected Unit Reactive Limit (CURL), 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 POIB, ERCOT, the interconnecting TSP, or that TSP's agent may require an IRR to disconnect from the ERCOT System for purposes of maintaining reliability.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ERCOT Nodal Protocols

Section 3: Management Activities for the ERCOT System

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Uncertainty / Inconsistencies around Reactive Capability at Zero MW

Discussion

- **Plant Definition Uncertainty**
  - Lack of clarity on how to define a plant with **mixed WTG technologies** or **hybrid configurations (e.g., wind + solar)**.
- **Ambiguity Between IBR Unit vs. IBR Plant**
  - **IEEE 2800 Figures 6 and 7** reference the **Reference Point of Applicability (RPA)**.
  - However, it's unclear whether some requirements apply **at the unit or plant level**, especially regarding reactive power.
- **Requirements Should Reflect Grid Needs, Not OEM Design**
  - Plant operational requirements should be based on **system reliability objectives**, not on **differences in OEM design**.
  - Applying **different reactive power standards** to turbines with the same fundamental technology is **inequitable**.
- **Protocol vs Operating Guide Inconsistency**
  - **Nodal Protocols**, **Nodal Operating Guide**, and **IEEE 2800** exhibit **inconsistent or undefined requirements** for VAR performance **between 0% and 10%** active power output.
- **Voltage Support Duration Should Be Explicitly Defined**
  - If reactive support is required **across full MW range or above 10%**, duration must be specified.
  - Without wind (i.e., no active power), converter **thermal limits** define how long VARs can be delivered.
- **Real-World Conditions Must Be Considered**
  - Factors such as:
    - Ambient temperature
    - Wind speed
    - Nacelle orientation
    - Pre-event operating state
    - Event duration
  - All significantly affect actual **reactive power capability**, regardless of turbine type.

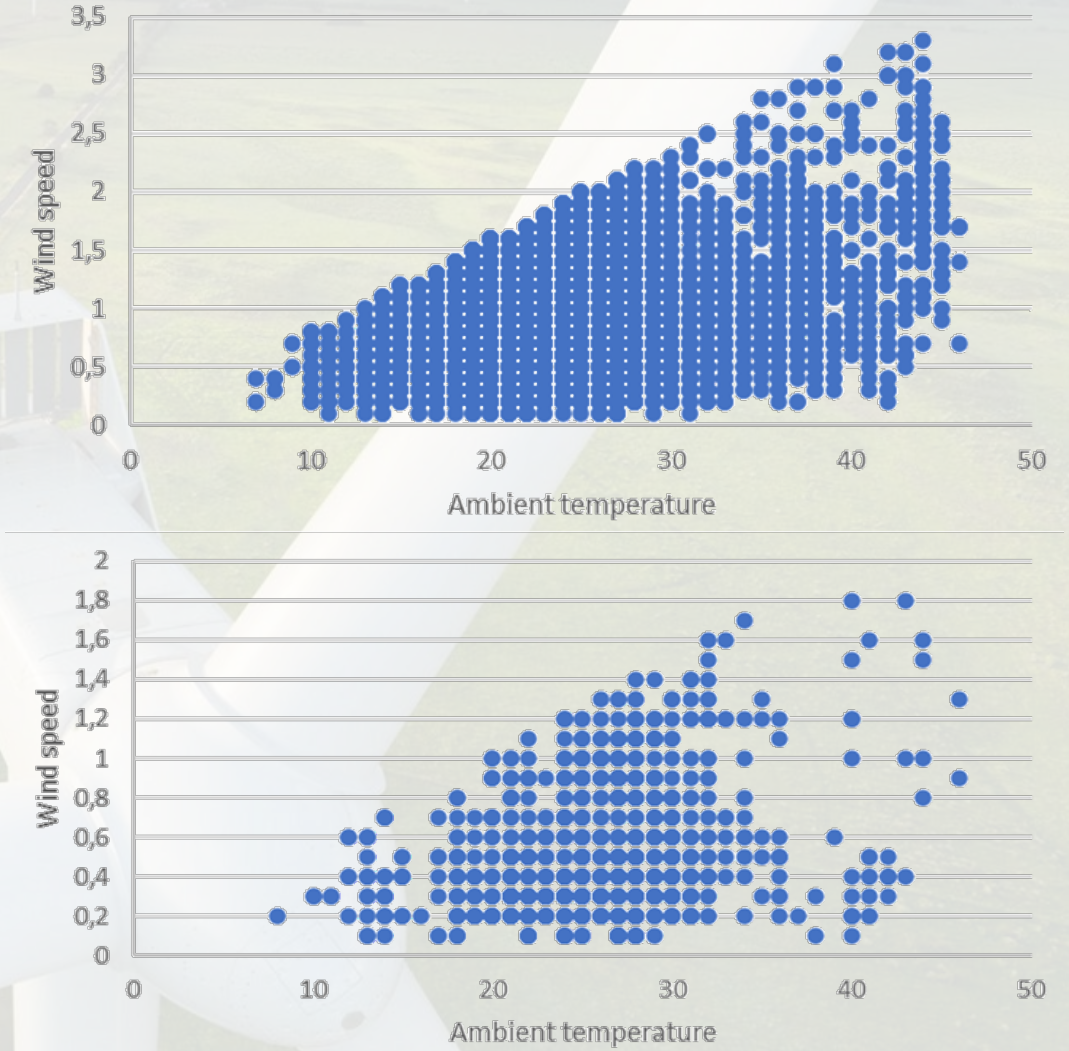
19 June 2025

Reactive Power Derating and Thermal Alarm Correlation at Zero Power

Observations

Observed Alarm Patterns

- 95% of high-temperature alarms on **Variant 5** occur when **Tamb/WSpd > 20**
- 95% of high-temperature alarms on **Variants 1 and 2** occur when **Tamb/WSpd > 12.5**
- ~96% of alarms on **Variants 1, 2, and 5** occur when **wind speed < 2.0 m/s**
- ~96% of alarms on **Variants 1 and 2** occur when **ambient temperature > 15°C**
- ~93% of alarms on **Variant 5** occur when **ambient temperature > 15°C**



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