



PRR835 – Reactive Power Capability Requirement

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The current ERCOT Protocol on reactive power capability requirements is obsolete

Ancillary Services Section 6.5.7 needs to be revised

- **All generators are not the same**
 - Synchronous generators have their own inherent reactive power characteristics
 - The reactive capability of wind generators is evolving
 - Early machines were Type 1 and 2 induction generators with no reactive capability
 - Type 3 machines consist of a Doubly Fed Induction Generator (DFIG)
 - Type 4 machines employ a full bridge converter design coupled to either an induction or synchronous machine
- **Other technologies such as solar and energy storage will have their own unique characteristics**
- **The imposition of a “one size fits all” approach to reactive power capability requirements will result in economic inefficiency and create barriers to entry for the adoption of new technologies**

Not only is the current ERCOT Protocol obsolete...it's also ambiguous

Ancillary Services Section 6.5.7 needs to be revised

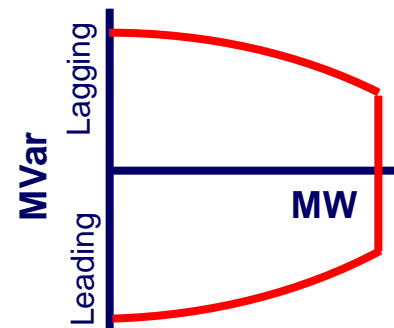
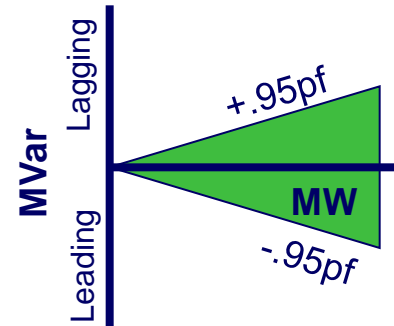
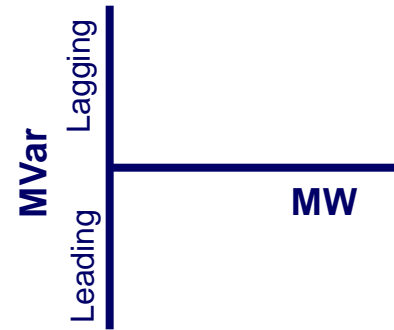
- **Protocol 6.5.7.1 (2) states that...**

“Generation Resources required to provide VSS....shall have and maintain a URL which has an over-excited (lagging) power factor capability of ninety-five hundredths (0.95) or less and an under-excited (leading) power factor capability of ninety five hundredths (0.95) or less, both determined at the generating unit’s maximum net power to be supplied to the transmission grid and at the transmission system Voltage Profile established by ERCOT, and both measured at the point of interconnection to the TDSP.”

- **Does “shall have and maintain” mean going forward in time or does it mean over the output range of the unit?**
- **PRR830, if adopted, would require a wind generator interconnected after February 17, 2004 to maintain a URL over the output range of the unit.**

Wind turbine generator technology continues to evolve

- Type 1 and 2 induction generators – no inherent reactive production capability
- Type 3 doubly fed induction generators - ± 0.95 pf (typical of GE 1.5 MW machines)
- Type 4 machines – reactive capability comparable to synchronous generators (typical of Siemens 2.3 MW machines and comparable to conventional synchronous units)

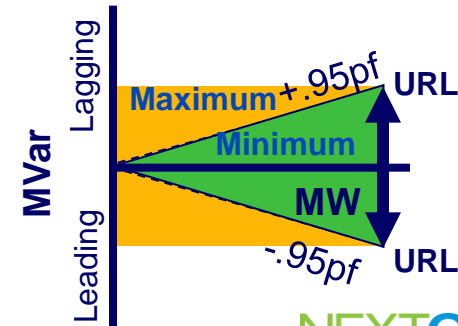
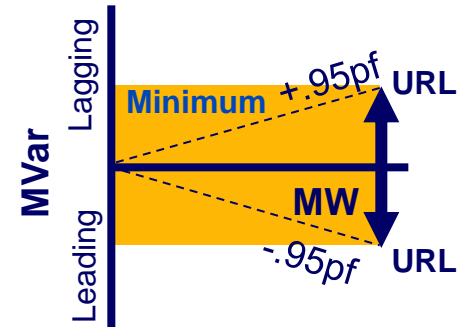
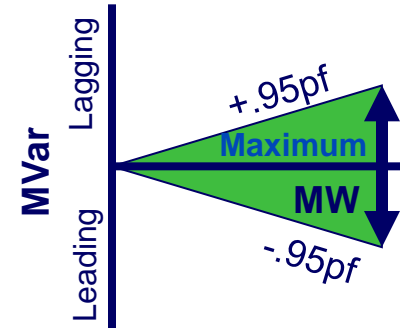


PRR835 does several things...

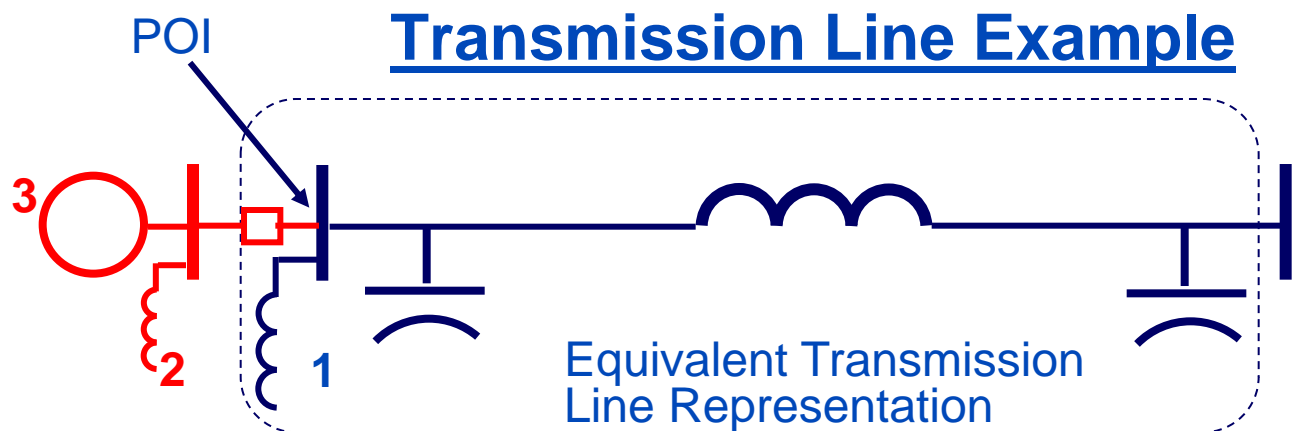
- It carves out a separate section for the reactive power requirements of Wind Generating Resources and requires a +/- 0.95 power factor range as the minimum requirement
- It provides for the imposition of additional reactive requirements consistent with PRR830 where it can be demonstrated through a system impact study that such capability is required to ensure safety and reliability
- PRR835 avoids requiring generators already interconnected to make costly investment in additional reactive capability where it is not justified
- PRR 835 exceeds FERC Order 661-A requirements

Comparison of PRR835 to PRR830 and FERC Order 661-A

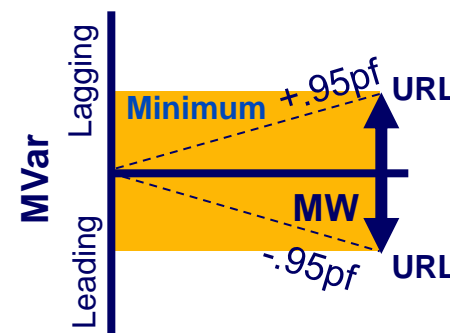
- FERC Order 661-A
 - Adopts +/- 0.95PF range as the maximum requirement
 - Requires wind plants to maintain the required power factor range only if the Transmission Provider shows, through the System Impact Study, that such capability is required of the plant to ensure safety and reliability
- PRR830
 - Adopts the URL measured at +/-0.95 PF and maximum net MW output
 - Requires URL over the full operating range of the plant
- PRR835
 - Adopts +/-0.95PF as the minimum reactive capability
 - May require URL over the full operating range of the plant only if the Transmission Provider demonstrates it is needed to ensure safety and reliability through a System Impact Study



PRR830 will result in redundant and excessive reactive capability where it is not needed



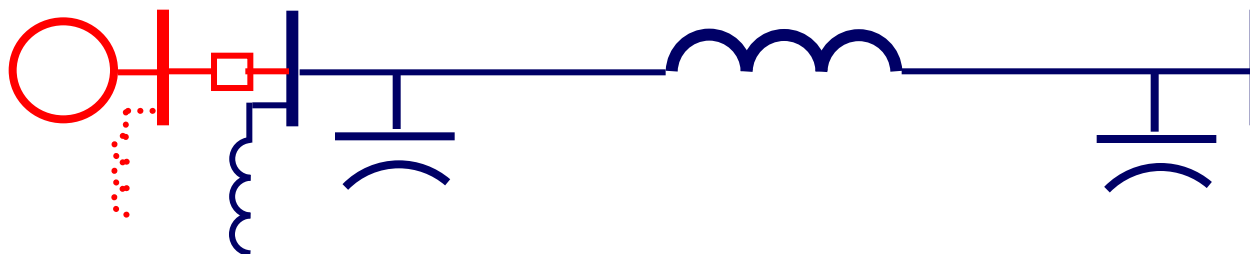
1. Transmission Owner must provide shunt reactors to offset line charging when wind is calm and generator is not generating
2. PRR830 would have the Generator install an additional shunt reactor to meet its URL requirement for leading reactive capability over its range of output
3. Inherent Generator reactive capability



PRR830 will result in the wasteful installation of redundant reactive resources.

PRR835 ensures system safety and reliability without mandating investment in reactive capability for providing VSS where it is not needed

Transmission Line Example



Generator shunt reactor (or capacitor) would not be required to meet its URL requirement for leading (or lagging) reactive capability over its range of output unless shown to be required by the System Impact Study

NextEra has engaged the services of Siemens-PTI to assess the current need for additional reactive resources in Western ERCOT

Study Assumptions

- **Reference case from ERCOT**
 - 2010/2011 Winter off-Peak (09/17/2009 update)
 - 39,569 MW total generation; 3,719 MW wind generation (9.4%)
- **Wind farms represented per ERCOT's modeling**
 - Reactive power capability expressed by Q_{\min} and Q_{\max} as given in the reference case (rectangular reactive power capability)
 - Wind farms represented by equivalent (aggregated) models
- **Sensitivity cases**
 - Different reactive power capability (triangular capability)
 - Different levels of wind generation

**Scenarios based on ERCOT case, from no wind to high wind penetration.
Limited reactive power capability in the wind farms (conservative).**

Wind Farm Generation Re-Dispatch was performed to model the following sensitivity scenarios

Sensitivity Scenarios

- **No-Wind scenarios**

- Constant load (conventional generation increased by 3,719 MW)
- Constant conventional generation (system load scaled down by 3,719 MW)

- **Increased wind generation scenarios**

- Scenario 3 (5,849 MW of wind generation, 14.7% of total)
 - Maximum wind generation in the Gulf Coast and Horse Hollow gen-tie
 - West Texas wind generation increased by 1,040 MW
- Scenario 4 (6,369 MW of wind generation, 16% of total)
 - Scenario 3 with an additional 520 MW of wind in West Texas
- Scenario 5 (same as scenario 4 but with additional wind in west Texas dispatched against local generation)

Preliminary results indicate that voltage violations are not the issue for the current Western ERCOT system

Results

- **AC contingency analysis**
 - ERCOT contingency file (9,000+ cat. B and cat. C contingencies)
- **Few post-contingency voltage violations**
 - Generally unrelated to the wind generation dispatch
 - Also unrelated to reactive power capability at the wind farms
- **Thermal violations**
 - Existing system configuration → restrictions to dispatch of West Texas wind generation
 - Significant overloads already identified before reaching full power output of wind generation in West Texas

Thermal overloads are the limiting factors. No condition has been identified that shows the need for additional reactive power capability from wind farms

Generator reactive capability requirements are driven by system topology and the imbalance between generation and load in Western ERCOT. This trend will become further exaggerated with CREZ implementation

- **Current ERCOT System**
 - West Zone load – approximately 4,000 MW
 - West Zone Generation – approximately 8,000 MW
- **ERCOT System post CREZ**
 - West Zone load – approximate 4,400 MW
 - West Zone Generation – 18,000 MW
- **WGR lagging reactive capability will need to increase with MW output to compensate for transmission line reactive losses.**
- **WGR leading reactive capability will have little value since shunt reactors will be required to offset transmission line charging anyway when the wind is calm.**

CREZ doesn't make things worse but amplifies the consequences of adopting PRR830!

Highlights of PRR835

- Sets minimum requirement of ± 0.95 Power Factor at the Point of Interconnection
- May require additional reactive requirements when supported by a System Impact Study
- Addresses the “Cone” versus “Rectangle” debate
- Wind generator reactive requirements and VSS are distinguished from non-wind generators
- Requires wind generators to provide real-time reactive capability through SCADA
- Does not unnecessarily limit aggregation of wind turbine generators based on size and type as does PRR830
- Grandfathers WGRs interconnected after May 17, 2005 and before the adoption of PRR835 in meeting the ± 0.95 PF requirement

What differentiates PRR835 from PRR830 is that it provides superior economies while ensuring system safety and reliability where justified and needed!