NOGRR124 Workshop: Additional VRT Requirement for IRRs

John Schmall, ERCOT System Planning
Shun-Hsien (Fred) Huang, ERCOT System Planning

Austin Texas
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Outlines

- Wind generation response during and after disturbance
- HVRT related findings
- NOGRR 124 language review and discussion

Wind Generation Response During and After Disturbance

Wind Generation Response – Steady State

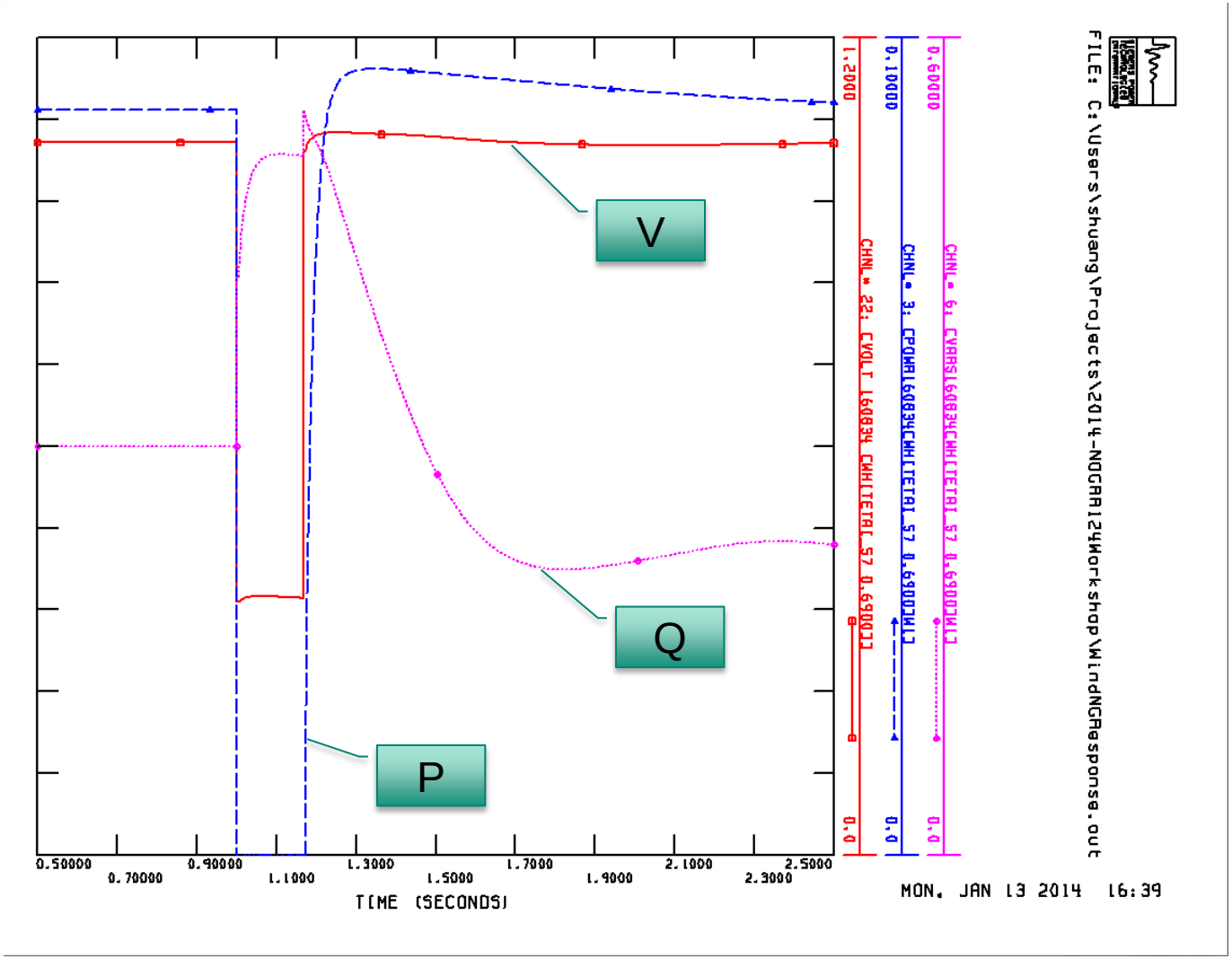
- In steady state:
  - Protocol 3.15, voltage support

Resource with +/- 0.95 pf or less reactive capability determined at the generating unit's maximum net power to be supplied to the ERCOT Transmission Grid measured at the POI

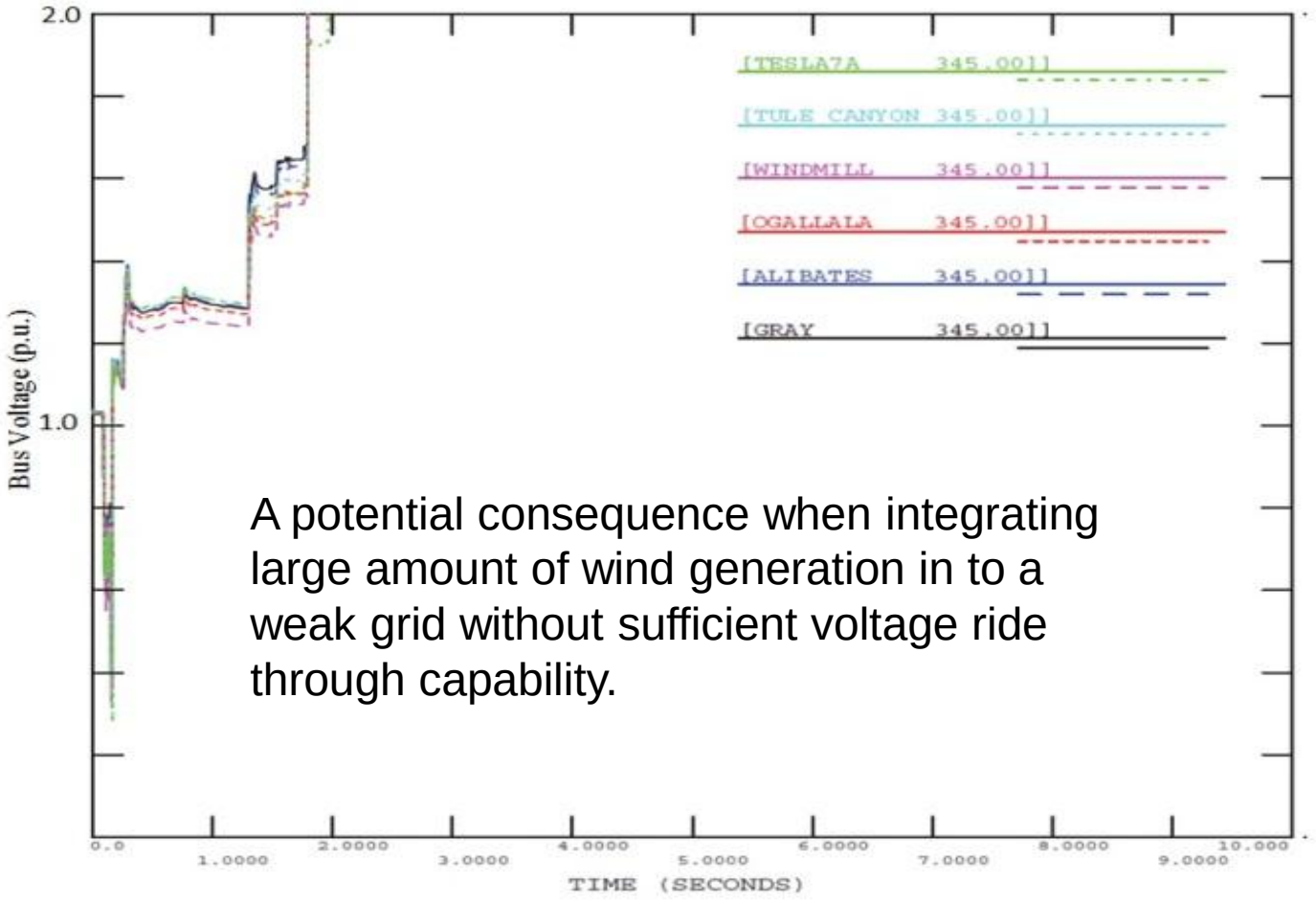
Wind Generation Response -- Dynamic

- During low voltage events
  - Turbine terminal voltage drops
  - If voltage drops below the threshold (0.8~0.9 pu), turbine suspends normal operation and starts to inject reactive current for voltage support
  - Active power drops as a function of the voltage dip.
  - Fault current is close to rated current (controlled current source, limited by power electronic device)
- After disturbance
  - After clear the event, active and reactive currents start to ramp back to their pre-fault values.
  - A fast active power recovery is generally desirable, but too fast power recovery can lead to stability issue and deteriorating voltage recovery when connecting to weak grid.

Wind Generation Response -- Example



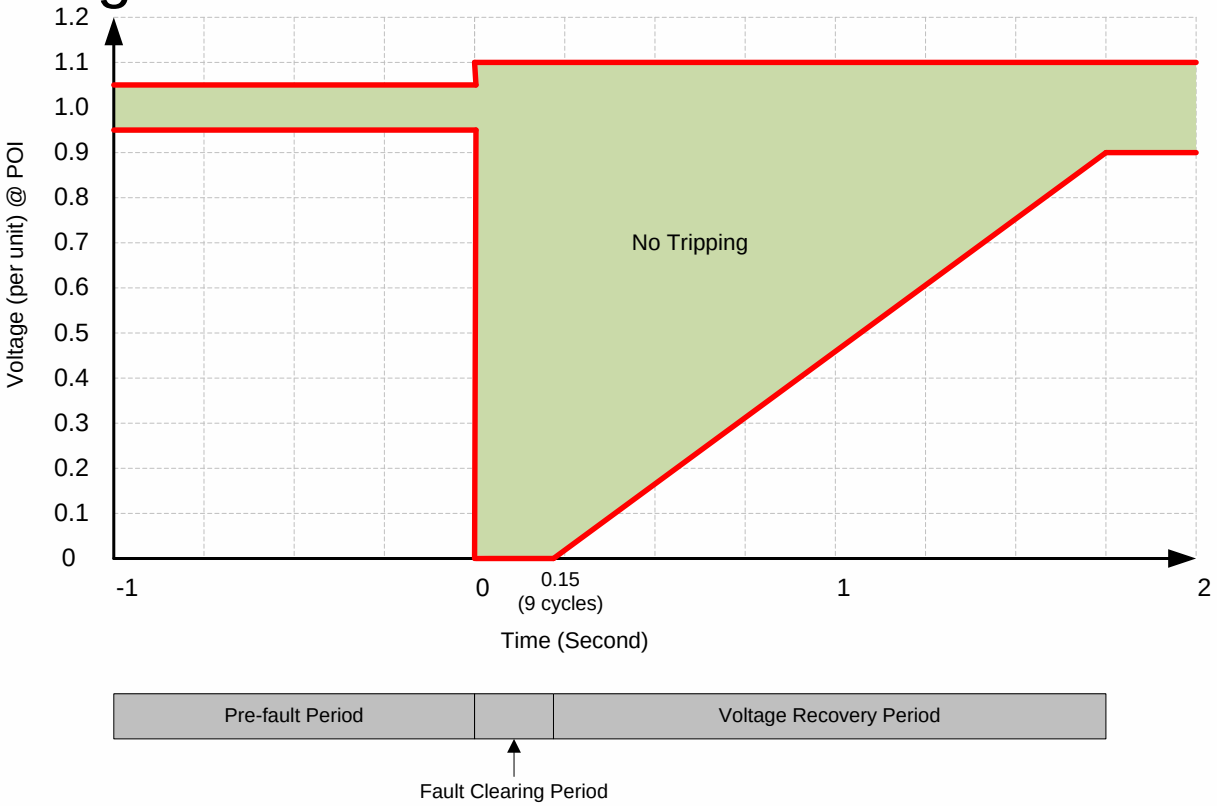
High Voltage Cascading – PREZ study



A potential consequence when integrating large amount of wind generation in to a weak grid without sufficient voltage ride through capability.

ERCOT Voltage Ride Through Requirement

- Operating Guide 2.9.1



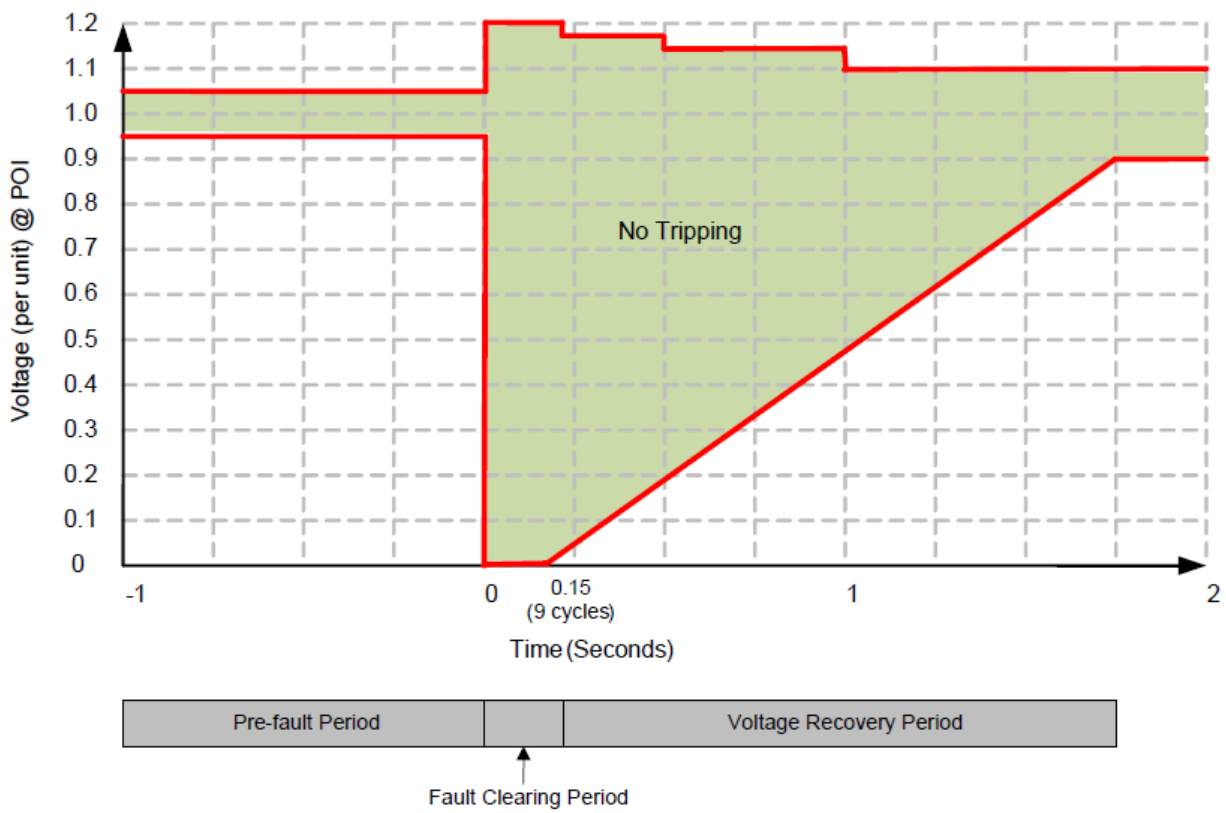
Considering the elements between turbine terminal and POI, including collector grid, step up transformer, and interconnection lines, zero voltage at POI can translate into residual voltage in the range of 10-15% at turbine terminal.

HVRT Related Findings

Background

- ABB CREZ Reactive Study (2010)
  - High voltage trips were observed and a follow up investigation was suggested
- PREZ Study (Spring 2013)
  - Overvoltage Trips Observed
  - Less HVRT Capability - Potential Overvoltage Cascading - Unacceptable
  - Trip Several Thousand MW of Wind Generation - Unacceptable
- HVRT Requirements Proposed (Summer 2013)
  - Based on PRC-024 (Adopted by the NERC Board of Trustees on May 9, 2013)

HVRT Proposal



HVRT Capability

- 1.2 pu
  - ➢ 0.2 seconds
- 1.175 pu
  - ➢ 0.5 seconds
- 1.15 pu
  - ➢ 1.0 seconds

Allowable amount of WGRs without HVRT capability?

There is no definite answer to that question!

Could be determined for a specific set of assumptions

- Changes Would Invalidate the Calculated Limit
  - Wind Capacity (lower limit may be required for higher capacity)
  - Location of Resources
  - Transmission Upgrades
  - HVRT Assumption (just meet the existing requirement?)
- Ideally All Resources Would “Ride Through”

HVRT Analysis – PREZ Study Case

- 3500 MW Panhandle WGRs (3700 MW Capacity)

- Tested Three Transmission Upgrade Options
  - Upgrade 1
    - Alibates-Windmill-Ogallala-Tule Canyon 345kV (2nd Circuit)
    - Synchronous Condenser (350 MVA) at Windmill
  - Upgrade 2
    - Upgrade 1
    - Ogallala-Long Draw 345kV Double Circuit
    - Synchronous Condenser (350 MVA) at Ogallala
  - Upgrade 1a (with Additional Synchronous Condensers)
    - Upgrade 1
    - Synchronous Condensers (350 MVA) at Ogallala & Gray

HVRT Analysis – Simulation Tests

- 177 Total Contingencies
  - Panhandle & CREZ System
  - Single Circuit/3-Phase Fault
  - Double Circuit/3-Phase Fault
  - Breaker Failure Event/1-Phase Fault
- Added POI Voltage Trip Relay for Panhandle WGRs
  - Varied Voltage Set Point (1.10 pu, 1.15 pu, 1.20 pu)
  - Varied Trip Delay Time (Instantaneous, 10 ms, 50 ms, 100 ms)
  - Wind Model Package Protection Relays Remained in Service
- Instantaneous Trips
  - Spurious Simulation Voltage Spikes?
  - Practical Relay Pickup Times?

HVRT Analysis – Simulation Results

- 1.10 pu POI Voltage Trip Setting
  - Instantaneous Trip
    - Current Requirement per Nodal Operating Guide 2.9.1
    - Unacceptable Result: 55% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 61% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 54% of Tested Contingencies for Upgrade 1a
  - 10 ms Delay (Less Than 1 Cycle)
    - Unacceptable Result: 48% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 46% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 40% of Tested Contingencies for Upgrade 1a

Current HVRT Requirement Is Not Sufficient

HVRT Analysis – Simulation Results

- 1.15 pu POI Voltage Trip Setting
  - Instantaneous Trip
    - Unacceptable Result: 45% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 36% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 26% of Tested Contingencies for Upgrade 1a
  - 10 ms Delay (Less Than 1 Cycle)
    - Unacceptable Result: 29% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 13% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 10% of Tested Contingencies for Upgrade 1a

Increasing HVRT Requirements To Allow Instantaneous Trip Only Above 1.15 pu Is Not Sufficient

HVRT Analysis – Simulation Results

- 1.20 pu POI Voltage Trip Setting
  - Instantaneous Trip
    - Unacceptable Result: 18% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 2% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 1a
  - 10 ms Delay (Less Than 1 Cycle)
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 2
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 1a

Increasing HVRT Requirements To Allow Instantaneous Trip Only Above 1.20 pu Is Sufficient

HVRT Analysis – Simulation Results

- Overvoltage Trips Not Eliminated
- Results for 1.2 pu Trip Setting with 10 ms Delay
  - Due to Standard Wind Model Protection Relays
    - Overvoltage Trips: 9% of Tested Contingencies for Upgrade 1
    - Overvoltage Trips: 5% of Tested Contingencies for Upgrade 2
    - Overvoltage Trips: 3% of Tested Contingencies for Upgrade 1a
  - Maximum Observed Trip Amount: 748 MW

HVRT Analysis – Simulation Results

- 1.10 pu POI Voltage Trip Setting
  - 3 Cycle Delay (0.05 seconds)
    - Unacceptable Result: 41% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 20% of Tested Contingencies for Upgrade 2
  - 6 Cycle Delay (0.1 seconds)
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 1
    - Unacceptable Result: 0% of Tested Contingencies for Upgrade 2
  - Overvoltage Trips Observed for 6 Cycle Delay
    - Overvoltage Trips: 15% of Tested Contingencies for Upgrade 1
      - Due to Both Standard Wind Model & POI Protection Relays
    - Overvoltage Trips: 5% of Tested Contingencies for Upgrade 2
      - Due to Standard Wind Model Protection Relays
    - Maximum Observed Trip Amount: 748 MW

HVRT Analysis – Conclusion

Simulations Suggest That HVRT Capability:

- Up To 1.2 pu Is Necessary (1.1 pu is clearly insufficient)
- Greater Than 1.1 pu Is Not Required Beyond 0.1 Seconds

Why Does NOGRR124 Require More HVRT Capability?

- Consistency With NERC PRC-024
- Reduce Amount of “Acceptable” Trips
- Margin (for more severe conditions/uncertainty)
- Limited Analysis – Not Exhaustive
  - Not Intended to Identify Minimum Required HVRT Capability
  - Suggest That the Proposed HVRT Requirements Are Adequate

HVRT Analysis – NOGRR 124

Most Proposed WGRs Satisfy Critical Aspects of the HVRT Capability Proposed in NOGRR124:

- No Instantaneous Trip for 1.2 pu POI Voltage
- No Trip If POI Voltage Returns Below 1.1 pu Within 0.1 Seconds
- Based on Protection Settings Within WGR Model Packages

Why Is NOGRR124 Necessary?

- Assume WGRs Will Exceed Current Requirements
  - Not Acceptable From a Reliability Perspective
  - Not Effective From a Planning Perspective

Consequences

- Without NOGRR 124
  - Lower Panhandle Export Limit
  - Higher Panhandle Wind Generation Capacity Required to Trigger Transmission Upgrades

Revise NOGRR 124

- Original NOGRR 124
  - All WGRs need to meet proposed HVRT if the synchronization date is on or after 8/30/2013
- A draft revision would require HVRT capability based on SGIA date on or after 8/30/2013
  - Exempt some projects from proposed HVRT requirement
  - HVRT capability appears to be adequate with proposed WGR equipment as listed in SGIA
  - If actual build has less HVRT capability, lower Panhandle export limit is expected
  - More projects with less HVRT capability will result in lower Panhandle export limit

Questions/Discussions