



Interconnection of Inverter-Based Resources (IBRs) in Weak Grids: ERCOT Practices and Experience

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Southwest Power Pool/Energy System
Integration Group Workshop

May 24, 2021

Outline

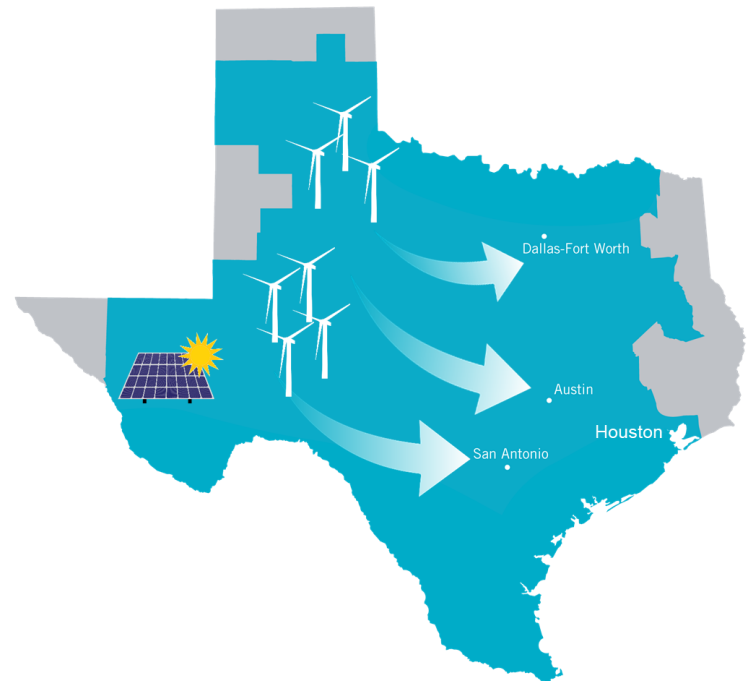
- Inverter-Based Resources (IBRs) in ERCOT
- IBR Interconnection
- Models
- Weak Grids
- Summary

IBRs in ERCOT

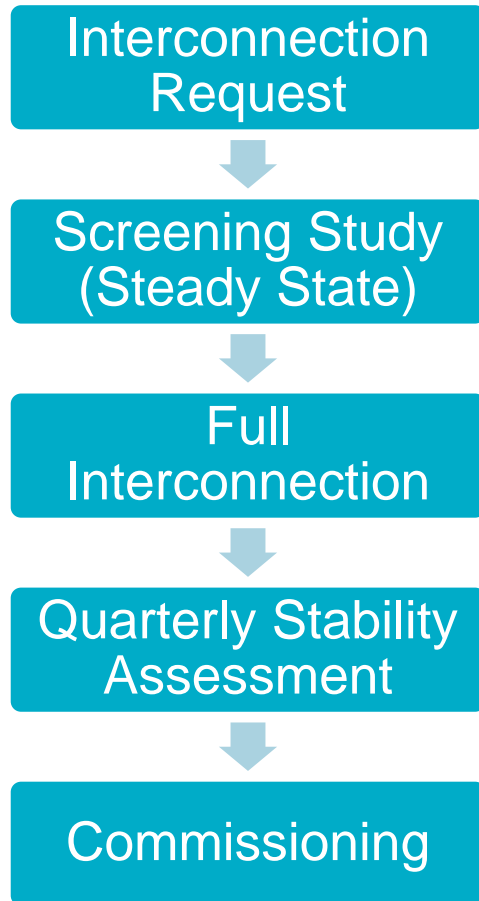
- > 46 GW IBRs are expected to be connected to the ERCOT transmission grid by 2021
- Most wind and solar generation are in West Texas
 - long distance transfer to load centers
 - limited/no online synchronous generators in West Texas during high IBR output periods
- Wind Generation Records (instantaneous)
 - Output: 22,893 MW, Jan. 14, 2021, 7:27 a.m.
 - Penetration (load served): 66.47%,
 - Mar. 22, 2021 12:46 a.m.
 - Wind power output at the time was 20,986 MW

2021	2023
<ul style="list-style-type: none">• >35 GW Wind• >10 GW Solar• >1.5 GW Battery	<ul style="list-style-type: none">• >38 GW Wind• >28 GW Solar• >2.2 GW Battery

*As of March, 2021



General Resource Interconnection Process



- Full Interconnection
 - Steady State, Dynamic, Short Circuit, and Facility Studies
 - Subsynchronous Resonance (if applicable)
 - Reactive Study
- Quarter Stability Assessment
 - Include existing resources and resources with planned initial Synchronization dates ~3-6 months in the future
- Include high renewable scenarios with the consideration of limited nearby synchronous generators and/or transmission outages

A typical time line for IBR Interconnection: ~24 Months

Dynamic Model Requirements

- IBRs are required to provide both dynamic (PSS/e and TSAT, User Defined or Generic) and EMT (PSCAD) models
- Resource Entities and Interconnection Entities are responsible for providing models and associated test results and document

Model Quality Tests (PSS/E and PSCAD)

- Flat Start, Voltage Test (small and large disturbance), Frequency Test (e.g., +/-0.3 Hz), **System Strength Tests**
- Phase-angle Jump (PSCAD only)

Unit Model Validation (PSCAD)

- Voltage Test (small and large disturbance), System Strength, Phase-angle Jump, and Subsynchronous Test

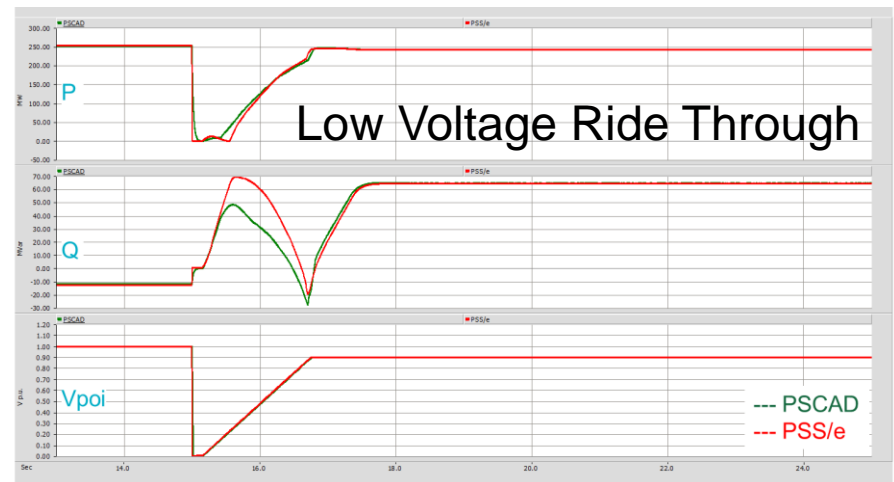
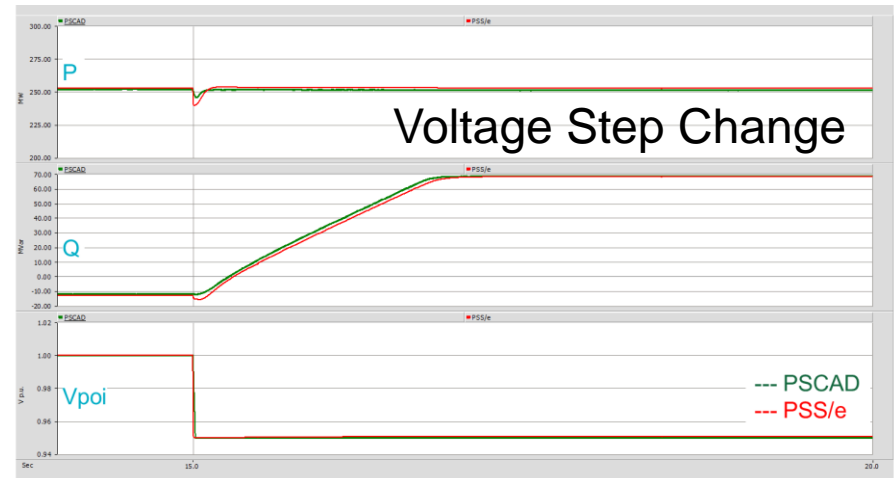
Model Verification

- Provide evidence that tunable model parameters match what is implemented in the field. For example: screenshots, nameplate photographs, signed manufacturer commissioning reports, etc.

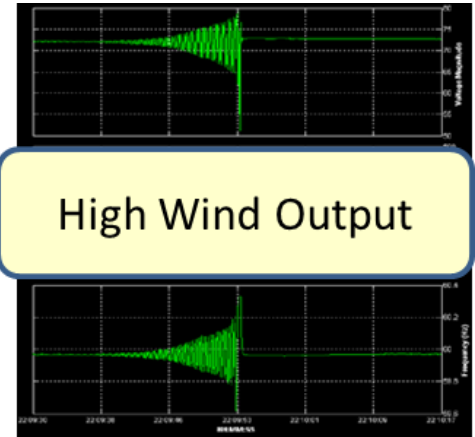
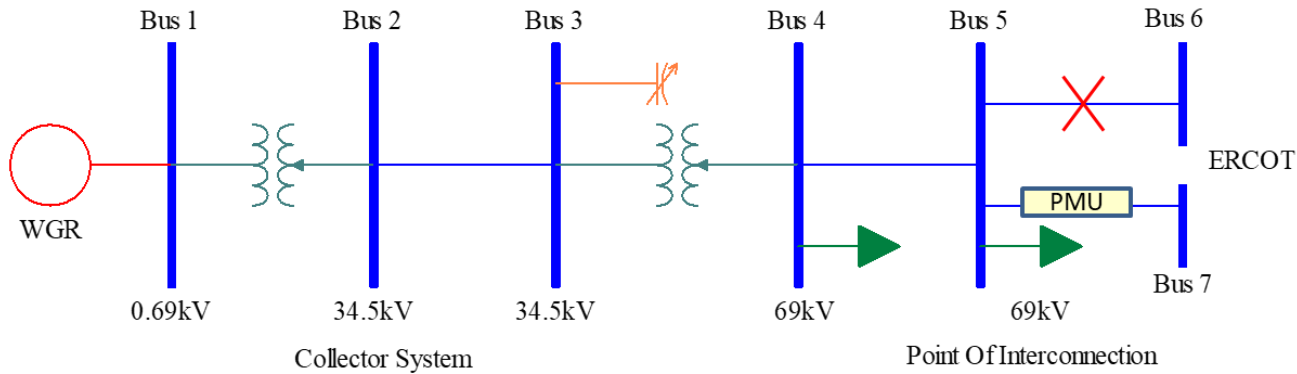
Few Modeling Notes

- Caution about Generic Models
 - Existing generic models may not work properly at weak grids
 - Equipment manufactures should be consulted for parameterization of generic models
- Use of dynamic model template
 - Excel spreadsheet
 - Facilitate consistent model submittal format
- Develop and share tools to help the model quality tests
 - For PSS/E models: Complete
 - For PSCAD models: 3Q, 2021

Example: Model Quality Tests

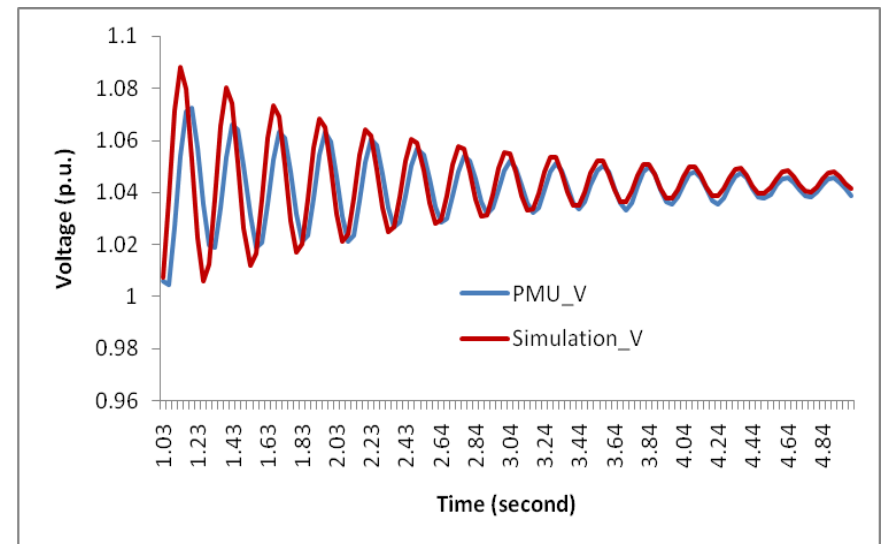


Weak Grid: Operation Examples



PMU Records

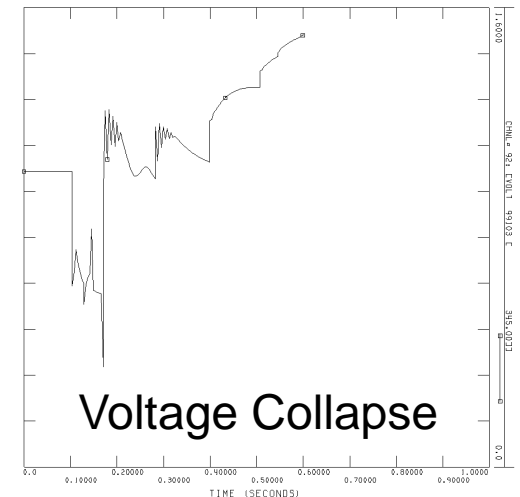
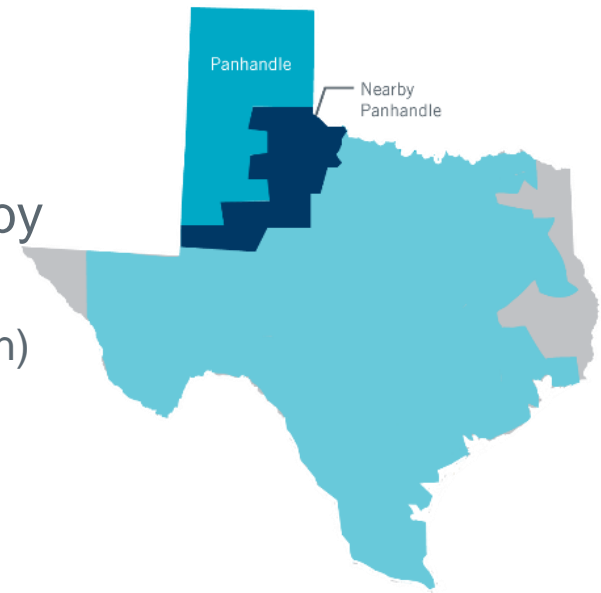
- Lesson Learned:
 - Model and tool adequacy
 - Impact on IBR control
 - Mitigation options
 - IBR dispatch
 - IBR control tuning
 - System strength enhancement



Simulation Benchmark

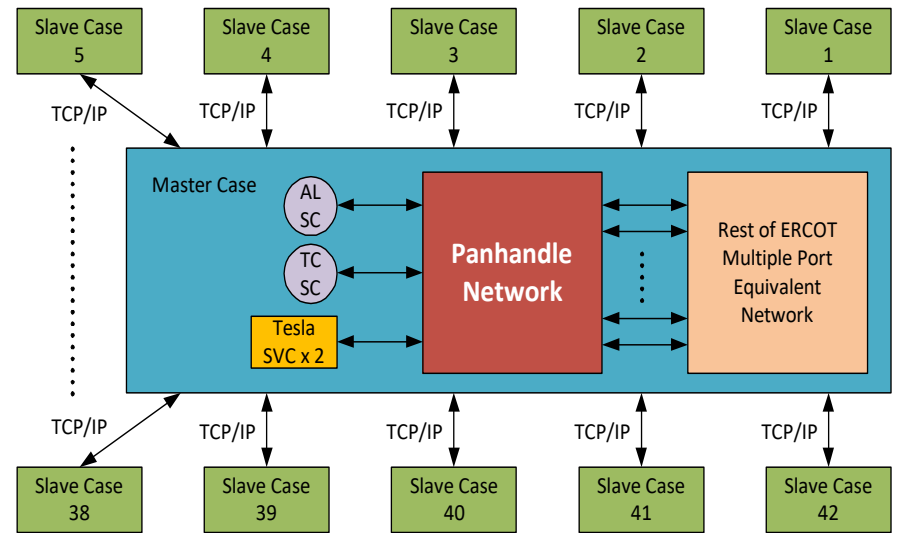
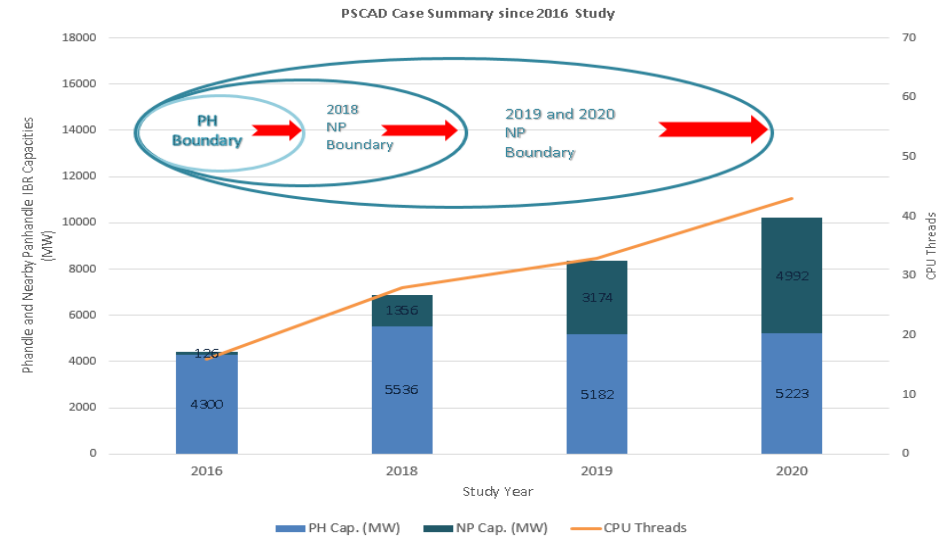
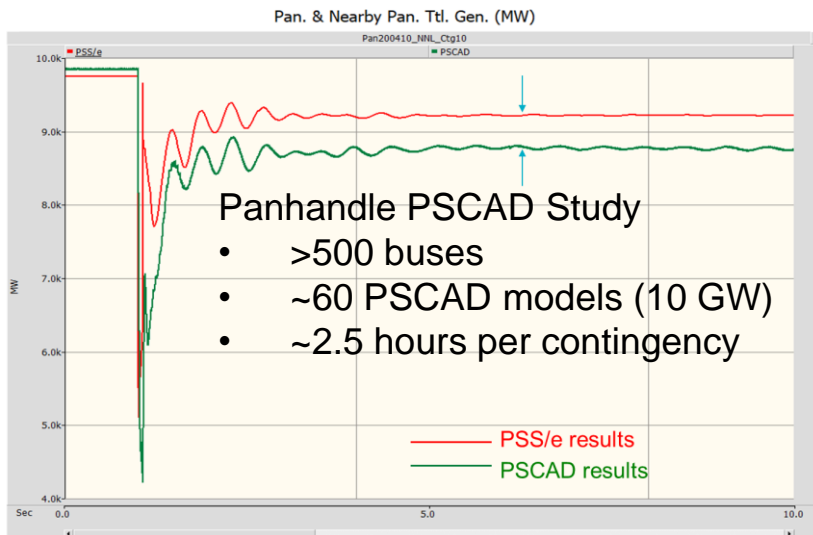
ERCOT Panhandle

- > 10 GW IBRs connect to Panhandle and nearby Panhandle
 - IBRs are located at remote areas (high IBR penetration)
 - Limited/no online synchronous generators (low short circuit)
 - Long distance large power transfer (high impedance)
- Indicators of weak grid
 - High frequency oscillation or numerical instability in PSS/e
 - High voltage overshoot or even high voltage collapse
 - Low WSCR (weighted short circuit ratio)
- Improvement Options
 - Two synchronous condensers were added to Panhandle: stability associated with condensers needs to be checked
 - Reduce impedance: adding new circuits
 - Control tuning and coordination



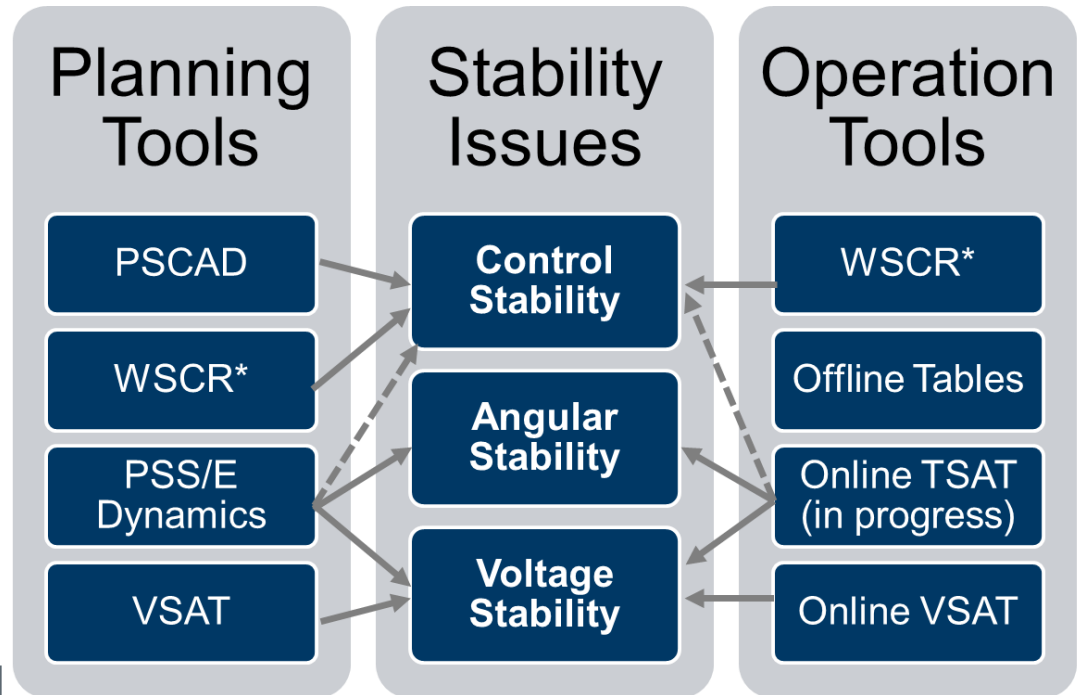
EMT (PSCAD) Study

- Require regular PSCAD studies
 - To assess the instability that may not be identified in PSS/E
 - To confirm the adequacy of dynamic models and simulation tools
 - To identify the adequacy and threshold of WSCR application



Stability Assessment and Tools

- With more IBRs
 - Increasing stability challenges
 - Require PSCAD studies: complex and time consuming
- Needs and Improvements
 - Model accuracy and usability
 - Tool and simulation efficiency
 - Better communication and coordination



* WSCR (weighted short circuit ratio) is used to identify the system strength of an area with multiple IBRs. Detailed PSCAD studies are required to validate the adequacy of WSCR application and its threshold for weak grid identification.

Summary: ERCOT Practices and Experience

- Increasing stability and system strength challenges with more IBRs connected to the grid
 - Complex, time consuming, model and tool adequacy
 - Additional stability challenges (control instability, overvoltage/high voltage collapse)
 - May require tight voltage control (may no longer be a local issue)
 - Identification and management of stability constraints in planning and operations
 - Early communication and coordination is always better
 - Continue to explore ways to reliably operate under weak grid conditions or improve the system strength

Appendix: References

- http://www.ercot.com/content/wcm/lists/168284/ERCOT_Model_Quality_Guideline.zip
- http://www.ercot.com/content/wcm/key_documents_lists/89026/2020_PanhandleStudy_public_final_004.pdf
- http://www.ercot.com/content/wcm/key_documents_lists/89026/The_Use_of_GTCs_in_ERCOT_July_2020.pdf
- http://www.ercot.com/content/wcm/lists/144927/Panhandle_and_South_Texas_Stability_and_System_Strength_Assessment_March....pdf
- http://www.ercot.com/content/wcm/lists/144927/Dynamic_Stability_Assessment_of_High_Penetration_of_Renewable_Generation_in_the_ERCOT_Grid.pdf