Dynamic Stability Assessment of High Penetration of Renewable Generation in the ERCOT Grid
- Year 2031 Condition

ERCOT Transmission Planning

RPG Meeting
March 27, 2018

Study Overview

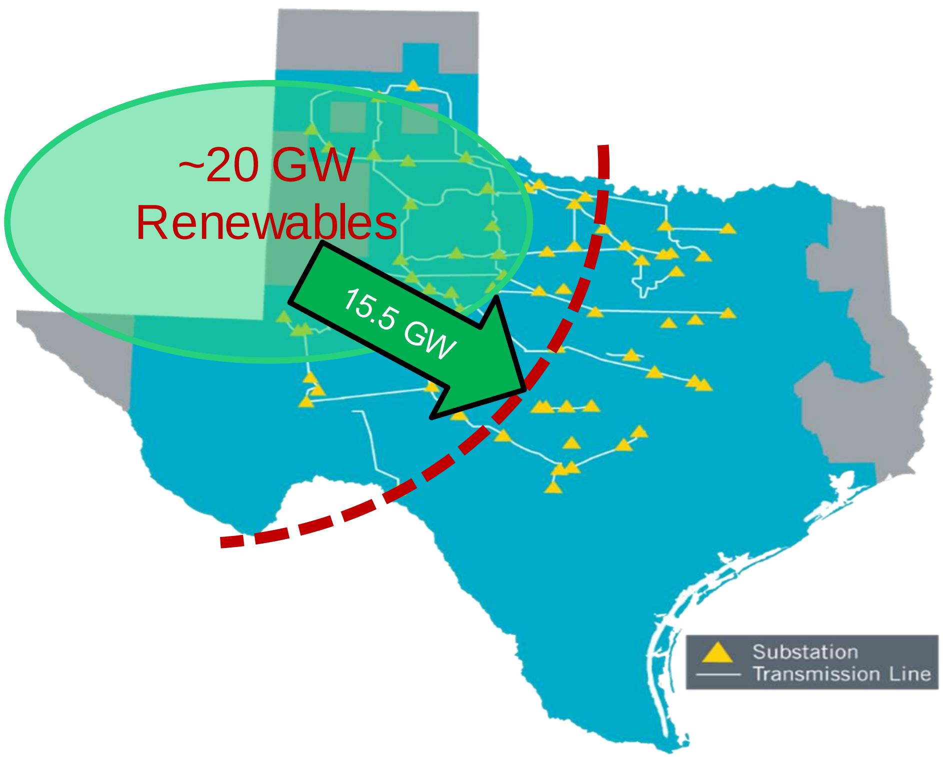
- November 2017 Presentation: http://www.ercot.com/content/wcm/key_documents_lists/108892/Nov_2017_RPG_Update_Dynamic_Stability_Assessment_of_High_Penetration_of_Renewable_Generation_in_the_ERCOT_Grid-Year2031_Preliminary.pdf
- Base Case Development
  - Transmission Topology from ERCOT 2016 LTSA Year 2031 Current Trends
  - System Load: 42.2 GW (includes self-serve load)
  - Renewable Gen Dispatch: 27.8 GW (~66% of system load)
  - System Inertia: 117 GW-sec
- 8 Key Observations (OBS)
- 9 Key Recommendations (REC)

OBS 1: Significant Power Losses

- Significant active and reactive losses due to long distance and large power transfer from North/West Texas to load centers.
  - Required the addition of static and dynamic reactive devices to maintain acceptable voltage response in normal operation and under contingency.

OBS 2: Additional West TX Transfer Path

- Adding a transfer path between West Texas and Central Texas (paralleling McCamey – Big Hill – Kendall) was beneficial.



OBS 3: Steady State Analysis Concerns

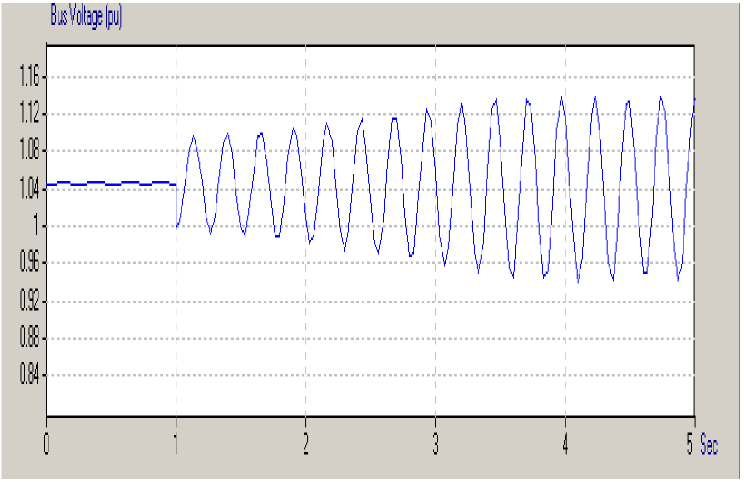
- An acceptable steady state condition may not guarantee a stable response in normal operations.
  - Low system strength could cause unstable controller operation even under a small disturbance, like capacitor switching or generation variation.
  - Steady state analysis may not capture the most limiting constraints for high renewable penetration conditions.

REC 1: LTSA with Stability Limits

- The LTSA should consider the impact of stability constraints.
- AC power flow analysis should be used to properly capture voltage support challenges.

OBS 4: Renewable Gen Controller Concerns

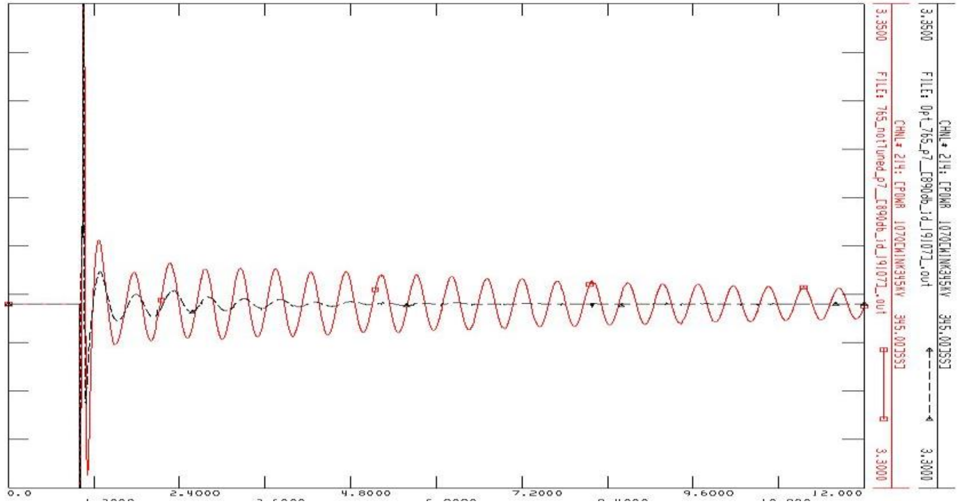
- All the existing inverter-based generation controllers require sufficient system strength for reliable and stable operation.
- Precise controller settings and coordination will be required under low system strength conditions.



Recorded unstable response for a wind plant connected to a weak transmission grid

REC 2: Controller Settings Coordination

- Generator controller settings and coordination should be regularly reviewed.
  - Generation controller settings that work fine in one system strength condition may not be suitable for different system strength condition.



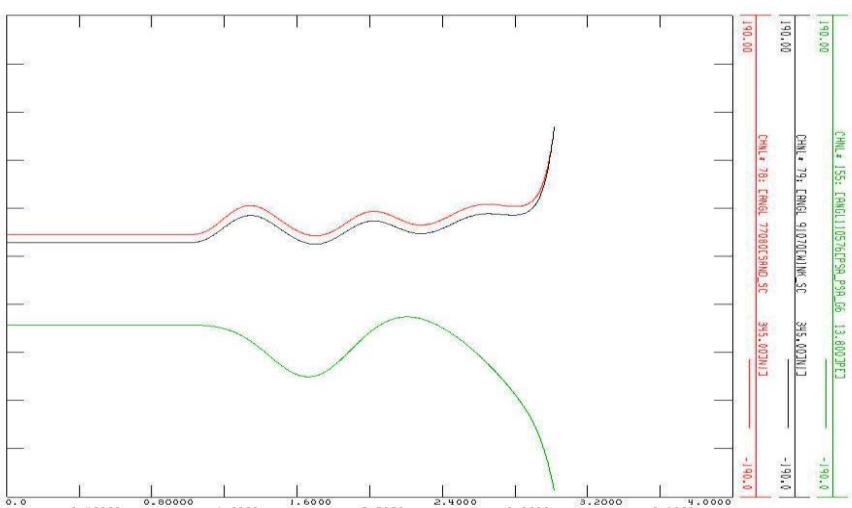
Tuned (BLACK) vs Not-tuned (RED)

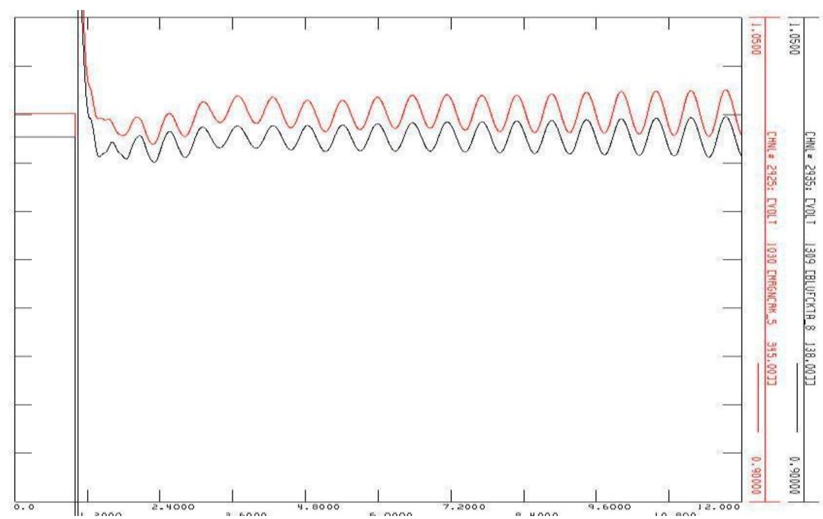
REC 3: Robust Inverter Control Capability

- Reliable operations at very high penetration levels of inverter-based generation for extended periods of time will require a fundamental change in operating practices or inverter control technologies.
  - Pursue development and commercialization of adaptive and/or innovative controls for inverters to allow reliable operation under a wider range of system strength conditions.
  - Consider implementation of system strength support requirements for generation resources.

OBS 5: Synch. Cond. Stability Challenges

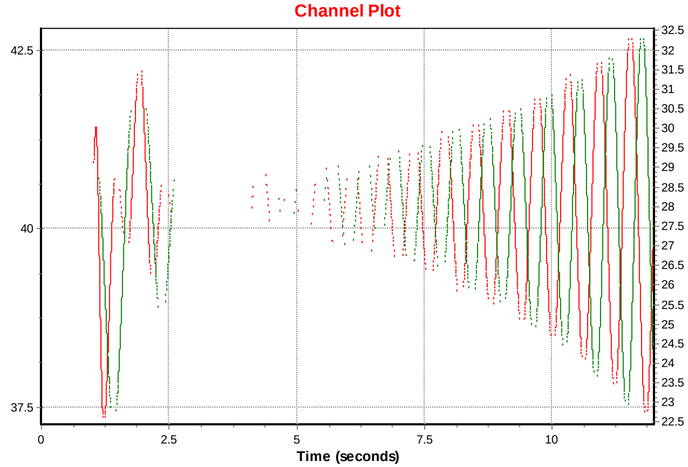
- Synchronous condensers were added for system strength and dynamic support.
- Angular instability and oscillatory responses were observed in simulations with the added synchronous condensers.



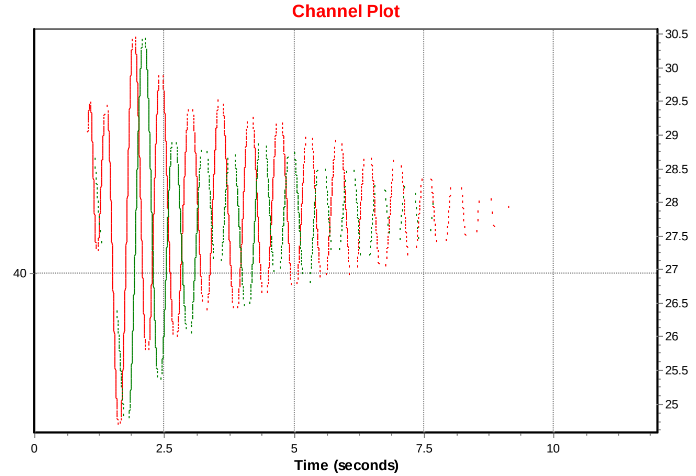


REC 4: Upgrades of Synch. Cond.'s and Circuits

- Low system strength is currently best addressed with a combination of transmission circuits and synchronous condensers.
  - Angular stability analysis should be performed when considering new synchronous condensers.



condensers only



condensers + new circuit

REC 5: Need of System Damping Support

- Need of damping support from generation resources and transmission devices.
  - Synchronous generators are required to have a power system stabilizer (PSS) that provides damping.
  - Consider the application of a PSS or PSS-like control functions for synchronous condensers, inverter-based generation, and transmission dynamic devices.

OBS 6: Dynamic Model and Simulation Tool Applicability

- Dynamic models developed for typical dynamic stability study purposes may not be suitable under low system strength conditions and could cause numerical instability.
- Careful review and adjustment of solution parameters in the study tool were necessary to overcome non-convergence and numerical instability issues under these conditions.

REC 6: Accurate Dynamic Model and Performance Validation

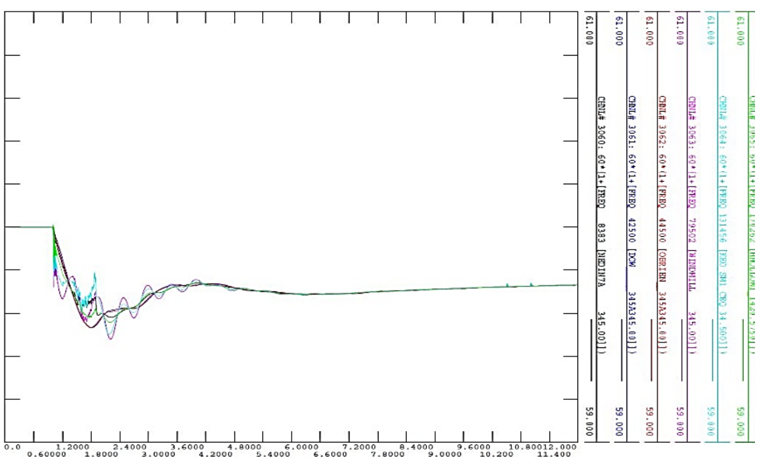
- Accurate dynamic models and performance validation for all these devices are vital for accurate system reliability assessment.
- ERCOT should consider requiring model validation requirements for transmission dynamic devices.

REC 7: Need of PSCAD Models and Wide-Area PSCAD Studies

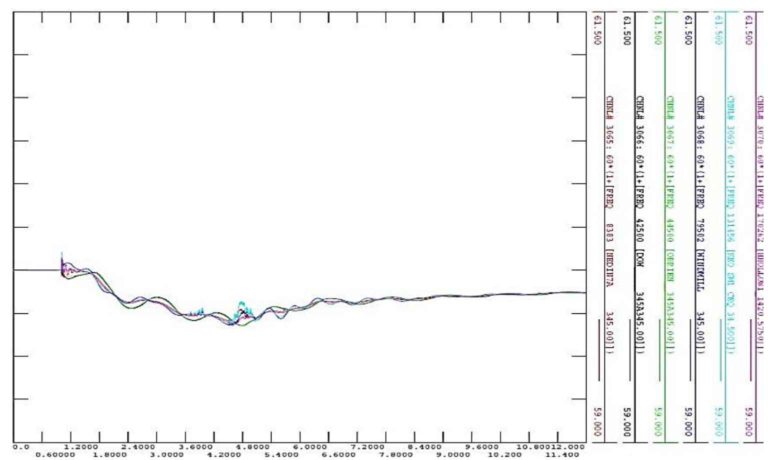
- Detailed PSCAD models for generators and transmission dynamic devices will be needed.
  - Developing "generic" PSCAD models for projected renewable gens would be a significant challenge and may limit the strength of conclusions.
- ERCOT should consider developing the capability of performing wide-area PSCAD study on a regular basis.

OBS 7: Low Voltage Impact on Freq Response

- A large generation loss may cause voltage deviations before large frequency deviations are observed.
  - Under low voltage stability, a loss of generation could cause a voltage depression resulting in a load reduction based on the modeled load dynamic response (less frequency deviation).



Plant #1 Trip
Large plant near DFW



Plant #2 Trip
Large plant near Houston

REC 8: Dynamic Load Model Review and Validation

- Accurate dynamic load model development is ongoing and should be reviewed and revised to properly reflect responses under voltage and frequency excursions.
  - Transient or prolonged low voltage recovery could have significant impact on load consumption depending on the assumed load models and dynamic response.

OBS 8: Higher Voltage Level Transmission Circuits

- New transmission circuits at a higher voltage level were found to be beneficial to system dynamic responses.
  - With limited tests, a 765kV transmission path was considered as an alternative upgrade to a 345 kV double circuit to evaluate the impact of higher voltage level transmission circuits.
  - It was found that both options addressed the stability issues and the need of synchronous condensers could be reduced when considering higher voltage level transmission circuits.

REC 9: Consideration of Higher Voltage Level Transmission Circuits

- Further study would be needed to evaluate the full benefit of a higher voltage level transmission circuit that could potentially be expanded into a higher voltage network.
- ERCOT stakeholders should consider developing processes to identify the value of higher voltage transmission solutions for transferring large amounts of power over long distances.

Next Steps

- Finalizing report
- Following up with identified recommendations

Questions