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

ERCOT Transmission Planning

RPG Meeting
November 14, 2017

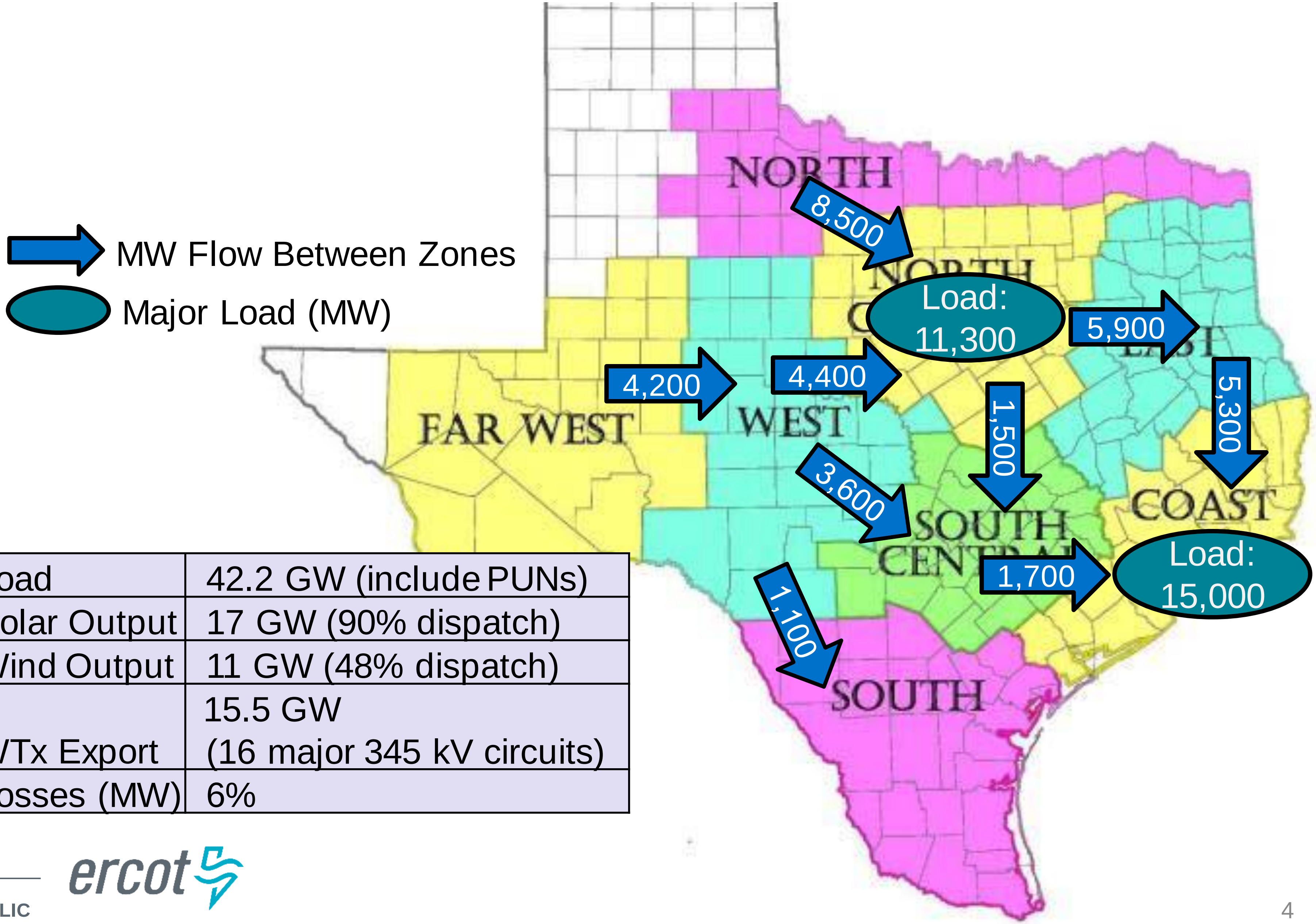
Objective

- Conduct a dynamic stability assessment of high renewable penetration in areas far from major load centers
- To identify system challenges from a stability perspective and evaluate potential solutions
- To facilitate communication and understanding of long-term system needs among stakeholders
- Not intended to recommend specific upgrade projects

Study Scenario

- ERCOT 2016 LTSA Year 2031 Current Trends is used as a reference to develop the dynamic stability study scenario for high penetration of renewable generation connected to the transmission grid
- Initial Base Case Development (stressed system condition)
  - Transmission Topology is consistent with ERCOT 2016 LTSA Year 2031 Current Trends
  - System Load: 42.2 GW (includes self-serve load)
  - Renewable Generation Dispatch: 27.8 GW (~66% of total load)
  - System Inertia (from on-line synchronous generators) : 117 GW-sec (more units decommitted compared to 2016 LTSA)

Initial Base Case Overview



Load	42.2 GW (include PUNs)
Solar Output	17 GW (90% dispatch)
Wind Output	11 GW (48% dispatch)
WTx Export	15.5 GW (16 major 345 kV circuits)
Losses (MW)	6%

Tested Contingencies

- Include 345 kV single or double circuits outages in West, Far West, and Panhandle areas with almost 100% inverter-based generation penetration in these areas.
- Include both single-line-to-ground (SLG) and three-phase-to-ground (3PH) faults

- Criteria: NERC and ERCOT Planning Criteria

Steady State (Load Flow) Observations

- Large reactive losses due to the long distance and high power transfer from renewable generation to the load centers

- Static reactive devices are required to maintain acceptable voltage response with tested contingencies

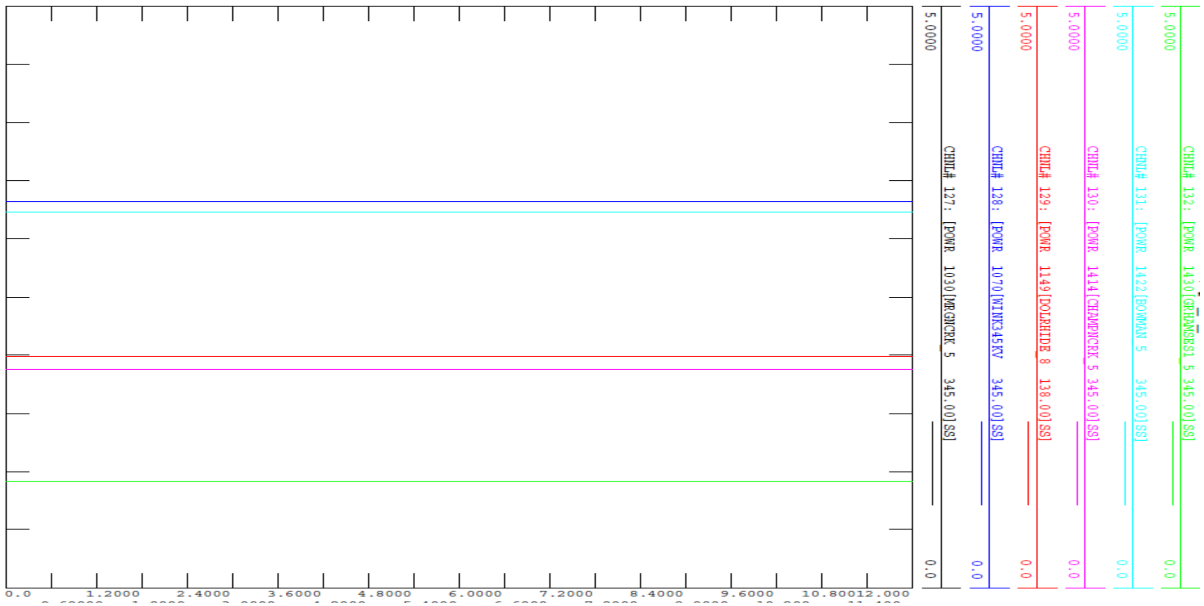
Dynamic Flat Start

- Flat Start Expectation
  - Flat response under no disturbance
  - Acceptable response under ring-down test (a perturbation to the system without tripping grid components)

- Generic dynamic models are applied to represent projected solar generation in the 2016 LTSA.

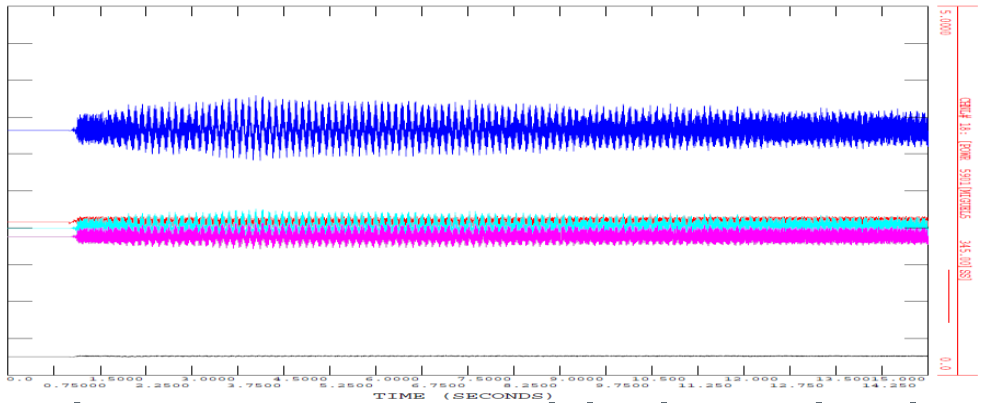
Flat Start Observations: No Disturbance Test

- Numerical instability and low system strength challenges
- Flat Start was obtained in the study area

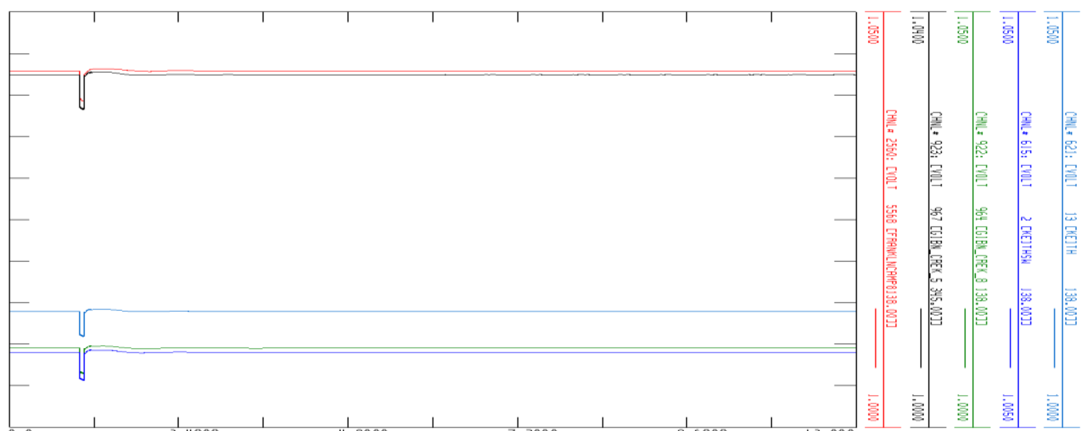


Flat Start Observations: Ring Down Test

- Initial Ring Down Test
  - Unacceptable

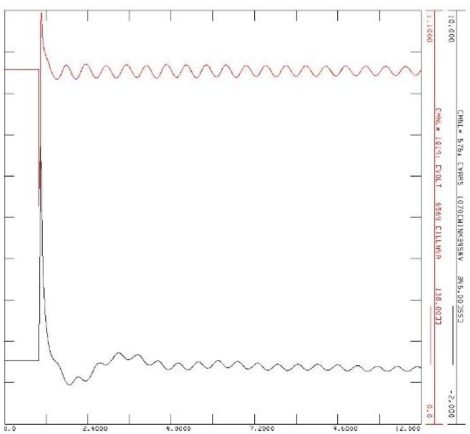


- Synchronous condensers were added to obtain acceptable response

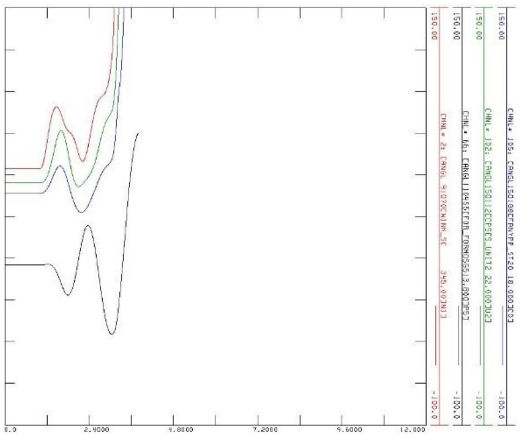


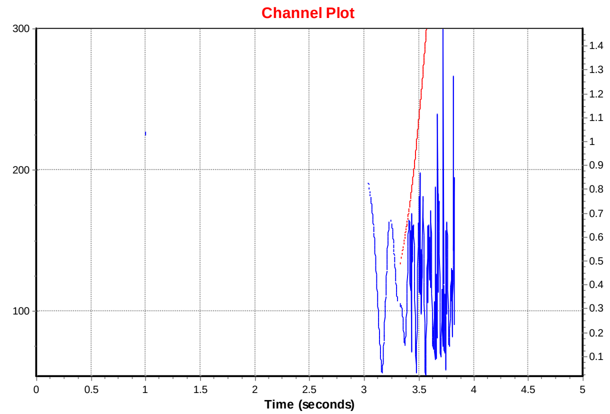
Dynamic Stability Assessment Observations

- More condensers were added for the tested 345 kV outages
- Unacceptable responses include:



Undamped oscillations

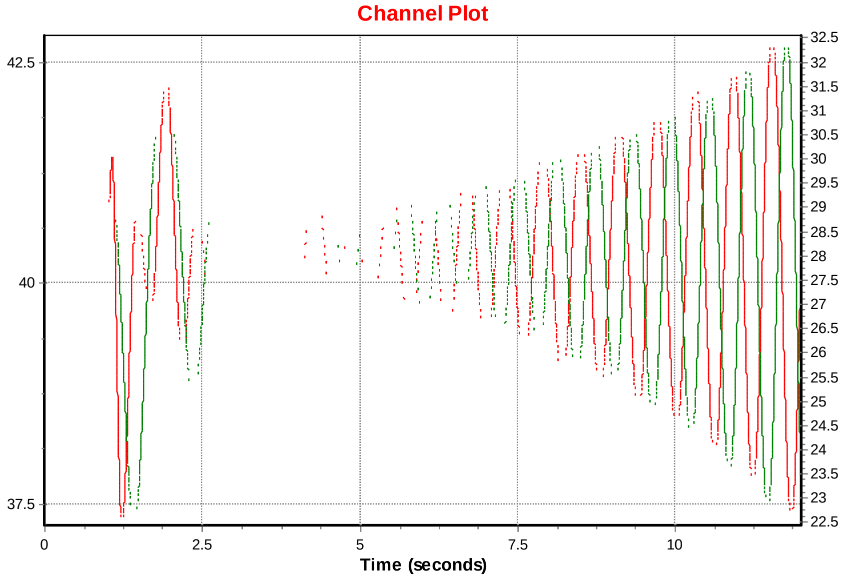




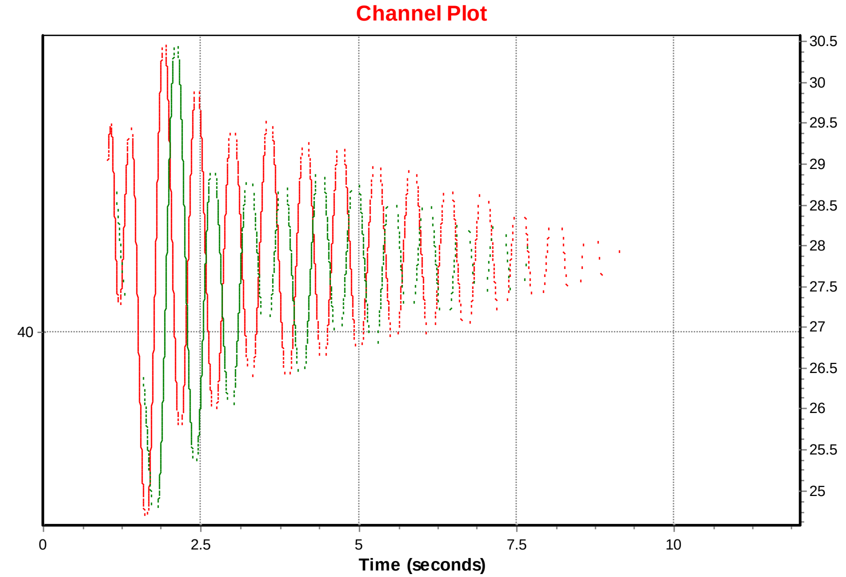
Angular Instability and Voltage Collapse

Synchronous Condenser Observations

- Provide system strength and reactive support
- Subject to typical stability challenges, like angular stability and intra/inter area oscillations



condensers only



condensers + new circuit

Preliminary Findings

- Acceptable steady state condition may not guarantee stable response in normal operations
  - Low system strength in the West, Far West, and Panhandle could cause controller instability

- When considering synchronous condensers to provide voltage and strength support, system stability (e.g. intra/inter-area oscillation) must be checked
  - Other upgrade options (e.g. adding new circuits) may be necessary to provide system improvement without introducing additional stability challenges

Next Steps

- Evaluate the impact of controller sensitivity
- Assess the impact of other upgrade options
- Complete the study and report by early 2018

Questions?