Final Update – Assessment of Synchronous Condensers to Strengthen West Texas System

Christian Danielson
Dynamic Studies, ERCOT

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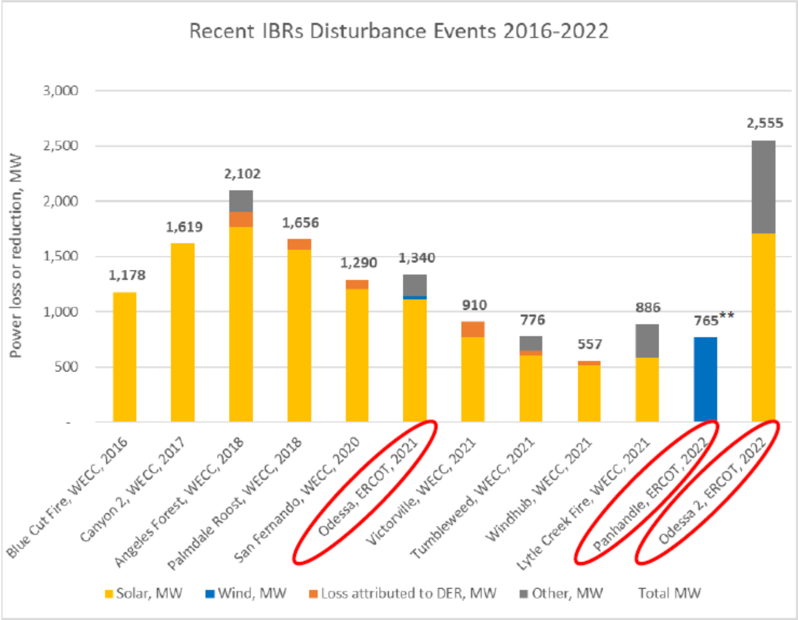
Recap

- Increasing and significant reliability risk due to potential unexpected loss of generation and/or load during disturbance(s).

- At the [Feb RPG meeting](), ERCOT Operation presented the operational challenges, recommending synchronous condensers (each 350 Mvar, total 2,100 Mvar) in six locations in West Texas (west side of FTX GTC Interface).



2023 Feb RPG meeting: [RPG Event Details (ercot.com)]()

- ERCOT presented the study scope at the [March RPG meeting]() and provided a status update (e.g., case development, system stress test, system strength, voltage dip, sensitivity analyses) at the [May RPG meeting]().

Objectives

- Conduct an ad-hoc study and assess operational challenges, while considering the 2022 RTP reactive power support need.

- Study reliability benefits of the potential synchronous condensers and adjust the reactive power support, if necessary.

- Confirm operational benefits and make recommendation such that TSPs can submit RPG projects.

Status

- Since the previous status update, ERCOT has conducted the following additional studies to assess the potential impact of synchronous condensers:
  - Impact on West Texas GTC limit
  - Impact on the long-term transmission improvement option associated with the West Texas Export
  - Sub-Synchronous Oscillation (SSO) Assessment

- At this RPG meeting, ERCOT will conclude the study of potential synchronous condensers including preferred locations and sizes.

Potential Impact on WTX GTC

- ERCOT conducted dynamic stability studies using the DWG study cases to evaluate the impact on the WTX GTC limit with and without the potential 6 synchronous condensers.

- Preliminary study did not show a significant impact on the WTX GTC limit.

- The WTX GTC will continue to be reviewed and updated in the future Quarterly Stability Assessments (QSAs).

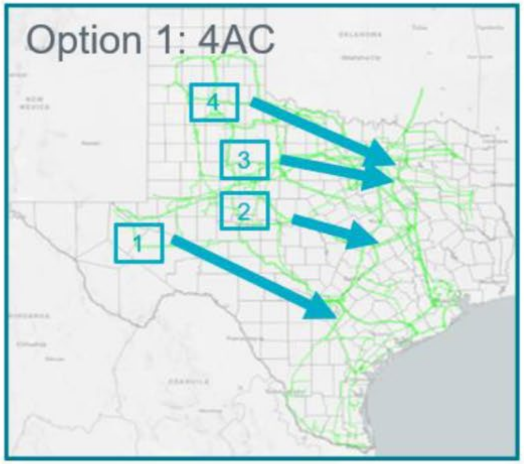
Sub-Synchronous Oscillation (SSO) Assessment

- ERCOT conducted a topology check for all the potential synchronous condensers. The results of the topology check indicated that all of the synchronous condensers except Reiter are considered to be potentially vulnerable to SSO.

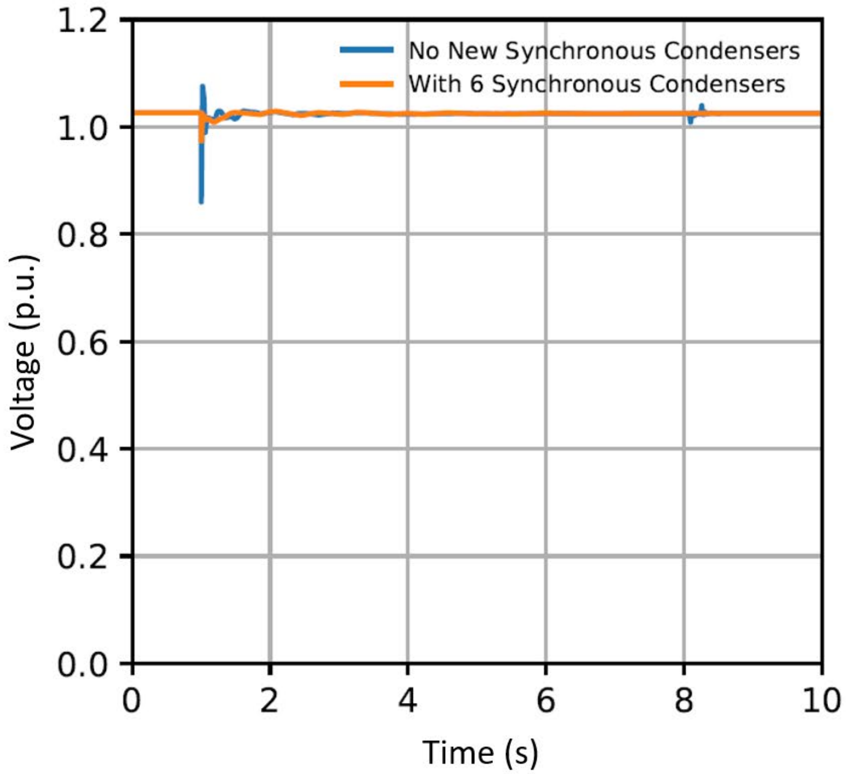
- A detailed SSO assessment is recommended, and the affected TSPs shall coordinate with ERCOT to perform and complete a detailed SSO assessment and any SSO Mitigation, if required, prior to energization of synchronous condensers.

Potential Impact on Potential Long-Term West Texas Export Option

- ERCOT conducted dynamic stability studies using the previous West Texas Export study case (year 2030) with the Option 1 (4AC) and tested select critical P7+P7 contingencies and found no adverse impact on the potential long-term WTX Export option.



1. Bakersfield-Howard
2. Brown-Bell
3. Clear Crossing-Watermill
4. Tesla-Royse

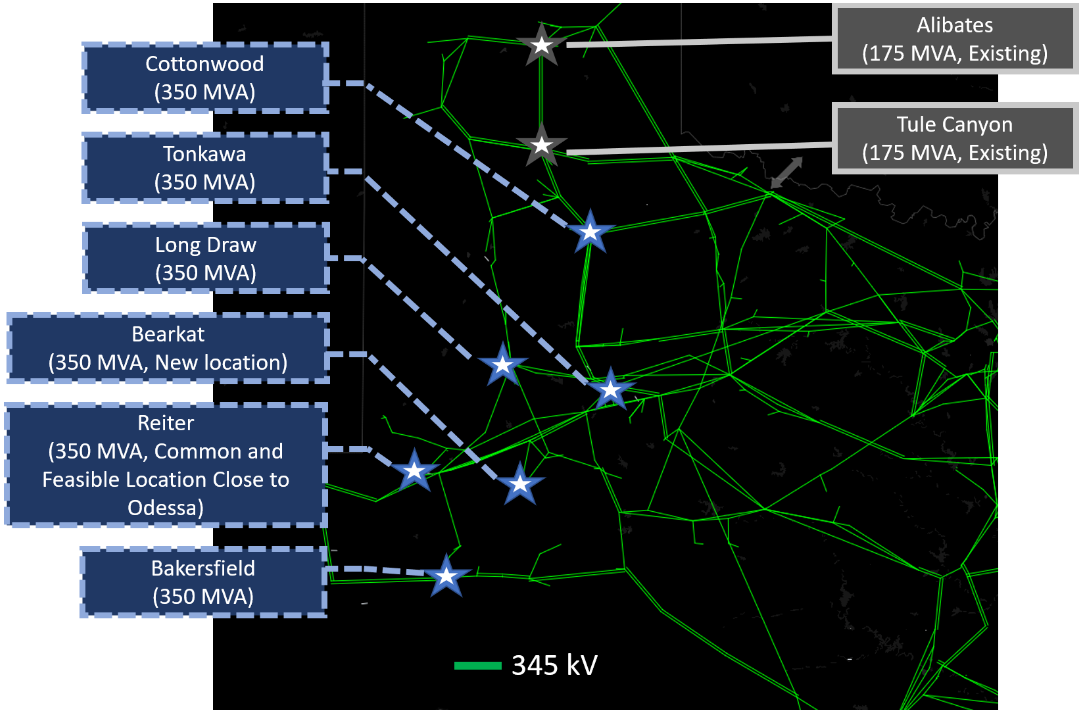


Key Findings

- A total of six synchronous condensers (2,100 MVA) were identified that will provide effective improvement to WTX.

- In general, the locations align with the operations assessment, except for the exclusion of the 345 kV Clear Crossing location and the inclusion of the 345 kV Bearkat location.

- Affected TSPs confirmed feasibility of the proposed synchronous condenser locations.



- ERCOT tested adding synchronous condensers at Big Hill, Divide, and Dermott. The inclusion of additional synchronous condensers may offer some marginal improvement, however the potential benefits (e.g., voltage dip) are anticipated to be diminished.

Key Findings (Continued) – Benefits of Synchronous Condensers

- Selection of locations provides support for broad number of faults across the WTX region.

- Additional system strength and resilience necessary to addresses operational challenges that may arise during unexpected disturbance conditions.

- Significant improvement in system responses for critical faults even under stressed system conditions (e.g., reduction in potential generation tripping, improved voltage recovery).

*Example benefits can be found in Appendix

Key Findings (Continued) – Benefits of Synchronous Condensers

- Reduces widespread impacts from transmission faults across WTX
  - By an average of 21%* reduction in numbers of 345 and 138 kV buses that experience severe voltage dips (less than .85 p.u.) for major WTX transmission faults
  - By an average of 22%* reduction in IBR capacity that experiences severe voltage dip at generator terminals (less than .85 p.u.) for major WTX transmission faults
  - 11%* increases in the system strength (voltage stiffness, measured in the WTX short circuit current level)

*Benefit calculated with 6 proposed synchronous condensers benchmarked against cases without any added synchronous condensers (including 345 kV Reiter)

*Example benefits can be found in Appendix

Key Findings (Continued) – Benefits of Synchronous Condensers

- Potential enhancements in the stability and GTCs within the WTX region
  - The McCamey GTC limit is expected to be improved by an average of 15%* with the potential synchronous condensers.
  - Preliminary study did not show a significant impact on the WTX GTC limit.
  - The McCamey and WTX GTC will continue to be reviewed and updated in the future Quarterly Stability Assessments (QSAs).
- No adverse impact on the potential long-term West Texas export option

*Improvement varies based on the events tested

Conclusions

- Six synchronous condensers would improve the reliability and resilience of the existing system.

- Both these improvements on the transmission system, and continued focus on improving IBRs' capability and performance, are needed to maintain the reliable operation of the ERCOT grid.

- Additional system improvements will be required to support the continued growth of IBRs in the ERCOT grid.

Recommendations

- ERCOT recommends six synchronous condensers at the following 345 kV buses;
  - Cottonwood, Tonkawa, Long Draw, Bearkat, Reiter, and Bakersfield.

- Engineering specifications:
  - * 350 MVA capacity measured at the machine terminal
  - * 3,600 A of 3PH fault current contribution to the 345 kV POI
  - Addition of 2,000 MW-s flywheel

*note: These specs were assumed in the study.

Next Steps

- ERCOT will post a final report and study cases on the MIS by the end of June.

- Affected TSPs will submit an RPG project.

- ERCOT will use the study report and the RPG submittal in lieu of ERCOT Independent Review as long as there are no significant changes to the synchronous condenser specifications.

Questions?

Comments are welcome to:

Christian Danielson, Christian.Danielson@ercot.com
Sun Wook Kang, Sunwook.Kang@ercot.com

Appendix: High Level Overview – Process and Tentative Schedules

Study Case:

2025 HWLL case developed for the 2022 DWG, updated for the study area

Operational need and benefit studies:

Dynamic stability, Short circuit, (e.g., system stress test, system strength, voltage dip, other studies)

Final Report:

Preferred Upgrades

List of benefits and cost

March 2023

Tentative: Q2 2023

Appendix: Study Case Development

- Study area is defined as the transmission system behind the West Texas Generic Transmission Constraint (WTX GTC).

- The study cases assumed a 350 MVAr synchronous condenser at the Reiter 345 kV substation to meet the common reactive power support need between the 2022 RTP and ERCOT Operations assessment. The selection of Reiter as the installation location was based on feedback received from Transmission Service Providers (TSPs) and the identification of reactive power support devices in the 2022 RTP and the proximity of Reiter to the Odessa location.

Appendix: Study Case Development (DWG 2025 HWLL)

- Added PG 6.9 generation in WTX based on the January 2023 Generation Interconnection Status (GIS) report published in February 2023.
- Added Large Loads consistent with the 2022 RTP, and modeled transmission upgrades identified in the 2022 RTP.
- Synchronous generators in WTX are offline.
- All IBRs (Battery, Solar, Wind) in WTX are online and dispatched to stress the WTX interface.
  - System may become unstable under certain critical P1 or P7 if the system is more stressed

Appendix: Study Case Development (SPWG 2025)

- Added PG 6.9 generation in WTX based on the January 2023 Generation Interconnection Status (GIS) report published in February 2023.

- Modeled transmission upgrades identified in the 2022 RTP.

- Synchronous generators in WTX are offline.

- All IBRs (Battery, Solar, Wind) in WTX are online.

Appendix: Synchronous Condenser Location: Key Considerations

- Relative ranking in terms of average WSCMVA.
- Properly spaced apart, avoiding proximity to existing synchronous condensers.
- Number of major transmission outlets at a substation (more connections to the system is better).
- Considered impact of future Bearkat – North McCamey – Sand Lake 345-kV Transmission Addition Project.
- Feasibility of installing Synchronous Condenser at each substation.

Appendix: Overview of Key Studies

- Weighted Short Circuit MVA (WSCMVA) (DWG study case):
  - Evaluate the impact on system strength by adding a synchronous condenser at each bus on all major WTX 345 kV buses. Repeating this step for all individual 345 kV buses and ranking those buses in terms of highest WSCMVA.
  - Sensitivity confirmed synchronous condenser locations with the endorsed Stage 2 upgrade (Bearkat - North McCamey - Sand Lake 345-kV Transmission Line Addition Project) in place.

- Voltage Dip (SPWG study case):
  - Apply a SLG fault on all major WTX 345 kV buses with and without the synchronous condensers modeled to further assess the impact on the voltages at all WTX 345 kV buses and generator terminals.

- Dynamic stability simulations:
  - Test SLG events at Odessa and other synchronous condenser locations with and without synchronous condensers to mimic operation events and further assess any potential operational benefit.
  - Test certain critical P1 and P7 events with and without synchronous condensers to further assess any potential reliability benefit.

Appendix: Potential Impact on McCamey GTC

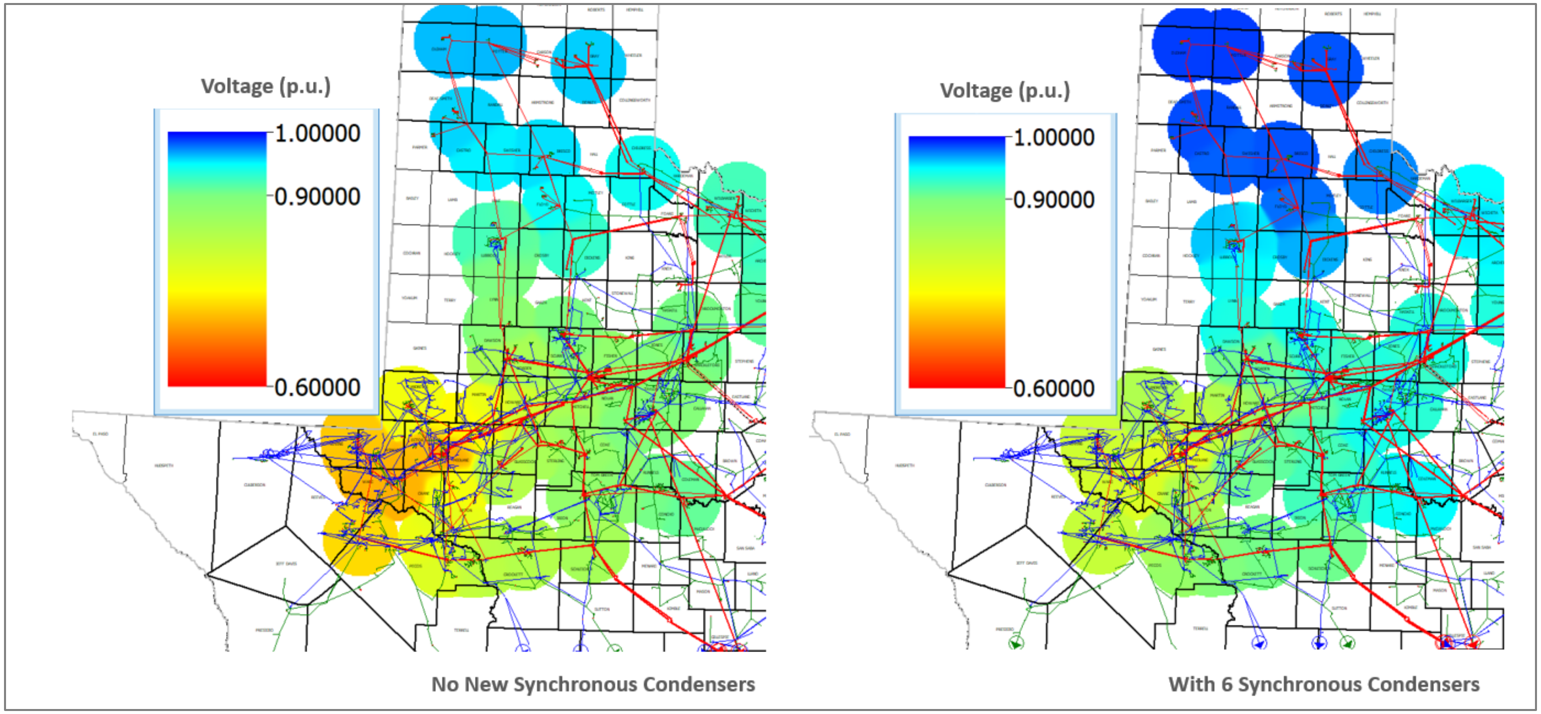
- ERCOT conducted dynamic stability studies using the latest QSA cases to evaluate the impact on the existing McCamey GTC limit with and without the potential 6 synchronous condensers.

- The McCamey GTC limit is expected to be improved by an average of 15% with the potential synchronous condensers.

- The McCamey GTC will continue to be reviewed and updated in the future Quarterly Stability Assessments (QSAs).

Appendix: Example Benefit – Voltage Dip

- Reduces widespread voltage dips and over-voltages across WTX



345kV WTX bus voltage profile contour with a SLG fault at Odessa-area 345kV bus

Appendix: Example Benefit (continued)

- Significant reduction in voltage overshoot and improvement in voltages under fault
- Improved system response after a fault event which could result in potential significant reduction in generation tripping when a critical event occurs under stressed system conditions