Online Stability Assessment at ERCOT

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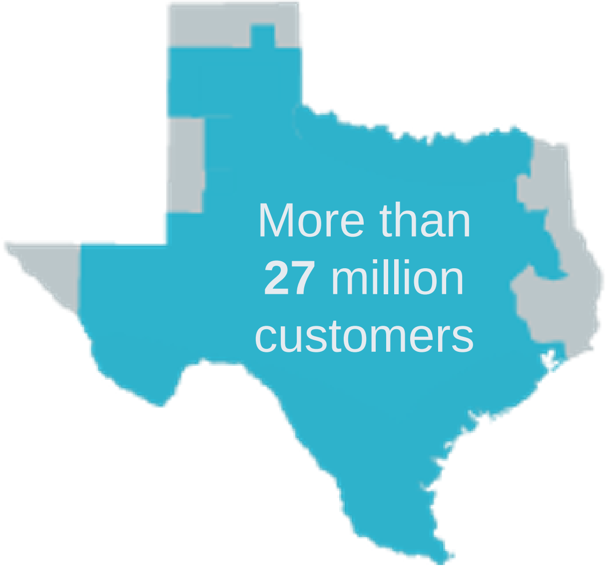
ERCOT Facts



85,508 MW

Record peak demand (August 10, 2023)

115,596+ MW

Expected capacity for summer 2025 peak demand (May 2024 CDR)

$3.8 billion

Transmission projects endorsed in 2024

2024 Generating Capacity

Reflects the forecasted operational installed capacity for Summer 2025 based on December 2024 CDR report.

Natural Gas	Wind	Coal	Solar	Nuclear	Storage	Other*	Hydro
44.3%	25.2%	9.8%	13.2%	3.5%	2.7%	0.9%	0.4%

The sum of the percentages may not equal 100% dues to rounding.
**Other includes biomass-fired units and DC tie capacity.*

2024 Energy Use

Natural Gas	Wind	Coal	Nuclear	Other*
44.3%	24.2%	12.6%	8.4%	10.5%

** Other includes solar, hydro, petroleum coke (pet coke), biomass, landfill gas, distillate fuel oil, net DC-tie and Block Load Transfer important/exports and an adjustment for wholesale storage load.*

39,518 MW

Wind

of installed wind capacity as of May 2025, the most of any state in the nation

28,550 MW
Generation Record
(March 3, 2025)

69.15 %
Penetration Record
(April 10, 2022)

30,305 MW

Solar

of utility-scale installed solar capacity as of May 2025

24,865 MW
Generation Record
(March 1, 2025)

54.23 %
Penetration Record
(March 1, 2025)

~76 % (~36,966 MW)

Preliminary **Wind + Solar** Penetration Record (March 1, 2025)

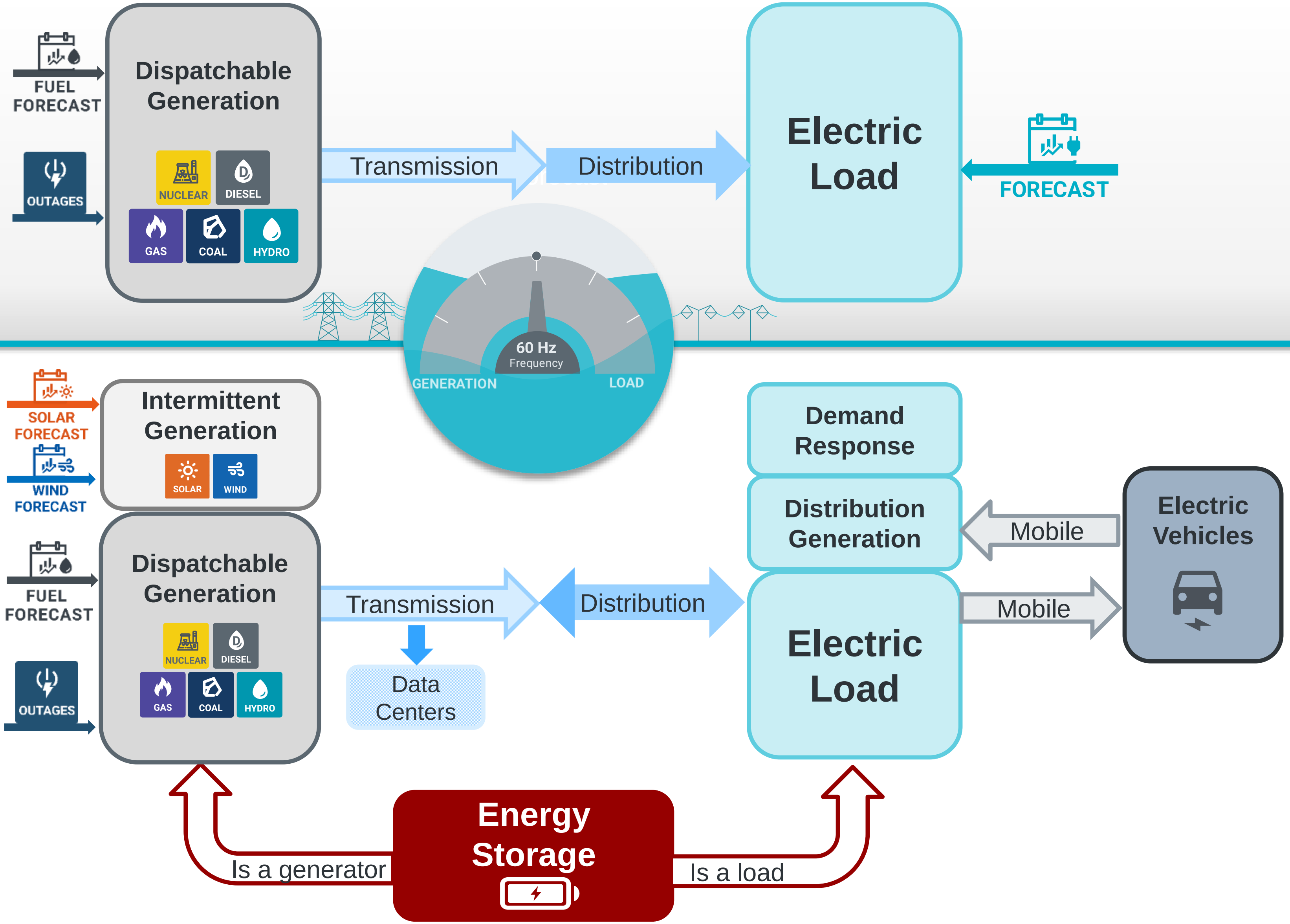
10,193 MW

Battery Storage

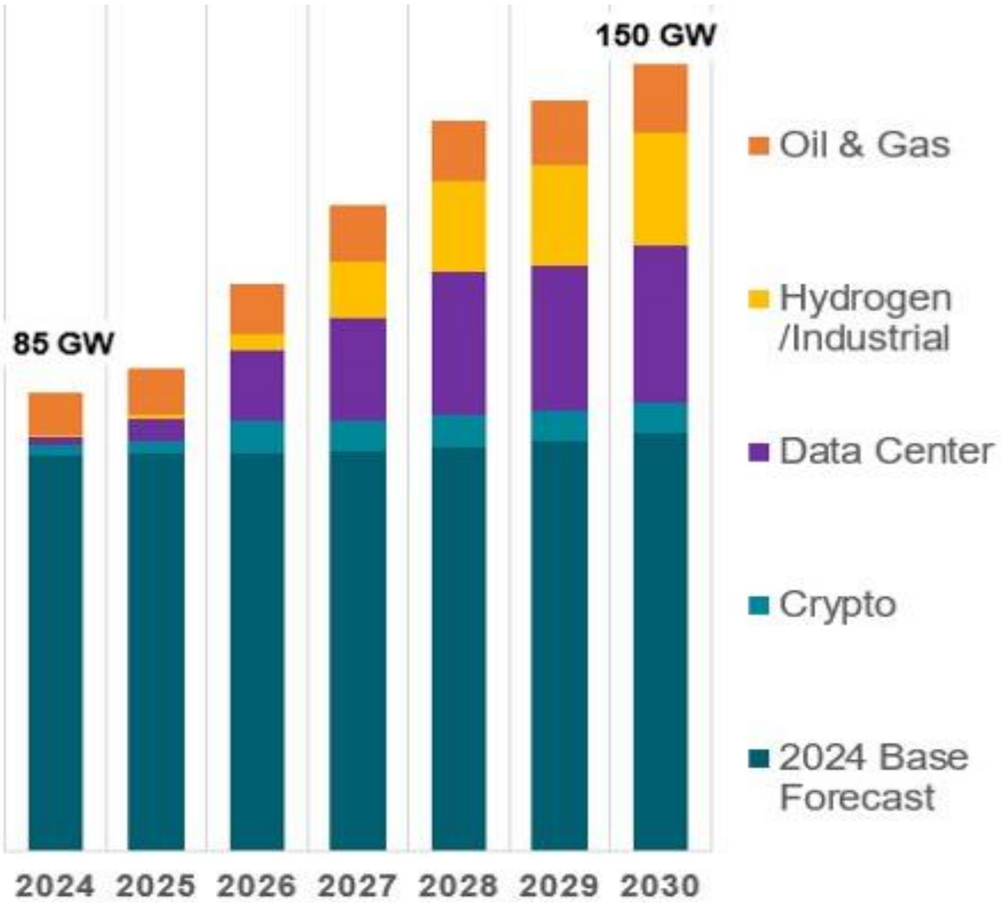
of installed battery storage capacity as of May 2025

4,927 MW
Storage Discharge Record
(March 5, 2025)

The ERCOT Electric Grid: Then and Now



New View of Load Growth in the ERCOT System



Key Takeaway: Forecasted load growth and the evolution of generation types and locations have led to a new era of system planning to reliably and efficiently facilitate large power transfer across the system.

Solar, Wind, and Storage Development

Solar		Wind		Storage	
2020	6,035 MW	2020	31,127 MW	2020	275 MW
2021	10,038 MW	2021	33,929 MW	2021	1,307 MW
2022	14,818 MW	2022	36,906 MW	2022	2,777 MW
2023	22,153 MW	2023	38,694 MW	2023	5,090 MW
2024*	29,148 MW	2024*	39,470 MW	2024*	10,027 MW
2025*	35,967 MW	2025*	40,919 MW	2025*	18,499 MW
2026*	53,115 MW	2026*	43,620 MW	2026*	28,709 MW
2027*	64,814 MW	2027*	45,240 MW	2027*	34,060 MW

Dispatchable Thermal Generation

(2009-2024) only 1,700 MW of net new dispatchable thermal generation added.

- 23,083 MW added
- 21,354 MW retired

61,027 MW of net new solar and wind added (2009-2024)

7,393 MW

Thermal Generation Retirements (2018-2024)

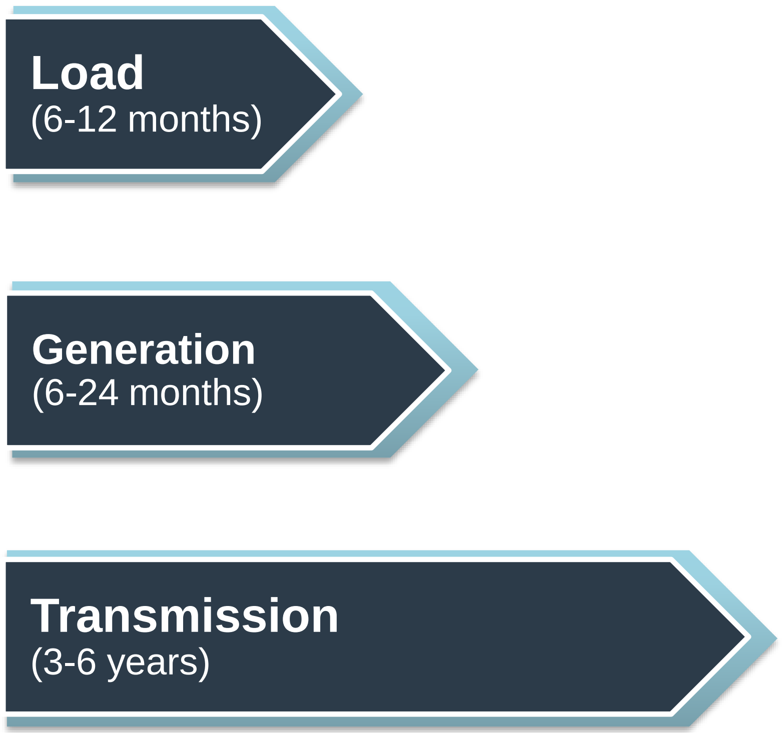
- Based on summer ratings

Key Takeaway: From 2021-March 2025, we synchronized approximately 45,000 MW of new generation, however, only ~1,700 MW of that was thermal generation.

*includes planned projects with Signed Interconnection Agreements

Transmission System Challenges & Complexities

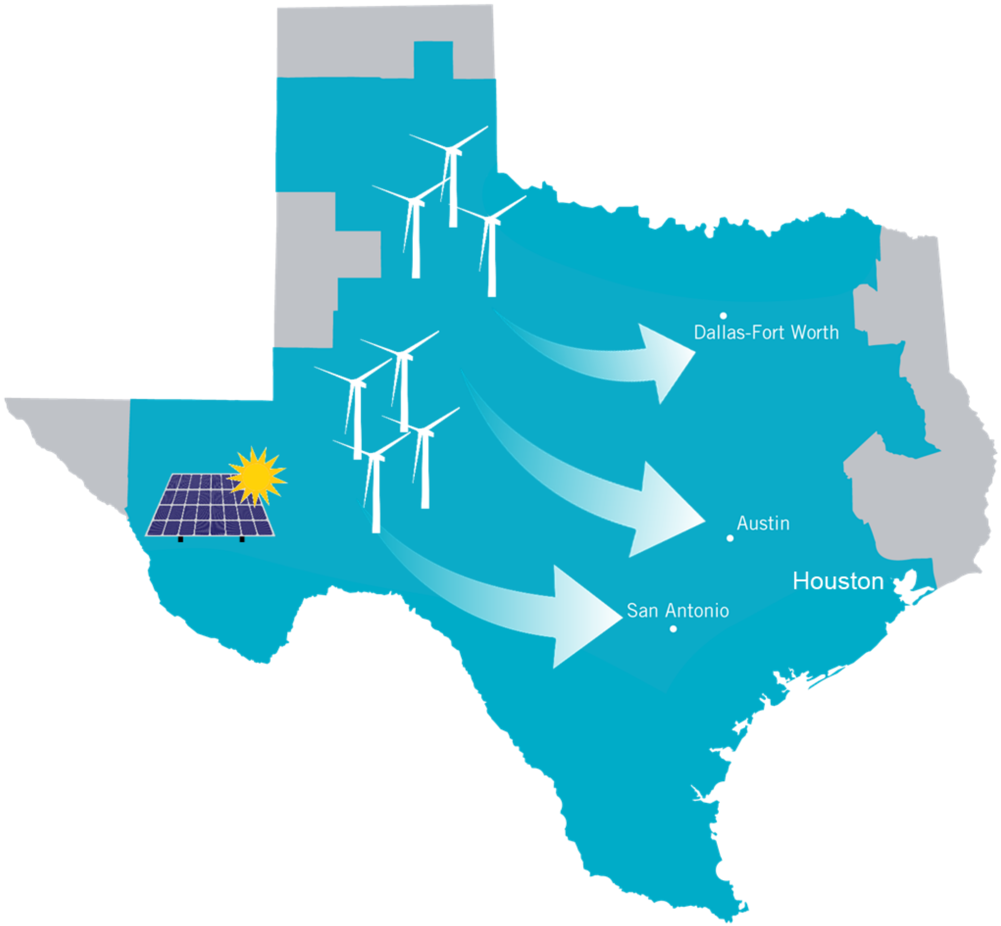
- Demand is escalating as new large loads are added to the ERCOT system faster and in greater sizes than historical interconnections.
- The current generation mix is more diverse than previous portfolios, can be built faster, and is more geographically disbursed from load centers.
- While we're seeing changes in the speed of load growth and generation coming onto the Texas power grid, transmission still requires 3-6 years to be energized.



Key Takeaway: The forecasted pace of load growth could exceed the pace at which transmission capacity can be built to support it.

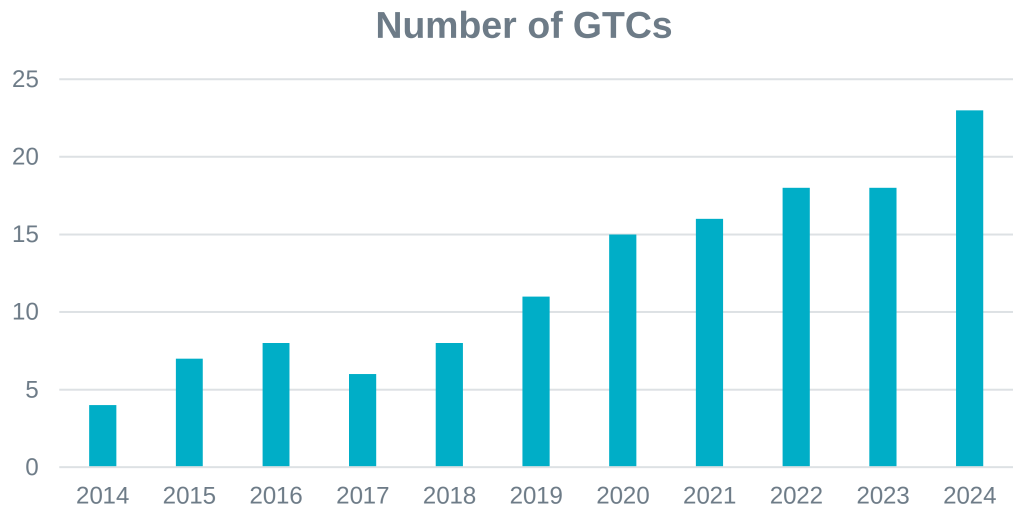
Stability Concerns

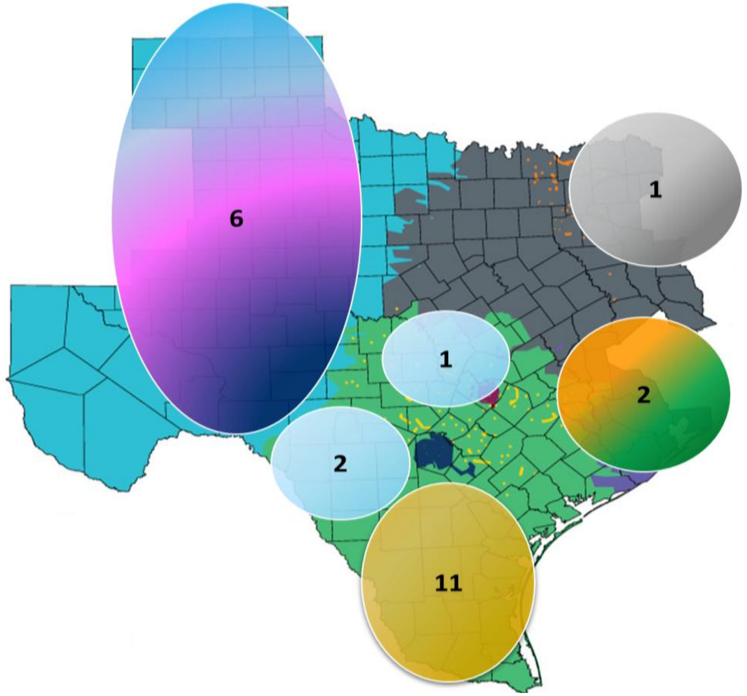
- Increased Renewable Generation
    - Renewable Generation concentrated in West, Panhandle and Costal areas
    - Long distance transfer to load centers
- Limited/no online synchronous generators in some areas during high IBR output periods
- Increasing stability concerns observed in Planning and Operations studies due to
    - Increasing IBRs with conventional controls
    - Reduced system strength
    - Variability and Uncertainty of Wind and Solar generation
    - Ride through capabilities



Increasing stability constraints

- A Generic Transmission Constraint (GTC) is a tool that ERCOT uses to manage stability limitations in real-time operations.
- ERCOT has seen an increase in stability constraints in recent years, particularly in West Texas and South Texas, which has led to an overall increase in the number of GTCs.
- These stability constraints can limit power transfers below the physical thermal ratings of transmission lines.
- Most of the GTC are based on off-line PSS/e simulation (one GTC limit set by PSCAD).





Managing stability constraints

- Stability Limits for the identified GTCs are calculated using Online Stability Assessment Tools (VSAT/TSAT) and offline PSS/e studies.
- Offline PSS/e studies determine the GTC limits for various outage conditions and are adhered to in real time operations and markets based on the network topology.
- EMS tools and Operating Guides are used for monitoring and managing the GTCs in real time. The tools evaluate the limit based on the telemetered equipment status from SCADA and the offline limits table.
- Security Constrained Economic Dispatch (SCED) tool is used to economically redispatch the generation to limit the GTC flows below the stability limits.
- The major GTCs result in top 10 congestions in ERCOT, needing high curtailment of wind and solar.

Online Stability Assessments:

- ERCOT has Online Voltage Stability Assessment Tool (VSAT) running in real time since 2004, and implemented the Online Transient Stability assessment tool (TSAT) with the dynamic models for all IBRs in November 2024 to calculate a subset of GTCs.
- ERCOT performs Online Stability Assessments every 10 mins using the real time system conditions determined by the State Estimator. State Estimator and Real Time Contingency analysis applications provide the required input model data to the Online VSAT/TSAT applications.
- The online analysis determines the reliable power transfer limits across the GTCs in the operations horizon enhancing the system security, even during multiple forced outage conditions, which would otherwise require restudy for offline assessments.
- Offline PSS/e studies are still used to determine the limits for some GTCs and ERCOT plans to continue to include more GTCs in online TSAT.

Challenges with the Online Stability Assessments

- ERCOT has seen an increase in stability concerns in recent years, resulting from the high integration of IBRs, which has led to an overall increase in the number of GTCs. This renders the online assessments exceptionally demanding in terms of computational resources.
- The dynamic models are not available for all the IBRs in the GTC areas for TSAT implementation. This requires extensive work with setting up the scenarios and identifying the improvements/adjustments needed to demonstrate appropriate performance.
- Inadequate voltage coordination between resource and transmission operators could lead to lower online stability limits.
- Maintaining the dynamic models and scenario data for online tools to match the constantly changing operations model is a challenge. The network model in ERCOT is updated weekly.

Benefits of Online Stability Assessments

- Allow ERCOT to establish the proper stability limit based on the real time system conditions, instead of depending on offline studies that are becoming increasingly challenging in addressing various grid conditions.
- Allow ERCOT to conduct post event analysis and validate grid and individual grid element performance.
- Allow ERCOT to evaluate grid stability in day-ahead considering the factors like load, wind and solar forecasts, transmission outages, to make necessary adjustments (e.g., reconfiguration, recall outages, or unit commitment) to maximize the transmission capacity.