Energy Systems Integration Group (ESIG) Spring Technical Workshop

Large Load Impact on Stability Limits

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What is ERCOT?

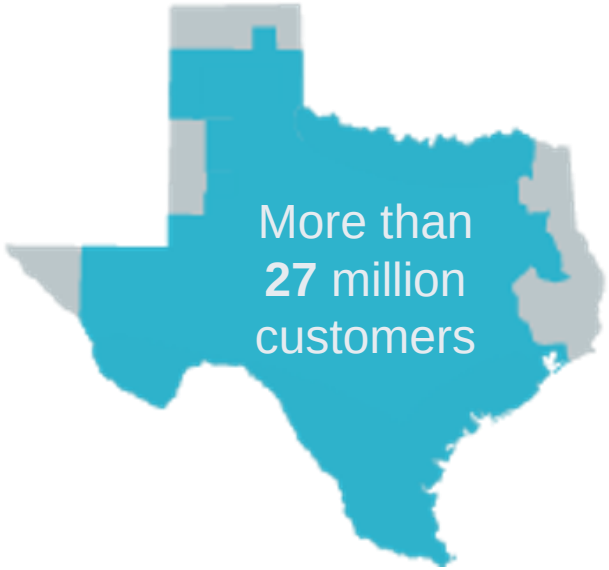
The Texas Legislature restructured the Texas electric market in 1999 and assigned ERCOT four primary responsibilities:

- **Maintain system reliability**
- **Facilitate a competitive wholesale market**
- **Ensure open access to transmission**
- **Facilitate a competitive retail market**

ERCOT is a nonprofit organization regulated by the Public Utility Commission of Texas, with oversight by the Texas Legislature.

ERCOT is not a Market Participant and does not own or maintain generation or transmission/distribution wires.

ERCOT Facts



85,508 MW

Record peak demand (August 10, 2023)

115,596+ MW

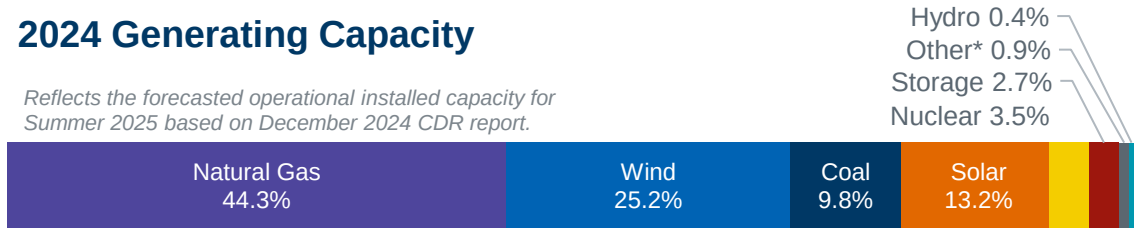
Expected capacity for summer 2025 peak demand (May 2024 CDR)

$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.



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

2024 Energy Use

** 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.*

1 MW of electricity is enough to serve about 250 residential customers during ERCOT peak hours.

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

25,041 MW
Generation Record
(March 10, 2025)

54.23%
Penetration Record
(March 1, 2025)

~76 % (~36,966 MW)

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

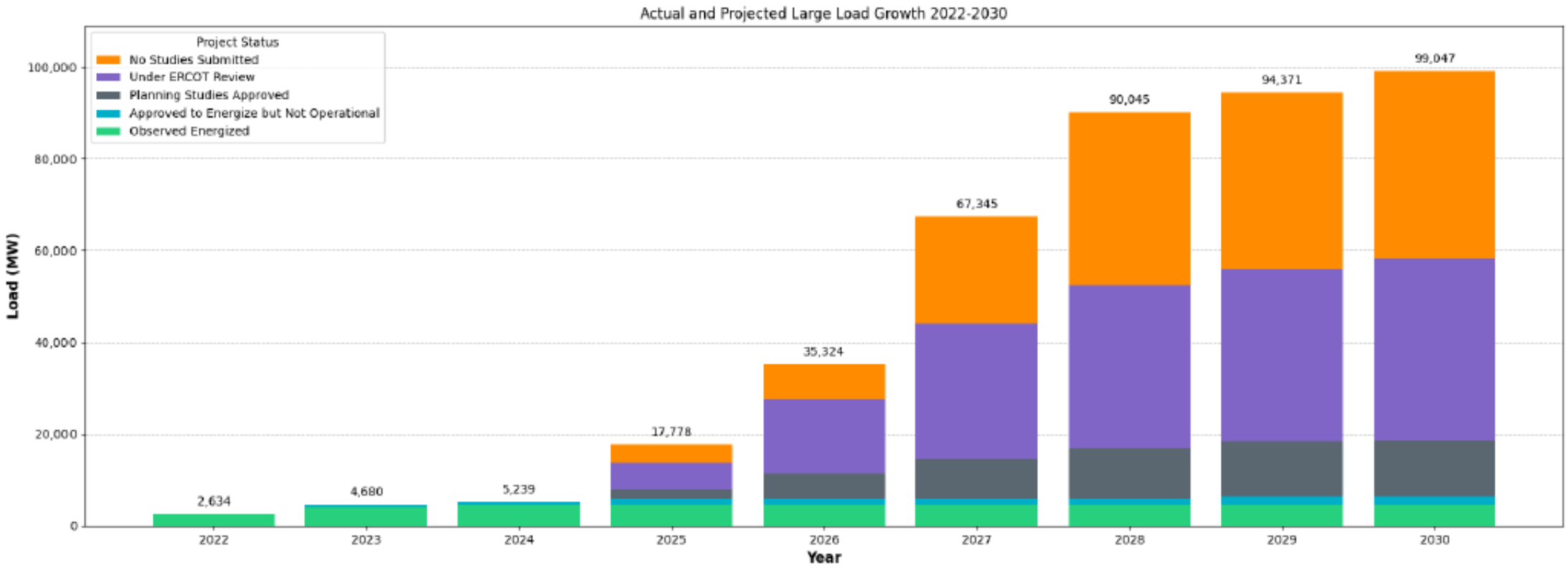
10,193 MW

Battery Storage

of installed battery storage as of May 2025

4,963 MW
Storage Discharge Record
(March 10, 2025)

Large Load in ERCOT

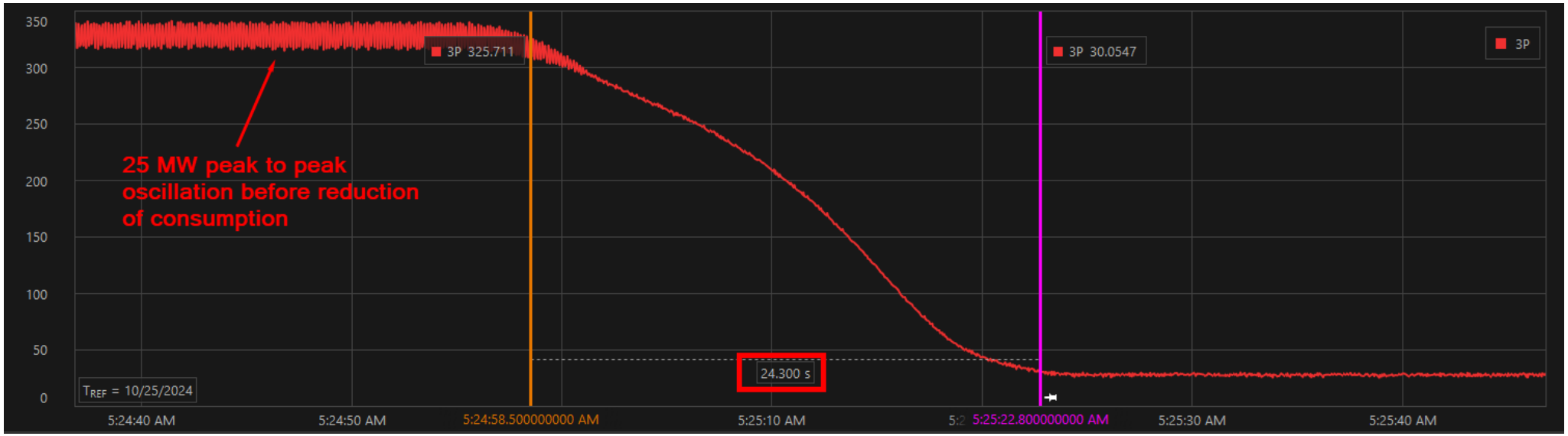


Project Status	2022	2023	2024	2025	2026	2027	2028	2029	2030
No Studies Submitted	0	0	0	4,034	7,686	23,418	37,576	38,472	40,799
Under ERCOT Review	0	0	0	6,012	16,198	29,364	35,529	37,509	39,639
Planning Studies Approved	0	0	0	1,726	5,435	8,558	10,934	12,084	12,303
Approved to Energize but Not Operational	0	569	623	1,390	1,390	1,390	1,390	1,690	1,690
Observed Energized	2,634	4,111	4,616	4,616	4,616	4,616	4,616	4,616	4,616
Total (MW)	**2,634**	**4,680**	**5,239**	**17,778**	**35,325**	**67,346**	**90,045**	**94,371**	**99,047**

Recent Large Load Events

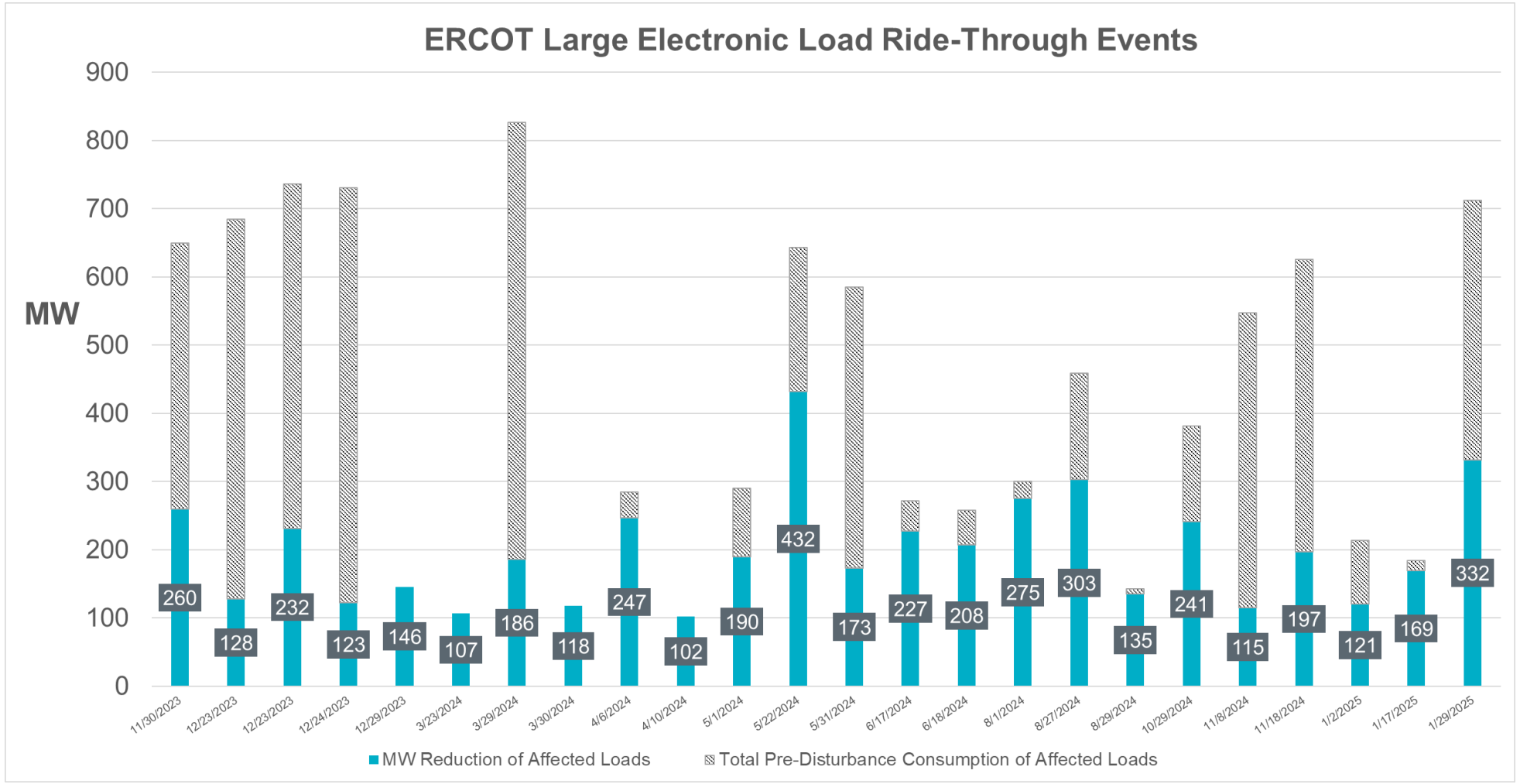
Oscillation events intermittently observed in a large load since July 2024

- Digital Fault Recorders (DFR) data shows ~23Hz oscillation frequency
- ERCOT and interconnecting TO confirmed the load is the source
- Limit the load below 300MW to mitigate the oscillation
- Load owner and operator did an operational test, determined older firmware versions on certain equipment as the root cause of the oscillation, and updated the older firmware
- No oscillation has been observed with higher than 300MW consumption after the upgrade



Recent Large Load Events

Large load loss/reduction events (Nov. 2023 – Present)



Stability Limits in ERCOT

- ERCOT uses Generic Transmission Constraint (GTC) and Generic Transmission Limit (GTL) to manage non-thermal system operating limits, including stability limits such as angular stability and voltage stability

Generic Transmission Constraint

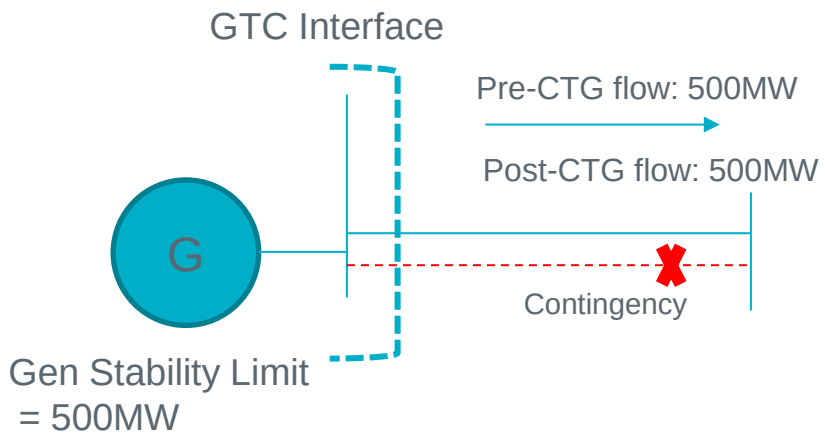
– A transmission constraint made up of one or more grouped Transmission Elements that is used to constrain flow between geographic areas of ERCOT for the purpose of managing stability, voltage, and other constraints that cannot otherwise be modeled directly in ERCOT's power flow and contingency analysis applications

Generic Transmission Limit

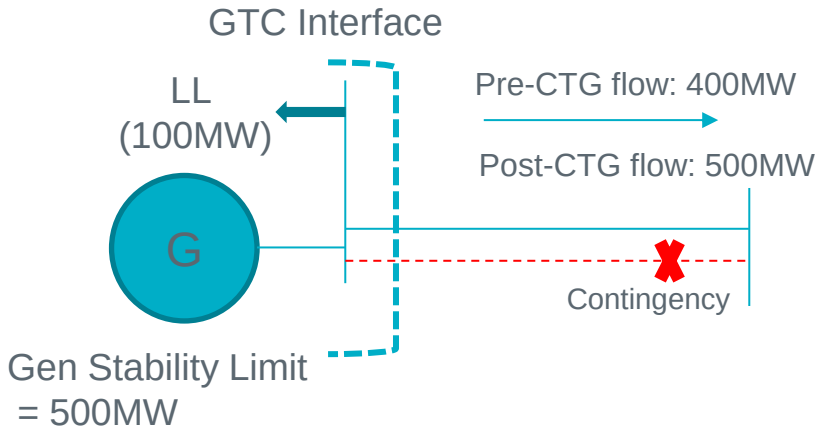
– The value of the transmission flow limit associated with a GTC

Large Load Impact on Stability Limits

- **Large loads** behind a GTC, if reducing power or disconnected during events, could lead to the lower GTC limits (GTLs)



GTL = 500MW
(without LL)



GTL = 400MW
(LLs behind the GTC reduce power
or disconnect during events)

Example: An area with high Invertor-Based Resources (IBRs) penetration and Large Load

- **The study area**
  - No synchronous generators in the study area
  - ~6GW IBRs in the study area
  - Operational large loads with total capacity of ~500MW
- **Dynamic model for large loads**
  - Composite load model “CMLD**U2” (motor + electronic) as provided by TSPs
  - In our study, the electronic component of large load is assumed to be tripped with no reconnection once the voltage drops below 0.75pu, based on the observation in recent actual events.
- **Large loads start to have material impact to reduce GTC limits**
  - Tripping of all operational large loads in the area observed in the critical event simulation
  - As a result, GTL is reduced to count for the potential trip of a large load that could lead to the exceedance of stability limit, compared to without large load or if large load can ride through the event.

Challenges

- **Continue assessing the large load impact on the stability limits**
  - GTC impact from angular/voltage stability perspective

- **Dynamic large load model**
  - Lack of dynamic large load model to accurately capture the delayed tripping and the gradual reconnection (the limitation of the current composite load model)
  - Work with researchers and industry to develop better large load dynamic model

- **Ride-through standard/capability**
  - Determine actual ride-through capabilities of each type of large load
  - Develop reliability criteria through studies
  - Examine potential ways to mitigate and/or minimize large load loss during fault events

Questions?