ERCOT Large Load Loss/Reduction Events
2020-2024

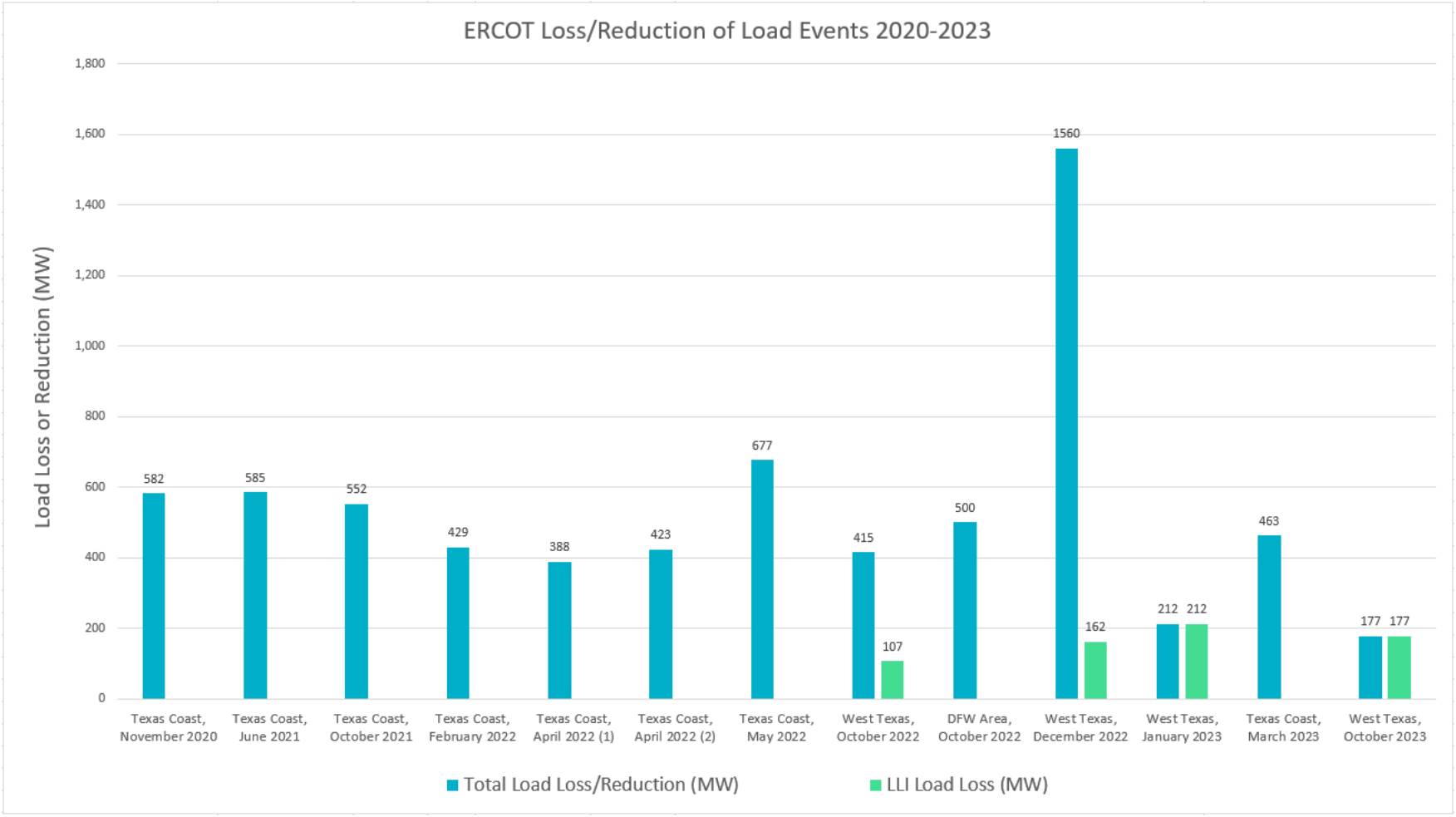
Patrick Gravois
Operations Engineer – Event Analysis

OWG Meeting
November 21, 2024

ERCOT Loss/Reduction of Load Events 2020-2023

- Originally presented at LFLTF in April 2024
  - All events involved system fault followed by reduction of one or more large loads
- Reviewed events to distinguish reduction of large loads that have gone through interim Large Load Interconnection (LLI) process
  - LLI loads may include crypto, AI, data center, hydrogen fuel cell loads, or industrial loads
  - All LLI loads involved in events are crypto (to our knowledge)
- 8 events involve a single large load on the Texas coast
- 3 events involve either multiple 3-phase faults or significantly delayed fault clearing
  - Events involve wide-spread reduction of consumption of many loads
- 2 events involve simultaneous loss of both IBR generation and LLI loads
- All events identified by Operations near real-time

ERCOT Loss/Reduction of Load Events 2020-2023



- LLI Load Loss included in Total Load Loss

ERCOT Loss/Reduction of Load Events 2020-2023

Texas Coast Load Loss Events (8 Events from Nov. 2020 – Mar. 2023)

- Single large industrial load
- Repeated large load reductions due to faults in the area
- 5 events identified as Frequency Measurable Events (FME); high system frequencies up to ~60.11 Hz with 7-minute recovery time
- Updated variable frequency drive settings and internal systems to improve ride-though capabilities
- Improved performance seen in 2024

West Texas Event – Oct. 12, 2022 @ 05:56 CT – 415 MW load reduction

- Multiple normally cleared Three-Phase Line-to-Ground (3LG) faults within one minute at 345 kV station
- ~60 loads in West Texas reduced a combined ~415 MW during the event
- 7 LLI loads reduced a combined 107 MWs during the event (all crypto)
- System frequency increased to 60.086 Hz

DFW Event – Oct. 31, 2022 @ 23:12 CT – 500 MW load reduction

- 3LG fault at 138 kV station with delayed ~10 cycle clearing due to breaker misoperation
- ~100 loads in the area temporarily reduced ~500 MW during the event
- No LLI load loss during the event
- System frequency increased to 60.132 Hz

ERCOT Loss/Reduction of Load Events 2020-2023

West Texas Event – Dec. 7, 2022 @ 03:50 CT – 1560 MW load reduction

- Multiple Single-Phase Line-to-Ground (SLG) faults and a 3LG ground fault at 138 kV station with delayed 19-cycle clearing due to beaker failure
- Hundreds of loads in Far West Weather zone reduced ~1,560 MW during the event due to extended low voltage period
- 10 LLI loads reduced a combined ~162 MW during the event
- Largest load reduction (~420 MW) from oil and gas production, processing, and delivery facilities
- Identified as FME; System frequency increased to 60.235 Hz and recovered in 12m27s

West Texas Event – Jan. 23, 2023 @ 12:19 CT

- SLG fault at 138 kV station with normal 3-cycle clearing
- 5 LLI loads reduced a combined 212 MWs during the event
- 253 MW of IBR generation loss (all solar)

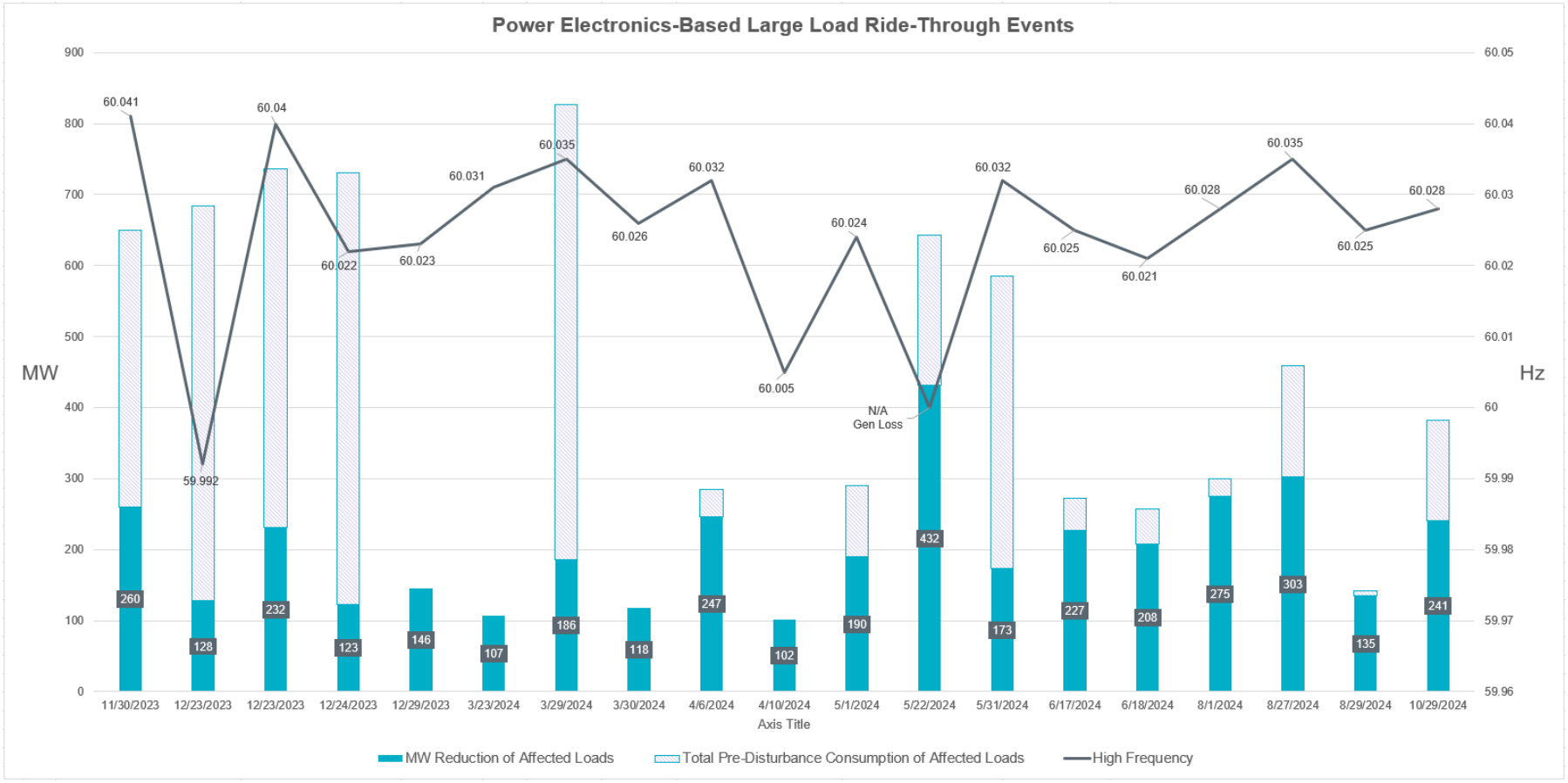
West Texas Event – Oct. 26, 2023 @ 10:28 CT

- SLG Fault at 138 kV station with normal 4-cycle clearing
- 6 LLI loads reduced a combined 177 MWs during event
- 246 MW of IBR generation loss (all solar)

Power Electronics-Based Large Load Ride-Through Events November 2023 - Present

- Searched for events in which LLI aggregate tag dropped >100 MW combined with PMU fault flag and system frequency spike
- Collected PMU/DFR data at POIB of large loads from interconnecting TSPs
  - Data availability (NOGRR 255)
  - Confirm fault details and low voltage at POIB during events
  - Confirm MW reduction in consumption of large loads
- 19 events from three distinct pockets of power electronics-based large loads (all crypto loads)
  - 8 events involving 4 loads in Central Texas
    - 890 MW of ERCOT approved consumption
  - 7 events involving 5 loads in West Texas (McCamey)
    - 410 MW of ERCOT approved consumption
  - 4 events involving 3 loads in Far West Texas
    - 345 MW of ERCOT approved consumption
    - All consequential loss – loss of line connecting loads during fault

Power Electronic-Based Large Load Ride-Through Events November 2023 - Present



Central Texas Events

Date	Fault Details	Load Zone	Load	Load Type	ERCOT Approved MW	Low Voltage at POI (pu & kV)	Pre-Disturbance Consumption (MW)	Post-Disturbance Consumption (MW)	Total Load Reduction (MW)	% Load Reduction
11/30/2023	345 kV line AG Fault 4 cycle clear	South	LOAD A	Crypto	345	0.489 (138 kV)(Aφ)	248	125.6	122.4	49.35
			LOAD B	Crypto	390	0.489 (138 kV)(Aφ)	353.5	239.3	114.2	32.31
			LOAD C	Crypto	65	0.489 (138 kV)(Aφ)	47.9	24.7	23.2	48.43
			TOTAL		800		649.4		259.8	40.01
12/23/2023	345 kV line AG Fault 4 cycle clear	South	LOAD A	Crypto	345	0.486 (138 kV)(Aφ)	321.8	169.9	151.9	47.20
			LOAD B	Crypto	390	0.486 (138 kV)(Aφ)	365.1	305	60.1	16.46
			LOAD C	Crypto	65	0.540 (138 kV)(Aφ)	49.5	29.9	19.6	39.60
			TOTAL		800		736.4		231.6	31.45
12/23/2023	345 kV line CG Fault 3 cycle clear	South	LOAD A	Crypto	345	0.844 (138 kV)(Cφ)	281.7	205.8	75.9	26.94
			LOAD B	Crypto	390	0.844 (138 kV)(Cφ)	354.6	312.3	42.3	11.93
			LOAD C	Crypto	65	0.844 (138 kV)(Cφ)	48.1	38.5	9.6	19.96
			TOTAL		800		684.4		127.8	18.67
12/24/2023	345 kV line CG Fault 3 cycle clear	South	LOAD A	Crypto	345	0.523 (138 kV)(Cφ)	314.5	235.3	79.2	25.18
			LOAD B	Crypto	390	0.523 (138 kV)(Cφ)	367.2	332.4	34.8	9.48
			LOAD C	Crypto	65	0.523 (138 kV)(Cφ)	48.8	40.1	8.7	17.83
			TOTAL		800		730.5		122.7	16.80
3/29/2024	345 kV line CG Fault 3 cycle clear	South	LOAD A	Crypto	345	0.555 (138 kV)(Cφ)	319.7	225.8	93.9	29.37
			LOAD B	Crypto	390	0.559 (138 kV)(Cφ)	364.1	302.8	61.3	16.84
			LOAD C	Crypto	65	0.559 (138 kV)(Cφ)	47.5	35.9	11.6	24.42
			LOAD D	Crypto	90	0.572 (138 kV)(Cφ)	95.1	76	19.1	20.08
			TOTAL		890		826.4		185.9	22.50
5/22/2024	345 kV lines & 3LG Faults	South	LOAD A	Crypto	345	0.54 (138 kV)(PS)	230	65.4	164.6	71.57
			LOAD B	Crypto	390	0.54 (138 kV)(PS)	310.2	135.1	175.1	56.45
			LOAD C	Crypto	65	0.54 (138 kV)(PS)	37.4	10.6	26.8	71.66
			LOAD D	Crypto	90	0.00 (138 kV)	65.4	0	65.4	100.00
			TOTAL		890		643		431.9	67.17
5/31/2024	138 kV line AG Fault 4 cycle clear	South	LOAD A	Crypto	345	0.407 (138 kV)(Aφ)	212.1	117.1	95	44.79
			LOAD B	Crypto	390	0.403 (138 kV)(Aφ)	337.7	268	69.7	20.64
			LOAD C	Crypto	65	0.401 (138 kV)(Aφ)	35.1	26.5	8.6	24.50
			TOTAL		800		584.9		173.3	29.63
8/27/2024	138 kV line 3LG Fault 3 cycle clear	South	LOAD A	Crypto	345	0.405 (138 kV)(PS)	91.8	24.3	67.5	73.53
			LOAD B	Crypto	390	0.405 (138 kV)(PS)	367.2	131.9	235.3	64.08
			TOTAL		735		459		302.8	65.97

- Reductions range from 17% - 66% of pre-disturbance consumption
- % reduction larger for 3LG faults than for SLG faults
- 19% reduction seen for shallow voltage dip of 0.844 on single phase

West Texas Events

Date	Fault Details	Load Zone	Load	Load Type	ERCOT Approved MW	Low Voltage at POI (pu & kV)	Pre-Disturbance Consumption (MW)	Post-Disturbance Consumption (MW)	Total Load Reduction (MW)	% Load Reduction
12/29/2023	138 kV line Unknown fault type & clearing time	West	LOAD F	Crypto	80	0.00 (138 kV)	72.7	0	72.7	100.00
			LOAD H	Crypto	80	0.00 (138 kV)	73.1	0	73.1	100.00
			TOTAL		160		145.8		145.8	100.00
4/6/2024	138 kV line AG Fault 3 cycle clear	West	LOAD E	Crypto	130	0.356 (138 kV)(Aϕ)	53.4	12	41.4	77.53
			LOAD F	Crypto	80	0.804 (138 kV)(PS)	69.5	0	69.5	100.00
			LOAD G	Crypto	80	0.804 (138 kV)(PS)	65.1	0	65.1	100.00
			LOAD H	Crypto	80	0.804 (138 kV)(PS)	63	0	63	100.00
			LOAD I	Crypto	40	0.804 (138 kV)(PS)	33.4	25.5	7.9	23.65
			TOTAL		410		284.4		246.9	86.81
5/1/2024	138 kV line AG Fault 3 cycle clear	West	LOAD E	Crypto	130	0.398 (138 kV)(Aϕ)	55.5	12.5	43	77.48
			LOAD F	Crypto	80	0.866 (138 kV)(PS)	66.8	61.3	5.5	8.23
			LOAD G	Crypto	80	0.866 (138 kV)(PS)	67.1	0	67.1	100.00
			LOAD H	Crypto	80	0.866 (138 kV)(PS)	67.2	0	67.2	100.00
			LOAD I	Crypto	40	0.866 (138 kV)(PS)	33.5	26.8	6.7	20.00
			TOTAL		410		290.1		189.5	65.32
6/17/2024	138 kV line AG Fault 3 cycle clear	West	LOAD E	Crypto	130	0.384 (138 kV)(Aϕ)	52.9	20	32.9	62.19
			LOAD F	Crypto	80	0.846 (138 kV)(PS)	63.3	0	63.3	100.00
			LOAD G	Crypto	80	0.843 (138 kV)(PS)	60.5	0	60.5	100.00
			LOAD H	Crypto	80	0.846 (138 kV)(PS)	62.7	0	62.7	100.00
			LOAD I	Crypto	40	0.843 (138 kV)(PS)	32.6	25	7.6	23.31
			TOTAL		410		272		227	83.46
6/18/2024	138 kV line BG Fault 3 cycle	West	LOAD E	Crypto	130	0.683 (138 kV)(Bϕ)	31.4	23.9	7.5	23.89
			LOAD F	Crypto	80	0.010 (138 kV)(PS)	62.7	0	62.7	100.00
			LOAD G	Crypto	80	0.717 (138 kV)(PS)	67.2	0	67.2	100.00
			LOAD H	Crypto	80	0.010 (138 kV)(PS)	62.1	0	62.1	100.00
			LOAD I	Crypto	40	0.717 (138 kV)(PS)	34.1	26.1	8	23.46
			TOTAL		410		257.5		207.5	80.58
8/1/2024	138 kV line BG and BC Faults; 3-4 cycle clearing times	West	LOAD E	Crypto	130	0.380 (138kV)(Bϕ)	80.2	0	80.2	100.00
			LOAD F	Crypto	80	0.716 (138 kV)(PS)	63.6	0	63.6	100.00
			LOAD G	Crypto	80	0.756 (138 kV)(PS)	63.2	0	63.2	100.00
			LOAD H	Crypto	80	0.716 (138 kV)(PS)	61.3	0	61.3	100.00
			LOAD I	Crypto	40	0.756 (138 kV)(PS)	31.9	25	6.9	21.63
			TOTAL		410		300.2		275.2	91.67
10/29/2024	138 kV line AG Fault 3 cycle clear	West	LOAD E	Crypto	130	0.305 (138 kV)(Aφ)	110.8	87.4	23.4	21.12
			LOAD F	Crypto	80	0.643 (138 kV)(Aφ)	68.7	0	68.7	100.00
			LOAD G	Crypto	80	0.628 (138 kV)(Aφ)	68.4	0	68.4	100.00
			LOAD H	Crypto	80	0.643 (138 kV)(Aφ)	67.8	0	67.8	100.00
			LOAD I	Crypto	40	0.628 (138 kV)(Aφ)	34.4	26.7	7.7	22.38
			LOAD J	Crypto	36	0.490 (138 kV)(Aφ)	31.5	26.9	4.6	14.60
			TOTAL		446		381.6		240.6	63.05

- Loads is this area having an impact on McCamey GTC limits
- Significant reduction in consumption for shallow positive sequence voltage dips; single phase voltage likely dipping ~0.5 pu at POIs

Key Observations

- Large variance in % of reduction due to similar voltage dips at POI
  - Some power electronic-based large loads more sensitive than others
- SLG faults causing larger reductions than shown in models for shallow positive sequence voltage dips as high as 0.85pu
  - Faulted phase likely reducing to ~0.5pu causing load reductions
- ~1,950 MW of operational large load in Far West Texas weather zone
  - High potential for reductions >1000 MW in Far West Texas with fault on 345 kV during high consumption
  - Additional ~3,500 MW in Far West Texas has been approved or is in Planning review
- Other weaker grid areas may see similar events with projected large load growth

Key Takeaways and Next Steps

- Operations to continue monitoring and tracking large load ride-through events
- Operations to continue working with TSPs to retrieve event data and ensure proper Disturbance Monitoring Equipment is in place
- High potential for larger events in certain areas with expected large load growth, specifically for 345 kV faults (SLG or 3LG)
- Challenges and issues to be addressed
  - Determine actual ride-through capabilities of each type of large load
  - Verify and validate load models for accurate representation of ride-through capabilities
  - Develop reliability criteria
  - Examine potential ways to mitigate and/or minimize large load loss during fault events
  - Difficulty performing event analysis without formal RFI process for loads

ercot

Questions?