Load Shed Protocols for the Electric Reliability Council of Texas (ERCOT) Region

Public Utility Commission of Texas

August 31, 2022

Senate Bill 1 (SB1),[1] passed by the 87th Texas legislature, requires the Public Utility Commission of Texas (Commission) to study the effects of load shed protocols in the Electric Reliability Council of Texas (ERCOT) power region. ERCOT conducted a load shed study (2021 Study) in 2021 following winter storm Uri. This 2021 Study identified the individual load shed capabilities and rotating load shed capabilities of all 19 transmission operators (TO) in the ERCOT power region.

Rulemakings

Since 2021, the Commission has implemented legislation related to load shed issues including:

- Adding new categories of critical load designations for load shed,
- Establishing a requirement for filing load shed procedures within the emergency operations plans of entities responsible for implementing load shed,
- Requiring retail electric providers to periodically provide information to customers about the electric utility's procedures for implementing load shedding,

[1] SB 1 (General Appropriations Act) Load Shed Protocols Study. "Using funds appropriated to the Public Utility Commission of Texas, the commission shall study the effects of load shed protocols in ERCOT, as that term is defined by Section 31.002, Utilities Code, and issue a report on the conclusions of the study to the legislature not later than September 1, 2022."

- Requiring ERCOT to conduct load shed exercises, and
- Mapping the Texas electricity supply chain.

In doing so, the Commission conducted rulemakings described below.

- In November 2021, the Commission adopted amendments to existing 16 Texas Administrative Code (TAC) §25.52, relating to Reliability and Continuity of Service. These amendments add end stage renal disease facilities to the list of health facilities prioritized during power restoration after a load shed and increase coordination between the electric and gas industries during energy emergencies by requiring designation of certain natural gas entities and facilities as critical during an energy emergency.

- In December 2021, the Commission adopted amendments to 16 TAC §25.479 that require electric utilities and retail electric providers to periodically provide to customers information concerning load shed, type of customers and procedure to be considered for critical care or critical load, and reducing electricity use at times when load shed events may be implemented.

- In February 2022, the Commission adopted a new rule 16 TAC §25.53, which implements standards for emergency operations plans required of electric utilities, transmission and distribution utilities, power generation companies, municipally owned utilities, electric cooperatives, retail electric providers, and ERCOT.

- In May 2022, the Commission adopted new 16 TAC §25.57 that establish the criteria for the content, activation, and termination of regional and statewide power outage alerts.

Load Shed in ERCOT Power Region

ERCOT is the reliability coordinator that can issue load shed instructions in the ERCOT power region. Load shed is a controlled and temporary interruption of electrical service used as a last resort to restore balance to the bulk electric system. Transmission Operators (TOs), Transmission Service Providers (TSPs) and Distribution Service Providers (DSPs) together implement ERCOT's load shed instructions.

A TSP is an entity under the jurisdiction of the Commission that owns or operates transmission facilities in the ERCOT transmission grid. Transmission facilities include power lines, substations, and associated facilities, operated at 60 kV or above. A DSP is an entity that owns or operates a distribution system for the delivery of energy from the ERCOT transmission grid to customers. The distribution system is part of the electric delivery system operating under 60kV. Transmission and distribution systems are commonly thought of as, respectively, the highways and byways of the grid.

Each TSP and DSP interacts with ERCOT through its TO. A TO communicates with ERCOT and is responsible for preserving reliability for a particular portion of the ERCOT system. The ERCOT Protocols require each TSP and each DSP to either register as a TO or designate another entity as its TO. A TO has complete authority to act on behalf of the designating TSP or DSP in the performance of all TO responsibilities. Each TO operating in the ERCOT power region is bound to follow load shed instructions given by ERCOT. In turn, each DSP is also obligated to follow any reasonable instruction given by its TO to fulfill its load shed obligations.

When ERCOT issues instructions for a certain amount of load to be shed, the percentage of that load that each TO is responsible for shedding is its load shed obligation. Load shed obligations are determined by ERCOT for each TO based on its peak load from the prior year. These percentage thresholds are reviewed by ERCOT and revised annually to reflect any new or changed TO designation.

Table 1 below shows the current load shed obligations by TO. Each TO decides how to allocate its load shed responsibility at the distribution level. ERCOT does not have visibility into or authority over which customers or feeders experience a temporary outage during a load shed event.

Table 1: ERCOT Load Shed Obligation by Transmission Operators, 2021

Transmission Operator	2021 Total Transmission Operator Load (% MW)
AEP Texas Central Company	8.41
Brazos Electric Power Cooperative Inc.	4.85
Brownsville Public Utilities Board	0.37
Bryan Texas Utilities	0.52
CenterPoint Energy Houston Electric LLC	25.89
City of Austin DBA Austin Energy	3.54
City of College Station	0.28
City of Garland	0.73
City of Lubbock	0.58
CPS Energy (San Antonio)	6.44
Denton Municipal Electric	0.48
GEUS (Greenville)	0.14
Golden Spread Electric Cooperative Inc.	0.36
Lamar County Electric Cooperative Inc.*	0.07
LCRA Transmission Services Corporation	5.89
Oncor Electric Delivery Company LLC	35.47
Rayburn Country Electric Cooperative Inc. DBA Rayburn Electric	1.34
South Texas Electric Cooperative Inc.	1.92
Texas-New Mexico Power Company	2.72
ERCOT Total	100

*Lamar County Electric Cooperative is a registered TO not on the ERCOT Hotline, City of Garland receives all their calls.
Source: https://www.ercot.com/files/docs/2022/04/18/ERCOT_Load_Shed_Table_Anticipated.xlsx

TOs, along with TSPs and DSPs, determine whether load shed rotation is feasible and how that load shed rotation will be implemented. Load shed rotation or rotating outages prevent individual customers from experiencing extended outages and bearing the full burden of the load shed event.

Discretion for determining load shed and load shed rotation priorities rests with TOs, TSPs and DSPs, because these entities have greater insight into the characteristics and capabilities of their individual systems than ERCOT or the Commission. For example, the load composition, which refers to the mix of different types of load on the system (e.g., transmission-connected industrial, residential, commercial, non-interruptible network, critical, etc.), varies widely by TO, and many of these load types present unique challenges from a load shed perspective. Larger TOs may have as much as 10-20% transmission-connected industrial load, which refers to large industrial facilities that connect directly to the transmission system rather than to the distribution system. Because most load shed is implemented at the distribution level, a high percentage of transmission-connected industrial load makes executing load shed instructions

more difficult for these TOs. Similarly, TOs with a larger number of level one trauma centers and other critical facilities must often make deeper cuts in other categories to avoid outages to these facilities.

While the load shed and power restoration priorities established by each entity differ based on the unique characteristics of its system, all entities try to avoid shedding circuits with critical load. Examples of critical load include public safety customers, chronic condition or critical care residential customers, certain industrial customers with potentially hazardous industrial processes, and natural gas facilities that are essential to the electricity supply chain. However, it is important to note that critical status designations do not guarantee customers an uninterrupted supply of energy during a load shed event.

Load Shed Protocols in ERCOT Power Region

There are four main conditions during which load shed is necessary to restore balance to the bulk electric system. A brief overview of these conditions is provided below, and more detailed explanations are found in the ERCOT Nodal Operating Guides available on the ERCOT website.[2]

Under-Frequency Load Shed (UFLS)

The ideal frequency for the ERCOT bulk electric system is 60 Hz, at which supply and demand of power are perfectly balanced. When the system frequency deviates from 60 Hz by certain defined thresholds, North American Electric Reliability Corporation (NERC) reliability standards require TOs to respond with automatic under-frequency load shedding (UFLS). During an under-frequency event, each TO must provide load relief by shedding the required percentage of its DSP load and transmission-level customer load using TO-selected automatic underfrequency relays. Each TO must shed a percentage of its load determined by which frequency threshold has been crossed, as noted on Table 2. TOs must maintain an operational plan for immediate execution that identifies UFLS feeders based on the predictability of

[2]https://www.ercot.com/files/docs/2022/06/30/July%201,%202022%20Nodal%20Operating%20Guide.pdf

demand on these feeders and to achieve geographic diversity in the feeders selected. Overall, at least 25% of the ERCOT system load must be equipped for automatic UFLS at all times.

An under-frequency event that would trigger the use of UFLS is uncommon and would take the sudden loss of approximately 6,265 MW of generation to reach the first UFLS Stage of 59.3 Hz. ERCOT Nodal Operating Guides Section 2.6.1, *Automatic Firm Load Shedding,* describes in detail the TO and DSP responsibilities to comply with these requirements.

Table 2: Under-frequency Relays and TO Load Relief

Frequency Threshold	TO Load Relief
59.3 Hz	At least 5% of the TO Load
58.9 Hz	At least 15% of the TO Load
58.5 Hz	At least 25% of the TO Load

Under-Voltage Load Shed (UVLS)

UVLS is a voluntary measure used by some TSPs in certain areas as a safety net to limit the impacts of under voltage conditions or voltage dips. While the effects of these under voltage conditions are localized, they can include voltage instability, voltage collapse, and cascading outages. To mitigate these conditions, a UVLS program uses distributed relays and controls to shed load automatically to restore system balance in the local area. Because these systems are automated, they are not designed to respond to ERCOT directives, rather they are preset to respond to real time conditions. However, a TO will consult with ERCOT while developing a UVLS program.

UVLS programs are governed by NERC reliability standard PRC-010, but there is no requirement for any entity to implement a UVLS program. Furthermore, because UVLS programs address localized issues, load shed as part of a UVLS program – or load shed to address other types of local emergencies – is not limited by or count towards a TO's load shed obligation as listed on Table 1 above.

Emergency Load Shed

During a temporary decrease in available electricity supply it may be necessary to reduce ERCOT system electricity demand by way of shedding load to maintain system reliability. A

drop in supply may be caused by an unexpected loss of generation, transmission equipment, or other key facilities.

ERCOT directs load shed after it has used all available resources and measures to respond to sudden system frequency disturbances or to maintain sufficient Physical Responsive Capability (PRC). PRC is the total amount of resource capability online and available to respond to system frequency disturbances. When the ERCOT PRC falls below 1,000 MW and is not projected to recover above 1,000 MW within 30 minutes, or when the average system frequency falls below 59.91 Hz for 25 consecutive minutes, ERCOT directs TOs to shed load in 100 MW blocks to maintain a steady state system frequency at a minimum of 59.91 Hz. ERCOT Nodal Protocols Section 6.5.9.4.2, *EEA Levels,* describes various levels of Energy Emergency Alert (EEA) and the actions ERCOT must take at each level to preserve the bulk electric system.

Load Shed to Maintain Transmission Security

To comply with NERC reliability requirements, ERCOT must operate the bulk electric system within specified operating limits. Failure to operate the system within these limits can permanently damage equipment that generates, delivers, or uses electricity. When all other mitigation measures, such as transmission reconfiguration and re-dispatching generation, are insufficient to secure system reliability, ERCOT will shed load to ensure that the bulk electric system remains within its operating limits. The ERCOT Transmission and Security Operating Procedure describes this process in detail. Load shed may be implemented to prevent cascading outages.

ERCOT Load Shed Study 2021

ERCOT initiated the 2021 Study to gather substantive and current information about the load shed and rotating outage capabilities of all TOs operating in the ERCOT power region. ERCOT sent out Requests for Information (RFIs) to each of the 19 TOs for available load that could be reasonably shed during an emergency event. Two separate RFIs were sent to each TO. To identify summer seasonal variations in the available load that can be shed, an RFI was sent in May 2021. Another RFI was sent in November 2021 to gather information about the winter seasonal variations. The 2021 Study helped ERCOT better understand how fast load shed might occur, increase its overall situational awareness, and adjust communication processes.

Load Shed RFIs

Each TO provided information about its individual percentage share of load shed obligation and specific load shed responsibility in MWs across three peak electricity demand scenarios for the summer and winter seasons. The three summer peak demand scenarios were based on ERCOT system wide loads of 60 GWs, 70 GWs, and 80 GWs, and the three winter peak demand scenarios were based on ERCOT system wide loads of 55 GWs, 65 GWs, and 75 GWs.

The RFIs also sought data about each TO's load responsibility on critical circuits, UFLS, non-interruptible network load, transmission connected industrial load categories, and the remaining percentage of load not in one of these categories.

Critical circuits load responsibility is the portion of each TO's total load on circuits designated as critical. TOs attempt to exclude these circuits from load shed whenever possible. This category can include circuits with end users such as hospitals, police stations, or gas compression facilities.

UFLS load shed responsibility is the percentage of each TO's total load reserved for under frequency load shed and is otherwise excluded from other types of load shed.

Non-interruptible network loads exist in dense downtown areas of major cities and other similar locations that are served by multiple, redundant distribution feeders. These redundancies make shedding load on a feeder-by-feeder basis unworkable. Networked circuits may also power vital communication equipment, hospitals, warming centers, essential government buildings, and streetlights; and shutting down these networks would also shut down these critical facilities.

Transmission-connected industrial load includes facilities such as refineries and manufacturing plants that may have complex industrial processes. Sudden loss of power to these loads could create dangerous conditions at the facility. TOs avoid shedding these loads due to the sensitivity of industrial processes and public safety concerns.

In response to the RFIs, each TO also identified the percentage of its load that can be shed via automated control systems and what percentage can only be shed manually by field personnel. These automated systems, known as Supervisory Control and Data Acquisition

(SCADA) systems, use a combination of computer programs and user interfaces to monitor, control, and manage industrial processes. TOs' abilities to shed load using SCADA systems vary and not all TOs, TSPs and DSPs have SCADA systems.

The RFI required each TO to identify the time periods within which these loads can be shed and whether they can be shed on a rotating basis. Information was also requested about percentage load on UFLS that can be shed by TOs while maintaining the minimum 25% UFLS obligation described above.

ERCOT aggregated the data gathered from the summer RFIs and presented this information at a Commission workshop on July 26, 2021. The specific RFI responses are classified as ERCOT Critical Energy Infrastructure Information (ECEII) and thus cannot be shared publicly.

Load Shed Capability

The 2021 Study results indicate ERCOT's summer load shed capability at a peak demand of 80 GW was 46%. This includes the UFLS megawatt capacity that could be shed while maintaining the requirements that TOs reserve 25% their loads for UFLS load shed. The system wide load shed capability was reduced to 40% if the TO's entire UFLS equipped load – not just the load required to meet the 25% UFLS requirement - was excluded from its load shed. ERCOT's winter load shed capability at a peak demand of 75 GW was 40% when only required UFLS equipped load was excluded and 35% when all UFLS load was excluded.

The decrease in load shed capability from the summer RFI responses to the winter RFI responses is due to differences in how electricity is used by consumers in different seasons. Residential and commercial electricity usage is higher in summer compared to winter. The largest portion of residential and commercial electricity usage is for air conditioning. Accordingly, the seasonal deviation in usage is smaller in regions that have electric heaters rather than gas heaters.

Table 3: ERCOT Seasonal Load Shed Capability

Description		**Summer**			**Winter**		
		60 GW	70 GW	80 GW	55 GW	65 GW	75 GW
1	Load Responsibility not on Critical Circuits, UFLS, Network Load (non-interruptible), or Transmission-connected Industrial load MW	23,346	27,494	31,450	18,755	22,637	26,323
2	- SCADA Interruptible	22,910	26,983	30,838	18,405	22,188	25,776
3a	- Can be shed within 5 minutes (SCADA & Manual)	4,677	5,431	6,258	4,078	4,930	5,796
3b	- Can be shed within 10 minutes (SCADA & Manual)	5,883	6,782	7,748	4,539	5,386	6,236
3c	- Can be shed within 15 minutes (SCADA & Manual)	13,265	15,577	17,831	10,298	12,374	14,385
3d	- Can be shed within 30 minutes (SCADA & Manual)	23,001	27,068	30,951	18,018	21,663	25,149
4a	- Can be rotated by SCADA	22,215	26,129	29,846	17,694	21,293	24,704
4b	- Can be rotated Manually	312	360	427	245	296	349
5	UFLS MW that can be shed while maintaining 25% minimum requirement	4,255	5,137	5,921	2,281	2,951	3,716
6	Total Interruptible Load (#1 plus #5)	27,601	32,631	37,372	21,036	25,587	30,040

Load composition within a TO load affects the total amount of load that can be shed or rotated on a TO's system. Some TOs may have no non-interruptible network load or industrial load while other TOs may have over 20% of their load serving non-interruptible network load or industrial load. Additionally, many TOs have 20% to 30% of their load designated as critical circuits. The load shed capability may be limited by the need to avoid the use of circuits that provide UFLS, serve critical loads, or are on non-interruptible networks. Those TOs without any non-interruptible network load have more flexibility for load shed and load rotation.

The RFI responses indicated that TOs' available load shed capability may vary based on specific weather conditions, time of the day, and season. The percentage of transmission-connected industrial load decreases as the total system load increases. Industrial load typically has smaller fluctuations throughout the day than residential and commercial load. It forms a lower percentage of the overall load during the day when the residential and commercial demand is comparatively higher than in the night. During non-peak hours, industrial load makes up a higher percentage of TOs' load because this load voluntarily reduces electricity usage in response to peak electricity prices.

During winter, residential and commercial load is comparatively lower; therefore, industrial load makes up a higher percentage of a TO's load. However, during the summer months, some industrial loads voluntarily reduce demand to lower their transmission costs.

The largest three TOs, by percentage share of ERCOT load shed obligation, have lower load shed capability as compared to other TOs, as shown on Table 4, due to a low percentage of interruptible load.

Table 4: TO Seasonal Load Shed Capability

TO	SUMMER TO Interruptible Load (%) Excluding UFLS and Critical Loads at 80GW	WINTER TO Interruptible Load (%) Excluding UFLS and Critical Loads at 75 GW
TO1	41%	32%
TO2	45%	41%
TO3	31%	31%
TO4	44%	44%
TO5	28%	25%
TO6	27%	26%
TO7	55%	55%
TO8	65%	65%
TO9	N/A	50%
TO10	53%	60%
TO11	30%	31%
TO12	46%	45%
TO13	N/A	57%
TO14	50%	54%
TO15	56%	45%
TO16	40%	34%
TO17	57%	57%
TO18	46%	34%
TO19	50%	41%

**Note: Data for certain new ERCOT members is unavailable for summer season*

Load Shed Implementation

Most TOs use SCADA systems for load shed. Loads that can be shed by using SCADA systems are called SCADA-interruptible loads. These loads can be shed within 30 minutes. While some SCADA-interruptible loads can be shed in as few as five minutes, others take longer due to communication and manual progress tracking that involves identifying and dropping individual feeders and tracking load shed progress. Therefore, only a small portion of load that is on SCADA automated applications can be shed within ten minutes. These progress tracking procedures and processes vary by TO according to their system characteristics and may lead to differences in the time needed to shed load using SCADA systems.

The 2021 Study assessed that at a peak summer electricity demand of 80GWs nearly 38% of ERCOT load was SCADA interruptible load. During the peak winter electricity demand of 75GWs, this figure fell to 34%.

Table 5: TO Load Shed Systems

Description		Number of TOs
SCADA Systems	Automated Application	8
	Personnel Selected	6
Manual (Field Personnel)		1
Mixture (SCADA and Manual)		4
Total		**19**

SCADA systems can have different operational capabilities, including whether they are personnel selected or automated applications. SCADA-Personnel Selected refers to systems that rely upon TO personnel to select individual load feeders that need to be shed to meet the TOs' load shed obligation. These feeders can only be turned on or off by personnel inside the substations. A TO with this type of system drops one load at a time by opening individual breakers and switches. Although the TO does not have to send personnel to *physically* open breakers and switches, identifying the mix of load to shed and dropping each load one-by-one by utility staff takes time.

SCADA-Automated Application refers to systems that have a single button click in the control system to identify the mix of loads to shed in defined geographic areas. These computerized operations automatically calculate the amount of load on each feeder and when to sequentially turn feeders off and on during a rotation to speed rotate and reduce load fluctuations. Utility staff must continue to monitor a computerized system and may take direct control when circumstances warrant.

Load Shed Rotation Capabilities

Nearly 37% of load could be rotated via SCADA during summer months as compared to 32% during winter months in the ERCOT power region, according to the 2021 Study.[3] TOs have

[3] The 2021 Study only required TOs to provide information related to their load shed and rotating outage capabilities and does not include substantial information or insights about the rotating outage capabilities of DSPs, who are largely responsible for rotating outages at the distribution level.

different capabilities to shed load on a rotating basis. The capability to rotate load depends on characteristics such as TO load composition and the availability of SCADA systems. Most TO feeder breakers have SCADA controls that allow TO personnel to remotely open and close a breaker to shed or restore load. This allows more frequent rotation of load shed. However, not all distribution level systems are SCADA enabled. Non-SCADA systems require a technician to physically go to a location to open or close a breaker or disconnect breakers. The frequency at which a load is rotated also depends on the TOs load shed procedures and the amount of load shed requested.

Moreover, load normally controlled via SCADA can be impacted by abnormal system conditions, communication issues, and cold load pick up issues that would impede the ability to switch remotely. Cold load pick up is the brief initial spike of power when a de-energized load is re-energized before it settles out to normal. This initial spike could, in some cases, cause protective relay actions to trigger or breakers to trip making it difficult to switch or rotate.

There are no guidelines on the amount of time a load can be out of service during a load shed event. Some TOs do not have a defined maximum time to rotate an outage but do have a target time. A common target is 30 minutes, but some larger TOs have a rotating target time of up to several hours. Several TOs noted that rotating outage target time is proportional to the magnitude of the load shed instructions issued by ERCOT.

ERCOT Protocol Revisions

In December 2021, the Commission approved Nodal Protocol Revision Request (NPRR) 1094. This allows a TO and a Transmission and Distribution Service Provider to manually shed load connected to under-frequency relays during an EEA Level 3 event if the affected TO can meet its overall 25% UFLS requirement and load shed obligation.[4] This NPRR increases the load available for rotating outages and helps spread the burden of those outages to a larger and more diverse pool of load.

[4] Nodal Operating Guides Section 2.6.1, Automatic Firm Load Shedding, and Nodal Operating Guides Section 4.5.3.4, Load Shed Obligation.

ERCOT Load Shed Exercises

As required by SB3, ERCOT has conducted two load shed exercises to review load shed procedures and provide training to market participants on various aspects of load shed. A winter load shed exercise was conducted in December 2021 and a summer load shed exercise was conducted in July 2022.

These exercises included ERCOT's explanation of its role in directing load shed – namely, identifying when load shed is necessary and issuing such directives to TOs. ERCOT and stakeholders reviewed the notification requirements in EEA 1, 2, and 3 events along with other communication requirements between market participants and ERCOT during load shed events. ERCOT also conducted simulations of hypothetical events that would eventually require load shed.

Additionally, volunteer TOs presented their load-shed practices and methods, including how they communicate with DSPs and provided explanations of how they would respond to directives issued by ERCOT. Participants shared past experiences, identified tools that assist in efficient load shedding and restoration of service, and recommended best practices. A common issue noted by many participants was that a high percentage of their distribution feeders had at least a small number of critical customers or other critical loads. Such a configuration makes it difficult to execute emergency load shed instructions without shedding any load with these critical designations.

Going forward, these exercises will be held by ERCOT at least twice a year – once during a summer month and once during a winter month. The next exercise is scheduled to be held on December 8, 2022.