ERCOT Control Room Situational Awareness Tools

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G-PST Future of Inertia

03/12/2024
The interconnected electrical system serving most of Texas, with limited external connections:

- 90% of Texas electric load; 75% of Texas land
- 85,508 MW peak, Aug. 10, 2023
- More than 54,100 miles of transmission lines
- 1,250+ generation units (including PUNs)

ERCOT connections to other grids are limited to ~1,220 MW of direct current (DC) ties, which allow control overflow of electricity.
ERCOT has experienced steady load growth and a significant change in the resource mix, relying less on coal and gas and more on wind and solar.
ERCOT leads the nation in installed wind generation capacity.

ERCOT has recently experienced a notable increase in solar capacity and may lead the nation within the next two years.
Battery storage capacity has increased substantially in ERCOT since 2021. Most of this capacity is 1-hour and 2-hour batteries.
Current Records

Peak Demand Record: 85,508 megawatts (MW)
- August 10, 2023, 5-6 p.m.

Weekend Peak Demand Record: 85,116 MW*
- Sunday, August 20, 2023, 4-5 p.m.

Winter Peak Demand Record: 78,314 MW*
- January 16, 2024, 7-8 a.m.

Wind Generation Records (instantaneous)
- Output: 27,548 MW
  - January 7, 2024, 6:42 p.m.
- Penetration (load served): 69.15%
  - April 10, 2022, 1:43 a.m.
  - Wind power output at the time was 23,977 MW

Solar Generation Record (instantaneous)
- Output: 17,136 MW (35.11% of load)
  - February 18, 2024, 10:59 a.m.
- Penetration (load served): 39.94%
  - February 18, 2024, 3:05 p.m.

*New records are preliminary, subject to change in final settlement

Recent Monthly Peak Demand Records

2024
- January: 78,314 MW* (Jan. 16, 7-8 a.m.)

2023
- November: 56,515 MW (Nov. 8, 3-4 p.m.)
- October: 71,181 MW (Oct. 4, 4-5 p.m.)
- September: 84,343 MW (Sept. 8, 5-6 p.m.)
- August: 85,464 MW (Aug. 10, 5-6 p.m.)
- July: 82,939 MW (July 31, 6-7 p.m.)
- June: 80,787 MW (June 23, 5-6 p.m.)

2022
- December: 74,525 MW (Dec. 23, 7-8 p.m.)
- October: 66,153 MW (Oct. 12, 4-5 p.m.)
- August: 78,505 MW (Aug. 8, 4-5 p.m.)
- July: 80,148 MW (July 20, 4-5 p.m.)
- June: 76,718 MW (June 23, 4-5 p.m.)
- May: 71,645 MW (May 31, 4-5 p.m.)
- April: 58,419 MW (April 5, 5-6 p.m.)

2021
- September: 72,370 MW (Sept. 1, 4-5 p.m.)
- February: 69,812 MW (Feb. 14, 6-7 p.m.)

2020
- July: 74,344 MW (July 13, 4-5 p.m.)
Real-Time Inertia Estimation
Critical Inertia

- With increasing integration of inverter-based generation, there could be periods when total inertia of the system could be low.

The level of inertia which causes the frequency to drop below the UFLS trigger before the “fastest” resources can provide sufficient frequency response for loss of RCC.
Critical Inertia Definition

- Minimum level of system inertia should ensure Load Resources (LRs) to be triggered before 59.3Hz (UFLS threshold)

Load Resources (LRs) deploy on relay at 59.70 Hz within 30 cycles
Frequency Response (Initial Stage)

Loss of 2750 MW Generation (1150MW PFR)

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Critical Inertia Quantification Methodology

Frequency Traveling Time (From LR setting to ULFS setting) vs. Inertia

- Second
- Inertia (GW*s)
Critical Inertia Quantification Methodology

Frequency Traveling Time (From LR setting to ULFS setting) vs. Inertia

\[ T = f(\text{Inertia}) = a \times \text{Inertia}^2 + b \times \text{Inertia} + c \]

At Critical Inertia Level:

\[ f(\text{Inertia}) \geq \text{LRs Response Time} \]
\[ \text{Inertia} \geq f^{-1}(\text{LRs Response Time}) \]

Critical Inertia \(= f^{-1}(\text{LRs Response Time})\)
Current Critical Inertia for ERCOT

\[ T = f (\text{Inertia}) = 3 \times 10^{-5} \times \text{Inertia}^2 + 0.0016 \times \text{Inertia} + 0.0048 \]

Critical Inertia: 94 GW*s

At Critical Inertia Level:
\[ 3 \times 10^{-5} \times \text{Inertia}^2 + 0.0016 \times \text{Inertia} + 0.0048 \geq 0.42 \]
\[ \text{Inertia} \geq 94 \text{GW} \cdot \text{s} \]

Critical Inertia = 94 GW*s
Critical Inertia

• Currently, the Critical Inertia Level for ERCOT appears to be around 100 GW-s (based on current operations and response characteristics of current resources)
  – Simulation results have shown that below this level RoCoF is high enough that frequency would drop below 59.3 (UFLS threshold) Hz for the loss of RCC.
Inertia Monitoring in Real Time

The system inertia is calculated as:

\[ M_{sys} = \sum_{i \in I} H_i \cdot MVA_i \]

where \( I \) is the set of online synchronous generators or condensers, \( MVA_i \) is MVA rating of on-line synchronous generator or synchronous condenser \( i \), and \( H_i \) is inertia constant for on-line generator or synchronous condenser \( i \) in a system (in seconds on machine \( MVA_i \)).

\( H_i \) is reviewed annually through our Dynamic Working Group Cases. Any updates are processed through the network model to be used by other systems.
Inertia Monitoring in Real-Time

- In 2016, inertia monitoring was implemented in the control room. Visual alarms are raised alarms when inertia gets close to critical levels.

- As inertia approaches critical levels, ERCOT System Operators may take actions to bring additional synchronous generation resources with sufficient inertia online.

120 GW*s >= Inertia Normal
120 GW*s > Inertia >= 110 GW*s Yellow
110 GW*s > Inertia >= 100 GW*s Orange
100 GW*s < Inertia Red
Approach for Maintaining Critical Inertia

• Monitor grid conditions closely when system inertia < 120 GW*s
• Take Actions when system inertia < 105 GW*s
  – Target increasing system inertia >= 105 GW*s
  – Possible Actions
    • Deploy Non-Spin from Offline Generation Resources (including Quick Start Generation Resource (QSGRs) that carry Non Spin)
    • Deploy remaining Quick Starts (not carrying Non-Spin)
    • RUC Generation Resource that can be turned on within one hour
Summer – Potential Inertia Contributions

![Bar chart showing potential inertia contributions across different time periods.](Image)

- "30-min" Non-Spin
- QSGR carrying Non-Spin
- Remaining QSGR

Item 6.2
ERCOT Public
ERCOT Inertia 2013-2023

Total Inertia by Year

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Min synch. Inertia (GW's)                  | 132   | 135   | 152   | 143   | 130   | 128.8 | 134.5 | 131.1 | 116.6*| 115.0 | 124.3 |


Non-synch. Gen. in % of System Load         | 31    | 34    | 42    | 47    | 54    | 53    | 50    | 57    | 66    | 65    | 61    |

* Measured at 109.6 GW*s, re-calculated using corrected inertia constants
1. Faster and/or Earlier Response e.g.
   – Faster Response from Load Resources
   – Fast Frequency Response (FFR) from Energy Storage Resources (ESRs)
     • Response within 15 cycles

2. Critical Contingencies
   – Currently to meet BAL-003, ERCOT must plan not to activate UFLS for loss of RCC
   – RCC equates to the loss of two nuclear units
   – Maintenance outages on these units is typically during shoulder months, which are typically periods with low system inertia.

3. UFLS settings
   – Study potential changes in UFLS to 59.1 Hz, 59.4 Hz
Real-Time Critical Inertia based Assessment

1. Account for outages to determine RT RCC
2. Future Change - Account for FFR available
Questions?

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Appendix
Top-Down Approach: ERCOT’s GridGeo Application

- ERCOT-developed, browser-based platform allowing for improved situational awareness.
- Targeted to control room operators, control room support staff, and operations training.
- Provides a combined view of the network operations model, real-time and historical information from reliability systems.
- Overlays current and future weather from external vendors.

One-Lines and Multi-Station One-Lines
Past and forecasted radar can be displayed
Texas Grid Map – Wind Layer

02/22/21 2 PM
IBR Tabular Displays
Bottom-Up Approach: Browser-Based Tabular Displays

- Initially developed for the new Reliability Risk Desk
- Utilizes OSIsoft’s Asset Framework model and WebAPI
- Available in the business and secure networks

Historical and Forecast Information is Available
Bottom Up: IRR Production and Curtailment
Bottom-Up: Forecast Displays
Bottom-Up: Energy Storage Resource Display

- Total Charging (Load): 48 MW
  - Total Max Charge Limit: 669 MW
- Net: 40 MW Charging
- Total Discharging (Generation): 8 MW
  - Total Max Discharge Limit: 1,873 MW
- Total SOC: 2,135 MWh
  - 64%

### Table

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<th>Name</th>
<th>QSE</th>
<th>Unit</th>
<th>Load Resource</th>
<th>Net Load</th>
<th>State of Charge</th>
<th>Max Charge Power Limit</th>
<th>Max Discharge Power Limit</th>
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