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The Essential Role for Explainable AI (XAI) in AI/ML

Enhancing Transparency, Trust, and Efficiency in Grid Operations

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Agenda

1. ERCOT Overview
2. Key Challenges in Grid Operations
3. Artificial Learning (AI) and Machine Learning (ML) in ERCOT Operations
4. Role of Explainable AI (XAI)
5. Case Study: Large Flexible Loads (LFLs)
6. Conclusion and Next Steps

What is ERCOT?

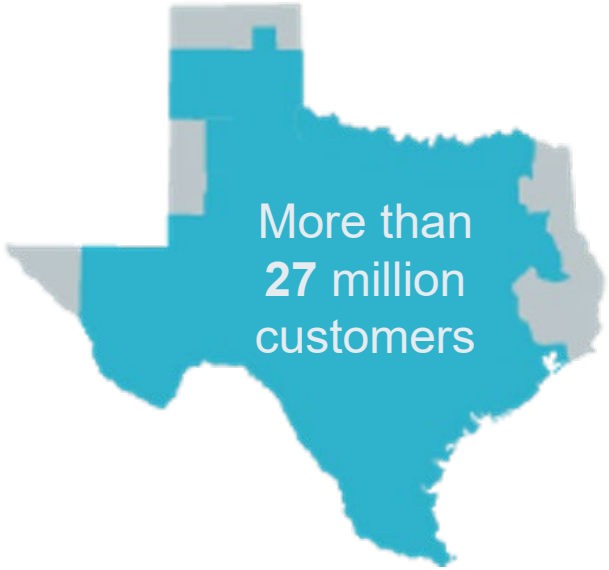
The Texas Legislature restructured the Texas electric market in 1999 and assigned ERCOT four primary responsibilities:

- **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

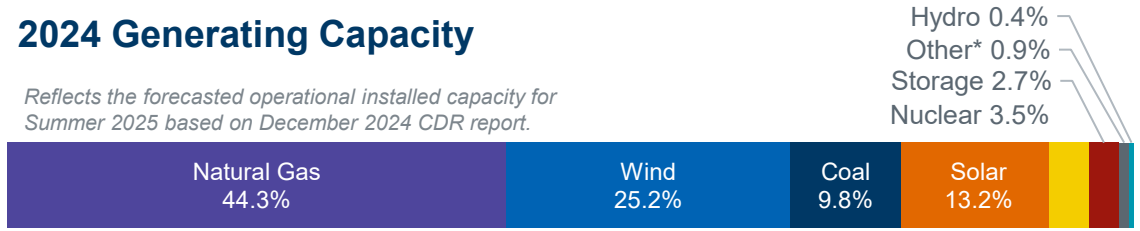
Expected capacity for summer 2025 peak demand (May 2024 CDR)

$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.

39,546 MW

Wind

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

28,373 MW
Generation Record
(January 4, 2025)

69.15 %
Penetration Record
(April 10, 2022)

28,817 MW

Solar

of utility-scale installed solar capacity as of February 2025

24,323 MW
Generation Record
(February 16, 2025)

48.61 %
Penetration Record
(February 16, 2025)

~75 % (~34,900 MW)

Preliminary **Wind + Solar** Penetration Record (March 29, 2024)

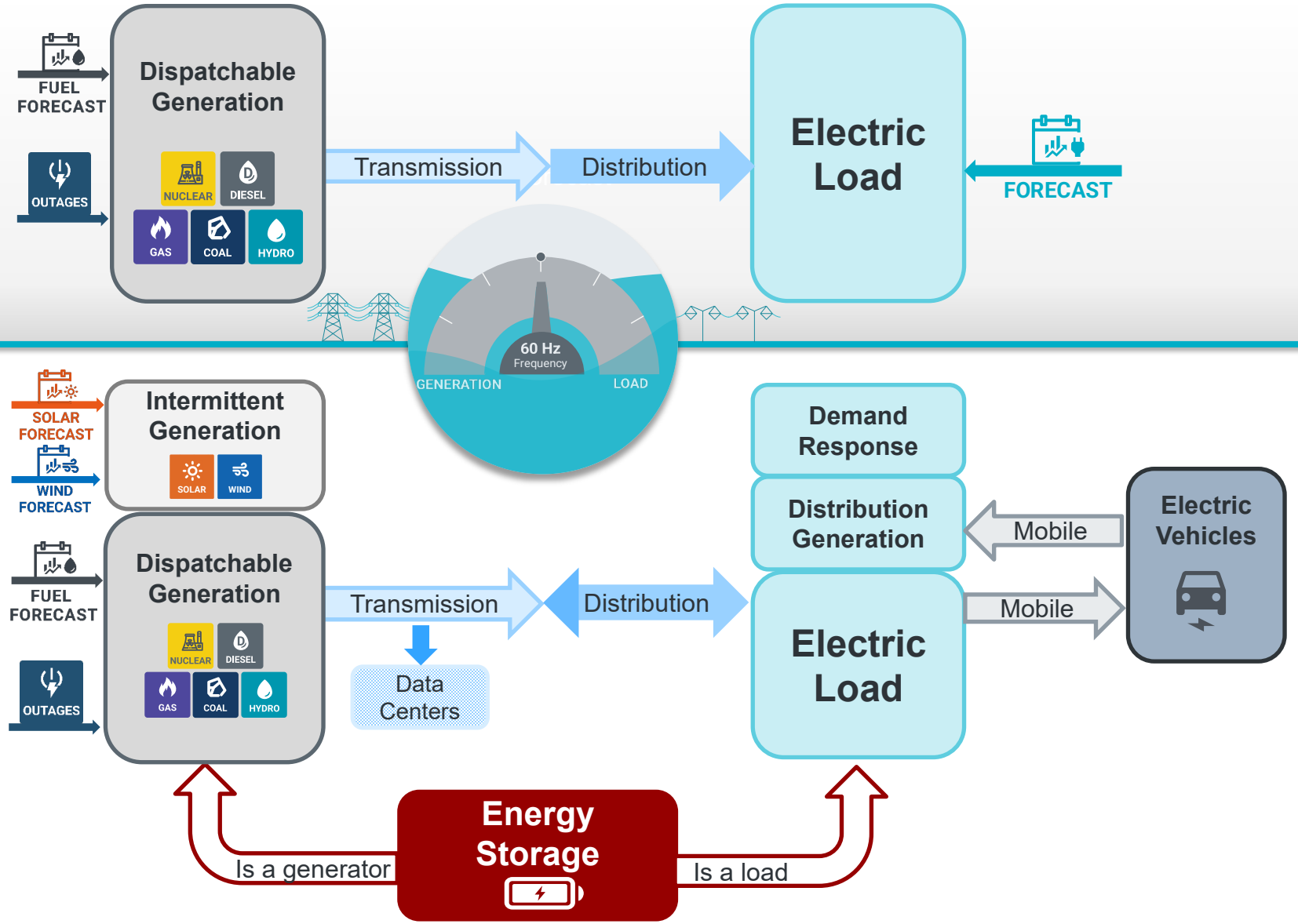
10,017 MW

Battery Storage

of installed battery storage as of December 2024

4,578 MW
Storage Discharge Record
(February 20, 2025)

The ERCOT Electric Grid: Then and Now



Key Grid and Market Functions and Applications Used

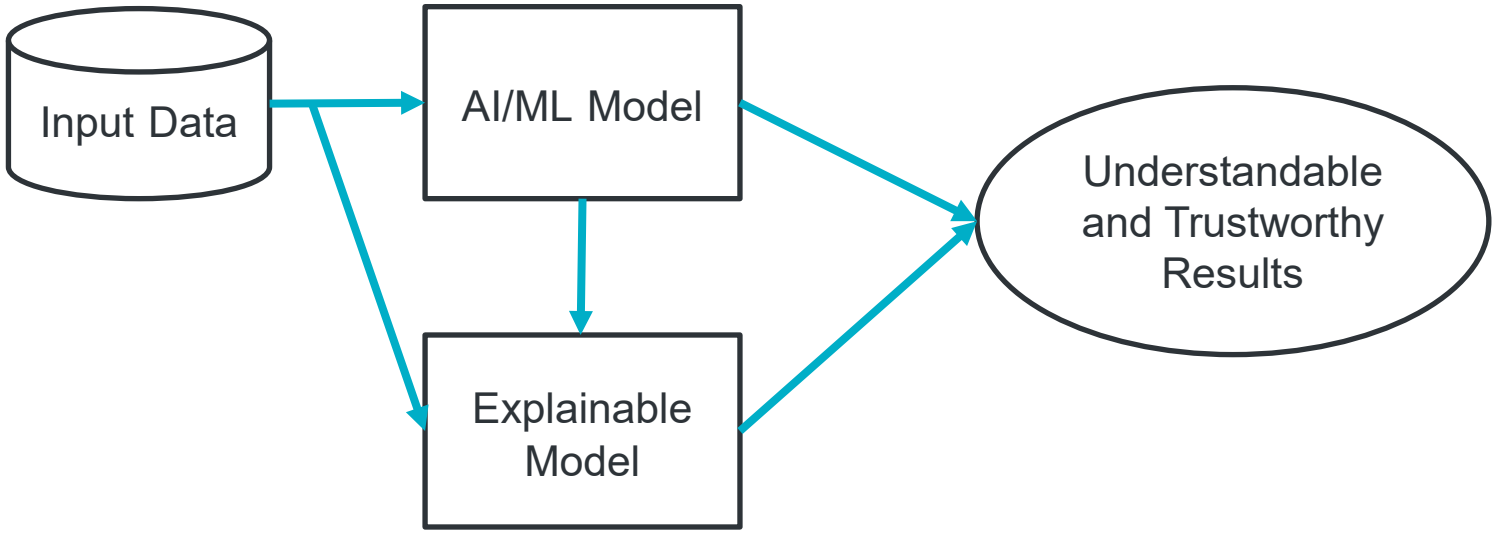
Key Functions	Applications Used
Grid Operations – Monitoring and Control	SCADA, Automatic Generation Control, Network Applications – State Estimation, Contingency Analysis, Voltage Stability Assessment, Transient Stability Assessment
Market Operations – Basepoints & Real-Time Prices	Security Constrained Economic Dispatch (SCED)
Operations Planning for Short Term (5 mins – 2 hours)	Reliability Unit Commitment, Security Constrained Optimal Power Flow, Forecasting – Demand, Variable Renewable Resources, State of Charge, Large Flexible Loads etc.
Market Planning for Day-Ahead (24 hours)	Security Constrained Unit Commitment and Security Constrained Economic Dispatch
Operations Planning for Medium-Term Time Horizon (7 days)	Demand Forecasting, Reliability Unit Commitment, Security Constrained Optimal Power Flow
Long-Term Planning & Congestion Management (months – years)	Power Flow, Optimal Power Flow, Security Constrained Optimal Power Flow, Stability Analysis, EMT studies, Protection Analysis, Demand Forecasting, Production Cost Modeling

Requirements for the Applications and the Reasons

Reliable	Keeping the Lights On
Reproducible	Regulatory Compliance
Interpretable	Legal Disputes
Trustworthy	Financial Implications
Traceable	Data Retention
	Risk Management

Explainable AI (XAI)

- **What is XAI?**
  - Transparent and interpretable AI models
- **Why does it matter for ERCOT?**
  - Trust, compliance, and improved decision-making



The NIST Four Principles of XAI

- **Explanation**
  - The system should provide meaningful, understandable explanations of its decisions and processes.
- **Meaningful**
  - The explanation should be relevant to the audience and understandable based on their expertise.
- **Explanation Accuracy**
  - The explanation should correctly reflect the system's actual decision-making process.
- **Knowledge Limits**
  - The AI should recognize when it lacks sufficient confidence or data to provide reliable results.

AI/ML in ERCOT Operations

- Cybersecurity Threat Detection (In Operation)
- Battery State of Charge (SOC) and Large Flexible Load Forecasting (In Operation)
- Market Anomaly Detection (Under Development)
- AI/Cognitive Search (Under Development)

Case Study: XAI and Large Flexible Load Forecasting

- **XAI's Role:** XAI can provide insights into the factors that influence LFL behavior, such as:
  - **Weather conditions:** Temperature, humidity, and other weather variables can affect energy consumption.
  - **Time of day:** LFLs may have different consumption patterns at different times of the day.
  - **Day of the week:** Energy consumption may vary on weekdays and weekends.
  - **Price signals:** Real-time electricity prices can incentivize LFLs to reduce their consumption.
  - **Grid reliability:** LFLs may be more willing to curtail their load during periods of grid stress.
- **Benefits of XAI:**
  - **Improved forecast accuracy:** By understanding the factors that drive LFL behavior, ERCOT can develop more accurate forecasting models.
  - **Enhanced grid reliability:** Accurate LFL forecasts enable better grid management and resource allocation.
  - **Increased LFL participation:** XAI can help ERCOT communicate the benefits of LFL participation to consumers, leading to greater adoption of demand response programs.
  - **Improved market efficiency:** Better LFL forecasts can lead to more efficient electricity markets.

Conclusion and Next Steps

- **Strategic Importance:**
  - XAI is essential for ERCOT's transition to a smarter, more adaptive grid.

- **Key Benefits:**
  - Strengthened grid reliability and operational resilience
  - Transparent, trustworthy AI-driven decisions
  - Regulatory compliance and risk mitigation
  - Continuous improvement in AI system performance

- **Future Outlook:**
  - By integrating XAI into its operations, ERCOT can navigate the evolving energy landscape while maintaining stakeholder trust and grid stability.

Thank You !!