

Real-Time Energy Market Intelligence & Anomaly Detection for ERCOT



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Introduction

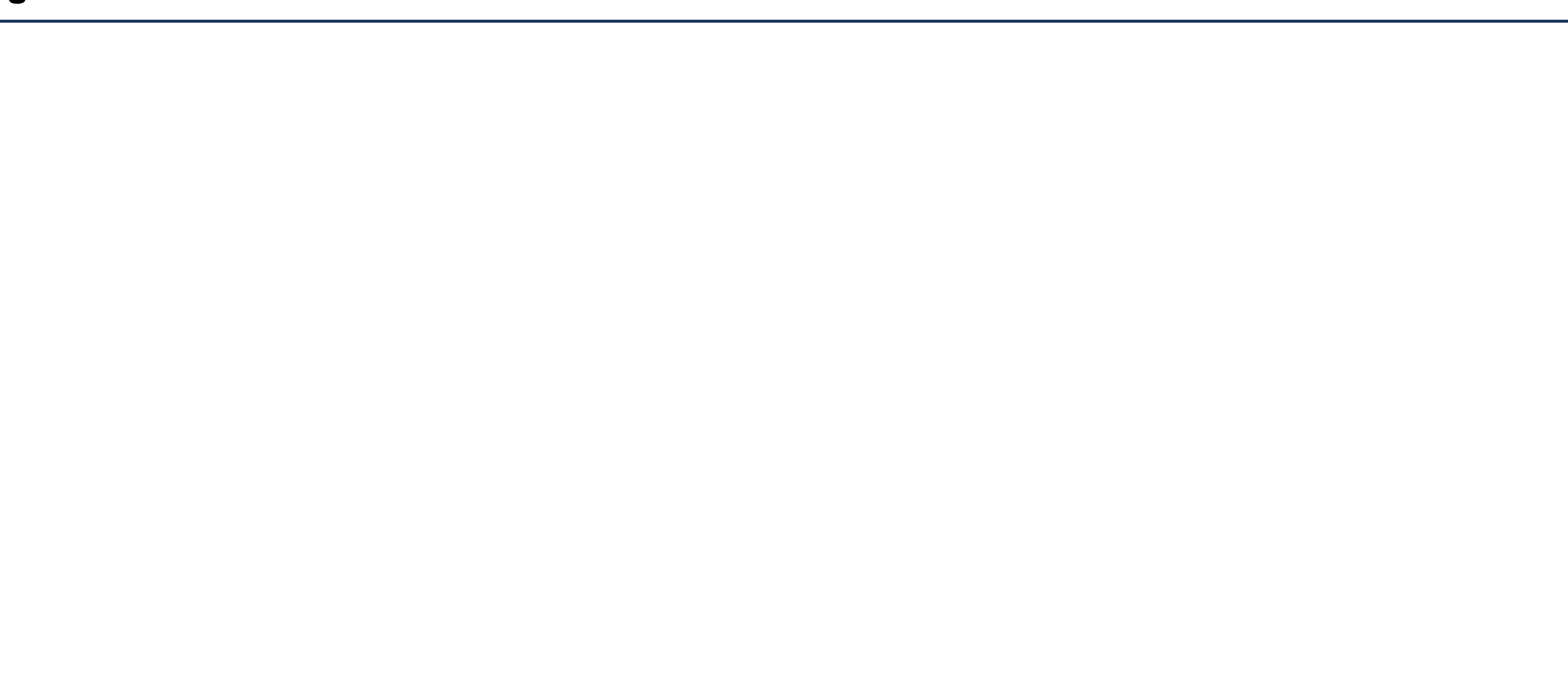
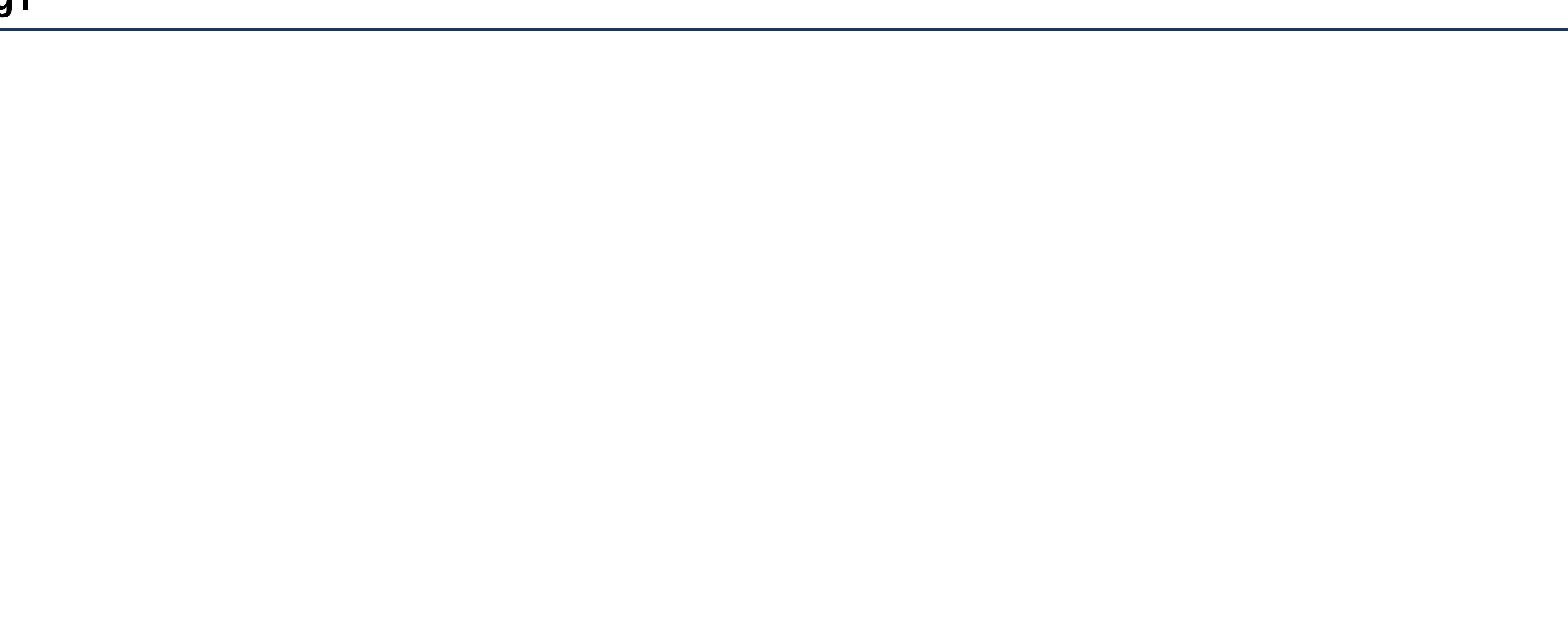
Electricity markets are becoming increasingly volatile due to extreme weather events, rising electricity demand, and rapid growth in renewable energy resources. These challenges are especially pronounced in the **Electric Reliability Council of Texas (ERCOT)** market, which operates as an isolated system with high exposure to weather-driven demand and generation variability.

- **Weather sensitivity:** Temperature extremes drive sharp load ramps and price spikes.
- **Operational risk:** Renewable intermittency and demand surges increase grid stress.
- **Analytical gap:** Traditional analyses rely on retrospective data, limiting real-time awareness.
- **Opportunity:** High-frequency market and weather data enable real-time forecasting and anomaly detection.

This project develops a weather-aware analytics framework to support short-term forecasting, anomaly detection, and proactive decision support.

Methodology

- **Data Sources:** hourly system load and price data from the Electric Reliability Council of Texas (ERCOT) are integrated with high-resolution Texas weather data, including temperature, humidity, wind speed, and solar radiation.
- **Data Processing:** datasets are time-aligned to an hourly resolution, cleaned for missing values, and transformed through feature engineering and normalization to create analysis-ready data.
- **Weather-Aware Analysis:** exploratory and baseline modeling approaches are used to examine nonlinear relationships between weather conditions, electricity demand, and market prices, with emphasis on seasonal and extreme weather behavior.
- **Anomaly Identification:** statistical summaries and distribution-based methods are applied to identify abnormal patterns such as load ramps, price spikes, and unusual generation behavior.
- **Pipeline Design:** a modular, scalable workflow is designed to support future near real-time ingestion and continuous monitoring.
- **Outputs:** visual insights, summary metrics, and anomaly indicators to support situational awareness and future decision-support development.



Objective

- **Explore Weather Variability**
Examine Texas weather data to identify seasonal, daily, and extreme-event patterns relevant to energy systems.
- **Understand Renewable Generation Behavior**
Analyze wind and solar generation data to characterize variability and intermittency.
- **Link Weather to Renewable Output**
Assess how key weather variables influence wind and solar energy production.
- **Study Extreme Weather Impacts**
Evaluate renewable energy performance during extreme heat and cold conditions.
- **Build a Foundation for Future Modeling**
Establish insights and features to support future forecasting and analytics in the Electric Reliability Council of Texas (ERCOT) market.

Future Work

- **Understand Renewable Generation Behavior**
Analyze wind and solar generation data to characterize variability and intermittency.
- **Link Weather to Renewable Output**
Assess how key weather variables influence wind and solar energy production.
- **Study Extreme Weather Impacts**
Evaluate renewable energy performance during extreme heat and cold conditions.
- **Build a Foundation for Future Modeling**
Establish insights and features to support future forecasting and analytics in the Electric Reliability Council of Texas (ERCOT) market.

Acknowledgment

- Use insights from exploratory analysis to inform feature selection and model design.