Forecasting Electricity Demand and Prices in PJM and MISO Markets

Group 5

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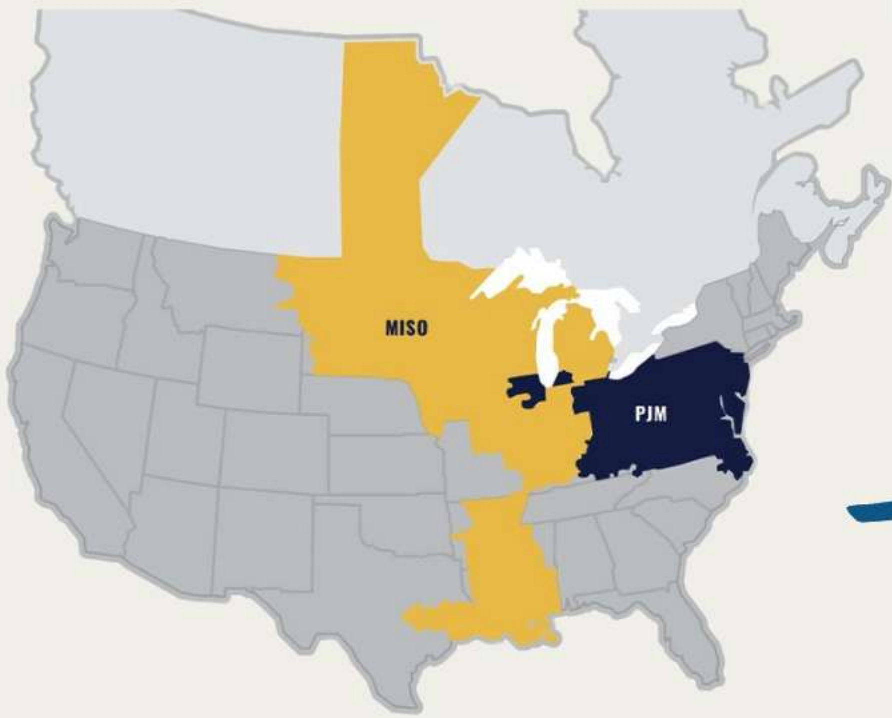
INTRODUCTION

Our Proposal



The US Electricity Market

MISO ➔ Midcontinent Independent System Operator

PJM ➔ PJM Interconnection

Background & Challenges

- Supply-demand mismatches
- Extreme weather
- Potential widening capacity gap

The Objective

Forecast electricity demand and prices in the PJM&MISO markets by analyzing key factors and relationships to improve grid management, reduce blackout risks, optimize pricing, and support long-term planning.

Dataset Overview

Target Variables

- **MISO & PJM Real-time Load (RTLOAD)**
- Actual electricity demand

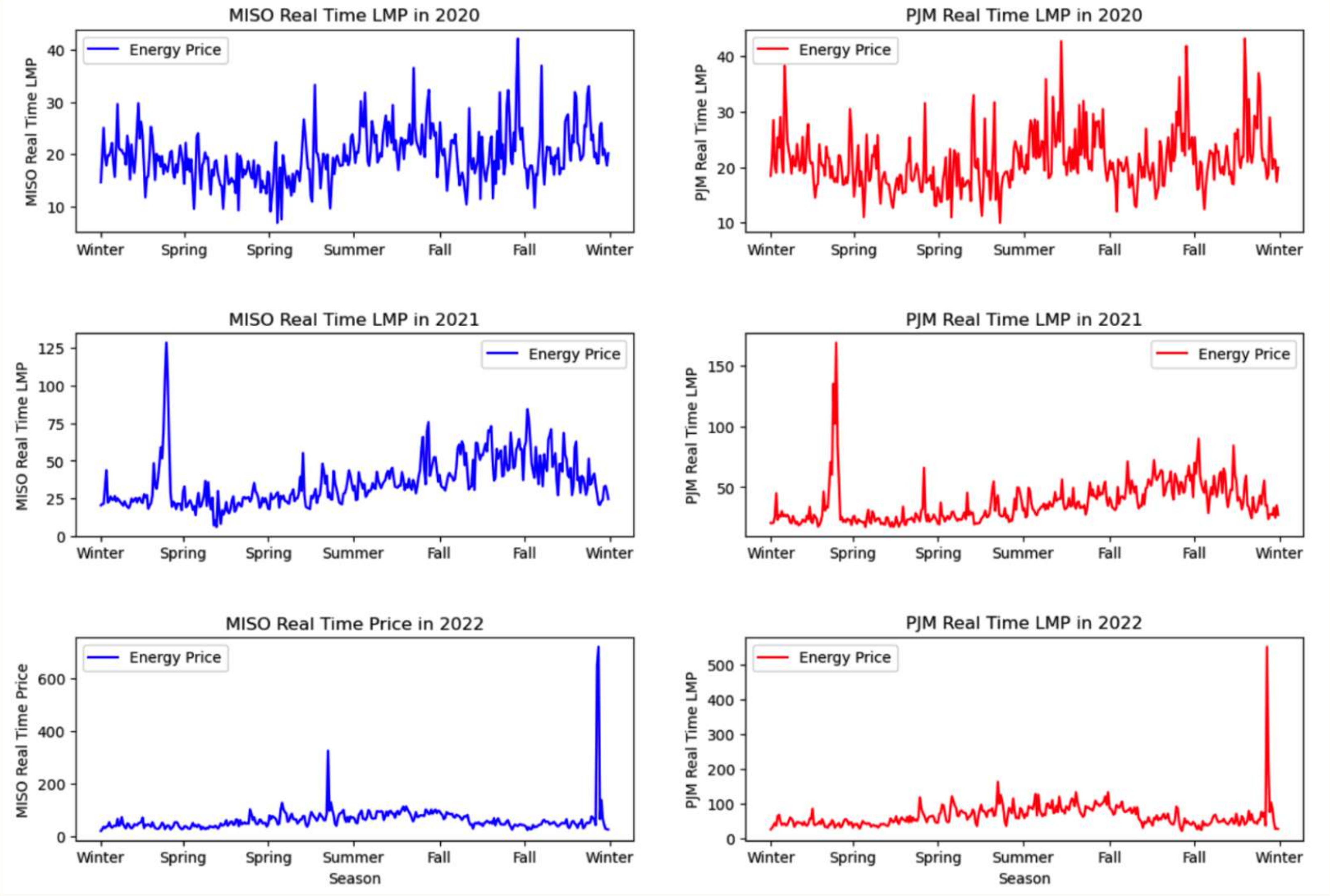
- **MISO & PJM Real-time Locational Marginal Pricing (RT LMP)**
- Electricity price at specific locations

Independent Variables

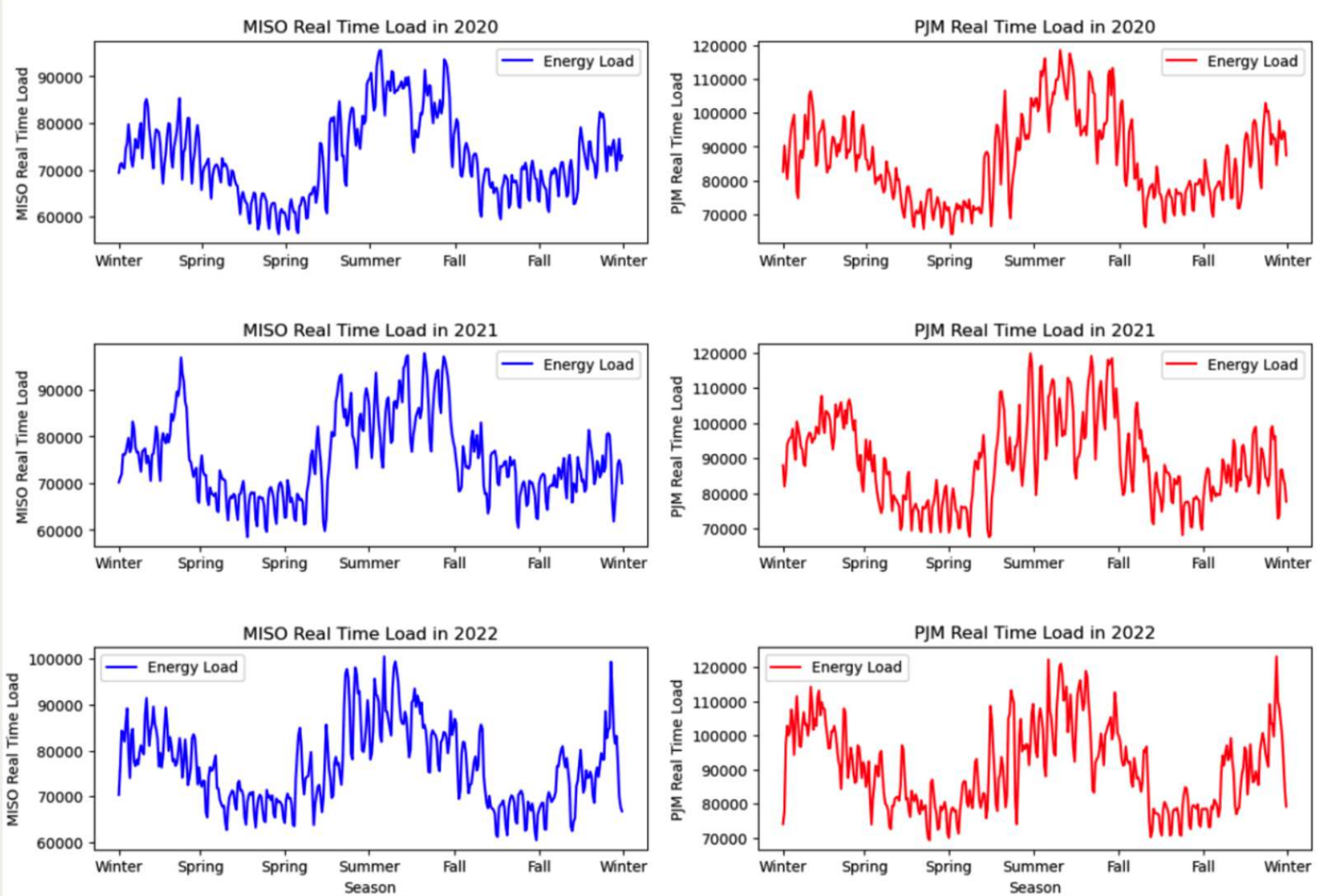
- Dates
- ON/OFF peak hours
- Real-time central region load
- MISO & PJM Congestion Costs
- Area control error values
- MISO&PJM Ramp Imports & Exports
- Gas/coal/nuclear/hydro generation data

Graph of Data

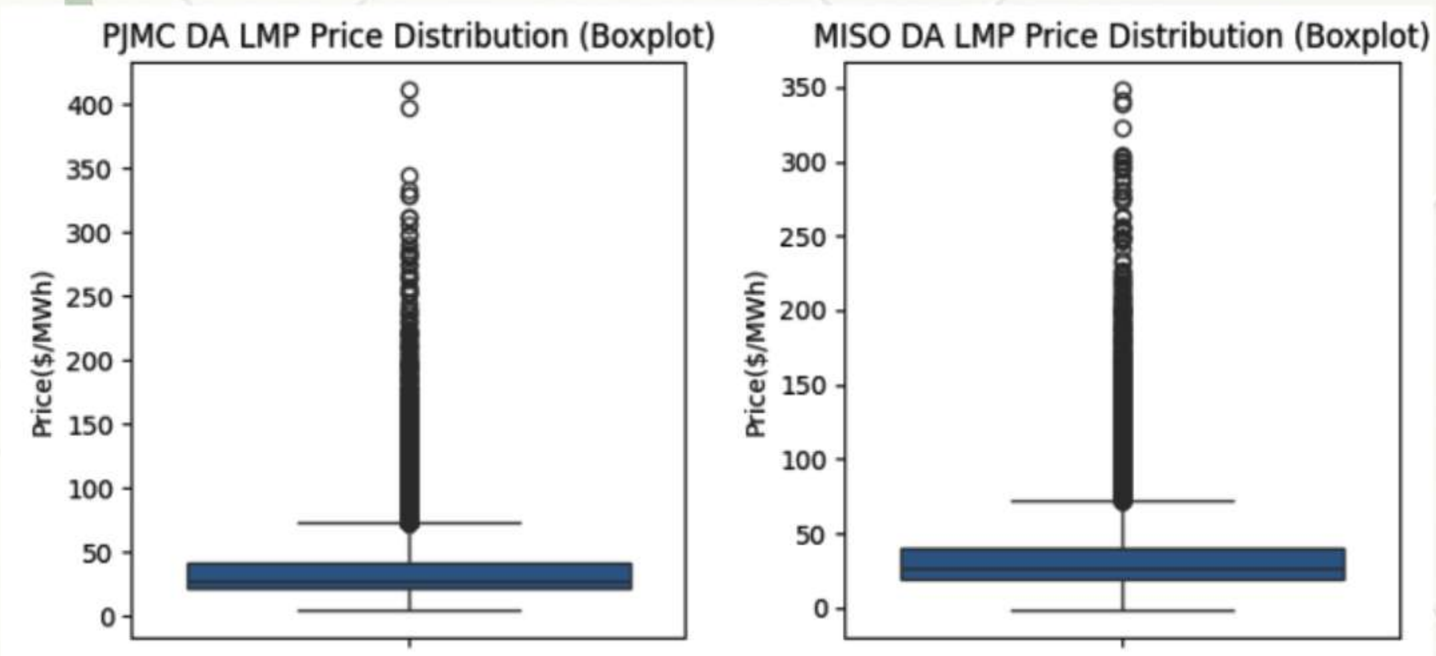
Energy Price in both markets from 2020 to 2022



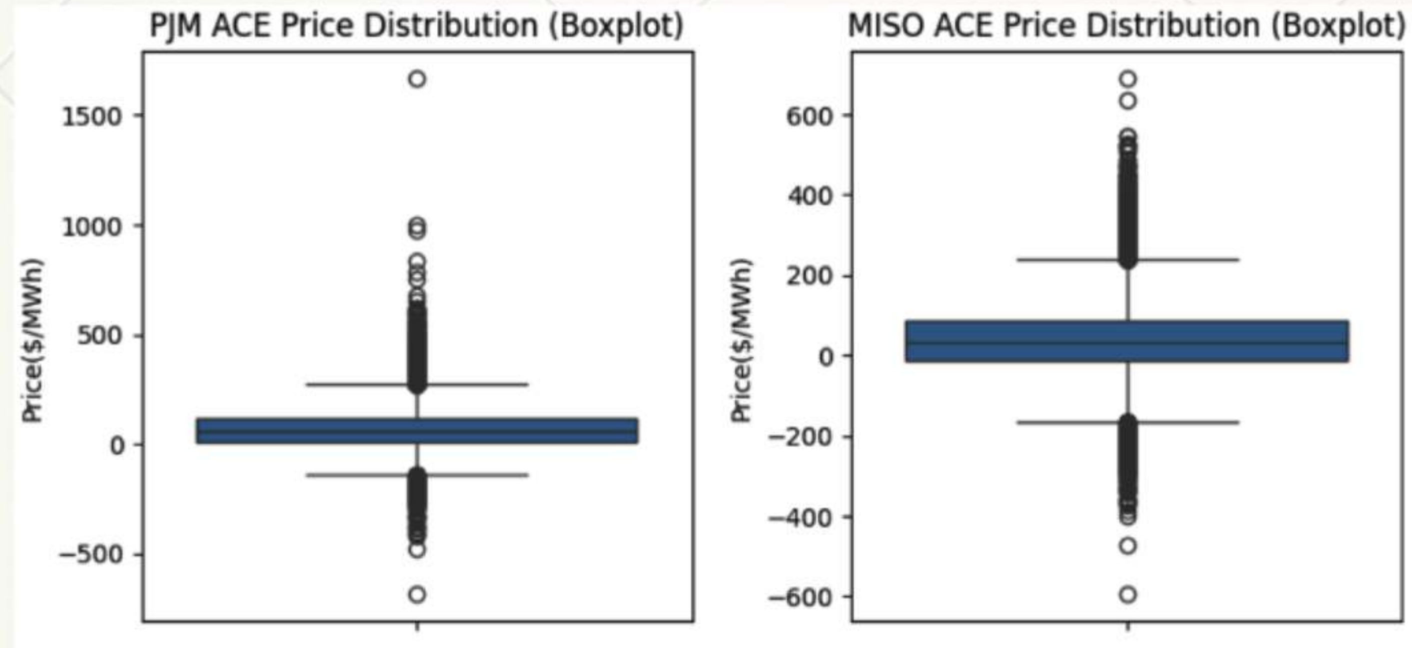
Energy Load in both markets for 2020 to 2022



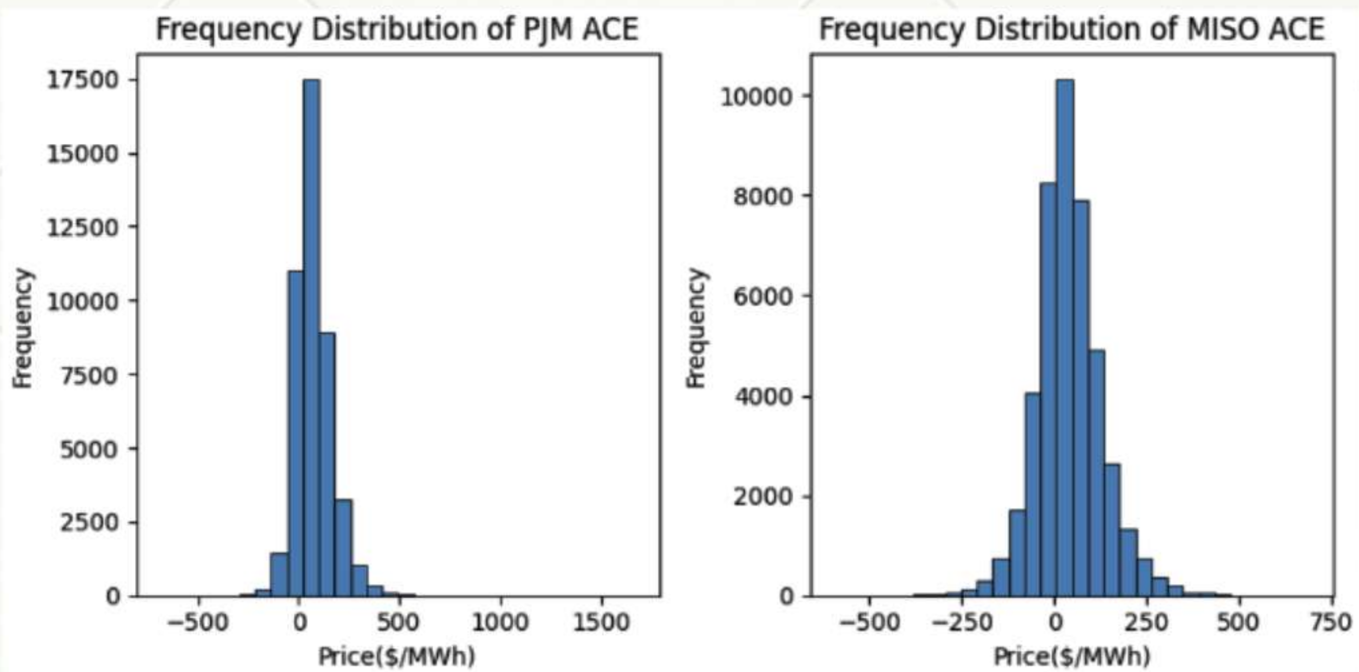
Day-Ahead LMP Price Distribution (PJMC & MISO)



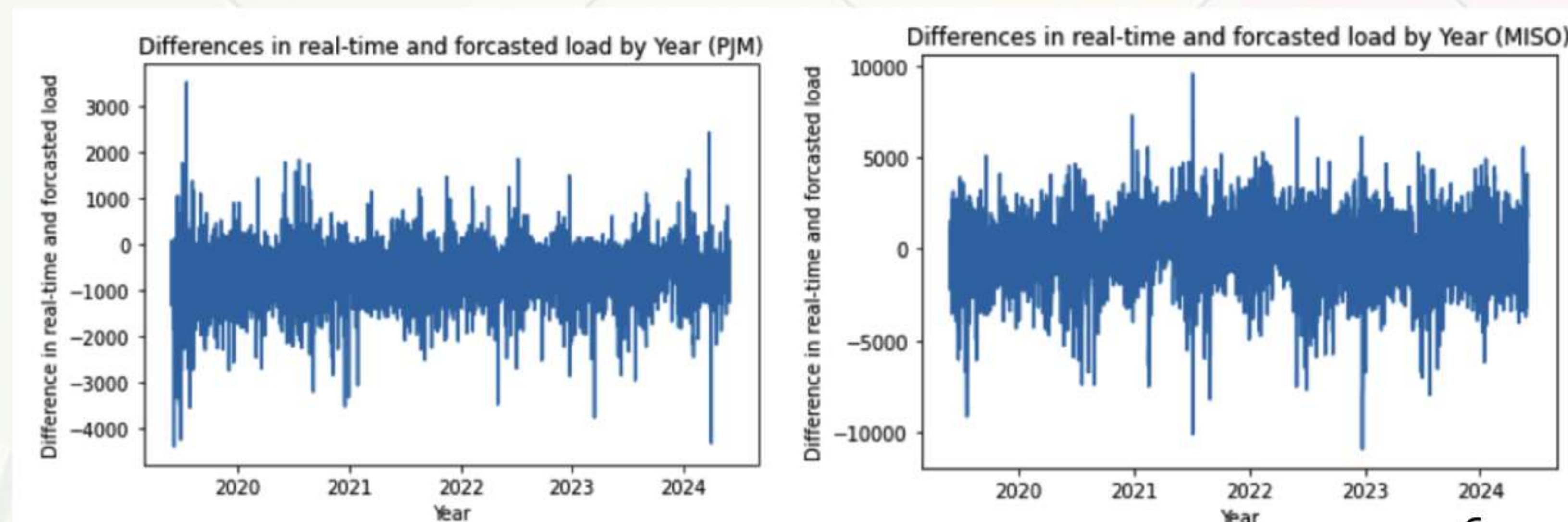
ACE Distribution Comparison (Grid Stability)



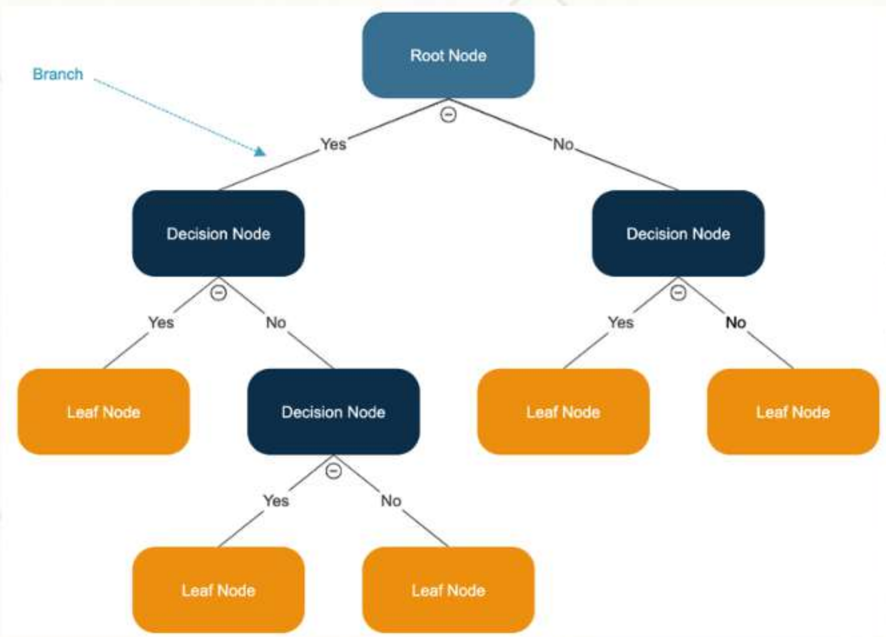
ACE Distribution – Histogram (Grid Stability)



Forecast Error in Electricity Load



Classification Model: Decision Tree



Predict by classify realtime electrical loads in MISO & PJM grids

Real-time electricity load in **both markets** will be divided into **3 classes: Low, Medium and High Demand** and the model structures data in tree-like branches of decisions with their possible consequences

The model then categorizes **target variable** into predefined classes based on the **input features.**

Components

Nodes that form the decision points
Branches represent the choices leading to different outcomes
Leaf nodes provide the final outcomes or decision results

MISO's Model Features

PJM RT LOAD
PJM LOAD FC
Real time and forcasted electric load

MISO DA GAS
Day-ahead supply by gas plants

Central RT Load
Real-time electrical load of the central region

PJM's Model Features

MISO RTLOAD
PJM/MISO RTLOAD
Real-time electrical load and differences across both grids.

MISO West Load
Real-time electrical load of the MISO west region

MISO Gas Gen
MISO Coal Gen
Electricity generated by Coal and Gas plants

Fine Tuning and Feature Optimization

3 steps process

Fit model with all possible features

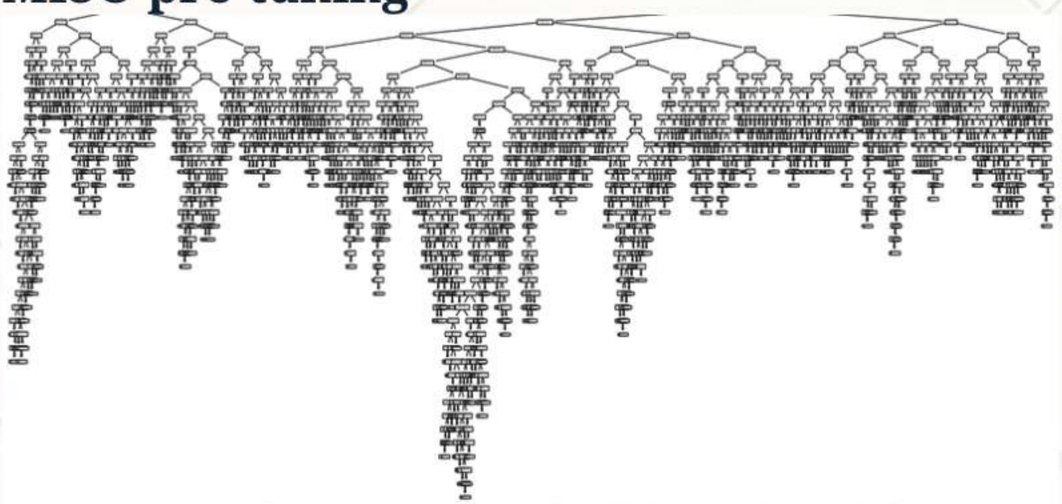
Model parameters tuning

Improve Overfitting

Find optimal selection of features

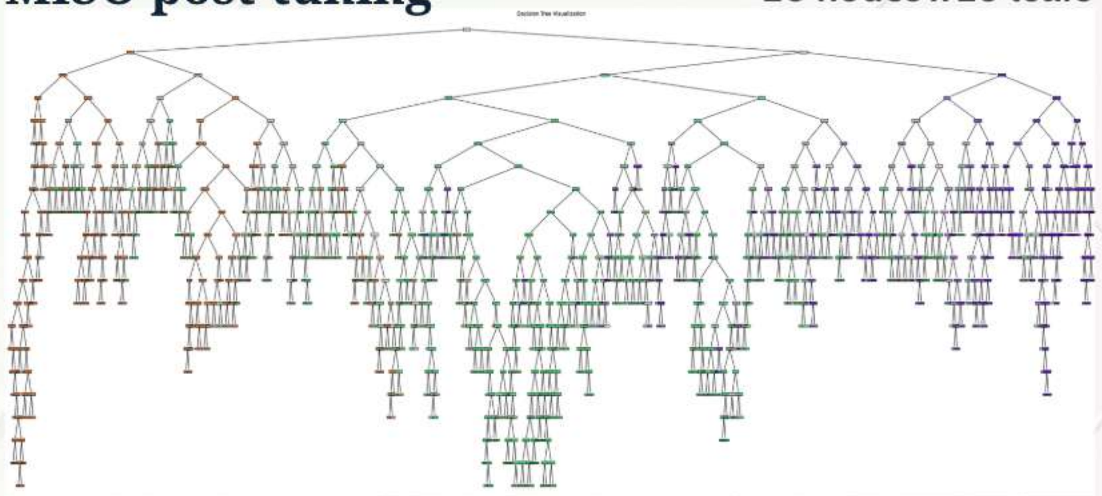
Through **RFE** (Recursive Feature Elimination Process)

MISO pre-tuning



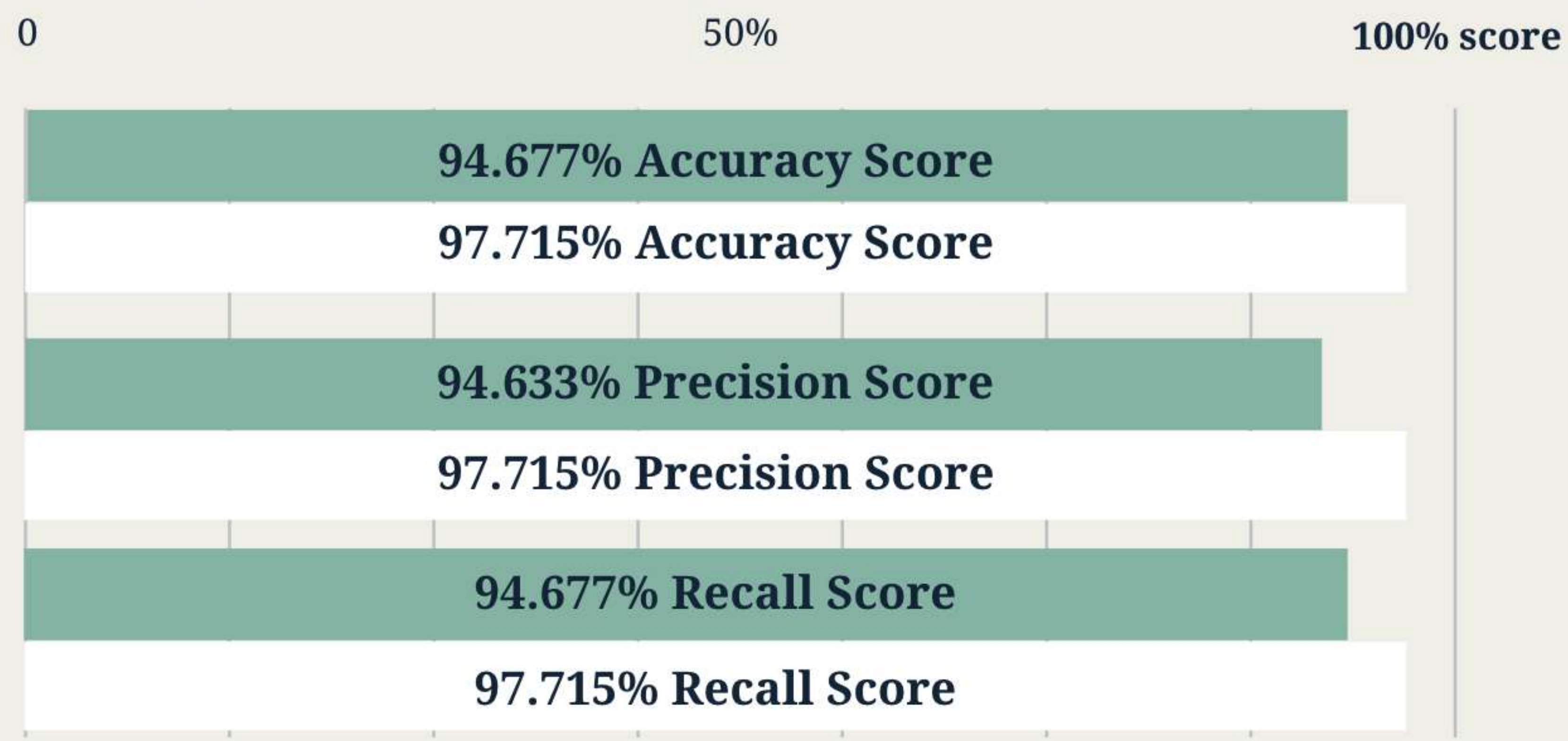
MISO post-tuning

20 nodes x 10 leafs



Classification Models Performance

MISO and PJM Test Set Result



Legends

MISO model

PJM model

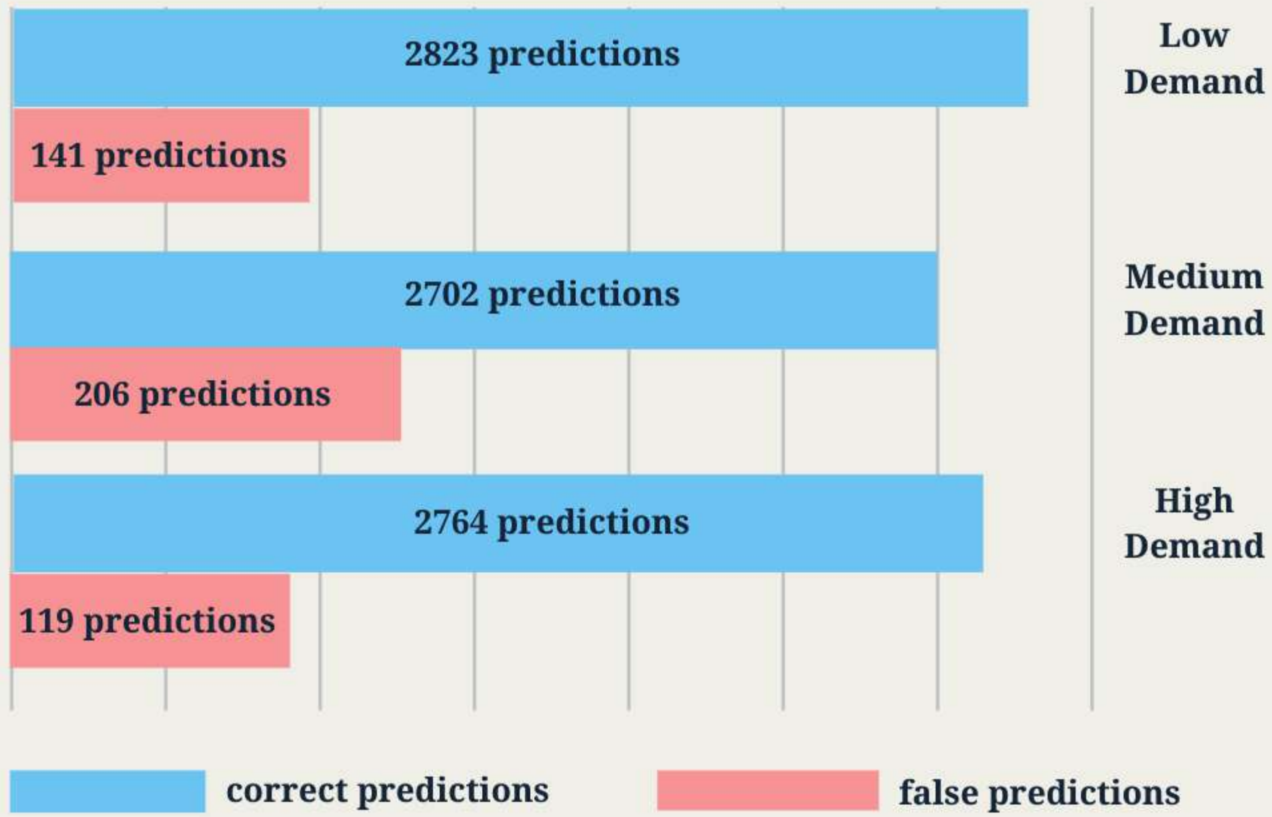
Observation

Both models are highly effective in predicting the correct demand categories across **almost all cases.**

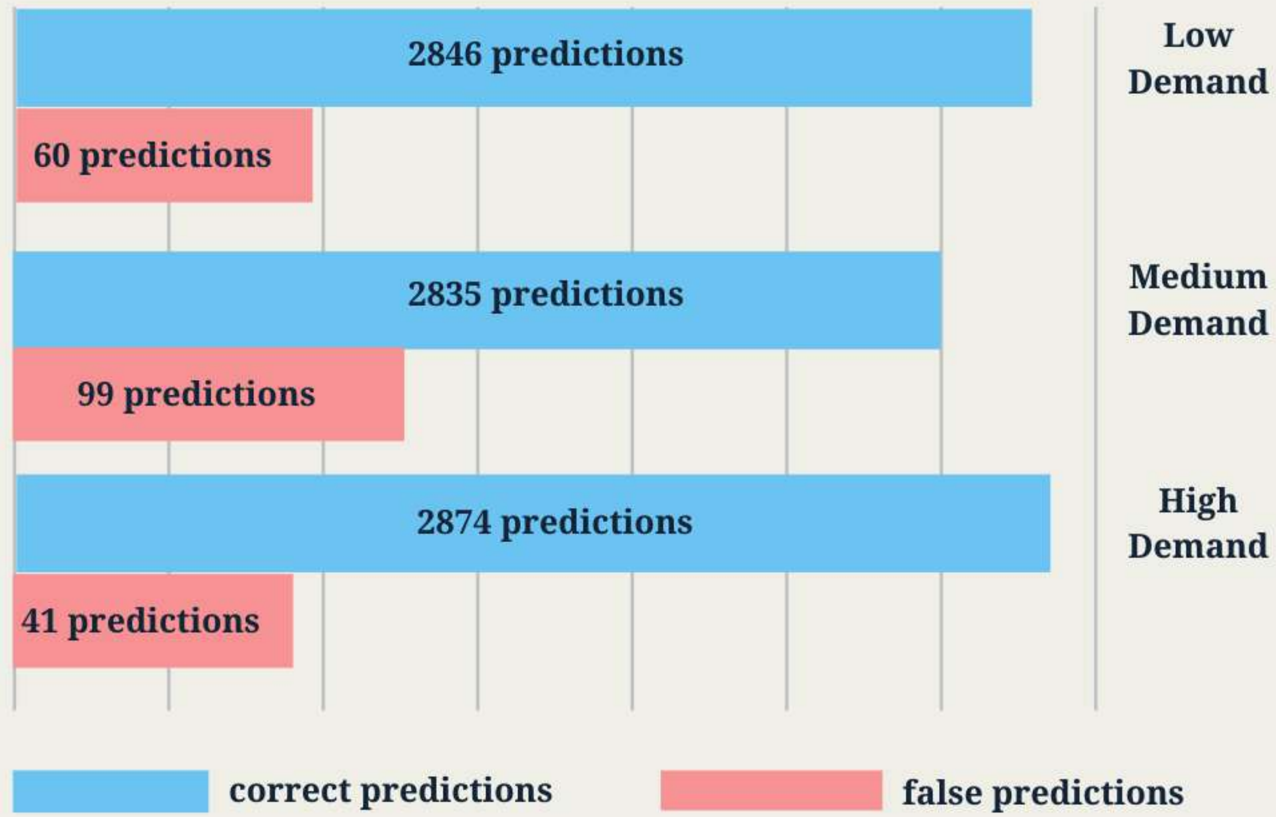
With **high percision** and **recall scores**, both model minimize the number of irrelevant cases that are incorrectly identified **(extreme outliers)**

Classification Model **Performance**

MISO Confusion Matrix Result



PJM Confusion Matrix Result



Regression Model : Predict MISO Electricity Price

Feature Selection

- Select features that is highly related to price
- Dropped features with corr > 0.85 to prevent multicollinearity

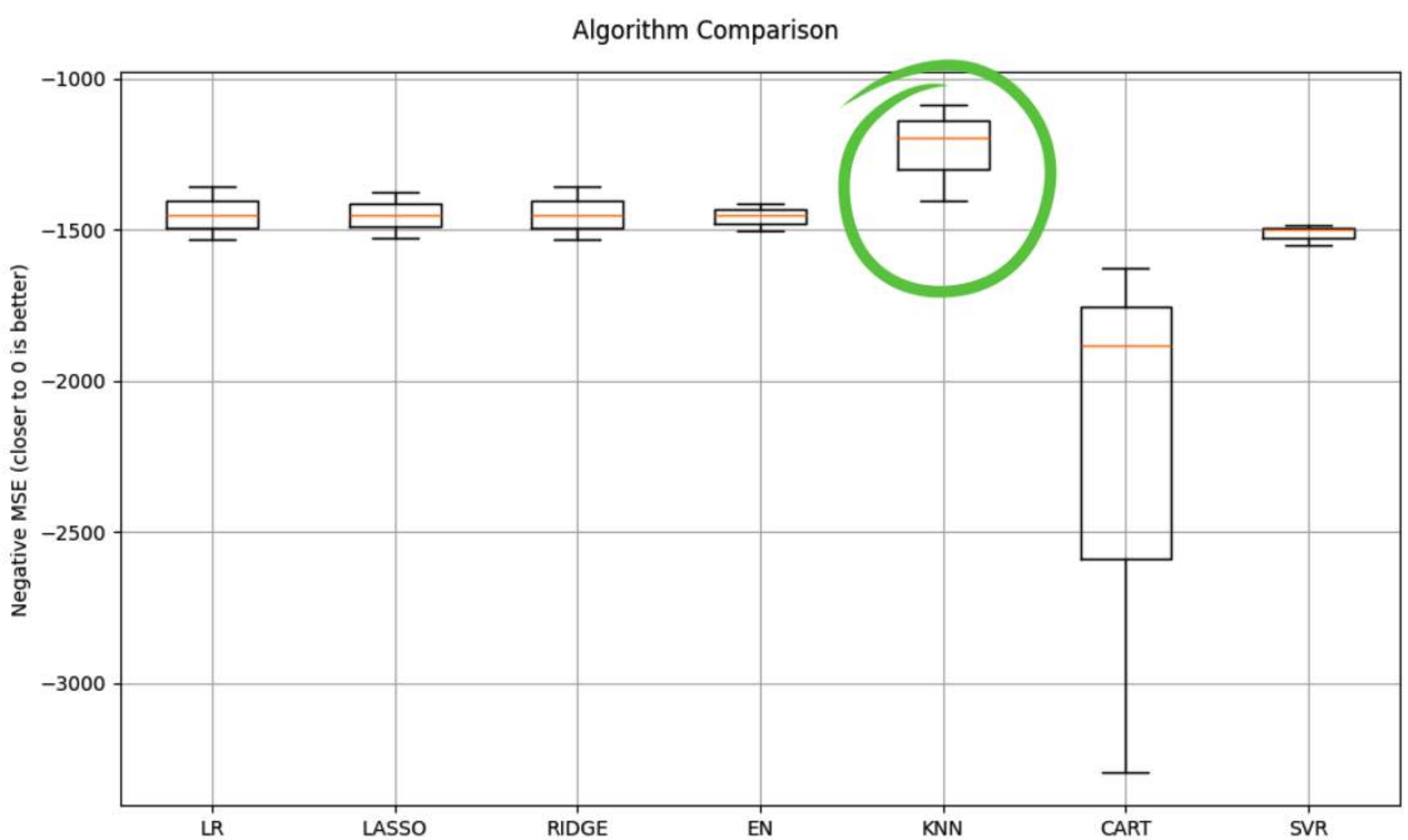
Selected Features

- MISO GAS GEN: Natural Gas Power Generation
- MISO COAL GEN: Coal-fired Power Generation
- MISO Hydro Gen: Hydroelectric Power Generation
- MISO RTLOAD: Real-Time Load
- MISO RT CONG: Congestion Cost
- MISO/PJMC RT CONG: Difference in Real-Time Congestion Cost

Data Preparation

- Convert to numerical format
- Rescale to equalize feature influence
- 80% training & 20% testing

Regression Model : Predict MISO Electricity Price



Best model: KNN
- **Mean MSE: 1227.92**
- **Std Dev: 132.20**

Worse model: CART
- **Mean MSE: 2144.48**
- **Std Dev: 827.90**

KNN Model Tuning & Results

Regression

- **Goal: Use '*GridSearchCV*' to test values of k from 1 to 20, and find the nearest K for KNN regression**
- **Performance was measured using Mean Squared Error (MSE) — lower the better**

2 step process → **80% for training** → **20% for testing** → **Results**

KNN Model Tuning (Using GridSearchCV) & Results

Part 1: 80% for training (to teach the model)

- **Tune model - Choose the best k**
- **Best MSE:1152.509952 using K=16**
- **This value gave the lowest average MSE across all training folds. The final model was trained using 16 nearest neighbours.**

Part 2: 20% for testing (to check how well it learned)

Predictions Results:
[21.91, 35.43, 26.14, 20.68, 46.30, 45.80, 27.98, 26.84, 15.38, 34.83]

Actual Results:
[21.04, 20.62, 18.48, 14.78, 48.82, 52.19, 27.58, 25.23, 14.77, 35.97]

A few predictions are off by margin (e.g., 35.43 vs 20.62, 45.80 vs 52.19).

Test MSE: 2770.76

Results from regression

Trained MSE < Test MSE
1152.51 < 2770.76

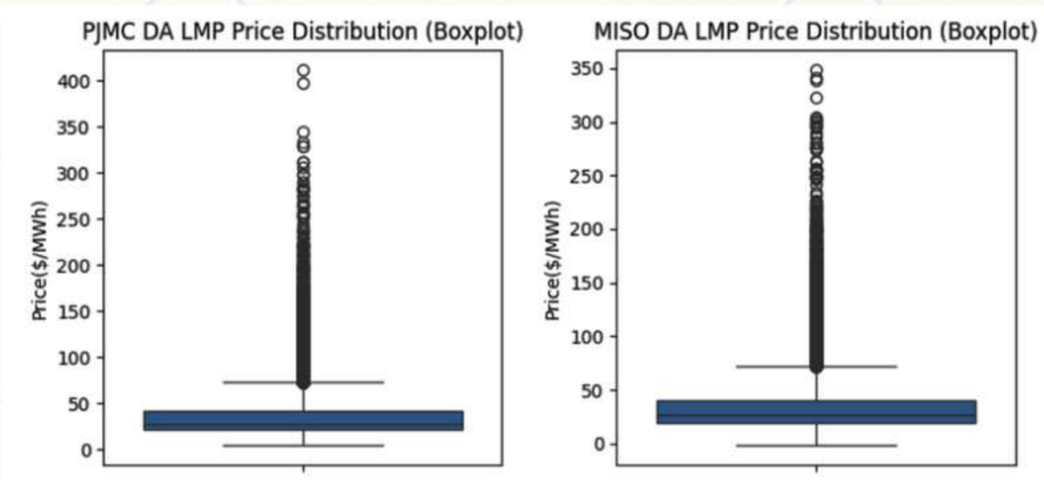
- **Overfitting** - Memorize training data instead of realistic patterns

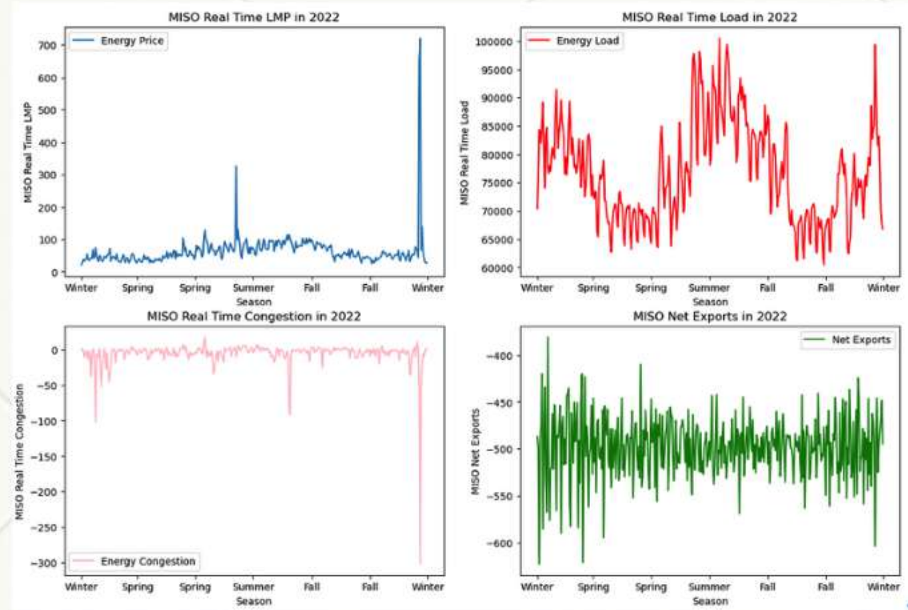
- Prediction results were relatively accurate compared to the actual results, indicating some patterns captured from the data

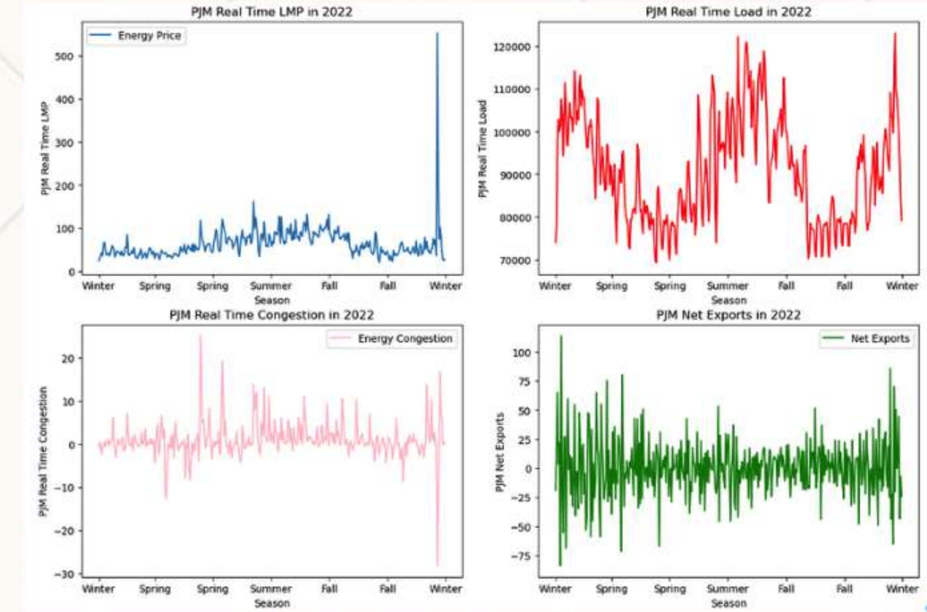
Link back to our objective:

- The model performs well on the training data and shows some accurate predictions on the test set
- However, due to the high test MSE, its real-world forecasting ability is limited at this stage.

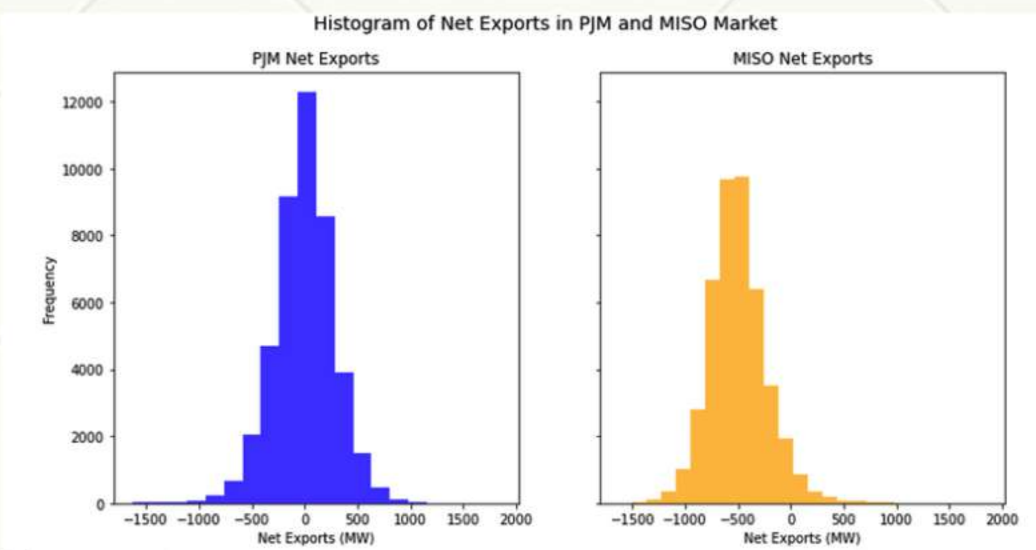
- **Our Goal: Forecast electricity demand and prices in the PJM and MISO markets**







Summary & Conclusion



Key Finding:

- **Electricity loads are seasonal (summer and winter)**
- **Price volatility is high and unpredictable**
- **PJM has more stable congestion forecasts**
- **MISO shows more efficient grid control (based on ACE)**

Thank You!