Predict New England's Electricity Demand with Deep Learning

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Background

As clean energy demand grows, accurate electricity forecasting becomes essential for grid operators like ISO New England to ensure reliable, efficient power delivery. Our project uses advanced demand forecasting to help ISO-NE **manage peak loads**, **prevent power shortages**, and **optimize grid operations**.

Broad Applicability:

While this project focuses on New England, our model can be adapted for other regions, such as California (CAISO), New York (NYISO), and Texas (ERCOT). By incorporating regional weather and demand patterns, our approach can help grid operators across the U.S. **manage aging infrastructure**, **balance supply and demand**, and **enhance grid stability** in a variety of climates and energy markets.

Key Benefits:

- **Reduced Strain on Infrastructure:** Helps extend the life of aging transmission lines by forecasting peak loads accurately.
- **Improved Grid Stability:** Enables better balance of supply and demand, preventing disruptions and blackouts.
- **Cost Savings:** Efficient resource allocation reduces operational costs.
- **Profit Opportunities:** Supports strategic energy buying and selling based on accurate demand predictions.

Data Selection

We obtained **15.6 MB** of historical electricity load data from ISO New England (ISO-NE) and sourced weather data from external platforms to enhance future demand predictions. Through web scraping, we compiled an extensive weather dataset spanning January 1, 2018, to September 30, 2024, including:

- **Temperature**: Capture seasonal & daily changes.
- **Dew Point**: Temperature where air saturates, reflecting humidity's impact on energy demand.
- **Weather Conditions**: General conditions (e.g., sunny, cloudy, rainy) influencing electricity use.

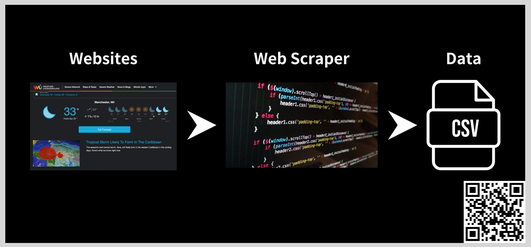
In addition to weather data, we included calendar-based variables:

- **Month**: Capturing seasonal demand fluctuations.
- **Day of the Week**: Numbers one to seven, capturing weekly demand patterns.
- **Holiday Indicator**: Identifying public holidays with unique demand characteristics.

Together, these datasets form a robust foundation for forecasting New England's electricity load, capturing weather and calendar influences.

Weather Data Scraping

To enhance demand forecasting, we used Python to collect historical weather data from websites.

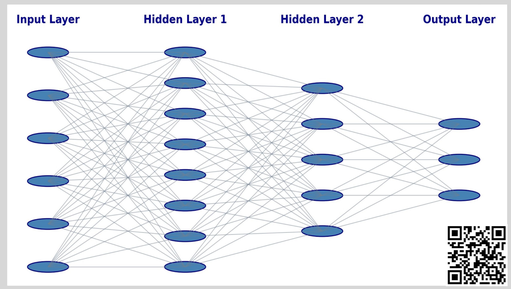


Methods

To develop a reliable electricity load forecasting model, we applied several machine learning and deep learning techniques, including:

- **Random Forest**: An ensemble method that improves accuracy and reduces overfitting.
- **K-Nearest Neighbors (K-N-N)**: Predicts load based on similarity to historical data.
- **Multilayer Perceptron (MLP)**: A deep learning model with multiple layers to capture complex patterns.

Through comparative analysis, we found that the **Multilayer Perceptron (MLP)** model yielded the best results, offering the highest accuracy in predicting electricity load based on historical and weather data.



Model Preprocessing

- **Feature Scaling & Encoding**: Standard scaling and one-hot encoding ensure stable training.
- **Neural Network Architecture**: 449 input neurons with hidden layers (64, 32, 16) for key patterns.
- **Dropout Regularization**: Prevent overfitting, letting the model generalize better to unseen data.
- **ReLU Activation**: Adds non-linearity, enabling the model to learn complex relationships in load data.
- **Target Normalization**: Stabilizes training and captures relative demand patterns.

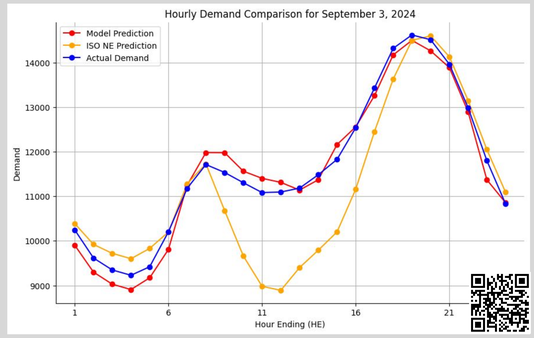
This preprocessing pipeline and neural network architecture help enhance model performance and ensure accuracy in load forecasting.

Hourly Performance

In our analysis, we identified distinct load patterns between weekdays and weekends:

- **Weekdays**: Typically exhibit higher, more predictable fluctuations due to regular work and business activities.
- **Weekends**: Show a different, often less variable load profile with unique demand characteristics.

By adapting our model to these patterns, we achieved a more nuanced understanding of electricity load behavior, ultimately enhancing the predictive performance across various time periods.

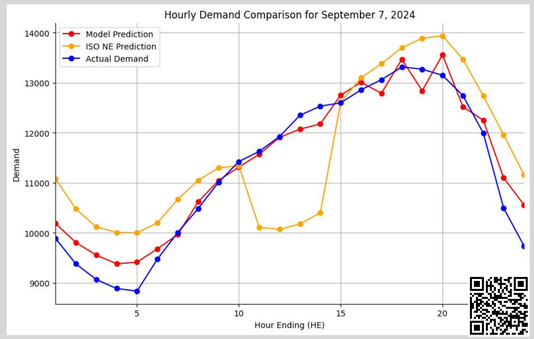


Weekday Load Demand Comparison: **Sep 3, 2024**

Key Insight: Our model provides a closer match to actual demand, with a **75.08% improvement in accuracy** over ISO-NE's forecast.

Results:

- RMSE (Our Model): **257.00**
- RMSE (ISO-NE): **1031.44**



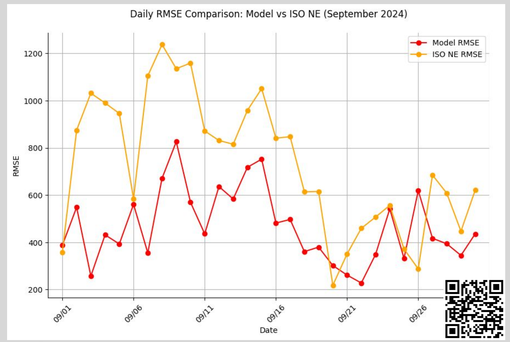
Weekend Load Demand Comparison: **Sep 7, 2024**

Key Insight: Even for weekend patterns, our model outperforms ISO-NE's forecast, showing greater alignment with actual demand, with an **RMSE improvement of 45.79%** over ISO-NE.

Results:

- RMSE (Our Model): **670.71**
- RMSE (ISO-NE): **1237.36**

Daily Performance



Key Insights:

- **Overall Performance**: Our model achieves an RMSE of **492.52**, which is **37.2% lower** than ISO NE's RMSE of **784.52.** This significant reduction in RMSE indicates a substantial improvement in prediction accuracy.
- **Daily Consistency**: The chart shows our model consistently outperforms ISO-NE in most days, with fewer peaks in RMSE values, suggesting it handles daily demand fluctuations more effectively.

Conclusion and Recommendation

We demonstrates the effectiveness of integrating weather data and Multilayer Perceptron, to improve electricity load forecasting. This project enhances grid reliability and is scalable for broader applications.

Recommendations:

- **Expand Data Integration**: Add detailed electricity load-related data to improve forecasting accuracy.
- **Scale Regionally**: Use this method in other regions to improve resource use and grid stability.

References

ISO New England. ISO New England - Independent System Operator of New England. https://www.iso-ne.com/

Weather Underground. Local Weather Forecast. https://www.wunderground.com/

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