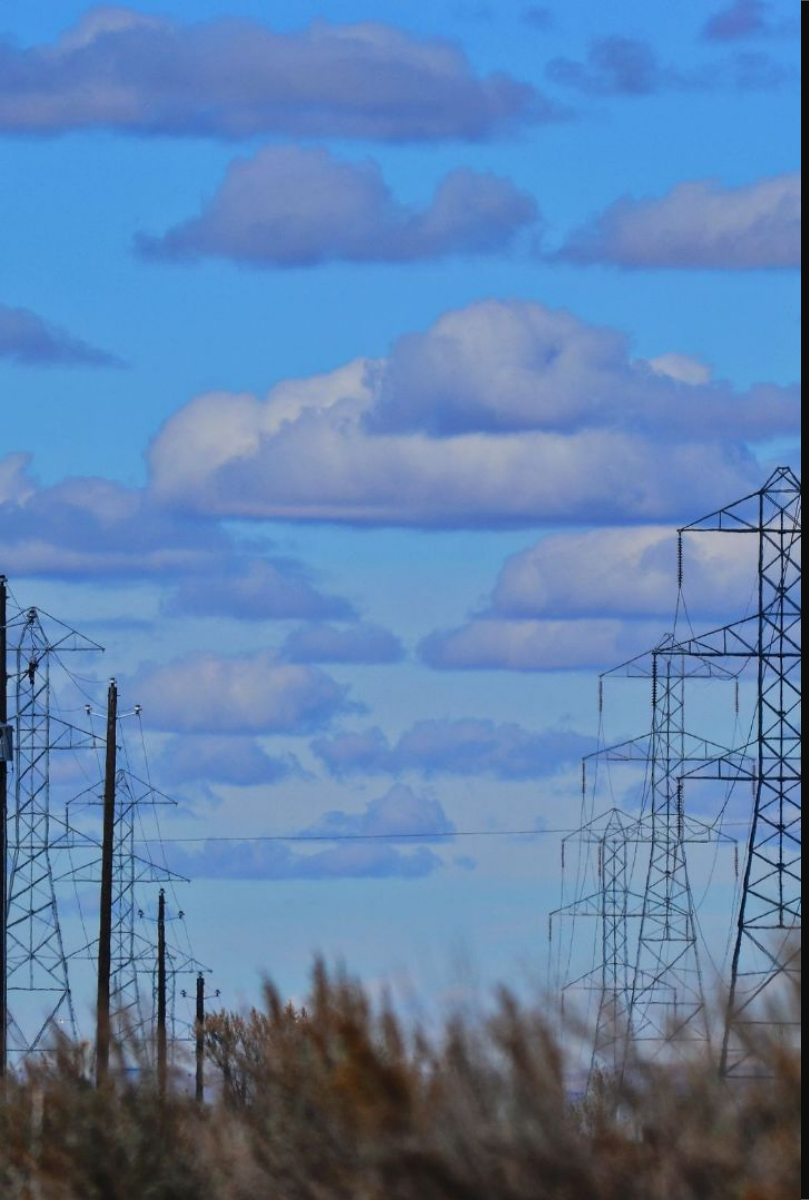
Time Series Analysis of Electricity Demand in Great Britain

Explore the fascinating world of electricity demand in Great Britain using SARIMA and Prophet models. Uncover valuable insights into the nation's energy landscape.

G **by Gary Waiyaki**

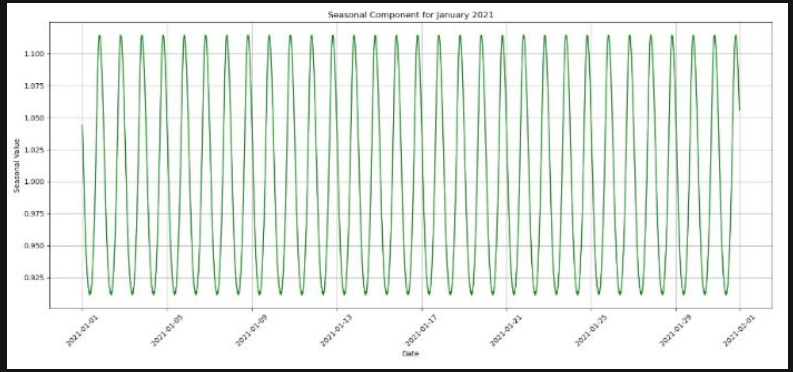


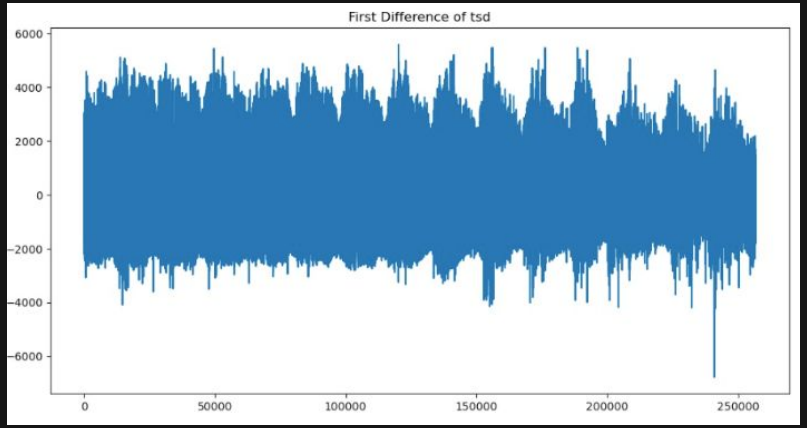
Introduction

Electricity demand forecasting is crucial for efficient power grid operation and planning in Great Britain. In this report, we use SARIMA and Prophet models to provide a comprehensive analysis and forecast of electricity demand in the country.

Methodology: Data Processing

We sourced the National Grid ESO dataset capturing electricity demand in Great Britain from 2009 onwards. We addressed missing values and rectified potential outliers to ensure data consistency and reliability.





Decomposition shows daily seasonality

A decomposition of the time series data was conducted, revealing strong daily seasonal variations, underpinning the importance of considering seasonality in our subsequent modeling.

Differencing time series data

To prepare for time series forecasting, especially for the SARIMA model, we applied differencing to achieve data stationarity, which was confirmed through the Augmented Dickey-Fuller (ADFuller) and KPSS tests.

Model Selection

1

SARIMA Model

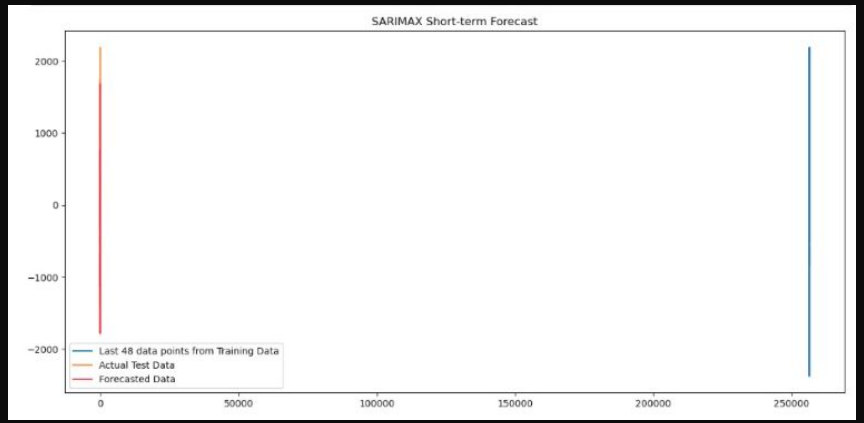
We employed the SARIMA model to forecast Great Britain's electricity demand, leveraging its effectiveness in managing the data's pronounced seasonality. To mitigate computational limitations, we narrowed our dataset to the most recent 1000 data points. Subsequently, we optimized SARIMA parameters using the auto_arima function and trained the model on 80% of the data, enabling us to generate forecasts for the remaining 20%.

2

Prophet Model

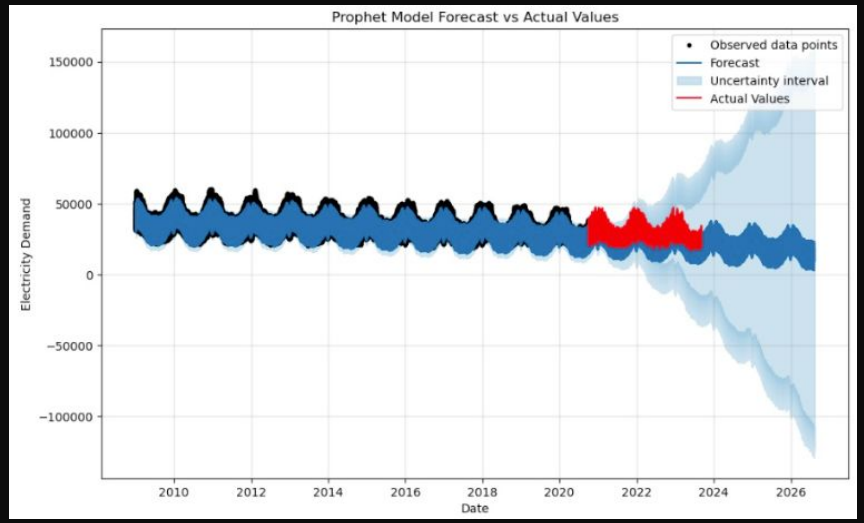
We harnessed the power of the Prophet model, developed by Facebook, to effectively capture daily, weekly, and seasonal patterns in electricity demand, all while benefiting from its capacity to handle large datasets without any subsetting. Additionally, we enriched its forecasting capabilities by incorporating the 'is_holiday' feature from our original dataset, allowing the Prophet model to consider holiday effects and provide an alternative approach to forecasting electricity demand in Great Britain.

Visual Analysis and Evaluation



SARIMA Model Visual Analysis

- The forecasted data (in red) aligns closely with the actual test data (in orange), particularly at the beginning. As the forecast progresses, one might expect potential divergence due to inherent uncertainties in distant predictions, but this isn't evident here. Minimal visible gaps between the two lines suggest the model's high predictive accuracy.



Prophet Model Visual Analysis

- The Prophet forecast is depicted in blue, with uncertainty intervals in light blue, while the actual test values are in red. Their close alignment indicates that the Prophet model effectively captured the underlying data patterns, providing an accurate prediction of electricity demand within the test set's timeframe.

Modeling and Results

1 SARIMA Model

The SARIMA model showcased strong prediction abilities, achieving an RMSE of 411.27, representing only 1% of the data range. This low error shows high accuracy in its forecasts.

2 Prophet Model

The Prophet model, which was fine-tuned with seasonal holiday patterns, yielded a higher RMSE of 10881.93. Although proficient at predicting demand trends, when compared to the SARIMA model's precision, the SARIMA model emerged as the more precise model.

Limitations

1

SARIMA Model Assumptions

SARIMA assumes linearity and was limited to a subset of the data due to computational constraints. It might not fully capture the non-linear complexities of electricity demand.

2

Prophet Model Simplifications

The binary nature of holiday effects in the Prophet model oversimplifies their actual impact on electricity demand. It's important to consider other factors that affect demand during holidays.

3

Long-term Predictions

Long-term predictions for electricity demand, influenced by societal and technological trends, were not explored in this analysis. Further research is needed to understand future demand scenarios.

Recommendations

1

Integration of Multiple Models

While both SARIMA and Prophet demonstrated commendable forecasting capabilities, an ensemble approach like XGBoost—integrating forecasts from multiple models—could potentially enhance precision and account for diverse data characteristics.

2

Incorporating External Factors

To further refine forecasts, it is essential to incorporate external factors such as severe weather conditions or major events that influence electricity demand fluctuations.

3

Periodic Retraining

Models should be periodically retrained to remain attuned to the current state of the power system, accounting for any changes in demand patterns or system dynamics.

Conclusion

1 Strong Seasonality

Electricity demand in Great Britain exhibits consistent daily, weekly, and yearly patterns. Understanding and accounting for this seasonality is crucial for effective demand management.

2 Effect of Holidays

Holidays significantly influence electricity demand, leading to noticeable variations in consumption. Considering holiday effects is vital for accurate demand forecasting.

3 Model Predictions

The SARIMA model provides reliable short-term forecasts for electricity demand in Great Britain. While the Prophet model is competent, it is less precise compared to SARIMA model.

4 Long-term Predictions

While our models provide a reliable forecast in the short-term, predicting further into the future is more uncertain, especially considering potential broader societal and technological shifts. Future analysis should explore these dynamics in more depth.

The Future of Electricity Demand

As societies and technologies evolve, the future of electricity demand in Great Britain will be shaped by factors such as the rise of smart cities, advancements in electric transportation, and innovative energy storage solutions. Therefore, to meet this future demand collaboration among stakeholders such as the National Grid ESO, policymakers and energy companies must begin the work of:

- Maintaining a sustainable power grid:
    - Incorporating renewable energy sources and ensuring accurate electricity demand forecasting are key strategies for maintaining a sustainable power grid in Great Britain.
- Ensure efficient resource utilization:
    - Accurate electricity demand forecasting helps maximize the utilization of renewable resources, minimizing waste and optimizing the efficiency of the energy grid in Great Britain.
- Adapt to changing energy demands:
    - The growing adoption of renewable energy impact energy demand. Recognizing this shift is crucial for planning and operations.
    - Ongoing technological advancements and innovations in the energy sector will continue to influence electricity demand, requiring continuous monitoring and analysis.