AEP Electricity Forecast: Phase 2

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Table of Contents

AEP Electricity Forecast: Phase 2

Overview

Deregulation in the energy industry allows consumers to choose suppliers, increasing market competition. Accurate demand forecasts help suppliers like AEP meet consumer needs and plan expenses. Our team forecasted AEP's hourly energy load for the Appalachian Power transmission zone from October 12, 2023, to October 18, 2023.

We developed a prophet model and an auto-regressive neural network model to forecast future energy load values. The prophet model forecast had a 4.58% mean absolute percent error (MAPE) and 173.50-megawatt mean absolute error (MAE) on the test data, outperforming the neural network forecast's 5.68% MAPE and 214.19-megawatt MAE.

Methodology & Analysis

Data Used

We received hourly metered energy data from the AEP Appalachian Power transmission zone. Our model underwent training using data from January 1, 2016, to October 4, 2023, and was validated using data spanning October 5, 2023, to October 11, 2023. Because of daylight savings, the data included duplicate and missing observations in some hours, which we addressed by mean-imputing energy values for those observations.

Model Development

We tuned our forecast models using the week of data from the validation set. We selected the best prophet model by developing and testing prophet models with different seasonal and holiday effects. The best-performing prophet model included two Fourier terms and hourly intervention variables to account for unusual past events. Validation MAPE was 4.64%.

Before fitting the neural network model, we used a Canova-Hansen test to determine the nature of the seasonality effect. The test indicated that hourly transmission load followed a stochastic seasonal pattern. Therefore, we seasonally differenced the data before applying the neural network.

We selected the number of autoregressive terms in the neural network by iterating through different model versions and comparing MAPEs on the validation set. The best-performing neural network model included three AR lags and three seasonal AR lags. The validation set MAPE was 9.02%.

Results & Recommendations

Model Evaluation

Table 1 displays the MAPE and MAE of our two models forecasted on the test data. The prophet model achieved a MAPE of 4.58% and an MAE of 173.50 megawatts, compared to the neural network model MAPE of 5.68% and MAE of 214.19 megawatts.

Table 1: Test Accuracy Metrics for Prophet and Neural Network Models

Model	MAPE	MAE (mw)
Prophet	4.58%	173.50
Neural Network	5.68%	214.19

We recommend deploying our prophet model over our neural network model because of its superior performance on both the validation and test data. This model is expected to forecast energy load with about 4.58% mean absolute percent error over the week-long period. This forecast will allow the AEP to manage operational expenses and align its operations to meet customer demand.

The prophet model was our best-performing model based on MAPE, but as is seen in the prophet plots below, the prophet forecast notably underpredicts actual energy usage. On the other hand, the neural network model overpredicted energy use in the first four days of the forecast. A review of AEP's 2022 Annual Report indicates that the cost of underpredicting energy load is not substantially different from the cost of overprediction (page 60, see Appendix 1). Therefore, we believe the prophet model remains the superior model.

Figure 1 and Figure 2 display the forecasted energy usage of the prophet and neural network models.

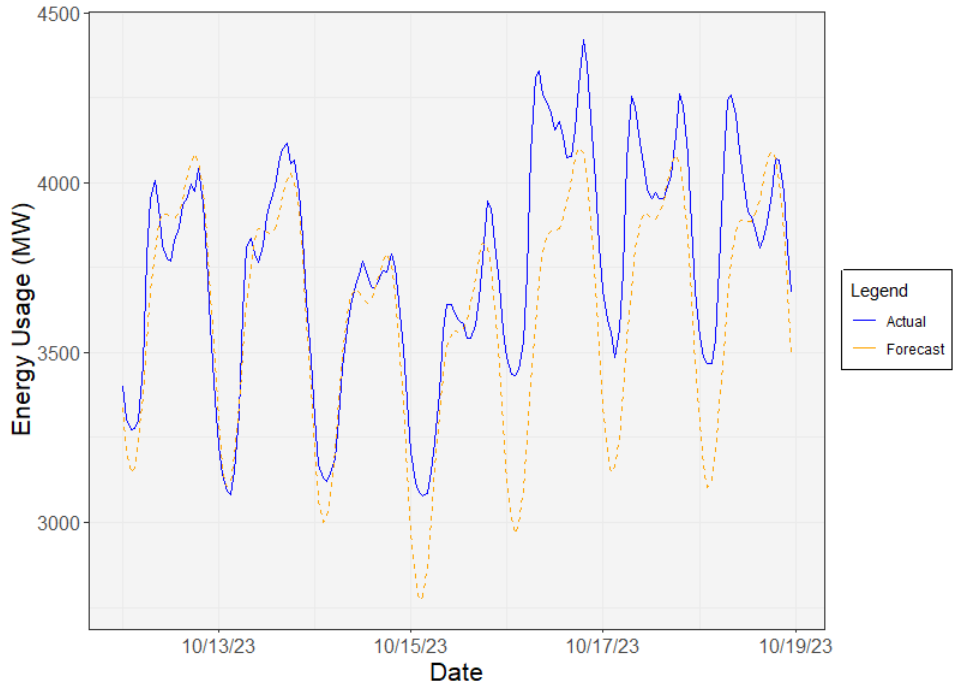

Figure 1: Prophet Model Forecast

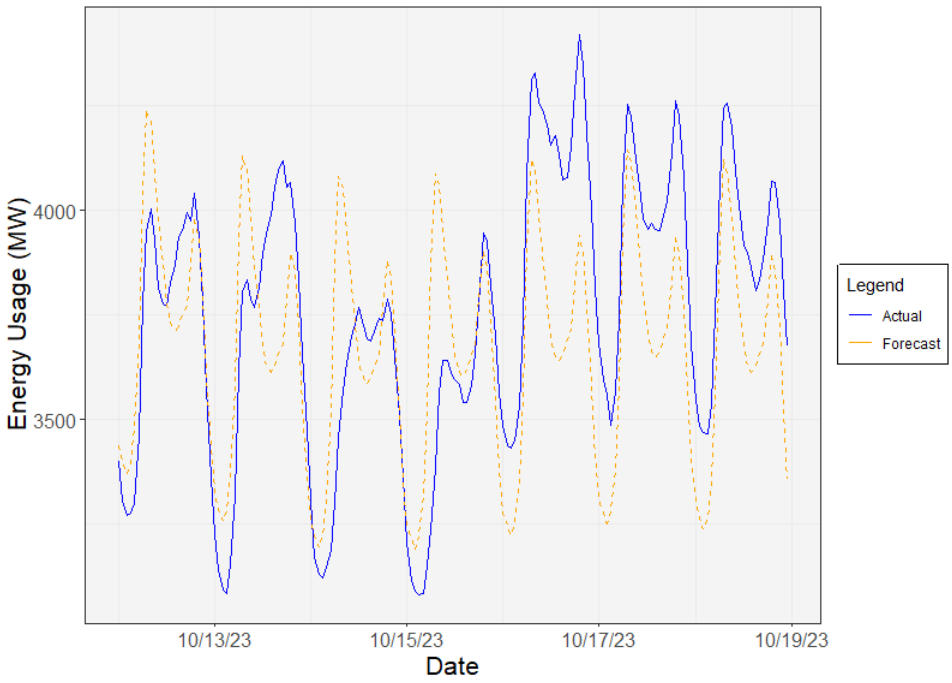

Figure 2: Neural Network Model Forecast

Conclusion

To forecast AEP's hourly energy load, we developed a prophet model and an autoregressive neural network model. We recommend the prophet model because it performed better than the neural network on the test data, with a MAPE of 4.58% and an MAE of 173.50 megawatts.

We suggest two areas of exploration for future modeling. A prophet model may improve upon these results by including different holiday effects. In addition, because the two models performed differently at different points within the forecast, an average of the forecasts would likely provide the most accurate results.

Appendix

Appendix 1

https://www.aep.com/assets/docs/investors/AnnualReportsProxies/docs/22annrep/2023ProxyAppendixA.pdf

Sections & Structure

Overview

JB	Is the overview concise?
JB	Does it provide context about the business problem? <Content>
JB	Does it briefly address your team's work, quantifiable results, and recommendations? <Action>
JB	Does it offer audience-centered reasons for recommendations? <Context>

Body Sections

JB	Does the report body include information on methods, analysis, quantifiable results, and recommendations?
JB	Is content grouped into appropriate sections (*methodology*, *analysis*, *results*, *recommendations*)?

Conclusion

JB	Does the report have a conclusion?
JB	Does the conclusion sum up the report and emphasize relevant takeaways?

Structure

JB	Does each major section have a heading?
JB	Are sections, subsections, and paragraphs organized logically for easy navigation?

Visuals

Introduction, Discussion, and Captions

JB	Is each visual introduced in the text before it appears?
JB	Is each visual close to where it is introduced?
JB	Does each visual include a title with the following information: type (*table* or *figure*), number, and a descriptive caption?
JB	Is each visual discussed and interpreted in the text?
JB	Are figures and tables numbered separately?
JB	Are table captions above the table? Are figure captions below the figure?

Visual Design

JB	Do figures/tables use audience-friendly labels rather than variable names?
JB	Are the visuals easy to interpret?
JB	Are the visuals appropriately sized?
JB	Do tables appear on one page (*not split between 2 pages*)?
JB	Are legends and axis labels included for figures?
JB	Are numbers in tables right aligned?
JB	Are the visuals designed well (*ex*: *re-created in Word or Excel*, *not blurry or stretched*,…)?

Document Design

Title Page Design

MK	Does it include a descriptive title?
MK	Does it state the team name, team members' names, and the submission date?

Table of Contents Design

MK	Does it list all the major sections of the report with corresponding page numbers?
MK	Do the page numbers and sections in the Table of Contents match the report?

Document Design for Entire Report

MK	Is a standard typeface (*Calibri*, *Arial*, *etc.*) used?
MK	Is the size of the body text between 10-12 pt.?
MK	Are headings and subheadings used to organize information?
MK	Are distinctive text styles (*bold*, *italic*, *etc.*) used to distinguish between heading levels?
MK	Are text styles for headings used consistently (*ex*: *all level-one headings are bold*)?
MK	Are all paragraphs an appropriate length (*fewer than 12 lines*)?
MK	Is white space used to indicate paragraph breaks?
MK	Are bullet lists used for a series of items and numbered lists to show a hierarchy?

Writing Style and Mechanics

Spelling and Capitalization

MK	Are spelling errors located and corrected?
MK	Is spelling consistent throughout (*no switching between acceptable spellings*)?
MK	Is capitalization used appropriately (*proper nouns*, *etc*.)?
MK	Is capitalization of words consistent throughout the report?

Grammar and Punctuation

MK	Are verb tenses used appropriately?
MK	Are marks of punctuation used appropriately?
MK	Is subject-verb agreement used in every sentence?
MK	Is the grammar checker updated and are underlined grammar issues addressed?

Writing Style

MK	Are all sentences in the report easy for your audience to understand quickly?
MK	Are most sentences written in active voice?
MK	Are idioms and vague words eliminated from the report?
MK	Are acronyms introduced before being used?
MK	Are well-written topic sentences included at the beginning of each paragraph?
MK	Are lists parallel?
MK	Is the appropriate point of view used when addressing your audience or describing team actions?