Temperature on electricity usage fluctuations

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Introduction

Electricity consumption fluctuates daily, with weather conditions amplifying these changes. Understanding these patterns improves grid management and demand forecasting. Specifically, how do temperature differences affect the daily fluctuations between peak and off-peak hours? The hypothesis states that the difference in consumption is significantly greater on days below the yearly median temperature than above it. A pattern was observed the data (figure 2) for consumption and temperature that led to choosing the variables. Results supporting this hypothesis could help us enhance our approach addressing this problem by predicting larger demand changes in different weather conditions.

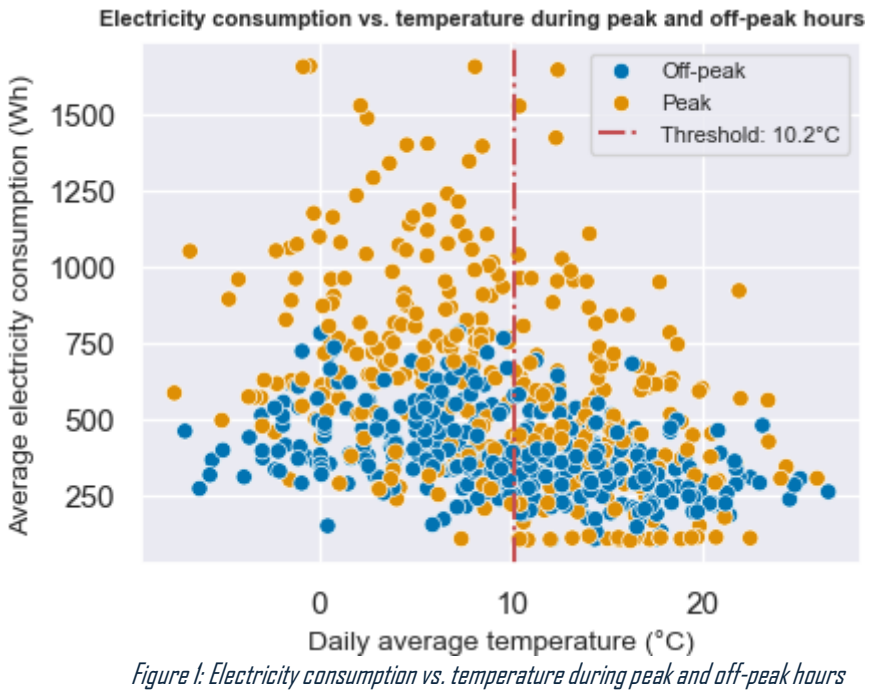

Figure 1: Electricity consumption vs. temperature during peak and off-peak hours

Methods

Rows with missing electricity or temperature values were removed to ensure accuracy. Hourly data were divided into peak (5-10 pm) and off-peak hours (the remaining hours), typical daily demand patterns. The mean daily temperatures were divided into two bins: below- and above the yearly median temperature. Then combinations of time periods and temperature categories were created. Lastly, from each combination, the mean electricity consumption was calculated and grouped by date. This way, the difference in consumption between peak and off-peak hours in different temperature conditions could be calculated. The atypical data were found by zooming in graphs and finding atypical spikes and then examining them by zooming in on hourly data. The atypical data for electricity was removed, even though they would not bias the results.

Results

A t-test for equality of means was performed on the two-sample data to answer the following one-sided hypothesis. H_0: mean usage difference below median temperature = mean usage difference above median temperature.
H_a: mean usage difference below median > mean usage difference above median temperature. For both households, the p-values are below 0.05 (table 1). Therefore, the null hypothesis is rejected. As the t-statistics are relatively large and the mean difference in electricity consumption during different temperature periods is considerably large (figure 2), the alternative hypothesis is accepted.

	P-value	T-statistic
Household 1	$1{,}1 \cdot 10^{-8}$	5,7
Household 2	$6{,}8 \cdot 10^{-22}$	10,2

Table 1 :Extracted t-test results

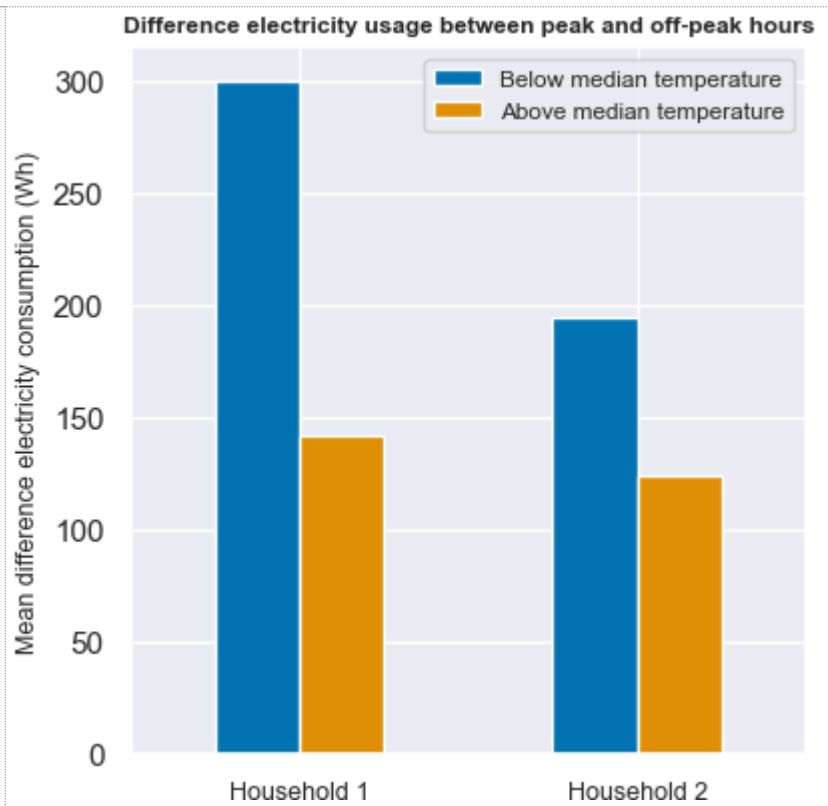

Figure 2: Electricity consumption difference between peak and off-peak hours

Discussion

The analysis has a testable hypothesis and a robust way for t-testing. Using the median as a temperature threshold ensured having equal number of datapoints for both categories. Due to lack of a systematic way for finding atypical data, it is uncertain that the data has been cleaned perfectly. Normality assumption of the data was not tested, doing so ensures greater reliability. Consumption patterns during work hours and sleep could be confounded, Longer daylight hours could be a reason for the results, too. Households' size can play a role, too. Incorporating the correct seasonal definition of peak hours in the filtering process should paint a more realistic picture of the results. Also, including a diverse range of weather variables such as precipitation and cloud cover could improve the generality of the results. The t-test was performed on uncleaned data and the differences were minimal.

Conclusion

The findings show that daily fluctuations in electricity consumption for both households are significantly greater on days with average temperatures below the yearly median in comparison to warmer days. Thus, the hypothesis is accepted. The temperature's influence on energy demand fluctuation is highlighted by the results. Understanding several patterns like these is crucial for creating a resilient, and stable energy system infrastructure.