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Smart Grids: Understanding Temporal Patterns of Device Energy Consumption in the Context of Weather

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TREO Talk Paper

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Abstract

The Smart Grid is a key development of modern power grids that includes among other features, greater communication between power consumers and producers. While the investment required to implement Smart Grid technology is substantial, some cities have already started to reap benefits from its adoption. Typically, in such setups, smart meters communicate and transmit usage data with high frequency. The capabilities of smart grids can be further harnessed when device-level integration and communication are enabled as this allows researchers to access device-level data and develop granular insights into energy consumption patterns.

One of the major issues with managing a large power grid is predicting the peak load. Battery technology is still not effective at storing large amounts of electricity, requiring power plants to produce on an as-needed basis. If there's not enough power to go around, subsections of the grid must be disconnected. Often, companies that distribute power must pay severe penalties if they require more energy from the providers than they expected. Thus, predicting the peak load is an important issue for the stability of the power grid, as well as for power companies themselves. Previous literature sponsored by the Environmental Protection Agency (EPA) has investigated the peak load of various devices using cost-benefit analysis (2010). However, this study is quite dated now due to new generations of devices and does not investigate energy utilization variation in the context of temporal or shifting weather patterns.

In this study, we perform a longitudinal device-level analysis within the context of weather to understand how energy demand patterns such as temporal power spikes vary at the device level. Such a device-level understanding could not only increase consumer awareness but also facilitate effective management of power costs and lead to the stability of a power grid. Our work takes the EPA (2010) further by using time series analysis to investigate when peaks occur for specific types of devices, and the effect of temperature. We use the Pecan Street Dataset (2022) comprising of device-level data from four different cities that use a smart grid and are located in three different states that experience different weather patterns: Texas, California, and New York. Data has been collected over a longitudinal period of 2012-2019 for more than a thousand homes. With temperature data from the nearest airport, we were able to look at the effect of time and temperature on not only the total power consumption of a domicile, but the individual devices such as air conditioners, refrigerators, etc. Homes with solar panels installed also had their net solar energy production included.

Preliminary results indicate that temperature is a key predictor for air conditioners, HVAC devices, and electric cars.

References

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