Detailed Energy Analysis of Stever House

Raafe Karim Khan

Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213  
+1 (317)-514-2097

rkk@andrew.cmu.edu

Saurabh Mishra

Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213  
+1 (412)-961-6462

saurabhm@andrew.cmu.eduRoja Malligarjunan

Carnegie Mellon University  
5000 Forbes Avenue  
Pittsburgh, PA 15213  
+91 (814)-416-2796

roja6055@gmail.com

**ABSTRACT**

In this paper, we will be looking at a Carnegie Mellon campus building’s energy consumption, Stever House, for one year and making suitable recommendations based on the dataset. The paper analyzes energy data by hour, week and day to understand occupant consumption patterns by correlating it with temperature data for the same building i.e. Stever House, and then making suitable recommendations which the Facility Management Services group can implement to lower consumption at peak load, thereby reducing costs.

**CCS Concepts**

• **Mathematics of Computing ➝Probability & Statistics** • **Information Systems➝ Data Management Systems**

**Keywords**

Energy; Power; Temperature; Dataset; Data; Regression; Tree

# INTRODUCTION

In the United States, buildings consume about 40% of the total energy generated, which translates to about 39 Quadrillion BTU [1]. To meet future demand, it is necessary for us to understand why, where and how we consume energy in households to reduce peak loads, cut costs and reduce our respective carbon footprint. By understanding consumption patterns, we can predict when demand for electricity will rise and fall based on time of day and then subsequently look at measures which will aid in reducing consumption without depriving consumers for energy or implicitly lowering their current standard of living.

# PROPOSED APPROACH

The approach of the paper is very simple; we have aggregated power consumption data for a year which we will disaggregate to conduct an analysis which will give us an insight about consumption patterns. The building in question is an undergraduate dormitory which is located at the intersection of Forbes and Morewood Avenue. First we analyze data by every week of the day after resampling for hourly intervals and then subsequently try clustering using a k-means approach and then run a linear regression after normalizing the data. In our approach, the response variable is power in Watts, whereas the feature variable is temperature in Fahrenheit. In a nutshell, we are looking to conduct exploratory data analysis by seeking what answers the data can give us about occupants’ energy consumption with respect to time and temperature.

# DATASET

The dataset was procured from the buildings meter and portfolio manager could give us temperature values for every instance of data recorded thanks to a sensor system present at the top of the building. The dataset doesn’t have equal intervals even though it records a data point every minute so resampling the data every hour was a natural choice in analyzing the data. The dataset has 479,836 rows and 3 columns. The dataset was initially in .txt format and was subsequently converted to a .csv format for ease of conducting analysis. The data points in the data frame were of type string, so using some pandas function we converted all string values to float32 values. Based on the sensors readings, the mean power consumption of the dataset was 110,127.46 W and the mean temperature was 57.23 F. The standard deviation of the power consumed was 34059.13 W, whereas the standard deviation of the temperature was 18.29 F.

# RESULTS

## Normal or Body Text

SAMPLE: Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

DOI: www.cmu.edu/energy

Please use a 9-point Times Roman font, or other Roman font with serifs, as close as possible in appearance to Times Roman in which these guidelines have been set. The goal is to have a 9-point text, as you see here. Please use sans-serif or non-proportional fonts only for special purposes, such as distinguishing source code text. If Times Roman is not available, try the font named Computer Modern Roman. On a Macintosh, use the font named Times. Right margins should be justified, not ragged.

## Title and Authors

The title (Helvetica 18-point bold), authors' names (Helvetica 12-point) and affiliations (Helvetica 10-point) run across the full width of the page – one column wide. We also recommend phone number (Helvetica 10-point) and e-mail address (Helvetica 12-point). See the top of this page for three addresses. If only one address is needed, center all address text. For two addresses, use two centered tabs, and so on. For more than three authors, you may have to improvise.[[1]](#footnote-1)

## First Page Copyright Notice

Please leave 3.81 cm (1.5") of blank text box at the bottom of the left column of the first page for the copyright notice.

## Subsequent Pages

For pages other than the first page, start at the top of the page, and continue in double-column format. The two columns on the last page should be as close to equal length as possible.

Table 1. Table captions should be placed above the table

|  |  |  |  |
| --- | --- | --- | --- |
| **Graphics** | **Top** | **In-between** | **Bottom** |
| Tables | End | Last | First |
| Figures | Good | Similar | Very well |

## References and Citations

Footnotes should be Times New Roman 9-point, and justified to the full width of the column.

Use the “ACM Reference format” for references – that is, a numbered list at the end of the article, ordered alphabetically and formatted accordingly. See examples of some typical reference types, in the new “ACM Reference format”, at the end of this document. Within this template, use the style named *references* for the text. Acceptable abbreviations, for journal names, can be found here: <http://library.caltech.edu/reference/abbreviations/>. Word may try to automatically ‘underline’ hotlinks in your references, the correct style is NO underlining.

The references are also in 9 pt., but that section (see Section 7) is ragged right. References should be published materials accessible to the public. Internal technical reports may be cited only if they are easily accessible (i.e. you can give the address to obtain the report within your citation) and may be obtained by any reader. Proprietary information may not be cited. Private communications should be acknowledged, not referenced (e.g., “[Robertson, personal communication]”).

## Page Numbering, Headers and Footers

Do not include headers, footers or page numbers in your submission. These will be added when the publications are assembled.

# VALIDATION

Place Tables/Figures/Images in text as close to the reference as possible (see Figure 1). It may extend across both columns to a maximum width of 17.78 cm (7”).

Captions should be Times New Roman 9-point bold. They should be numbered (e.g., “Table 1” or “Figure 2”), please note that the word for Table and Figure are spelled out. Figure’s captions should be centered beneath the image or picture, and Table captions should be centered above the table body.

# DISCUSSION

The heading of a section should be in Times New Roman 12-point bold in all-capitals flush left with an additional 6-points of white space above the section head. Sections and subsequent sub- sections should be numbered and flush left. For a section head and a subsection head together (such as Section 3 and subsection 3.1), use no additional space above the subsection head.

## Subsections

The heading of subsections should be in Times New Roman 12-point bold with only the initial letters capitalized. (Note: For subsections and subsubsections, a word like *the* or *a* is not capitalized unless it is the first word of the header.)

### Subsubsections

The heading for subsubsections should be in Times New Roman 11-point italic with initial letters capitalized and 6-points of white space above the subsubsection head.

#### Subsubsections

The heading for subsubsections should be in Times New Roman 11-point italic with initial letters capitalized.

#### Subsubsections

The heading for subsubsections should be in Times New Roman 11-point italic with initial letters capitalized.

# FUTURE WORK

In subsequent work we plan on incorporating a larger dataset with more feature variables so that prediction can be made more accurately, thus making the algorithm robust.

# ACKNOWLEDGMENTS

The authors would like to thank the Facility Management Services group at Carnegie Mellon University in providing us data to conduct our analysis. We would also like to express our sincere gratitude to Dr. Mario Bergés and Mr. Henning Lange for providing us feedback and support through the course of this project. Lastly, we would like to thank our families and friends for their encouragement and unwavering support, always.

# REFERENCES

1. United States Energy Information Administration (EIA), ‘How much energy is consumed in residential and commercial buildings in the United States?’. Updated April 2016. Accessed Dec 2016. <http://www.eia.gov/tools/faqs/faq.cfm?id=86&t=1>
2. Series. ACM, New York, NY, 19-33. DOI= <http://doi.acm.org/10.1145/90417.90738>.

1. If necessary, you may place some address information in a footnote, or in a named section at the end of your paper. [↑](#footnote-ref-1)