2010 Chicago Energy Usage

EAS 503: Final Project

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1 Abstract

The city of Chicago, Illinois provides the public with access to several datasets detailing public works, health measures, and other aspects of the city that may be of interest. Our group looked at the 2010 Chicago Energy Data to explore various relationships between electric and heat energy usages with respect to various population and infrastructure measures. Using a variety of graphical methods we were able to make key conclusions about energy usage in Chicago during 2010.

2 Introduction

Our group analyzed the energy and heat usage of individual census blocks in the city of Chicago during 2010. The information, easily accessible by the public, provides a historical snapshot of the citys resource consumption. This data would be useful for future comparison in order to track the citys progress with respect to energy and heat usage moving forward. The focus of our exploration was to find answers to the following inquiries:

1. How did the age of a building affect its energy and heat consumption?
2. How did the total square footage of a building affect its energy and heat consumption?
3. How did the building type (residential vs. commercial) affect its energy and heat consumption throughout the year?
4. How did the energy consumption of a given district change monthly during 2010?
5. How did the heat consumption of a given district change monthly during 2010?
6. How can we visualize the annual energy consumption of a district during 2010?
7. How can we visualize the monthly energy consumption of a district during 2010, and how it changed over time?

We will describe the dataset in greater detail and explain our approach to these questions. Additionally, we will summarize our findings and suggest topics for further research.

3 Data

Our dataset contained approximately 67,000 observations each with 73 attributes, the most notable of which were the monthly electric kilowatt-hour (KWH) and heat therm energy usage of each city census block from January through December of 2010. KWH was used to measure electric energy usage while them was used to measure heat consumption. Each observation was that of a unique city census block, and could be aggregated based on the 77 community areas and 9 districts of Chicago [4]. In addition to electric and heat energy consumption data, we also have information about building type, structure specifications, and related population measures. Our data-processing included the removal of observations for which our target attributes were missing, as well as removing attributes that were not pertinent to our analyses, such as statistical metadata. We split the original dataset into different files based on aggregations to community area and districts levels, and acquired additional geographic data from the portal to underlie our maps.

4 Model

We decided to analyze our data at four levels: citywide, district, community area, and census block. These different aggregation modes allowed us to look for trends in layers, and draw conclusions from there. Citywide analyses were completed using geographic data to create colormaps and pie charts to analyze the energy usage of different municipal designations (residential, commercial, and industrial). District and community area analyses utilized scatter plots and bar graphs to explore both longitudinal energy usage (January-December) as well as relationships between total energy usage and measures such as total population and average building age. Additionally,

5 Analysis

5.1 Citywide Colormaps of Energy Consumption Analysis

For the basemap section, a .csv file with the community areas of Chicago was obtained from the Chicago Data Portal [1]. This file had a list of all community areas and corresponding geographical coordinates. The coordinates were parsed and stored as NumPy arrays and appended to a list in python. The points were then plotted using basemap and matplotlib polygons. The polygons were subsequently assigned a color from the viridis colormap based on the values that corresponded to each community area. The viridis colormap was used as it is more uniformly spaced than the jet colormap, and therefore shows gradients more clearly, and because the viridis colormap is easily visualized by people that are colorblind [2].

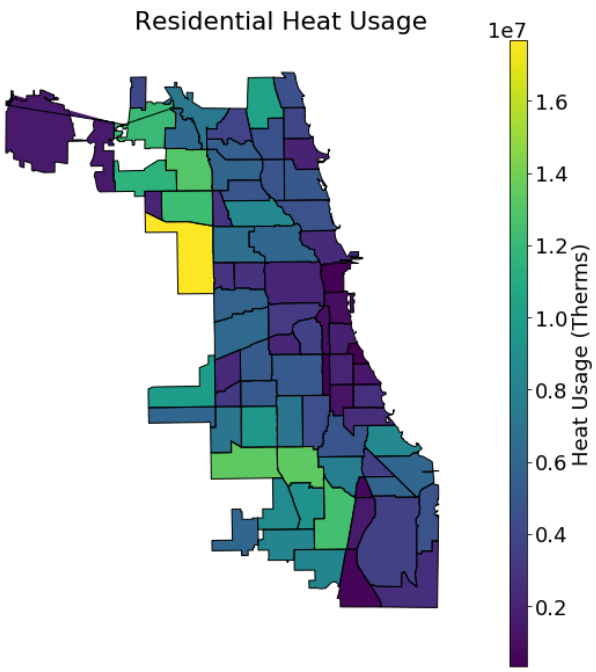

Figure 1: Residential Heat Usage

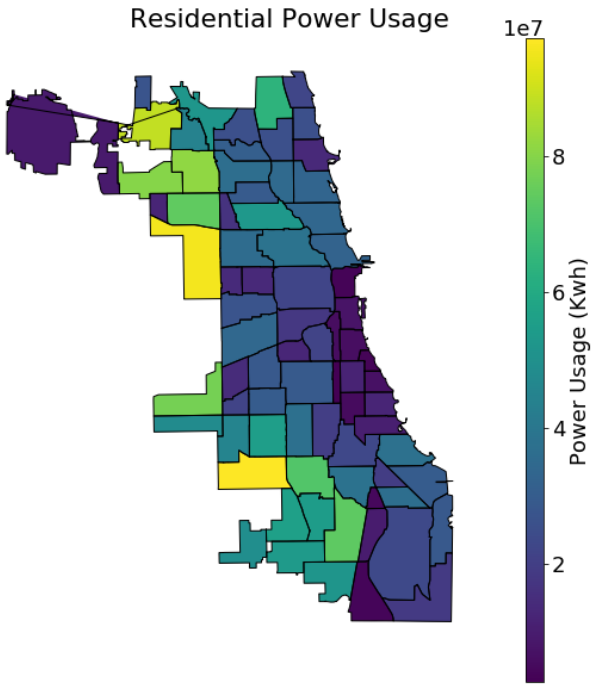

Figure 2: Residential Power Usage

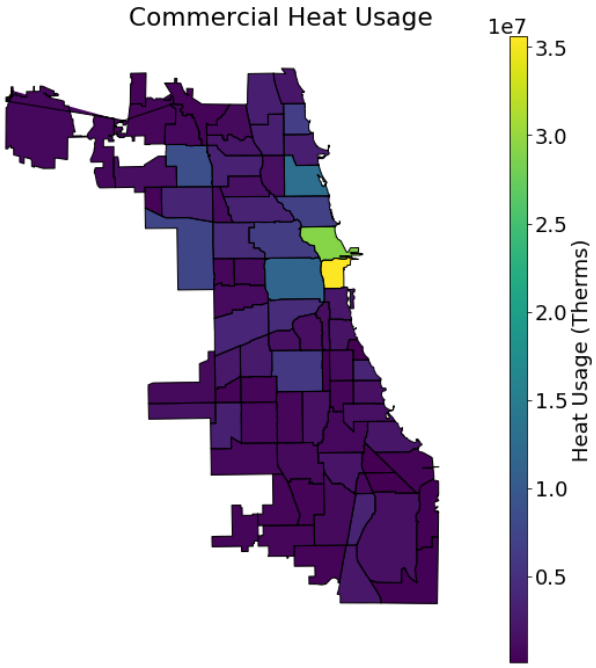

Figure 3: Commercial Heat Usage

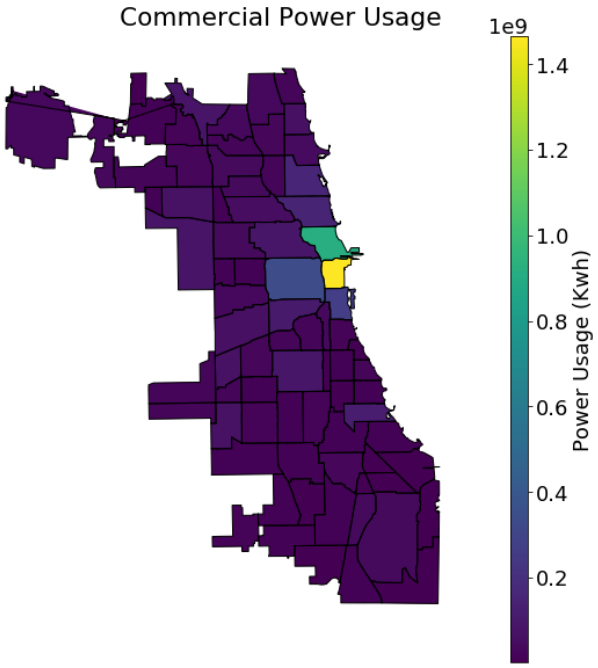

Figure 4: Commercial Power Usage

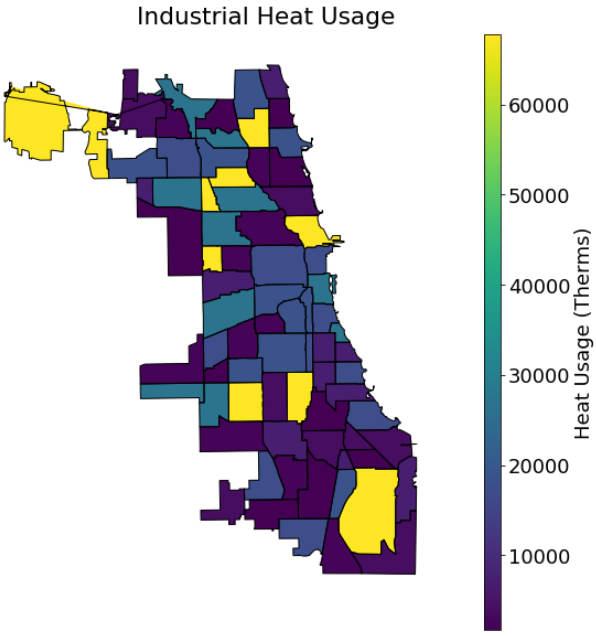

Figure 5: Industrial Heat Usage

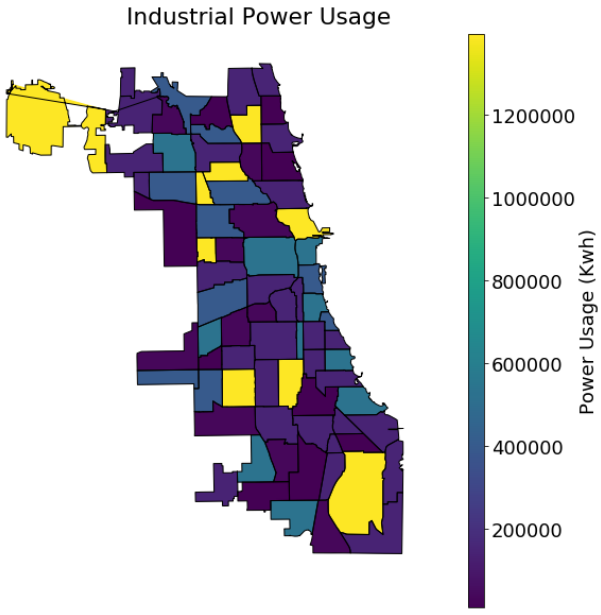

Figure 6: Industrial Power Usage

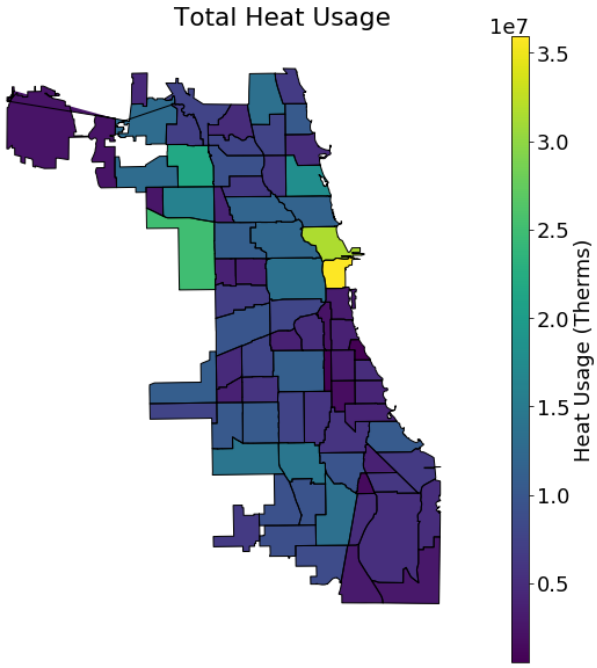

Figure 7: Total Heat Usage

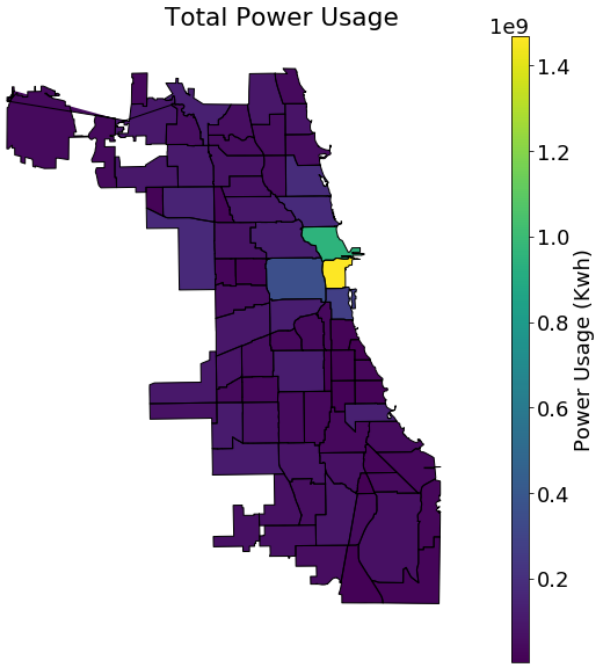

Figure 8: Total Power Usage

Based on the citywide data on energy usage of the residential, commercial, and industrial sectors we were able to create pie charts visualizing the contribution of each sector to the overall consumption levels.

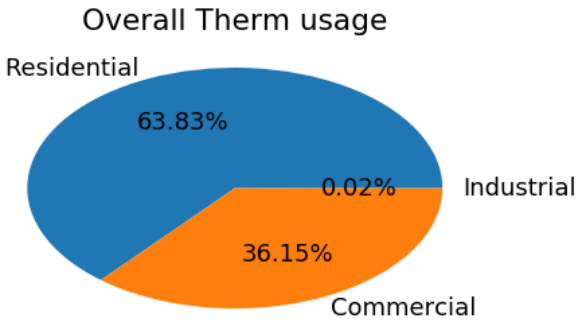

Figure 9: Overall Therm Usage

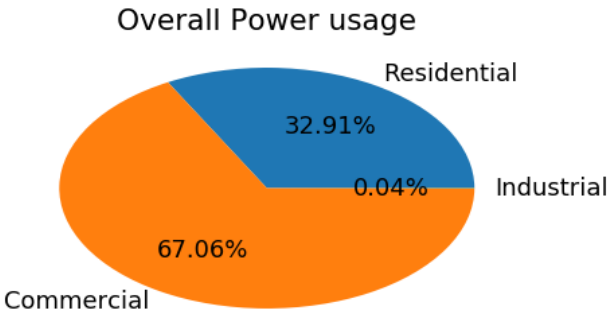

Figure 10: Overall Power Usage

5.2 District Level Analysis

At the district level we created barcharts to analyze any relationship that may have existed between electric and heat energy consumption and the average age of building in a district as well as the total population of each district. We also created bar charts to visualize the monthly energy consumption of each district.

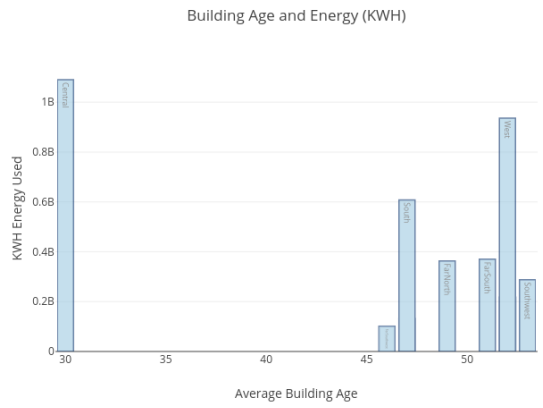

Figure 11: Building Age Energy Usage

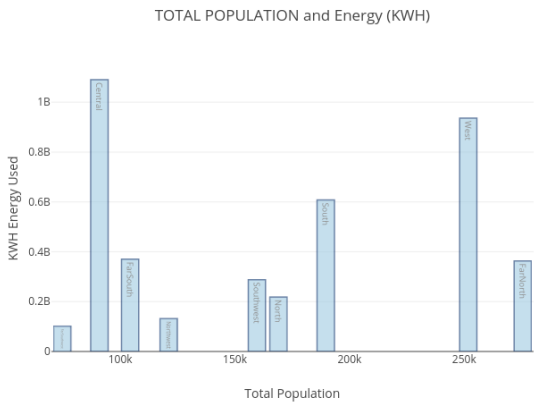

Figure 12: Total Population Energy Usage

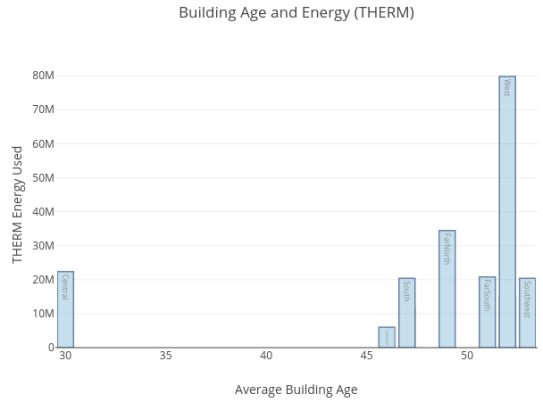

Figure 13: Building Age Heat Usage

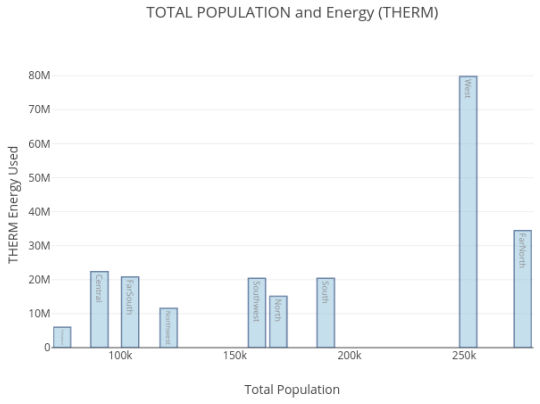

Figure 14: Total Population Heat Usage

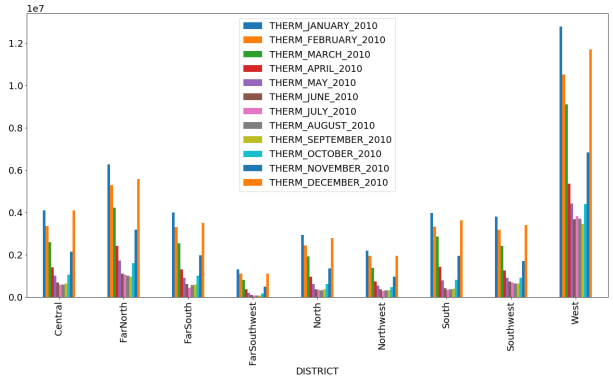

Figure 15: Monthly Heat Usage

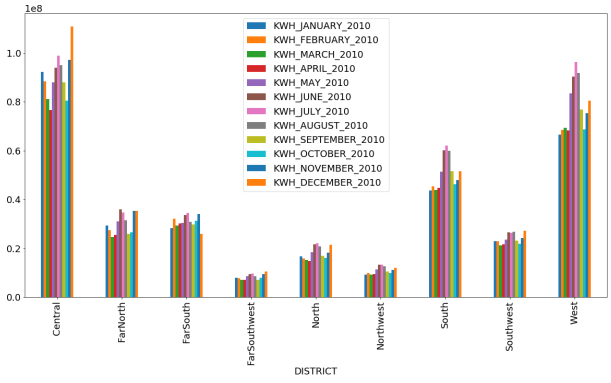

Figure 16: Monthly Power Usage

5.3 Community Area and Census Block Level Analysis

At the community area level we again looked into the relationship between electric and heat energy usage and the average building age and total population of each of the 77 community areas by creating scatterplots of the data.

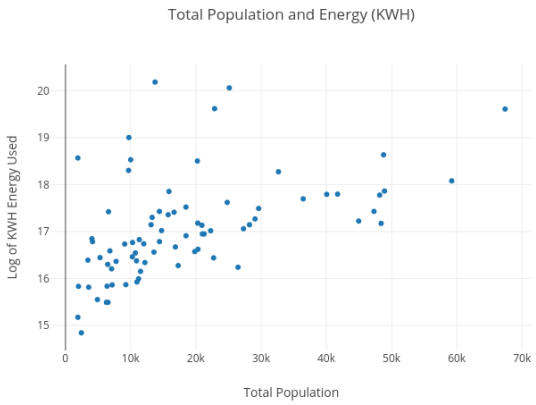

Figure 17: Total Population Energy Usage Scatter

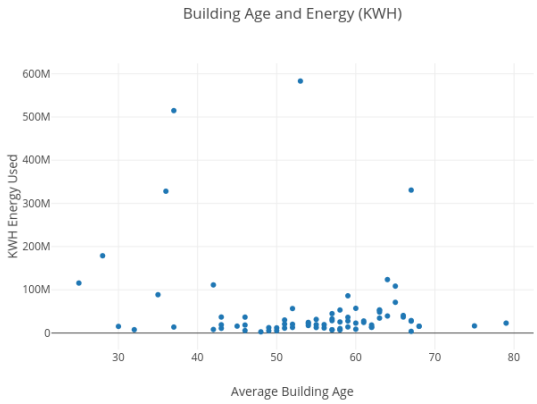

Figure 18: Building Age Energy Usage Scatter

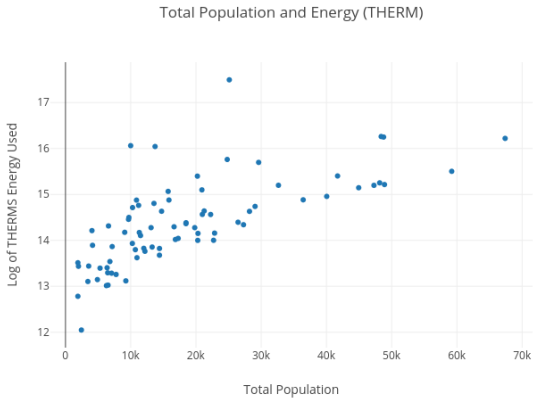

Figure 19: Total Population Energy Usage Scatter

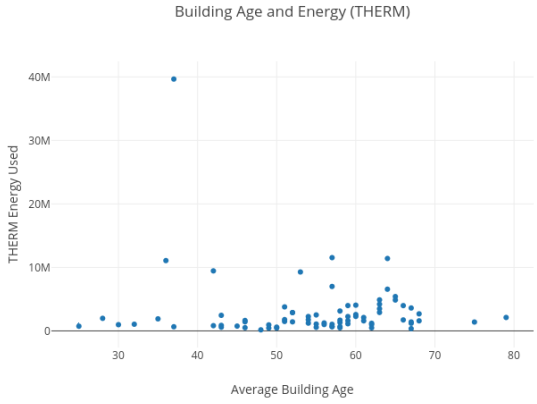

Figure 20: Building Age Heat Usage Scatter

Additionally, we created scatterplots for all of the census blocks to plot the relationship between energy usage and and the total building square footage for both residential and commercial buildings.

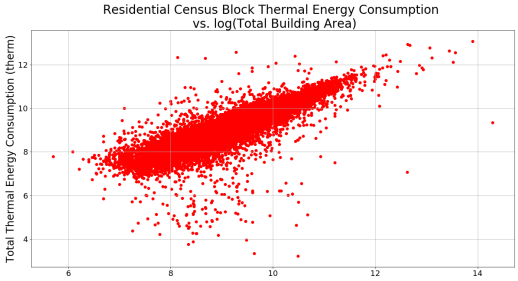

Figure 21: Residential Census Block Heat Usage

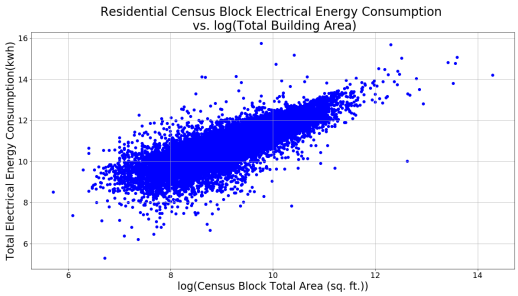

Figure 22: Residential Census Block Energy Usage

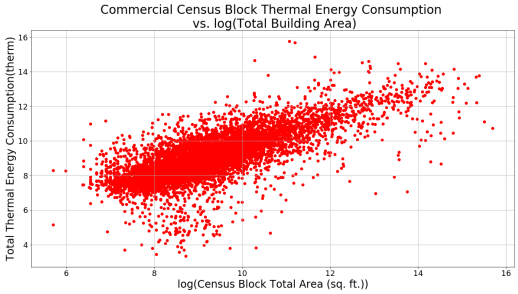

Figure 23: Commercial Census Block Heat Usage

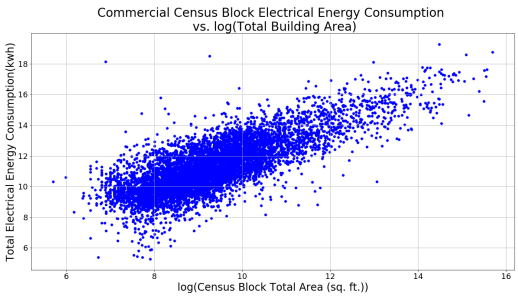

Figure 24: Commercial Census Block Energy Usage

6 Results and Conclusion

From our graphs we learned that while residential buildings accounted for a majority of heat energy usage, commercial buildings accounted for the majority electric energy usage, and industrial buildings accounted for relatively small amounts of each. This is likely due to the small overall number of industrial site in Chicago for which the data was collected. Surprisingly, there was no discernible relationship between energy usage and average building age or total population at the district level, but at the community are level there was a modest positive relationship between the log of energy usage and total population. Additionally, when looking at the monthly energy usage of the districts it was clear more was used during the winter months than the rest of the year. This was to be expected given the cold weather Chicago experiences during these months. Finally, there was a clear positive relationship between the log of total building square footage and energy usage for both residential and commercial buildings. For many of the scatter plots the log of the measures were taken to account for the spread in the data.

7 Future Research Direction

The city of Chicagos data portal is a great resource for anyone interested in municipal data. As this dataset was just for the year 2010, in would be of interest to the city to continue to record data similar to this in upcoming years for the purpose of preforming a longitudinal study of the citys energy usage. Such a study would be useful in determining targets for improvement as this dataset falls under the category of environment and sustainable development. It could also help the city determine if it is meeting its energy consumption benchmark goals from year to year.

8 References

[1] - Schenk, T. (2013, January 6). Boundaries - Community Areas (current). Retrieved November 1, 2017, from https://data.cityofchicago.org/Facilities-Geographic-Boundaries/Boundaries-Community-Areas-current-/cauq-8yn6/data

[2] - Choosing Colormaps. (n.d.). Retrieved from https://matplotlib.org/users/colormaps.html

[3] - Schenk, T. (2013, April 21). Energy Usage 2010. Retrieved November 1, 2017, from https://data.cityofchicago.org/Environment-Sustainable-Development/Energy-Usage-2010/8yq3-m6wp

[4] - Chicago Neighborhoods. (n.d.). Retrieved from http://www.thechicago77.com/chicago-neighborhoods/