

Electricity Usage in Toronto's Public Facilities: Analyzing the Impact of Building Size on Energy Consumption*

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This study examines the relationship between building size(m^2) and electricity consumption(kWh) in Toronto's public facilities. Data from over 500 buildings, including schools, libraries, and hospitals, show a consistent positive correlation between GFA and electricity usage. Larger facilities, particularly healthcare centers, demonstrate higher energy consumption per square meter. These results help inform efforts to improve energy management in Toronto's public buildings.

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1 Introduction

Public infrastructure, including schools, libraries, healthcare centers, and government offices, forms the backbone of urban services in any modern city. As Toronto continues to expand, managing electricity usage in public buildings becomes increasingly critical. Energy efficiency in public facilities not only reduces operational costs but also contributes to environmental goals, such as carbon reduction and climate change mitigation(Droege 2018).

One of the primary determinants of electricity consumption is building size, commonly measured as Gross Floor Area (GFA). Larger buildings tend to consume more energy for lighting, heating, cooling, and equipment operations, but this relationship is influenced by other factors such as building type, operational hours, and energy management systems (Hong et al. 2016). As such, it is crucial for policymakers to understand how building size and other factors influence electricity consumption in Toronto's public facilities (Li and Colombier 2009).

*Code and data are available at: https://github.com/zilin1017/Toronto_annual_energy_consumption.git.

Several studies have shown that energy efficiency measures in public buildings can lead to significant reductions in electricity consumption. For example, retrofitting large government buildings or healthcare facilities with modern energy management systems can reduce energy use, while smaller buildings like libraries and schools often exhibit lower per-square-meter energy consumption (Scott et al. 2008).

This paper explores the relationship between Property GFA (m^2) and electricity usage (kWh) in over 500 public facilities in Toronto. The study aims to identify patterns in electricity consumption and provide insights for optimizing energy use in Toronto's public sector.

2 Data

2.1 Raw data

The data used in this paper came from the OpenData Toronto portal through the library (Gelfand 2022). Data were cleaned and analyzed using the open source statistical programming language R (R Core Team 2023). The particular data set used to analyze the Consumption of Energy is the Annual Energy Consumption Data in 2021 (Toronto Open Data Portal, n.d.). The following packages helped with the data analysis: tidyverse (Wickham et al. 2019), here (Müller 2020)), dplyr (Wickham et al. 2023) and ggplot2 (Wickham 2016) was use for making graphics. All data analysis was conducted using R (R Core Team 2023).

The data used in this analysis comes from the City of Toronto's Open Data Portal(Gelfand 2022), specifically focusing on energy consumption across various property types in Toronto for the year 2021(Toronto Open Data Portal, n.d.). The dataset consists of 1,802 unique entries, each representing a specific property in various regions of Toronto. For each property, the data captures critical metrics such as the building size, self-reported in gross floor area (GFA) in square meters (m^2), and the total electricity consumption, measured in kilowatt-hours (kWh), purchased from the grid. No personal or property-specific information is included. The data was last updated on July 4, 2023, and helps understand energy usage trends across different building types in Toronto.

2.2 Cleaned Data

The cleaning process focused on removing irrelevant or incomplete data to ensure the dataset was suitable for analyzing electricity consumption patterns in Toronto's public sector. Missing values(NA) were removed during the data cleaning process, particularly those related to electricity usage. And buildings that did not meet the size criteria (less than 30 square meters or greater than 2,500 square meters) were also filtered out.Additionally, variables irrelevant to the study's focus were also omitted. Furthermore, the cleaned data retains only the key variables required for the analysis: property type, electricity use, floor area, and log-transformed area.

This ensures that the final dataset is both accurate and relevant for understanding electricity consumption trends across different public facilities in Toronto.

A sample of the cleaned data can be seen in Table ?? . The cleaned analysis dataset is loaded using the R programming language (R Core Team 2023). The folder structure for this analysis is also inherited from Professor Rohan Alexander (Alexander 2023). Figures and tables are then generated using the knitr (Xie 2023) and tidyverse (Wickham et al. 2019) packages.

Table 1: Sample of cleaned data

Property Type	Electricity Use (kWh)	Area (m ²)	Log of Area (m ²)
Police Station	610692.1	2395.0	7.781138
Other - Public Services	9469.3	40.0	3.688880
Other - Lodging/Residential	76707.2	1783.7	7.486445
Office	124585.4	934.0	6.839476
Heated Swimming Pool	344470.3	1922.0	7.561122
Pre-school/Daycare	81602.7	652.0	6.480045

2.3 Data Analysis

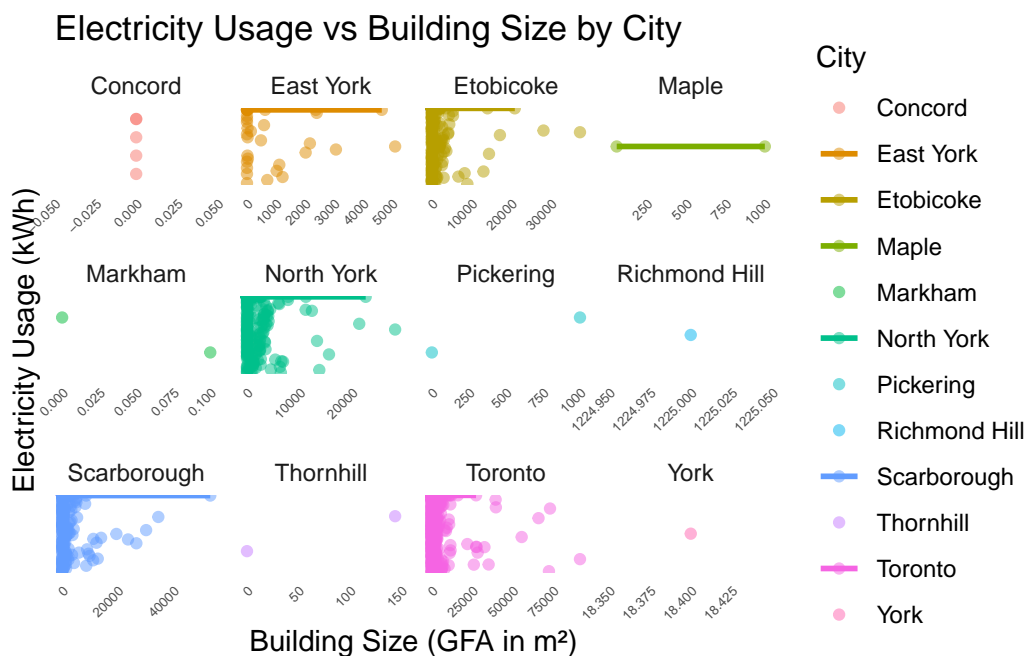


Figure 1: Density Plot for Property Area in Toronto

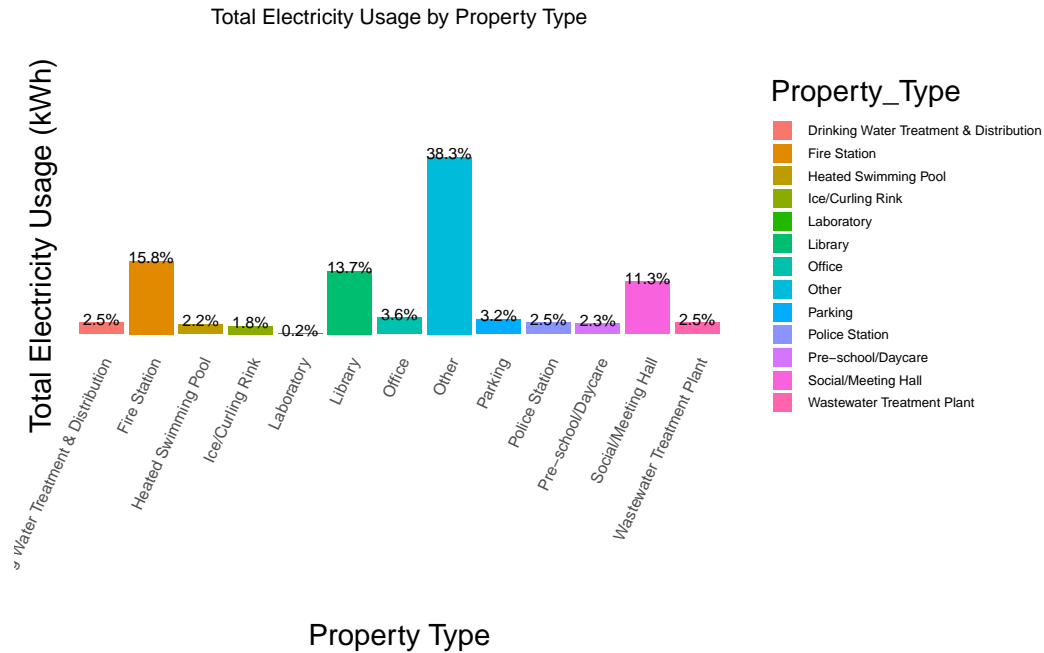


Figure 2: Percentage Electricity Usage by Properties

Talk more about it.

And also planes (?@fig-planes). (You can change the height and width, but don't worry about doing that until you have finished every other aspect of the paper - Quarto will try to make it look nice and the defaults usually work well once you have enough text.)

Talk way more about it.