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**Building Demand Characterization Study – Progress Report**

Purpose

The purpose of building demand characterization is to study the different aspects of what makes a building demand profile, so that real-life buildings can be compared with buildings generated by a simulation – EnergyPlus. The end goal is to be able to see clearly where simulation building models deviate significantly from real buildings and to take steps towards altering simulation outputs to look more like real building outputs. Once we know how to make simulation outputs look more realistic, we can give a more realistic look to the demand profiles that will be shown in the Building Specifications section of the EAGERS design tool. An additional advantage is that forecasts based on projected demand will be more accurate with a more realistic estimate of future demand.

Progress Thus Far

Thus far, the following has been accomplished:

* Downloaded all buildings from NYSERDA database with total facility energy demand and total facility power demand data.
* Of those downloaded buildings, thirty were selected as buildings with data that looked clean enough to render them worthy of study.
* A series of MATLAB functions that provide some information about the building data have been written.
* Workflow has been put in place for study of simulated buildings as well. There may need to be some tweaking of the MATLAB code, but the functions created for the NYSERDA buildings should be applicable to the data retrieved from OpenStudio simulations.

Metrics

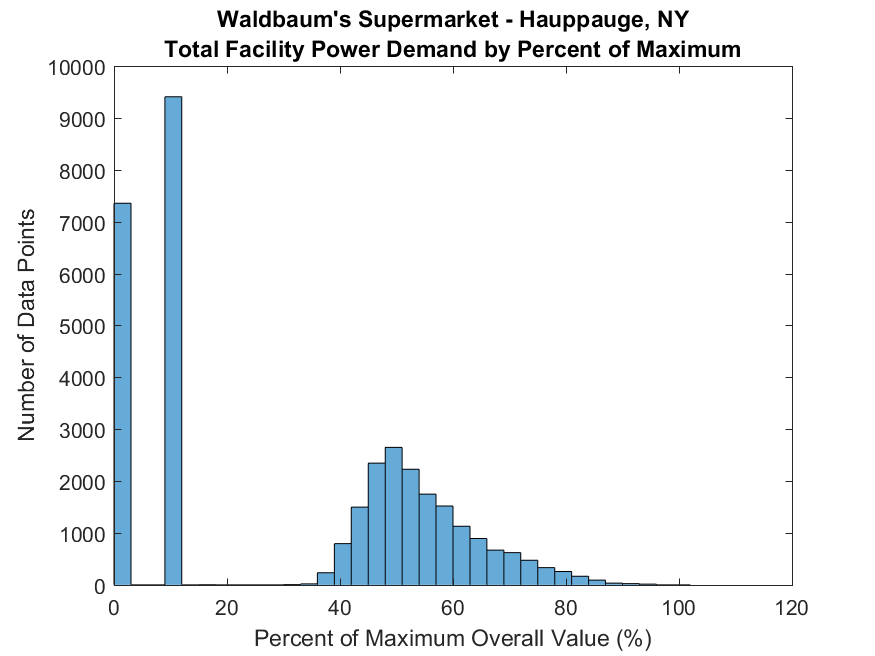
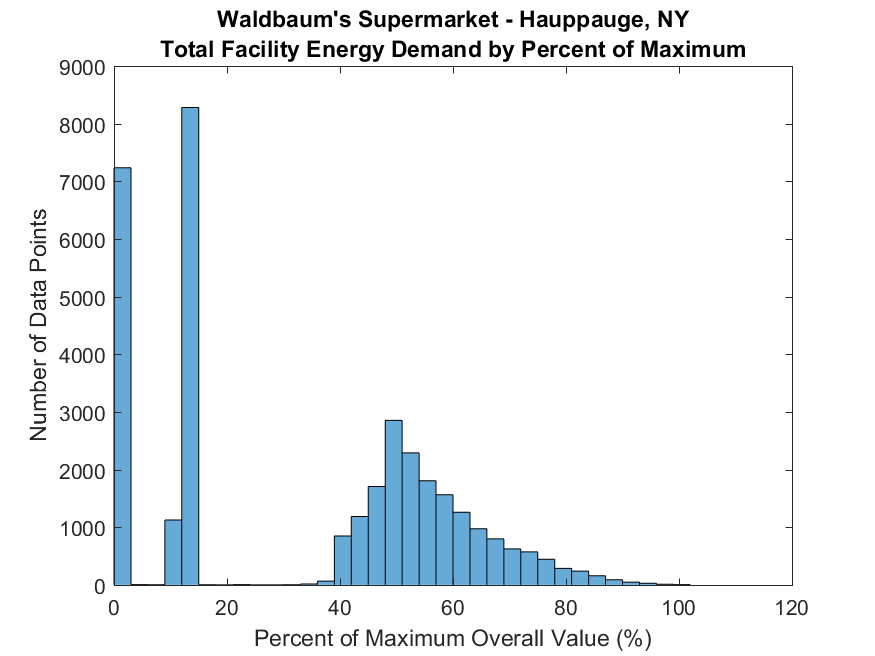
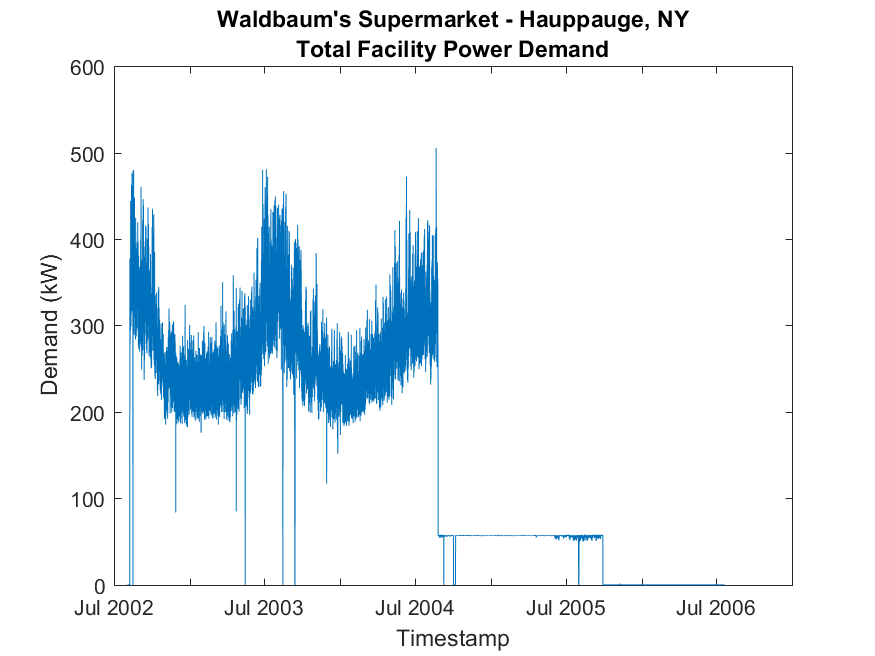
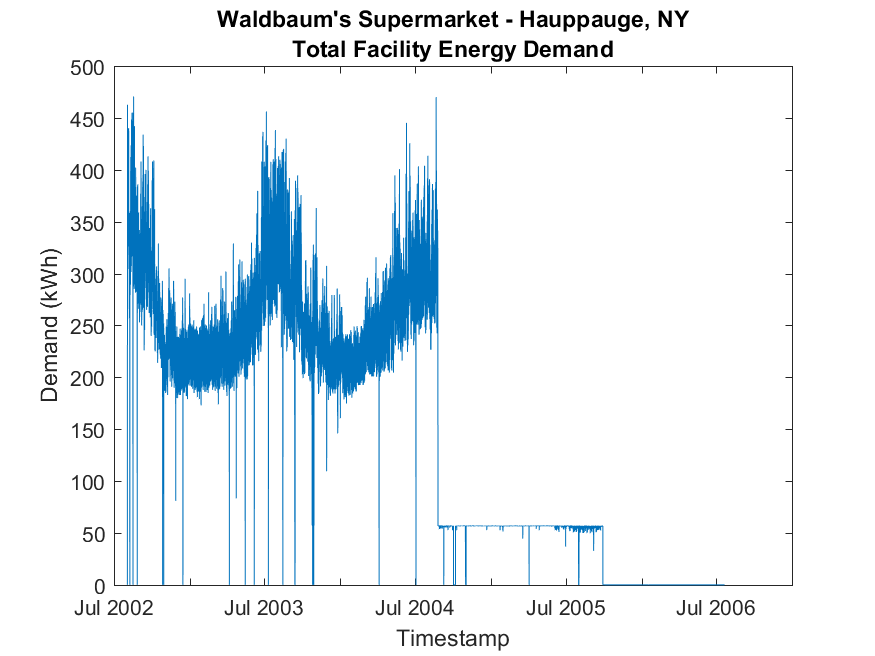
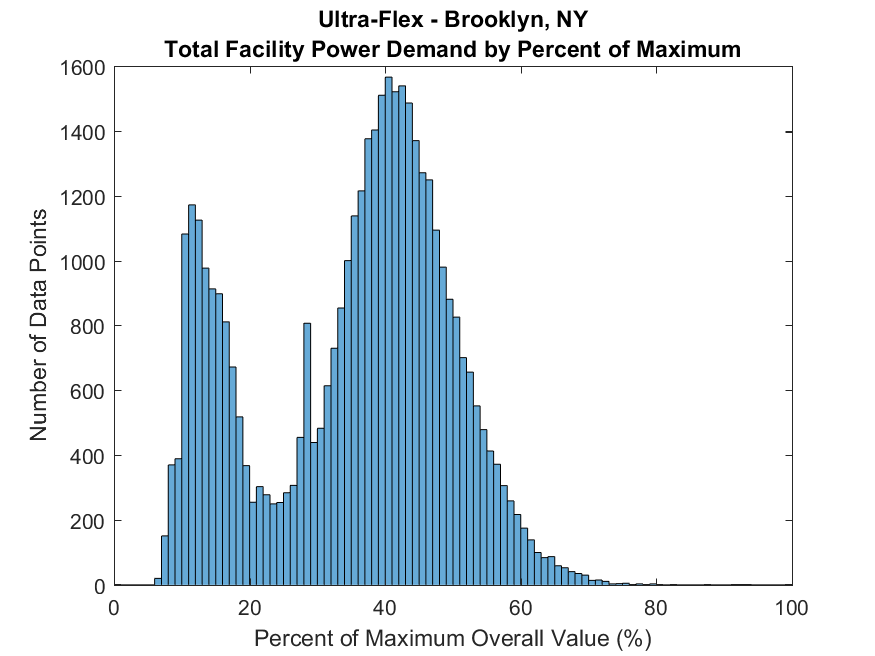
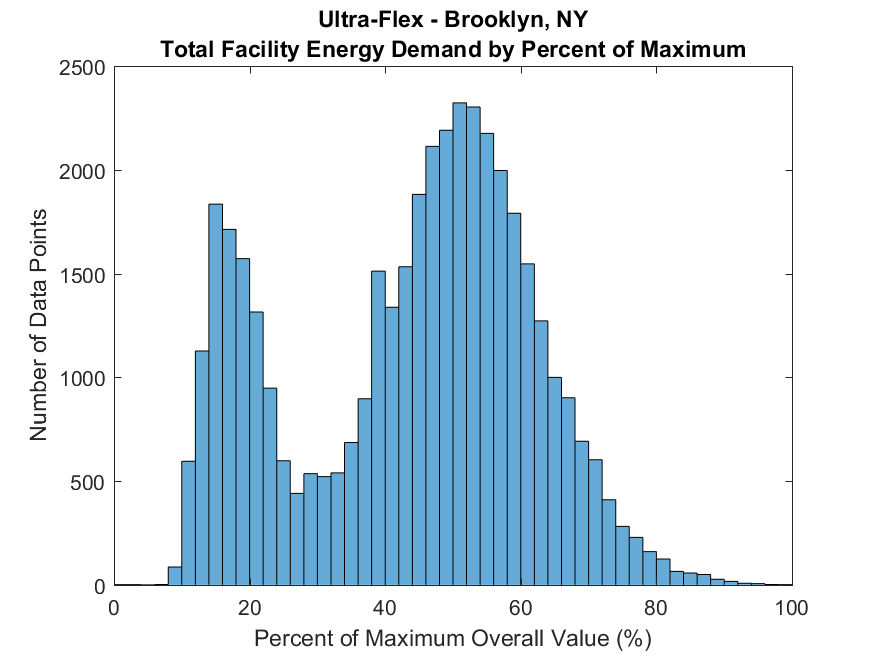
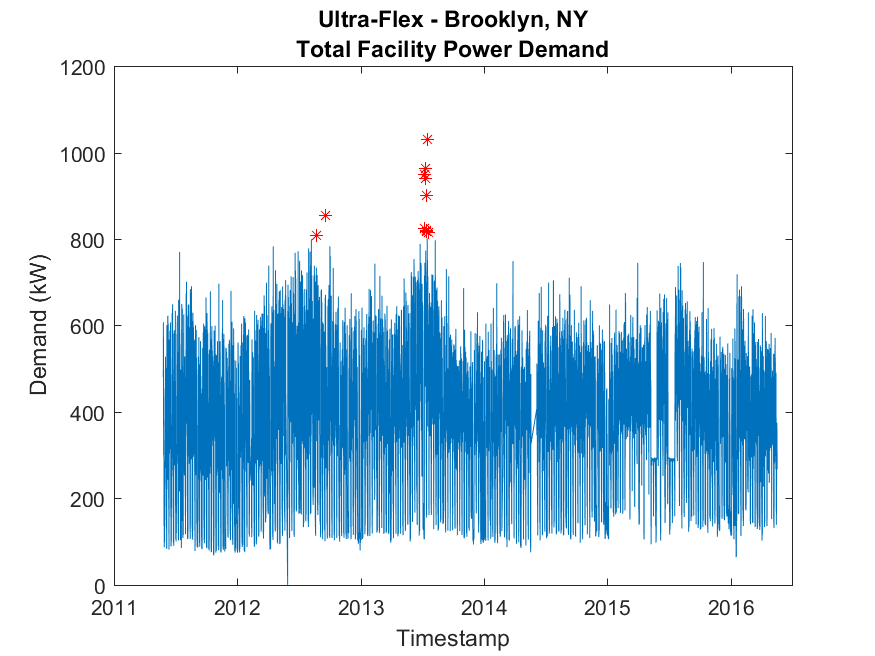
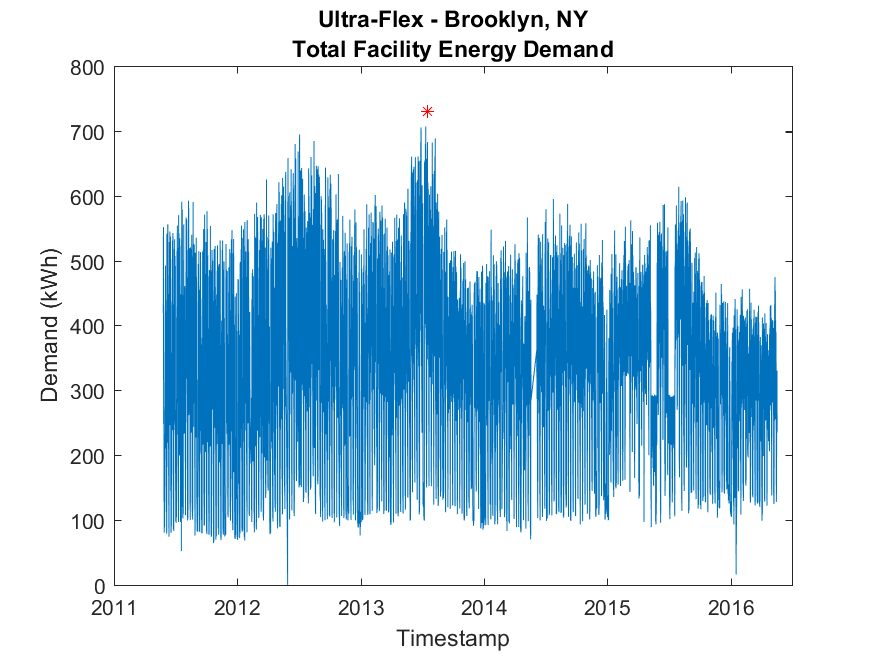
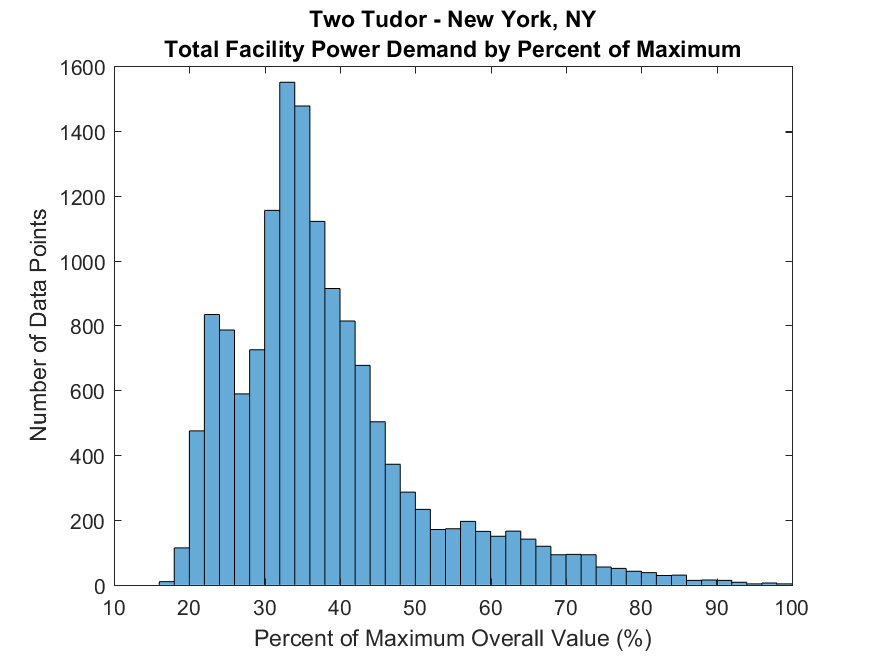
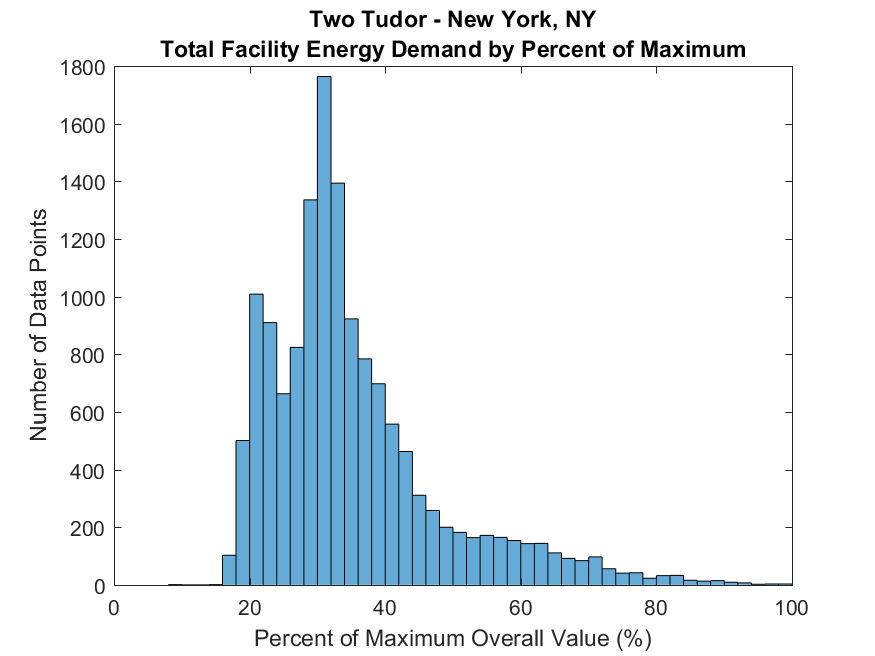
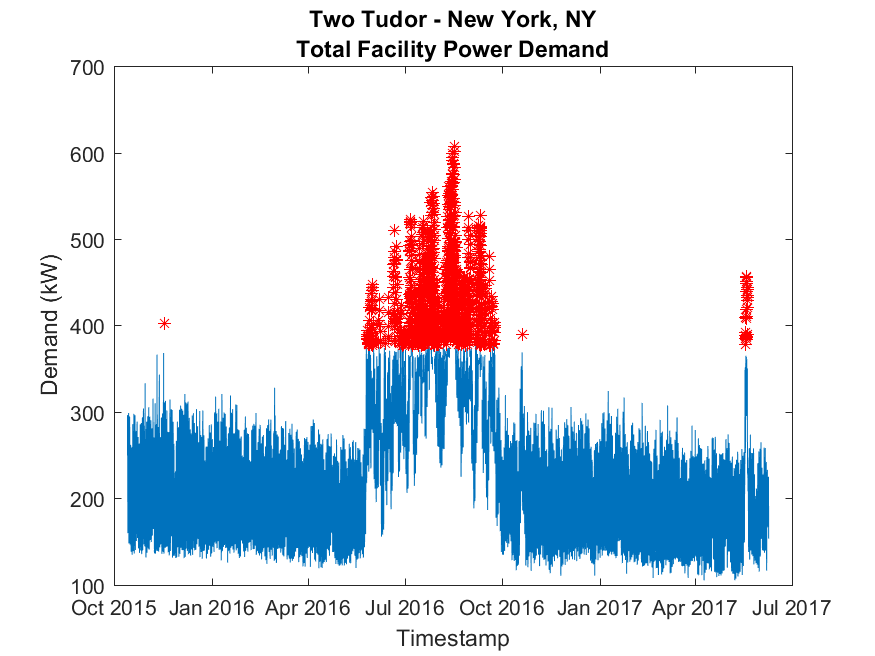
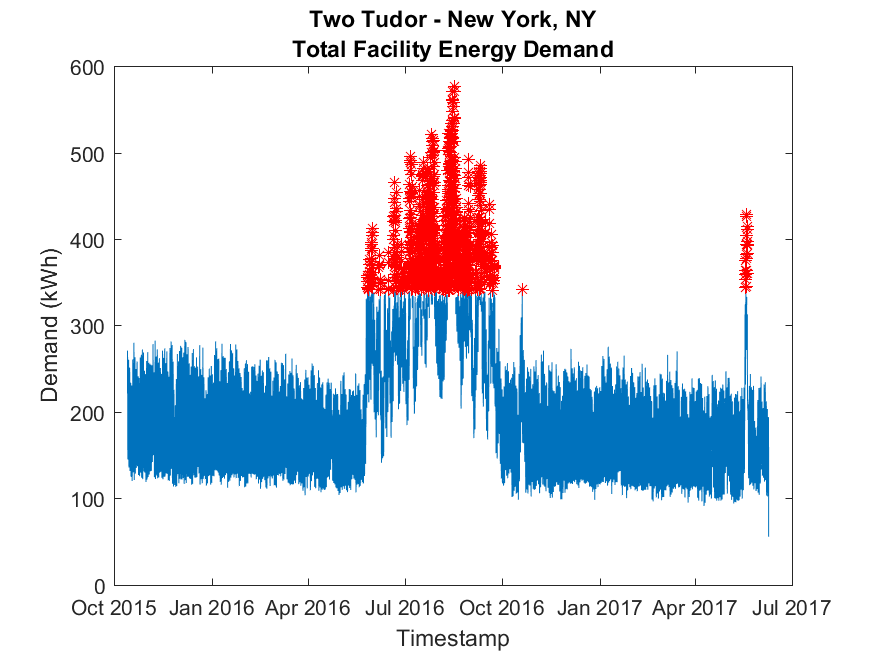
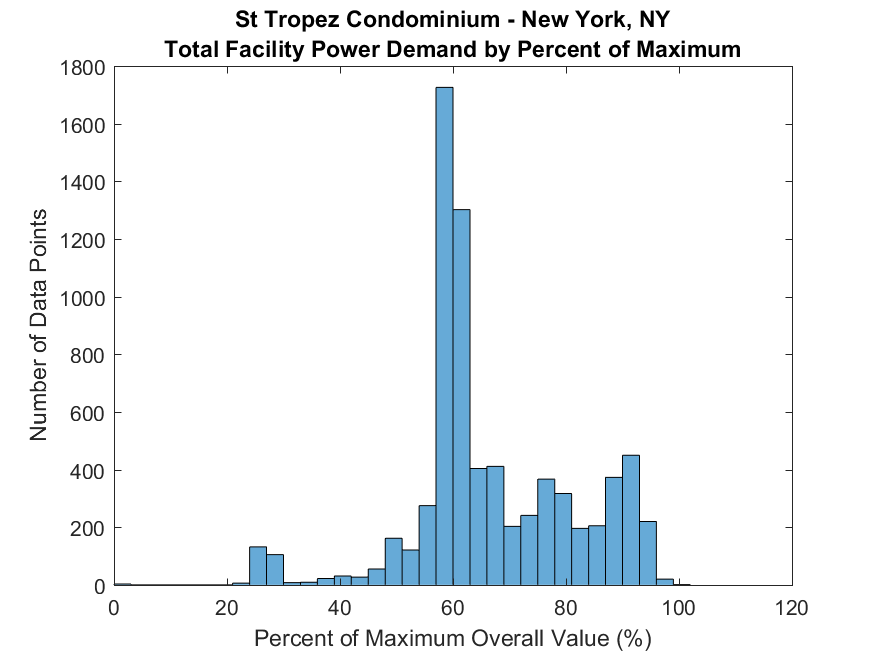
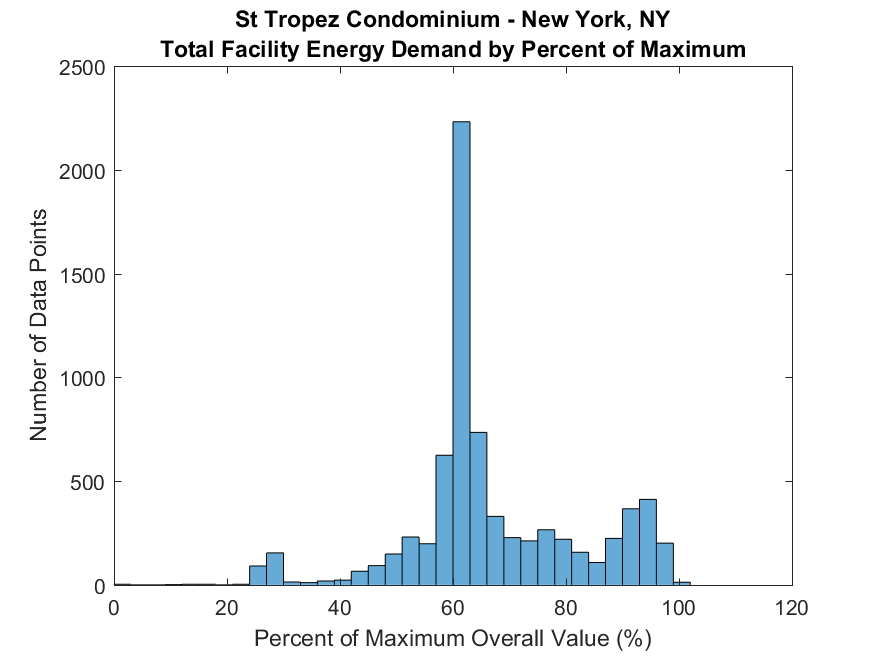
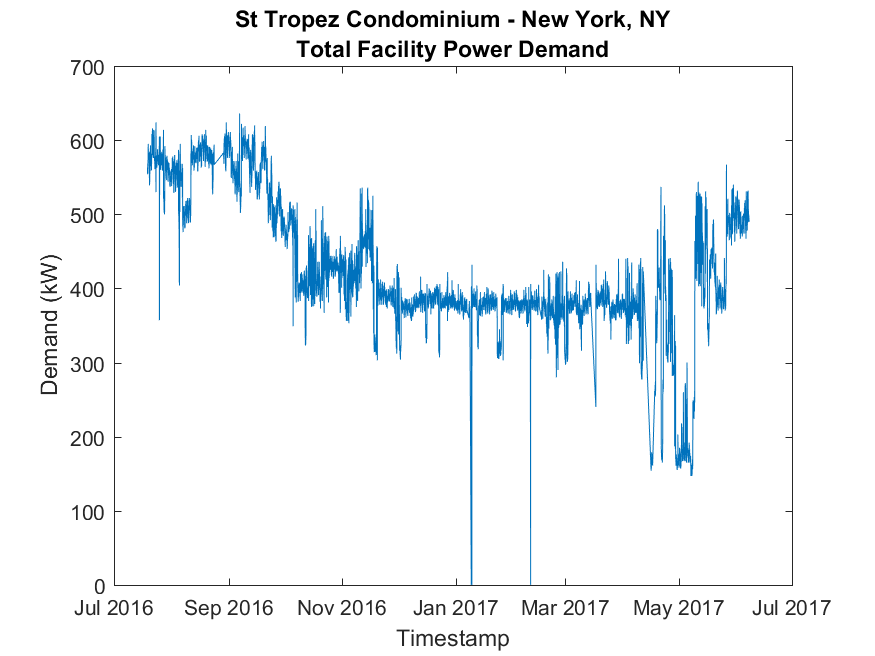
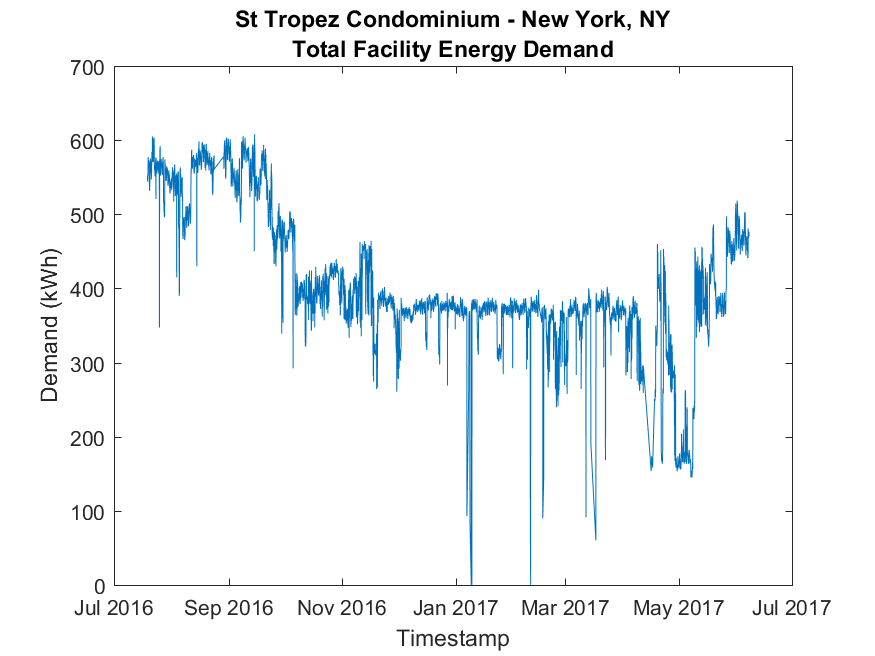
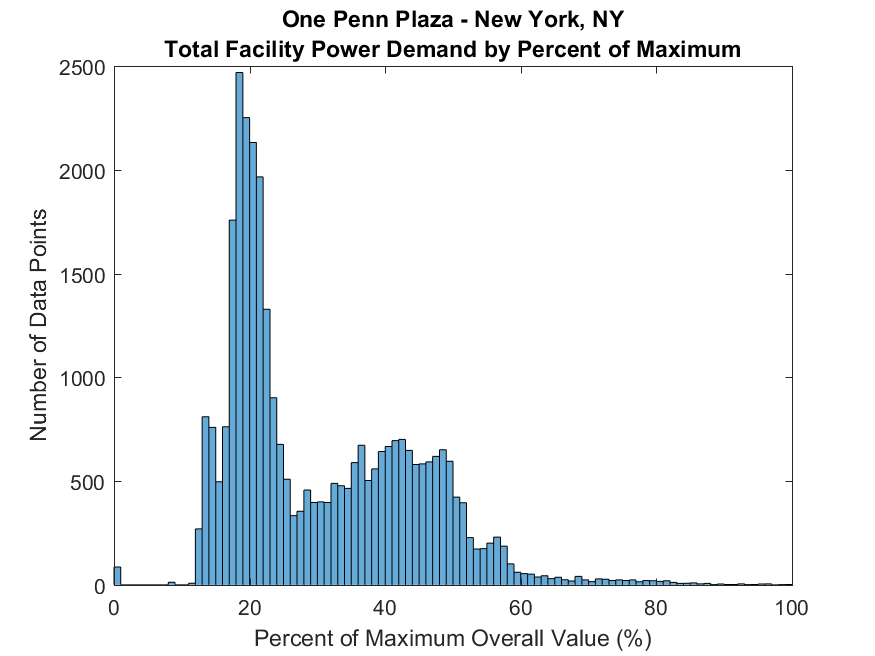
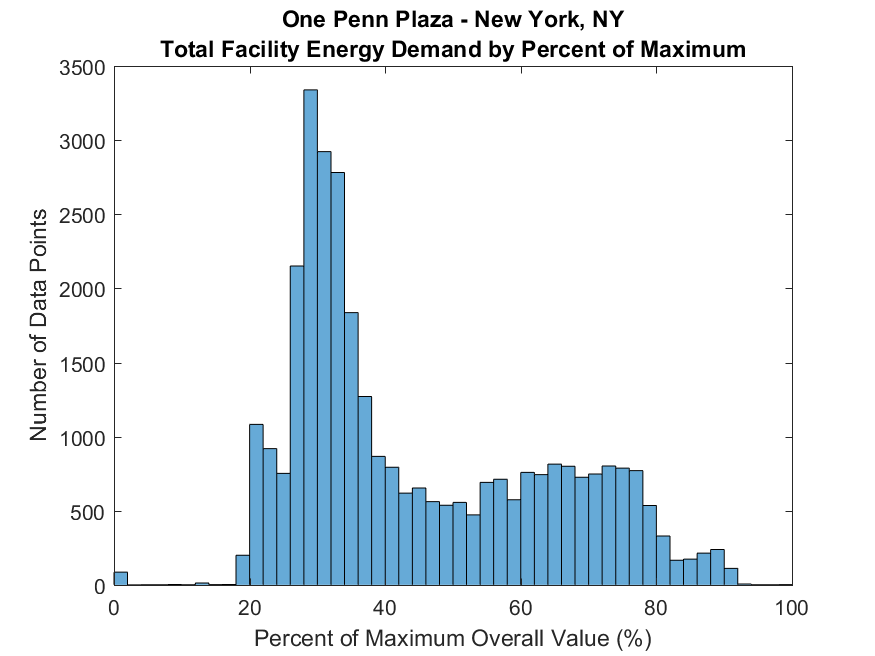
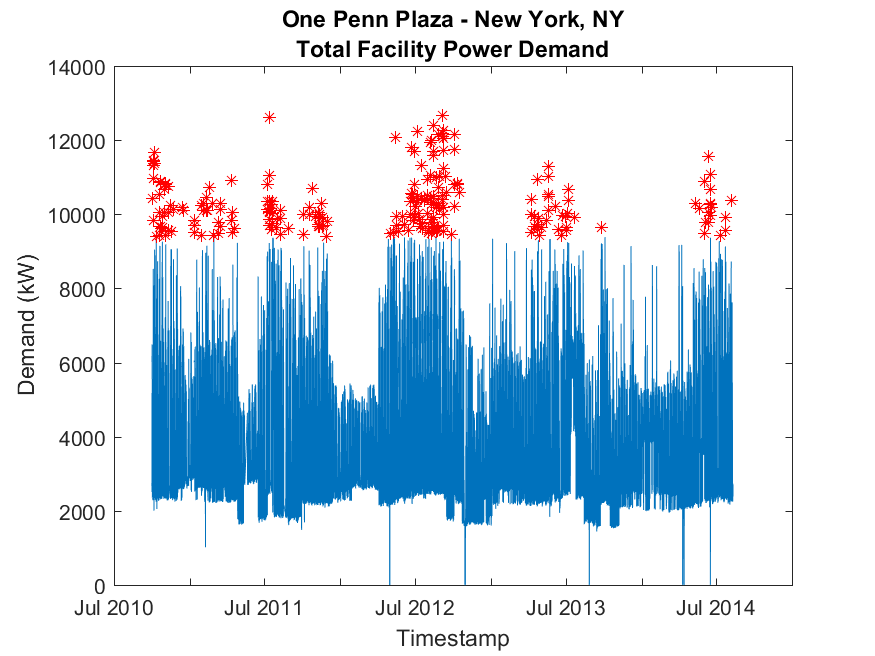
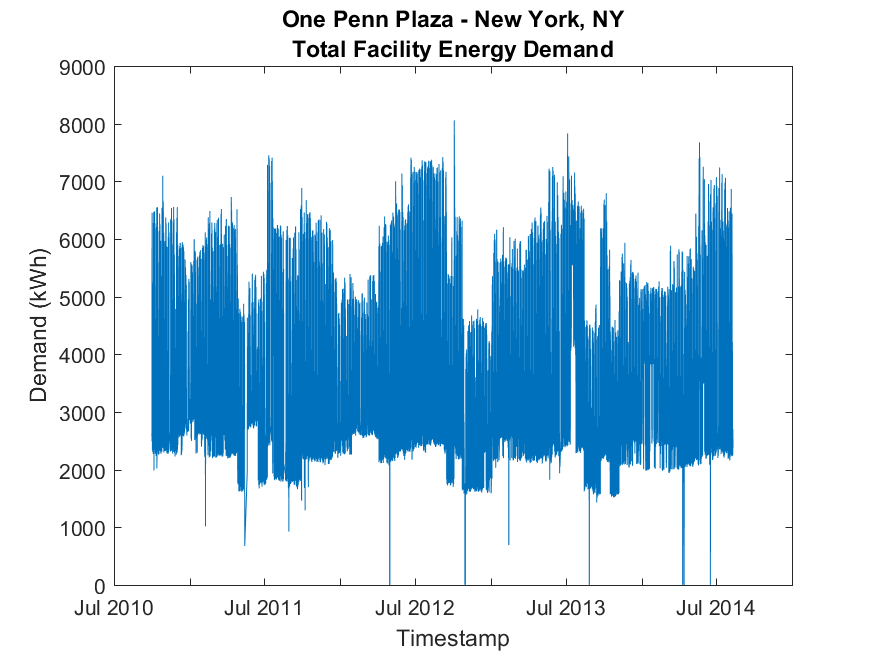
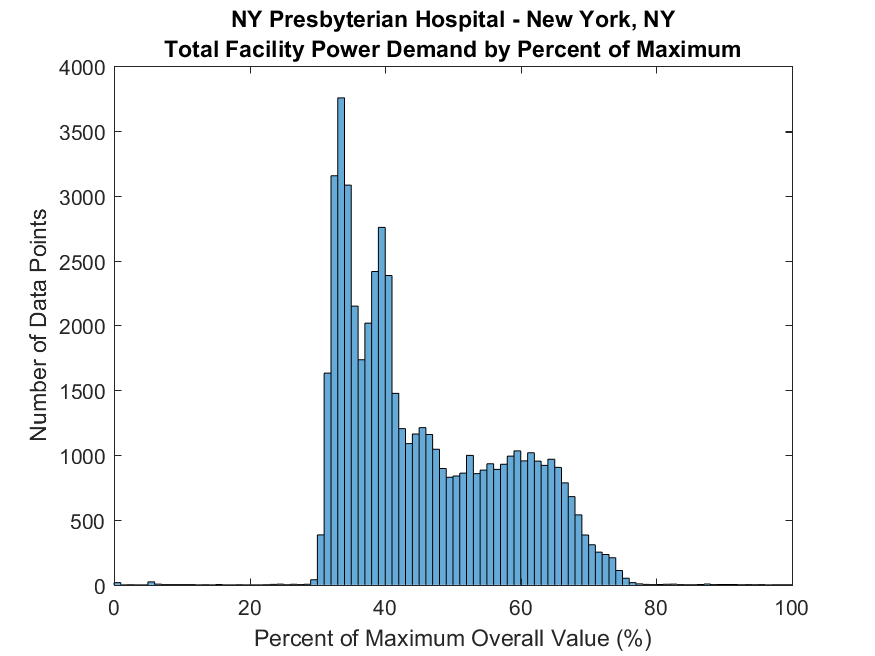
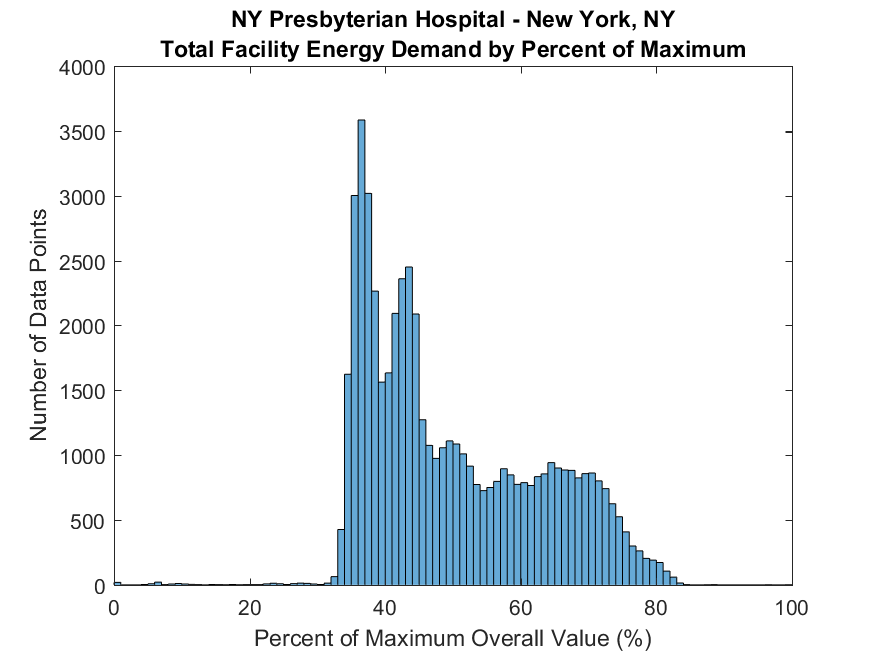
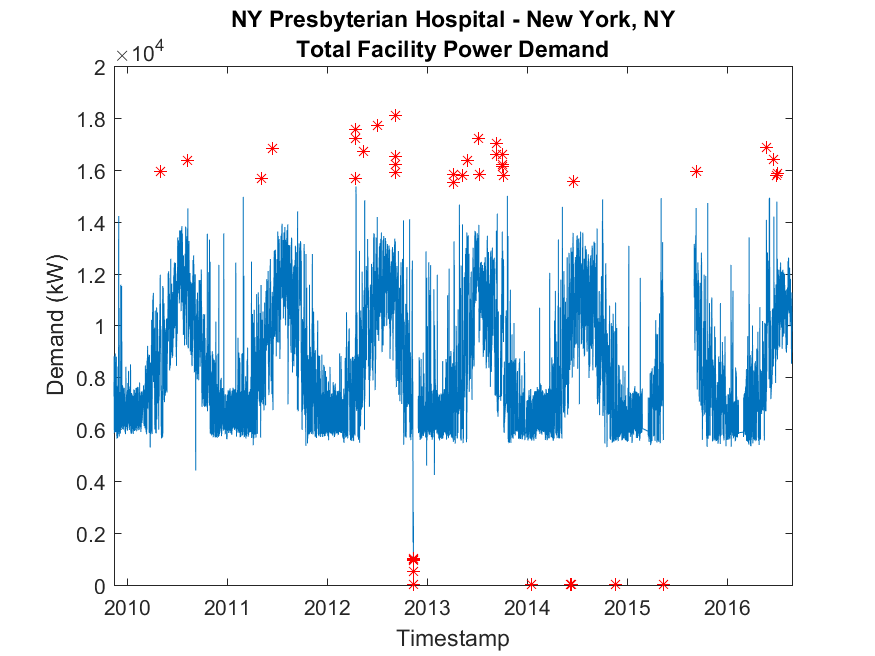
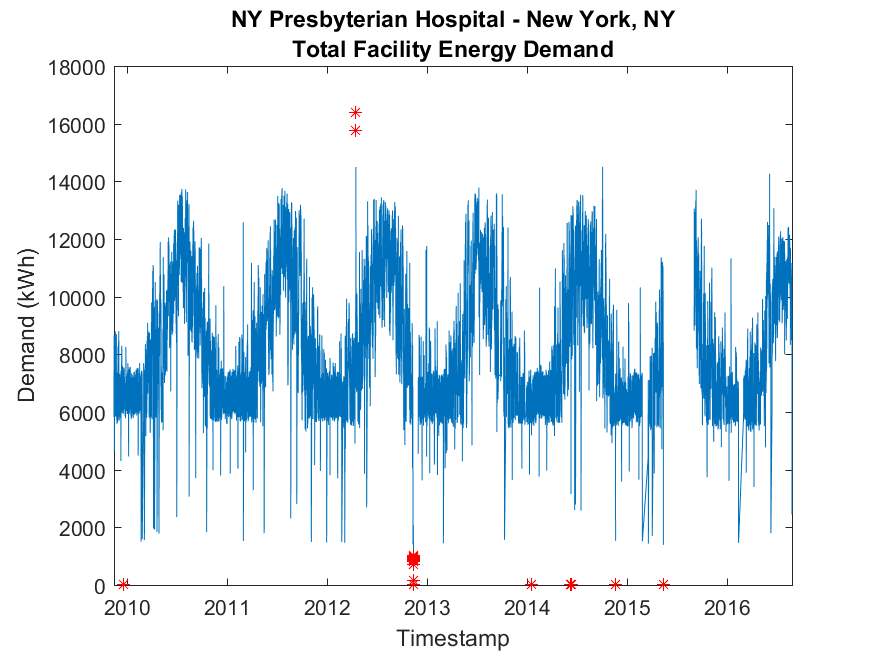
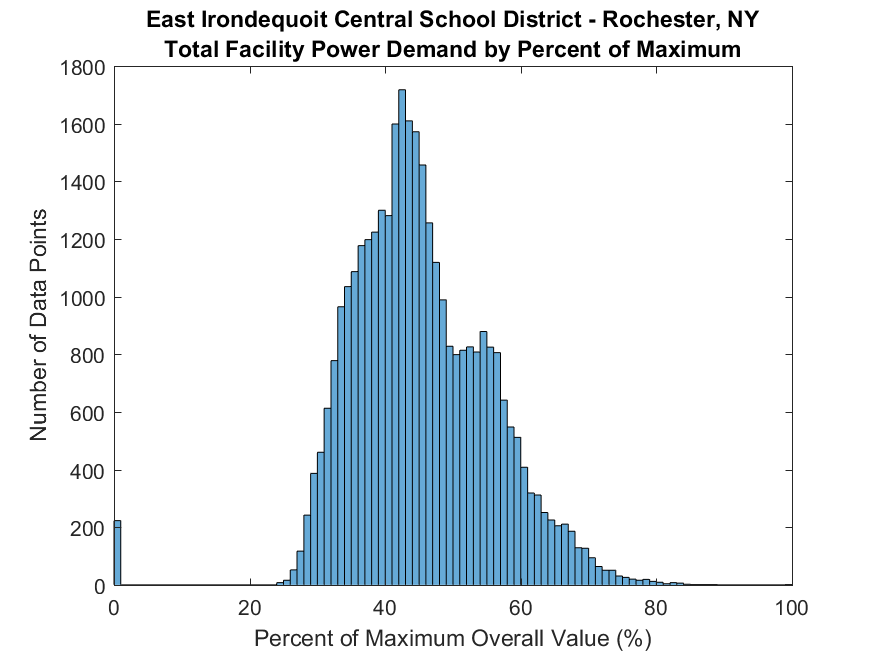
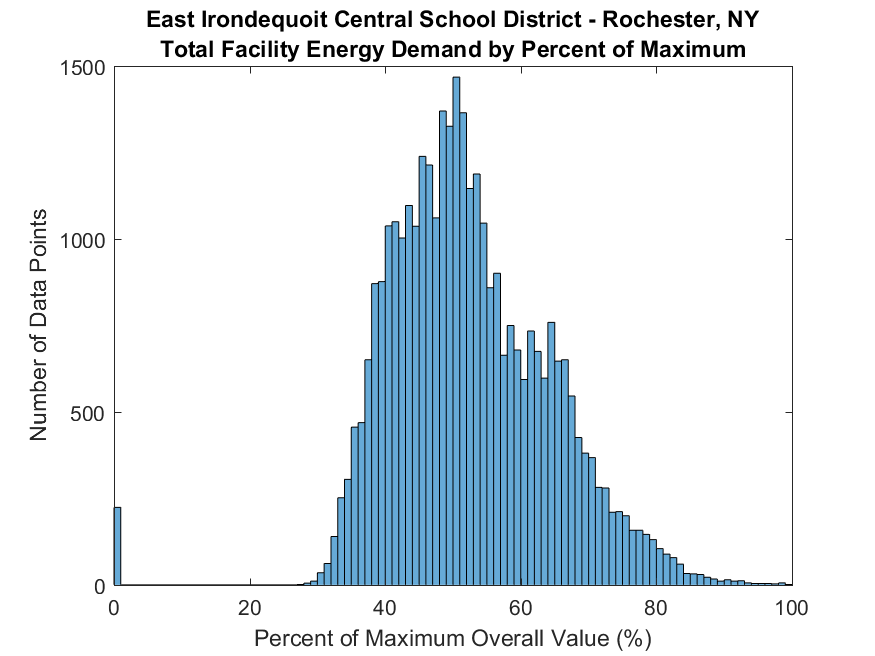
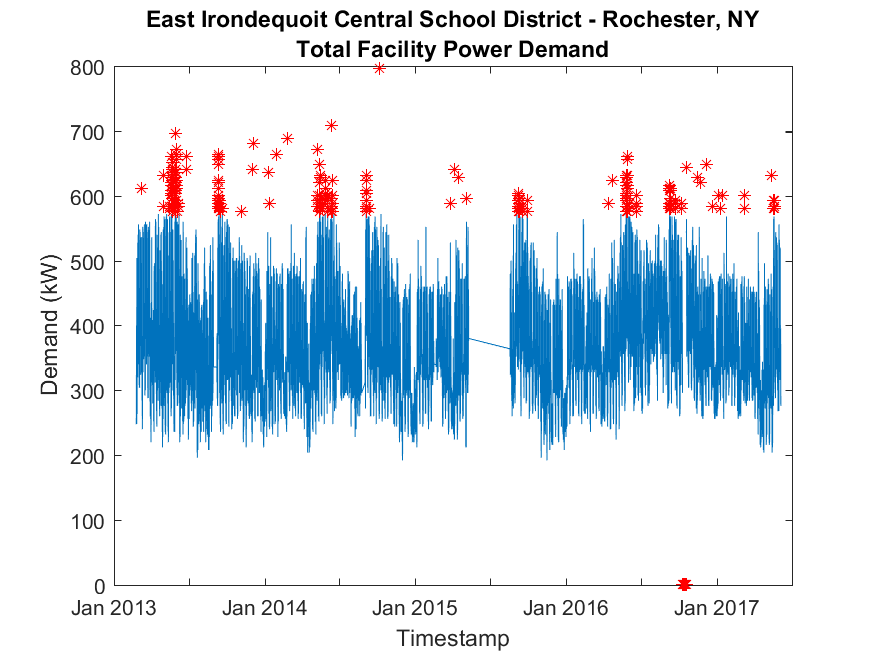
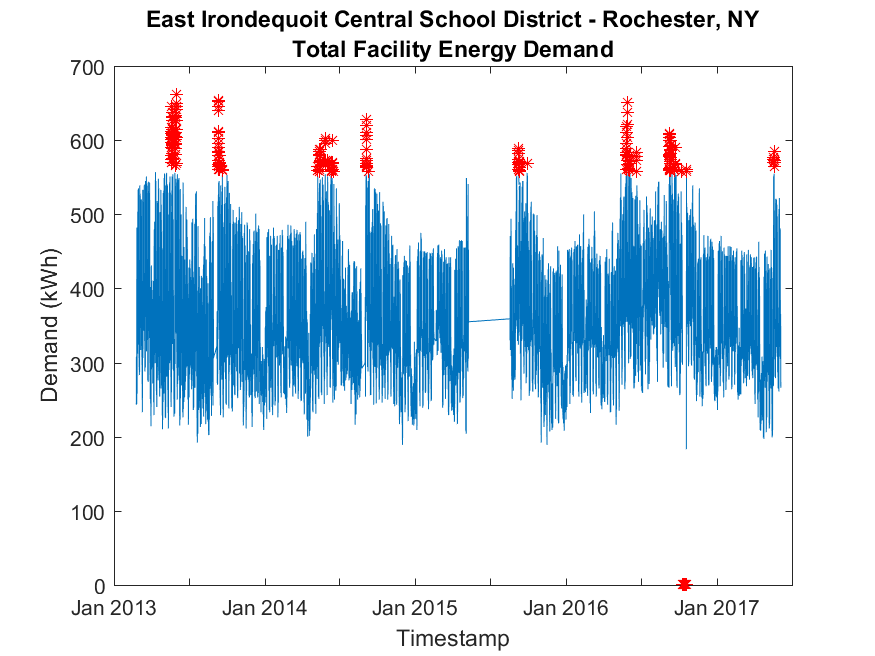
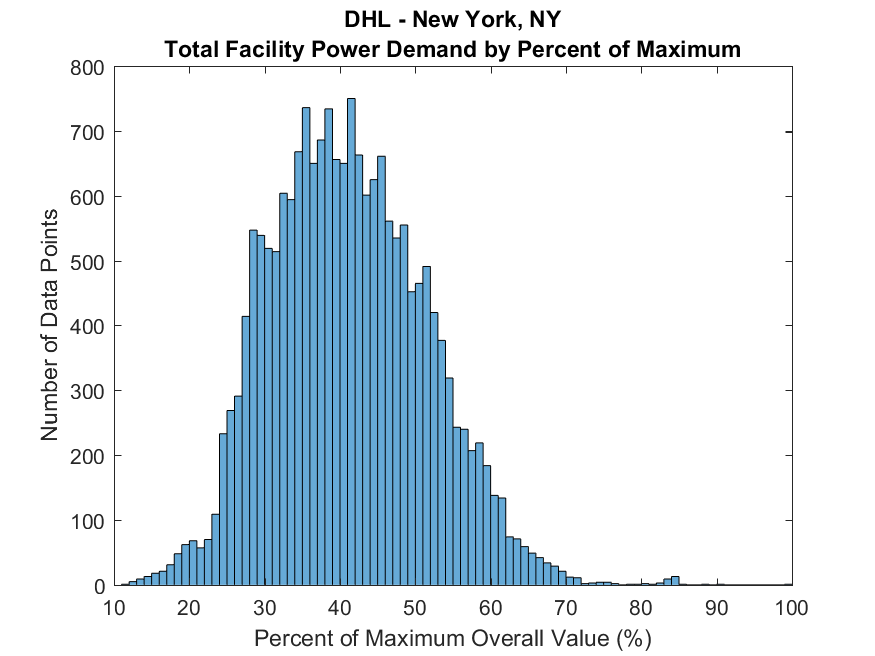
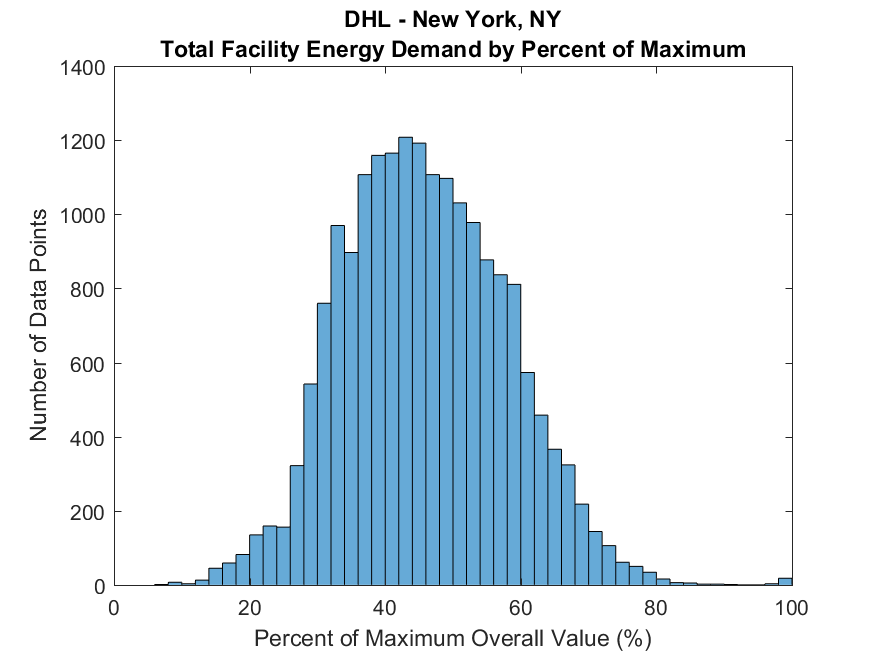
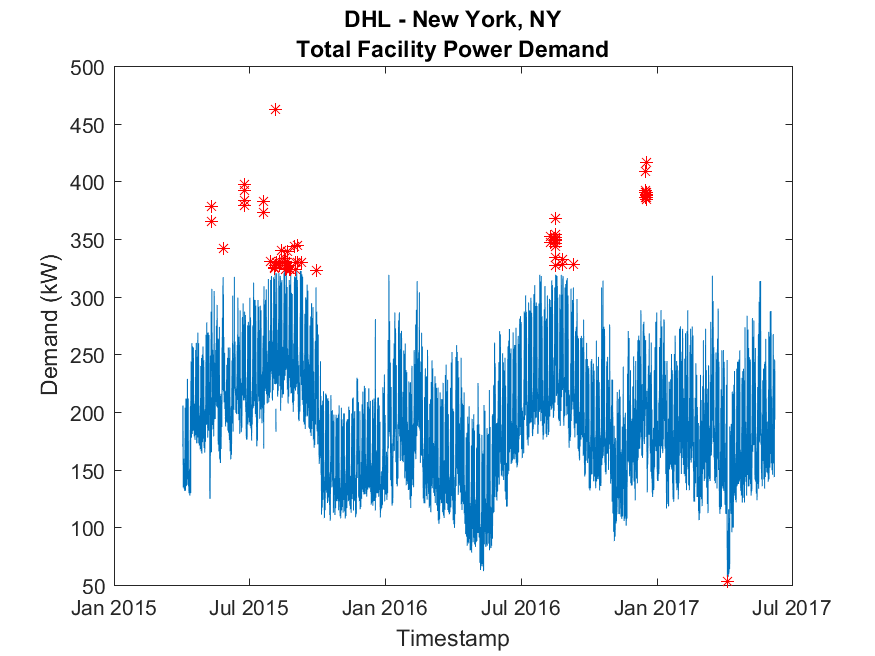
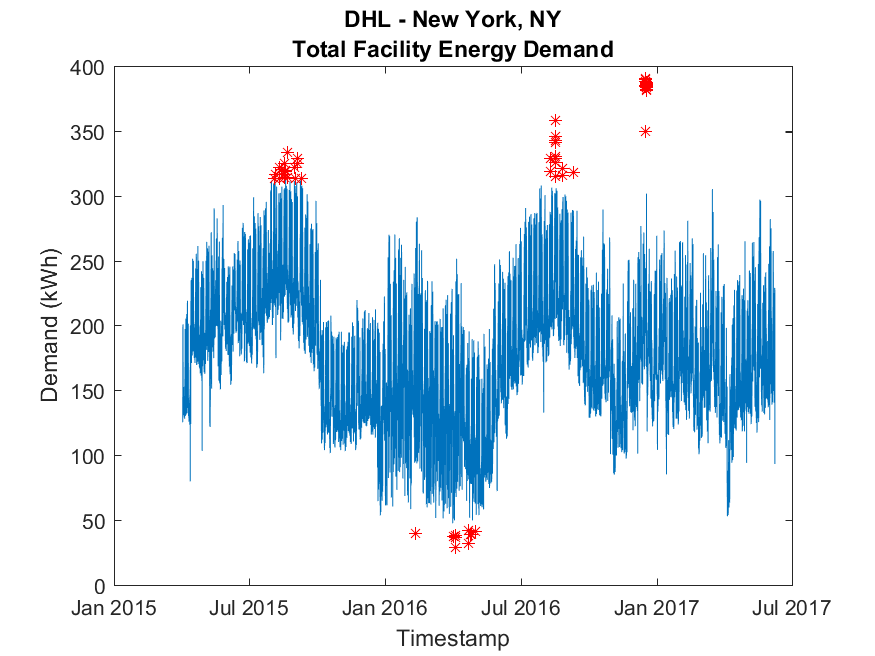
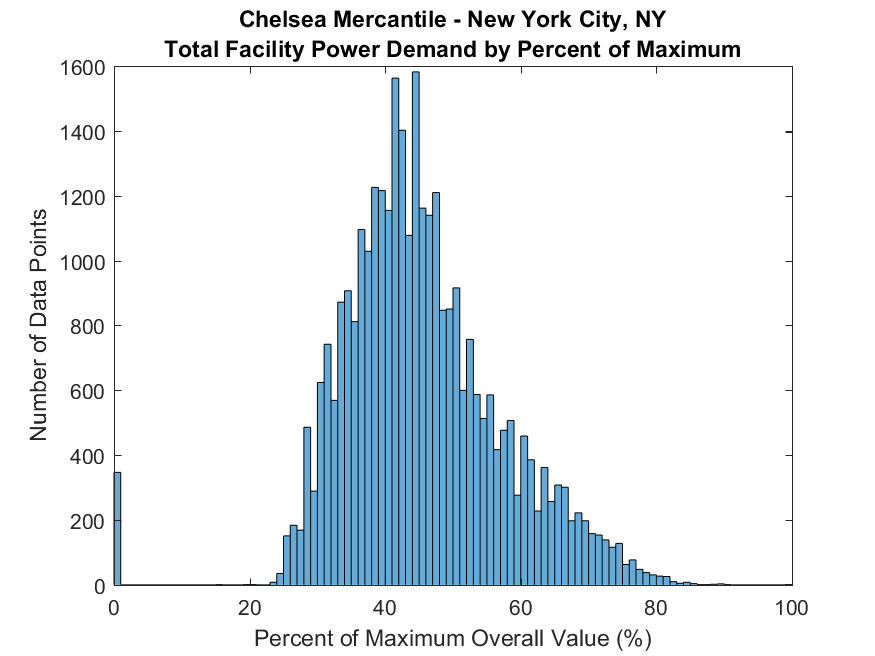
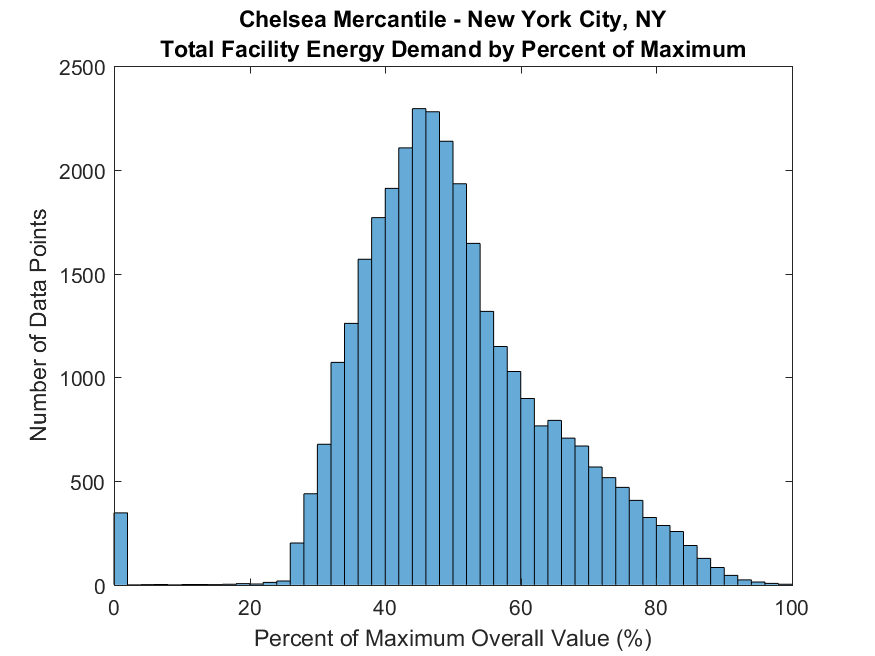
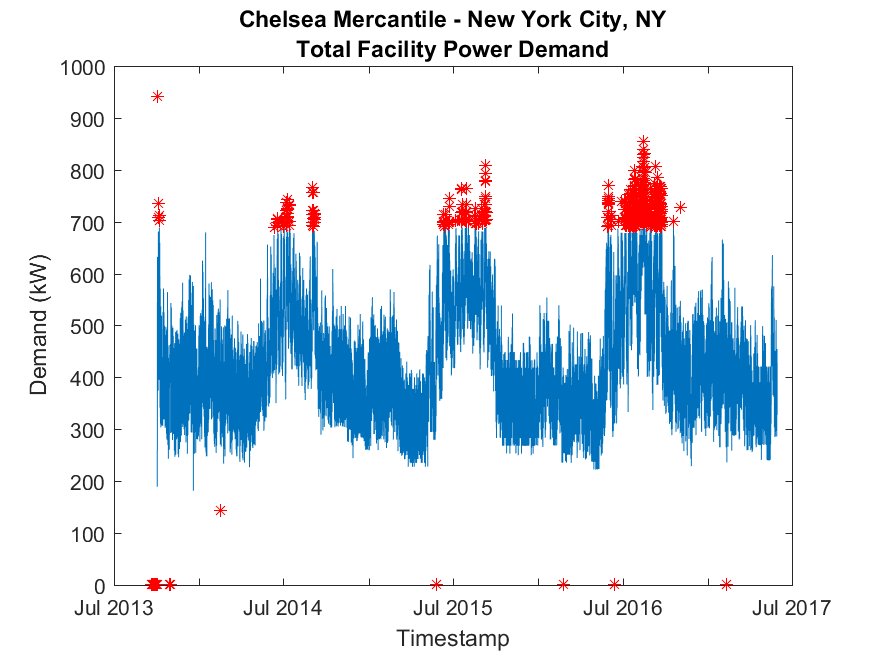
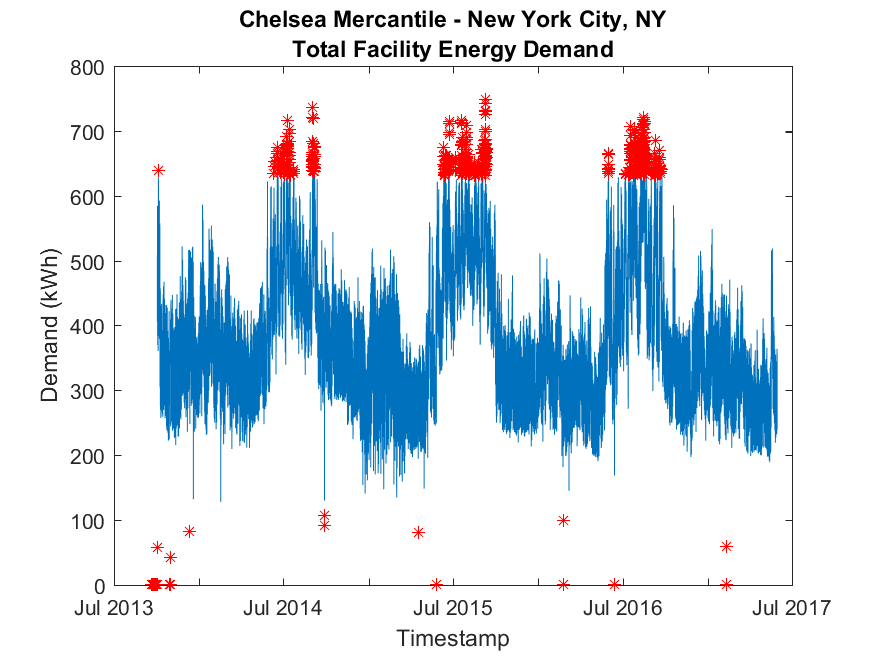
The table below outlines the metrics that we came up with for characterization of building demand profiles.

|  |  |
| --- | --- |
| **Name** | **Precise Mathematical Description** |
| Turndown Ratio | Max. value / min. value |
| Minimum 95% Range | 95% of data points that result in lowest range (min-max) |
| Outlier Difference – (low, high) | Low: Absolute minimum minus min. 95% range minimum  High: Absolute maximum minus min. 95% range maximum |
| Demand Histogram (% of peak demand) | Number of data points within 0-10%, 10-20%, …, 90-100% (For width = 10%) |
| Cumulative Demand Histogram (% of peak demand) | Cumulative histogram of Demand Histogram |
| Peak Magnitude Standard Deviation with Seasonal Bias Correction | Average a week or two to left and right to get seasonally averaged demand. Then find st. dev. of daily peaks |
| Peak Magnitude Standard Deviation without Seasonal Bias Correction | Average all data points to get total averaged demand. Then find standard deviation of daily peaks |
| Peak Time (hrs) | Range of hours between which peak occurs. Peak defined as the hours within 5% of peak value determined by Min. 95% Range |
| Trough Time (hrs) | Range of hours between which trough occurs. Trough defined as the hours within 5% of minimum value determined by Min. 95% Range |
| Peak Duration (hrs) | Number hours within 5% of peak value determined by Min. 95% Range |
| Trough Duration (hrs) | Number hours within 5% of trough value determined by Min. 95% Range |
| Maximum Ramp Rate to Peak (%/hr) | Maximum slope of 3-point averaged (current, one behind, and one ahead) demand |
| Transience (%/hr) | Mean abs. value of slope |
| Turbulence (%/hr2) | Mean abs. value of change in slope |
| Maximum Slope Difference (%/hr) | Maximum of slope differences from hour to hour |
| Number Local Peaks |  |
| Peak Demand Value (kWh) | Absolute largest magnitude of demand |
| Average Demand Value (kWh) | Mean of all values in one day |
| Annual Trend (kWh/hr) | Final minus initial value of seasonally averaged demand, divided by 8760 hours |
| Peak Skew (%) (only applies for non-plateauing behavior) | This would be difficult… |
| Time Unsteady (hrs) | Number of hours within which demand is changing by more than 10% of peak demand |
| Noise | Standard deviation of data minus smoothed data (2- or 4-hr smoothing) |
| Measurement Noise | Average of % Peak Power Demand minus % Peak Energy Demand values |
| Trend of Average Daily Value | Plot of average daily values for all days containing data. |
| Average Daily Value Standard Deviation | Standard deviation in the average value across all days with complete set of data. |
| Average Daily Maximum Standard Deviation | Standard deviation of daily maximum value across all days with complete set of data. |
| Average Daily Minimum Standard Deviation | Standard deviation of daily minimum value across all days with complete set of data. |
| Heating-Electric Overlap | L2-norm (sum of square errors). Errors are abs(%electric - %heating) |
| Cooling-Electric Overlap | L2-norm (sum of square errors). Errors are abs(%electric - %cooling) |

Results

The following results have been obtained for nine of the thirty buildings selected from among the entire set of NYSERDA database files. These nine were selected prior to any filtering of data, and as such were selected on the basis of the relative “niceness” of their data. In other words, the data for these nine buildings do not contain any egregious outliers that would skew the results of statistical analyses performed on them. The analyses performed on this subset of buildings so far includes a demand histogram, a plot of the data showing outliers based on 150% of the interquartile range, and lastly a set of box plots showing the distribution of each building’s daily turndown ratios.

**Demand Plots and Histograms**



**Turndown Ratios**

