2016 Cambridge Building Energy and Water Use Report

January 2017

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I. Introduction

This report presents an initial analysis of the energy and water data gathered through the 2016 cycle of the Building Energy and Water Use Disclosure Ordinance (BEUDO). The data described in the following analysis covers calendar year 2015 and is self-reported by properties covered by the ordinance. The analysis includes properties who submitted a report by September 6, 2016. In 2016, the Ordinance expanded to include nonresidential properties 25,000 ft^2 and larger, as well as residential properties with fifty or more units and municipal properties 10,000 ft^2 and larger.

The trends section of this reports compares the energy use performance among buildings originally subject to BEUDO in 2015 and who reported for the second time in 2016. These calculations also include weather normalized metrics, which

2016 BEUDO Reporting Cycle

Compliance Rate	Number of Buildings Reported/Total Subject to Ordinance	Average ENERGY STAR Score	Total Area Passed Checks/Submitted	Reports Analyzed
91%	1,015/1,117	65	65 million ft^2/ 76 million ft^2	591/702 received

BACKGROUND AND CONTEXT

The 2016 reporting cycle gathered energy and water use data for properties subject to BEUDO for the 2015 calendar year, January 1 through December 31, 2015. This is the second year of reporting for buildings that were originally subject to BEUDO during the 2015 reporting cycle. For these properties, the second-year data has been disclosed to the public and is available on the Cambridge Open Data Portal. Data for properties reporting energy and water use for the first time in the 2016 reporting cycle will be disclosed in 2017.

The energy analysis presented in this document is based on 84% of total submissions received, after filtering reports for data quality. Data quality checks are detailed in “Review of Filtering and Outreach”.

	Cambridge (2015)	2015 BEUDO	%	2016 BEUDO	%
Total Buildings	14,040	980	7%	**1,117**	**8%**
Total Area (ft^2)	127,200,000	72,500,000	57%	**77,400,000**	**61%**
Total Units	52,101	15,249	29%	**16,089**	**31%**

II. Building Characteristics

Energy and water use data is submitted to the City through ENERGY STAR Portfolio Manager, an online platform used for benchmarking energy and water use consumption. Depending on available meter configurations, property owners and managers may submit their data at the building or property level, where a single data submission represents energy and water use at multiple buildings. We refer to each report received through Portfolio Manager as a "property" in order to account for both situations.

In 2016, we received data covering approximately 76 million square feet in 702 individual Portfolio Manager reports. Of these, 65 million square feet in 591 reports passed data quality checks. This represents 61% of the total building space in Cambridge.

The area distribution by property type is shown in Figure 2.1. College/university and multifamily housing are the two largest property types among properties subject to BEUDO, representing over 50% of the total portfolio. It is important to note that the college/university property type is made up of several space uses, including classrooms, offices, laboratories, residential areas, etc. College/university properties are typically reported as campuses with shared meters. Offices represent another 18% of properties and laboratories 9%. While this distribution is similar to 2015, there was an increase in the amount of office space reporting in 2016 (9.7 million square feet to 11.9 million square feet). The Ordinance also covered parcels with 25,000 ft^2 or more of building space this year, in addition to the 50,000 ft^2 or more covered last year. Most of the additional buildings required to report in 2016 were office space types, followed by laboratories and college/university.

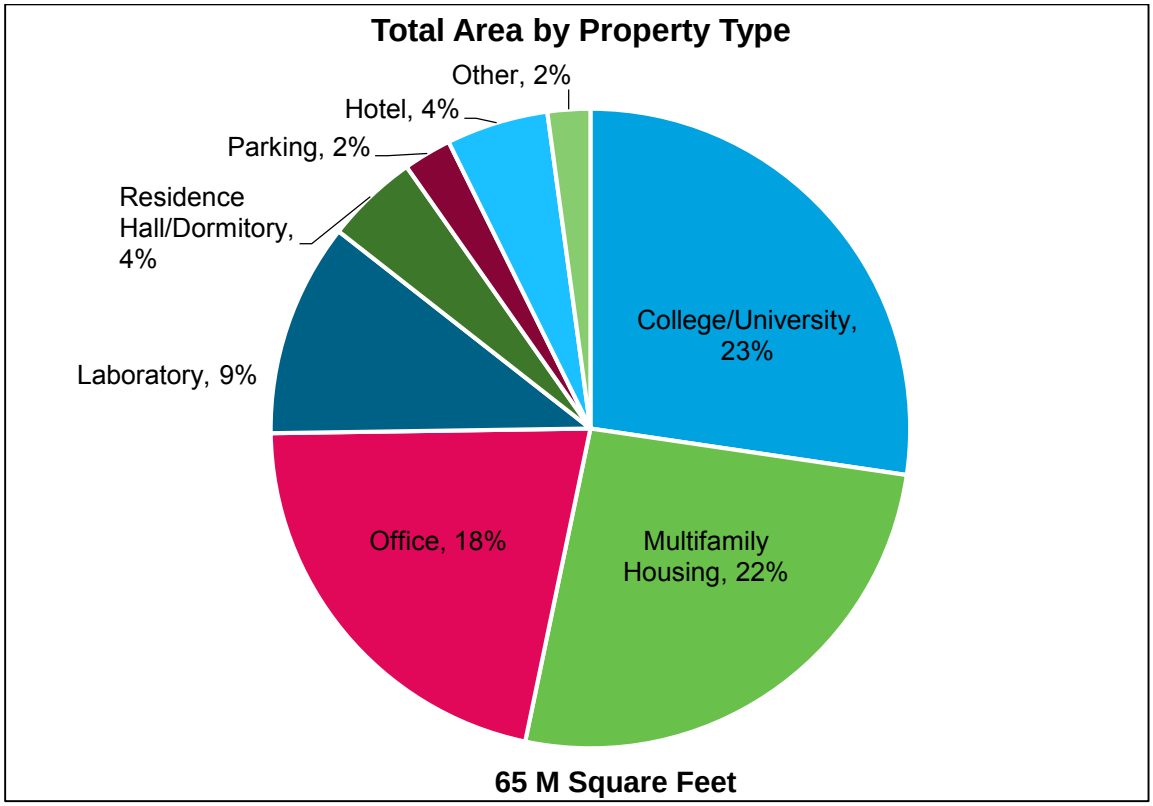

Figure 2.1: Total Area by Property Type

BEUDO applies to properties at the parcel level and as a result smaller buildings were also captured. While the median area of properties was 73,347 ft^2, most properties were between 6,500 ft^2 and 400,000 ft^2. Larger properties are typically properties made up of several buildings and reported together. Figure 2.2 shows the floor area distribution among analyzed BEUDO properties.

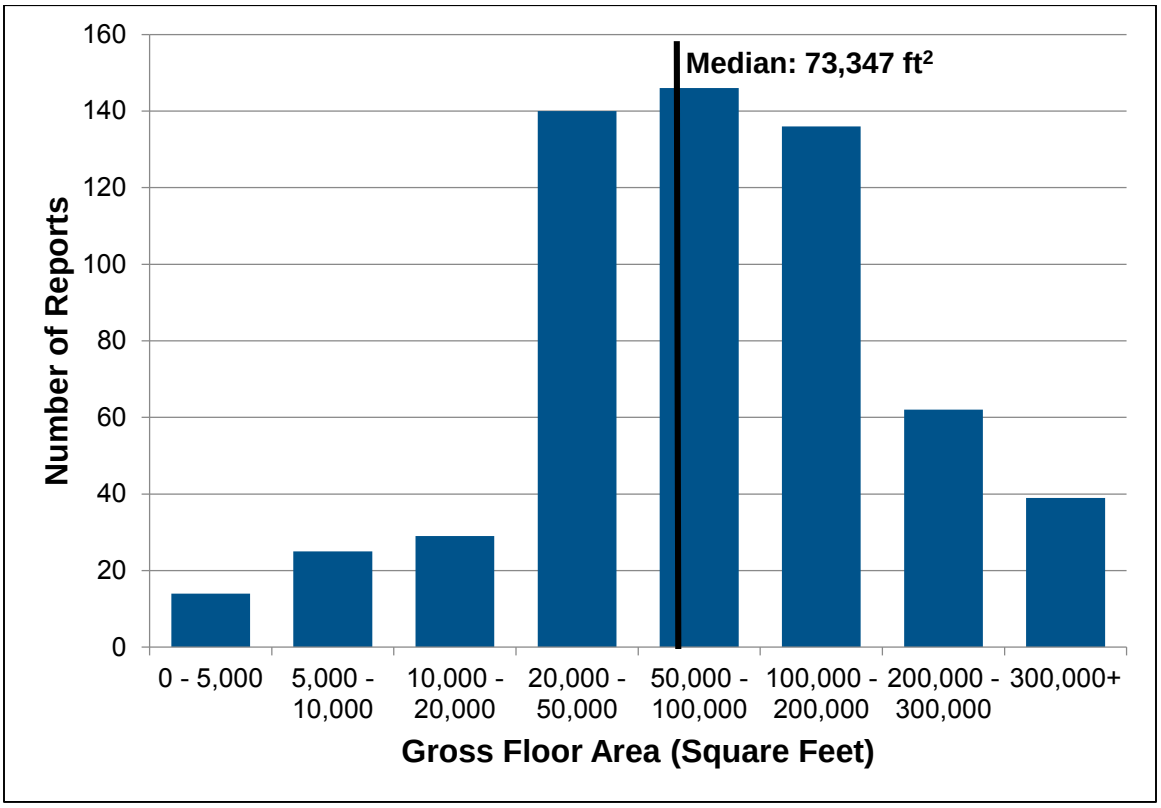

Figure 2.2: Property Floor Area Distribution

III. Building Energy Performance

The energy data received by the City is a yearly aggregate for each fuel type used in a building. Source energy includes the amount of energy used in transmission and distribution for each fuel type. As shown in Figure 3.1, in 2016 the median source EUI for the total portfolio of evaluated properties was 155.3 kBtu/ft^2, while the median source EUI in 2015 was 164.6 kBtu/ft^2. Median site EUI (Figure 3.2) also decreased from 87.6 kBtu/ft^2 in 2015 to 82.4 kBtu/ft^2 in 2016. This may be due to the addition of smaller, less energy use-intense buildings to the portfolio. The trends section details changes in EUI among the same cohort of properties that reported in 2015.

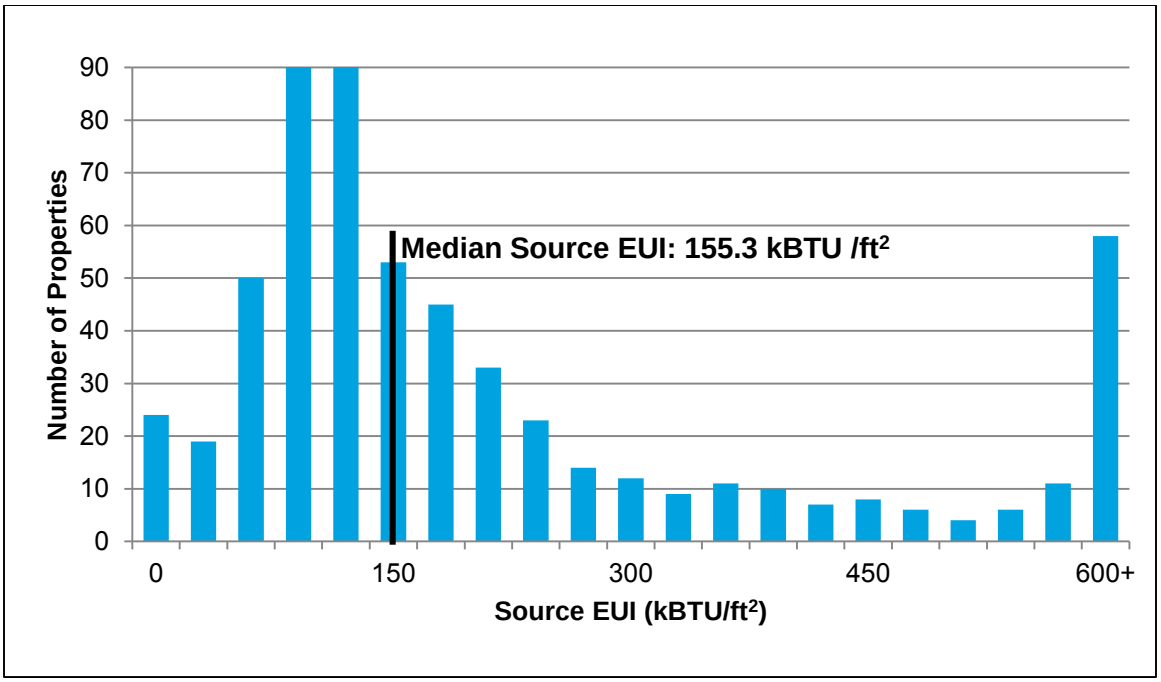

Figure 3.1: Source EUI Distribution

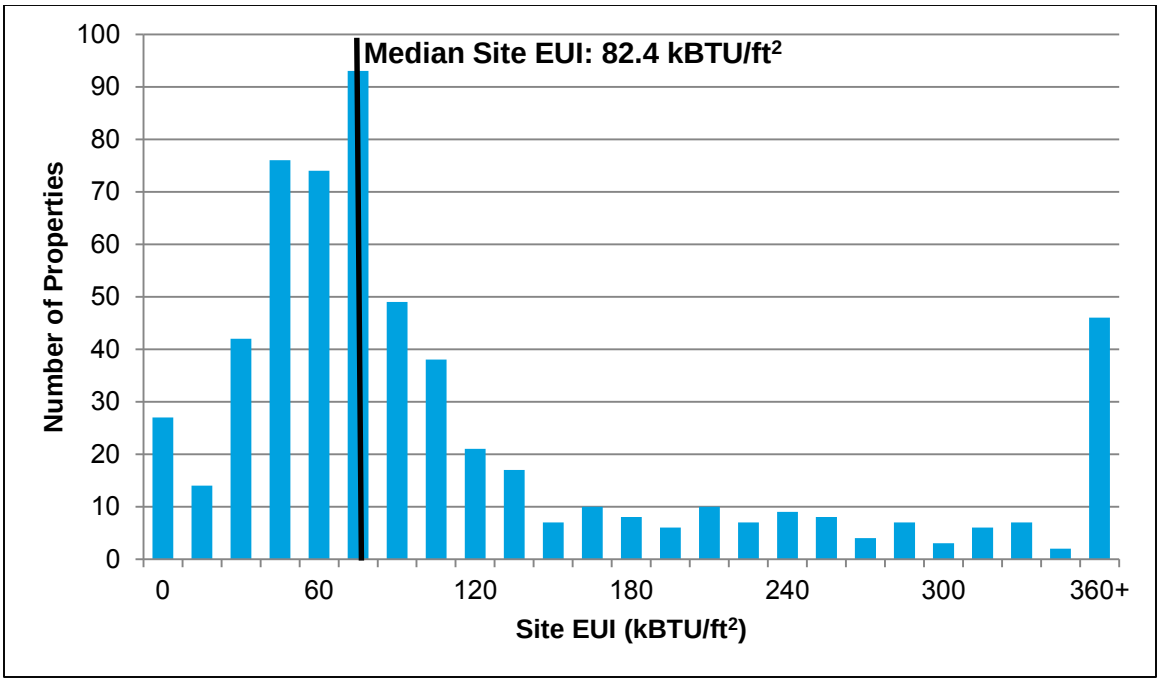

Figure 3.2: Site EUI Distribution

Figure 3.3 compares median site EUI for the property types with the largest energy consumption in Cambridge to the national Commercial Building Energy Consumption Survey (CBECS) database. While there is newly available 2012 survey data available from CBECS, this data has not yet been incorporated into ENERGY STAR Portfolio Manager, so the comparisons depicted in the following graph are based on the 2003 dataset. For laboratories, the latest Labs21 dataset for the 6A climate zone was used to calculate a national median site EUI. College/university, multifamily housing and residence hall/dormitory property types all performed better than the national median site EUI. Offices, laboratories, k-12 schools and hotels performed better nationally than in Cambridge. Laboratories are the most energy-intense property types among BEUDO properties.

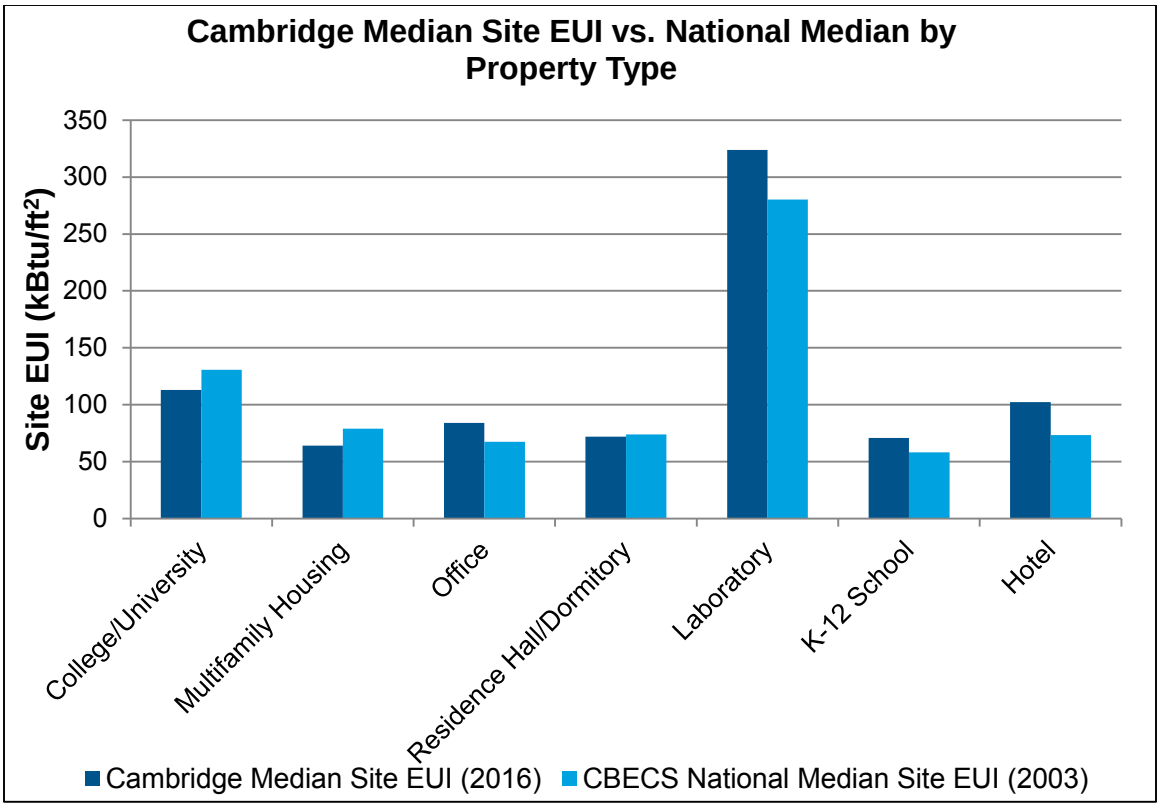

Figure 3.3: Median Site EUI Compared to National Median Site EUI, by Property Type

Among other labs reporting energy data in the Labs21 dataset for the 6A climate zone, BEUDO laboratories had an average source EUI of 624 kBtu/ft^2, while the Labs21 average source EUI was 601 kBtu/ft^2 (Figure 3.4). Laboratories vary drastically in their functions. The Labs21 data includes biological, chemical, physical and combination laboratory types.

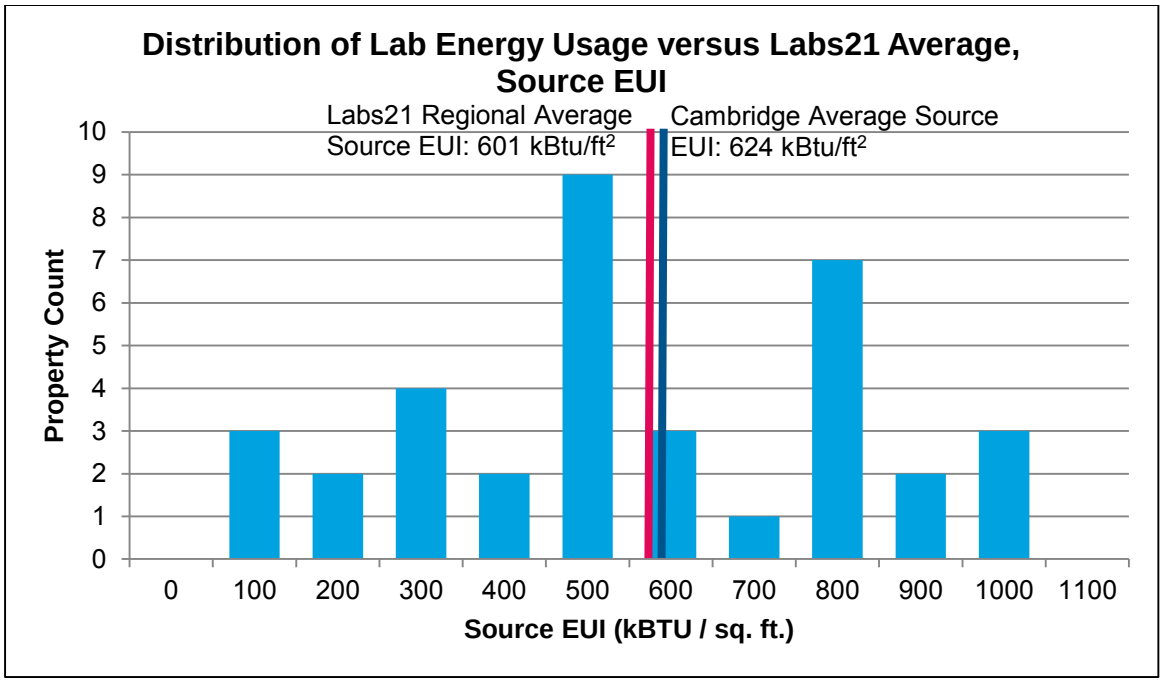

Figure 3.4: Laboratory Energy Use Distribution

Figure 3.5 shows the variation in site EUI among the most common BEUDO property types. The multiplier indicated in the center of each respective property type's range in site EUI conveys the difference between the 5th and 95th percentile of site EUI. The large multiplier for the college/university property type reflects the various space types that may make up a property designated as college/university, from smaller, less energy intense space uses such as dorms to larger, energy intense space uses such as laboratories. Hotels and K-12 schools have the least variation in site EUI. Larger variations may suggest opportunities for energy improvement.

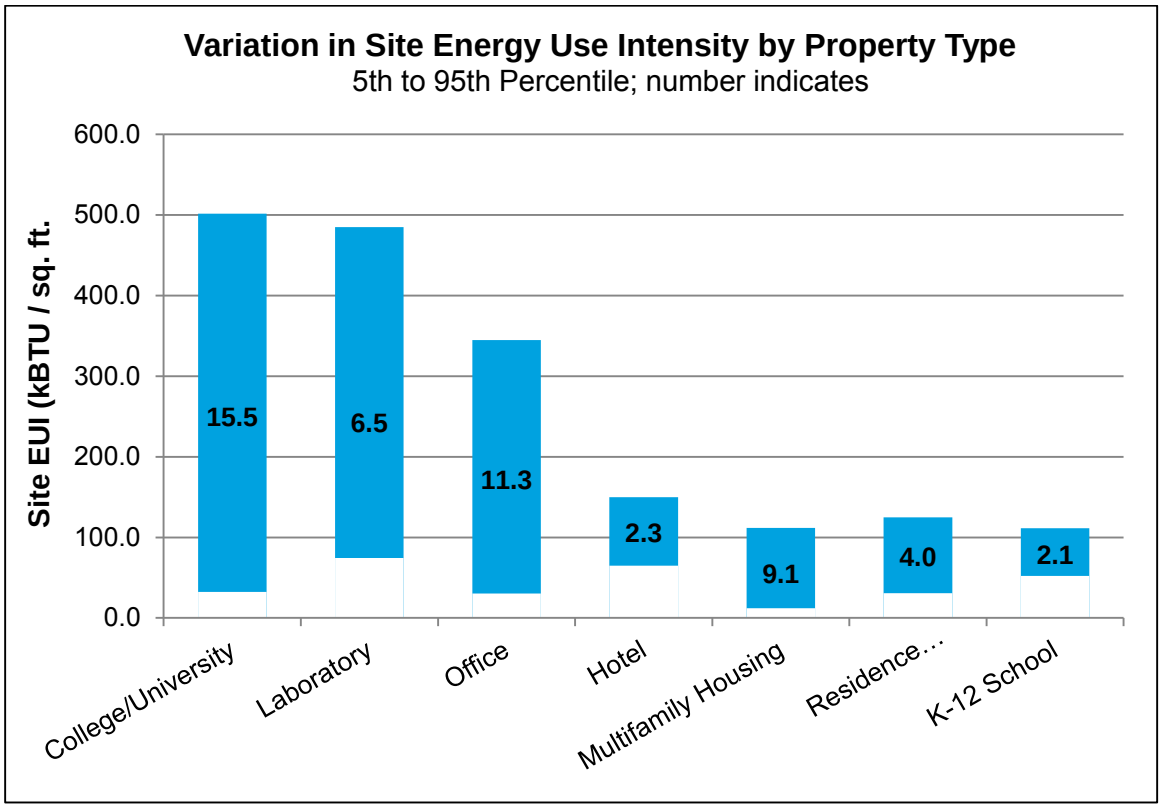

Figure 3.5: Variance in Energy Use by Property Type

While the total amount of energy reported in BEUDO submissions increased from 2015 to 2016 (from 8.4 billion Btu to 9.3 billion Btu), it is important to keep in mind that there were additional buildings subject to the ordinance in 2016. Energy use distribution among property types remained consistent (Figure 3.6). College/university properties consumed the largest share of energy among BEUDO properties (31%), followed by laboratories (20%), offices (16%), and multifamily housing (11%). Laboratories are 9% of the total area of properties in the BEUDO dataset, but consume 20% of the total energy. Multifamily housing is 22% of the total area of properties, but represents 11% of total energy use. These associations are similar to 2015, with laboratories consuming a slightly larger share of energy in 2016 (20%) than in 2015 (16%).

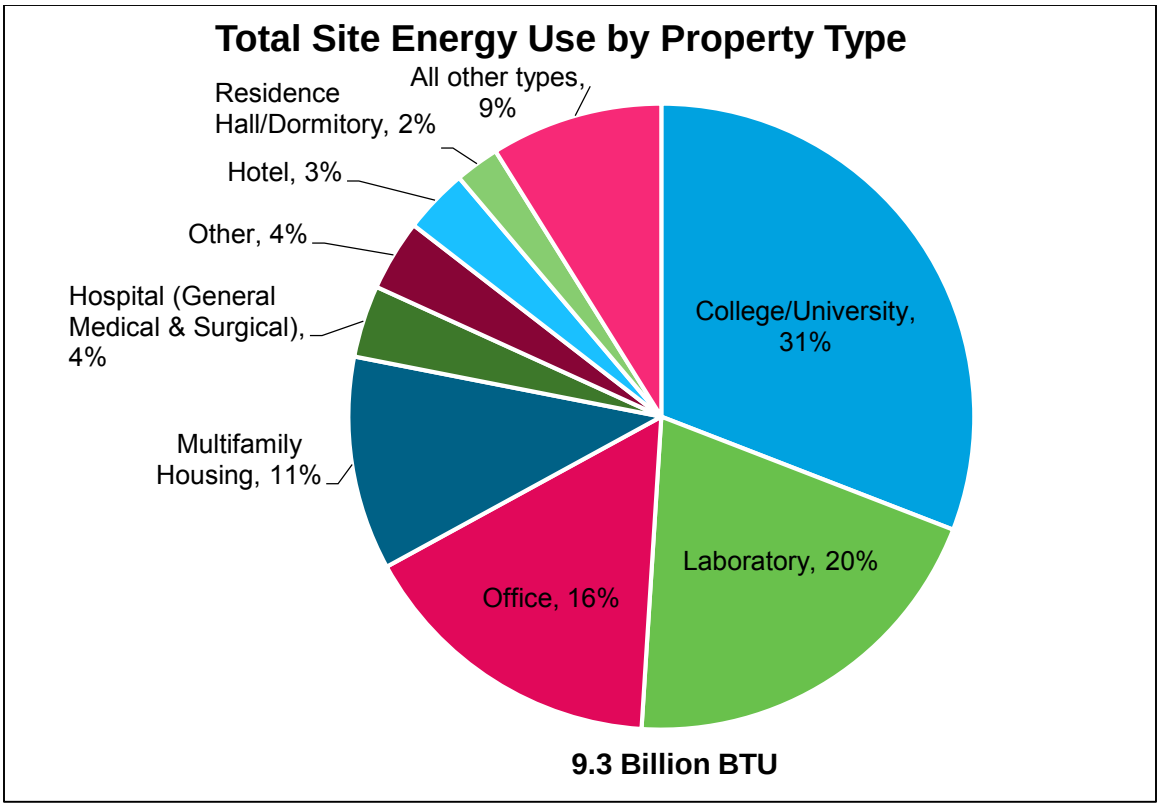

Figure 3.6: Share of Total Energy Use by Property Type

There were 269 properties eligible for an ENERGY STAR score in 2016 (46% of the data checked properties), compared to 225 in 2015 (42% of the data checked properties). Among these properties, the average score was 65, compared to 61 in 2015. Figure 3.7 shows the distribution of ENERGY STAR scores. Fifty-three properties have a score of 75 or higher and are eligible for ENERGY STAR certification.

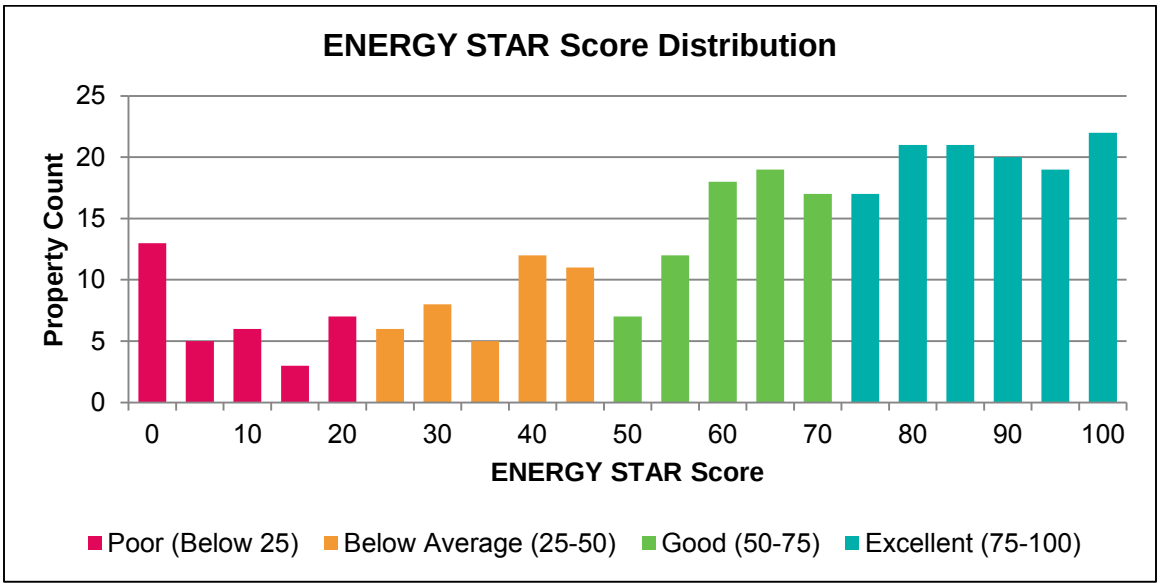

Figure 3.7: ENERGY STAR Score Distribution

Residence hall/dormitories and K-12 schools have the largest share of properties performing at or better than the national average of 50 (Figure 3.8). Sixty percent of hotels and 35% of offices receiving an ENERGY STAR score have a poor or below average score. Hotels and offices also have site EUIs higher than the national median, so this may present an opportunity for implementing energy saving measures. K-12 schools have a high median site EUI but also high ENERGY STAR score, suggesting that these properties consume large amounts of energy efficiently.

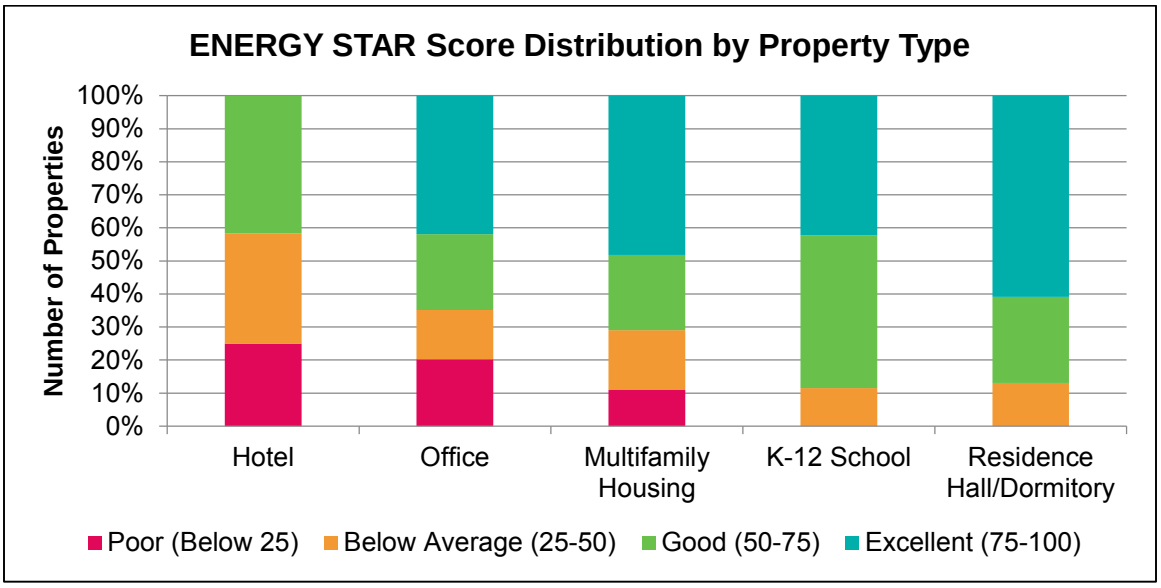

Figure 3.8: ENERGY STAR Score Distribution by Property Type

IV. Fuel Mix and Emissions

Greenhouse gas emissions for each property are calculated for each property and reflect the emissions generated by each fuel type. Figure 4.1 shows the comparison of total energy use to total GHG emissions by fuel type. The factors used for determining emissions by Portfolio Manager are the same nation-wide. Some BEUDO properties which consume power generated on-site and in combined heat and power plants may have different associated emissions depending on the fuel mix used in the plants.

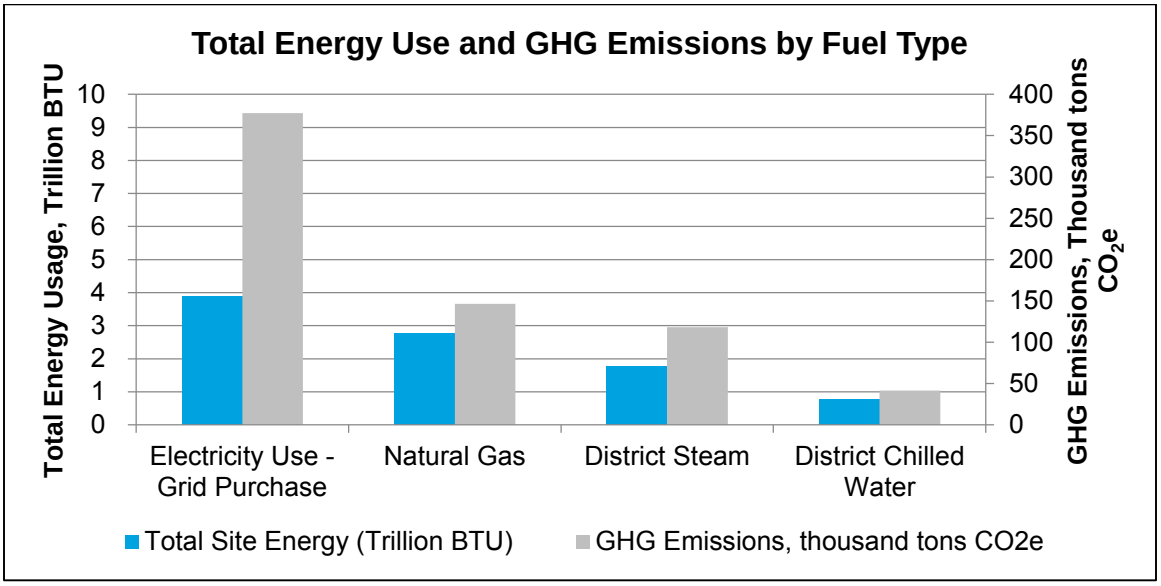

Figure 4.1: Total Energy Use and Greenhouse Gas Emissions by Fuel Type

Figure 4.2 shows the proportion of total GHG emissions contributed by the largest BEUDO property types and Figure 4.3 shows the fuel mix by property type. College/university properties have the largest GHG emissions of all properties in the BEUDO dataset. These properties, along with residence halls, have a high proportion of chilled water and steam use (~70%), which have low GHG emissions. The large proportion of GHG emissions as these properties is likely due to their share of the overall BEUDO portfolio. Offices are large electricity users that also have large variations in site EUI and have higher median site EUI than the national median, suggesting they are good candidates for implementing energy saving measures. Multifamily housing and hospitals are large natural gas users.

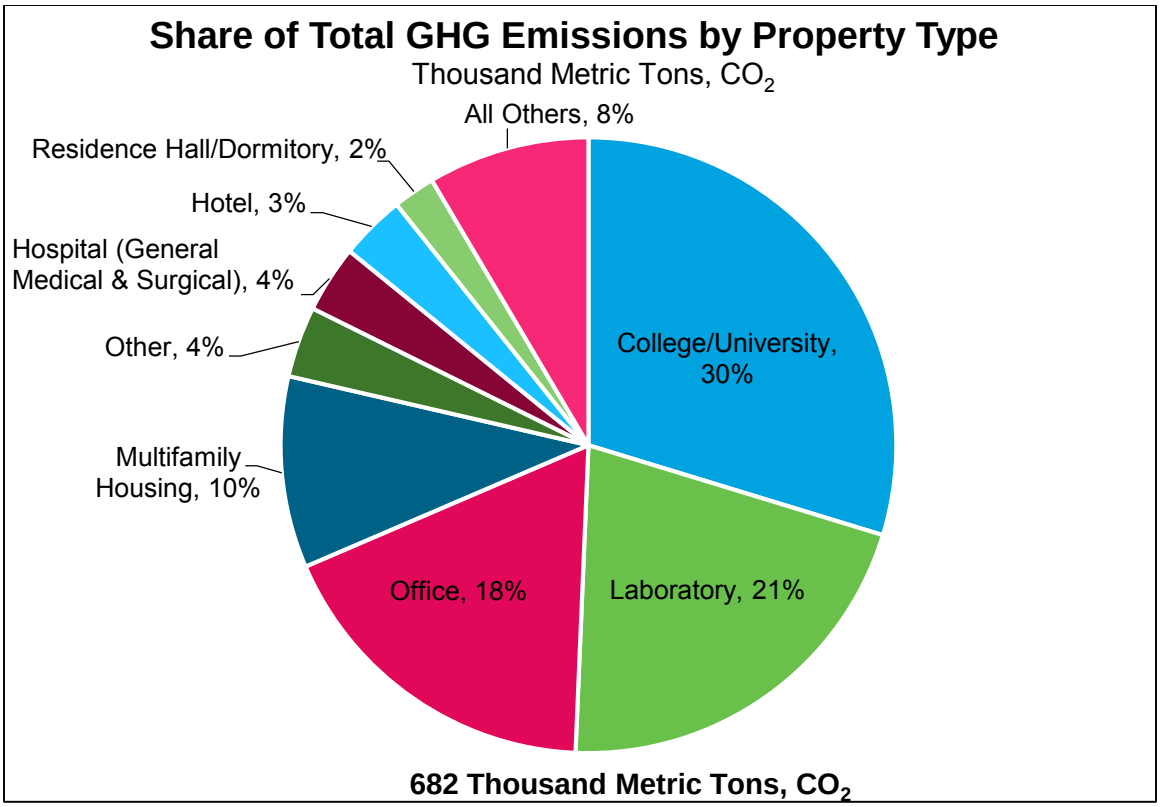

Figure 4.2: Total Greenhouse Gas Emissions by Property Type

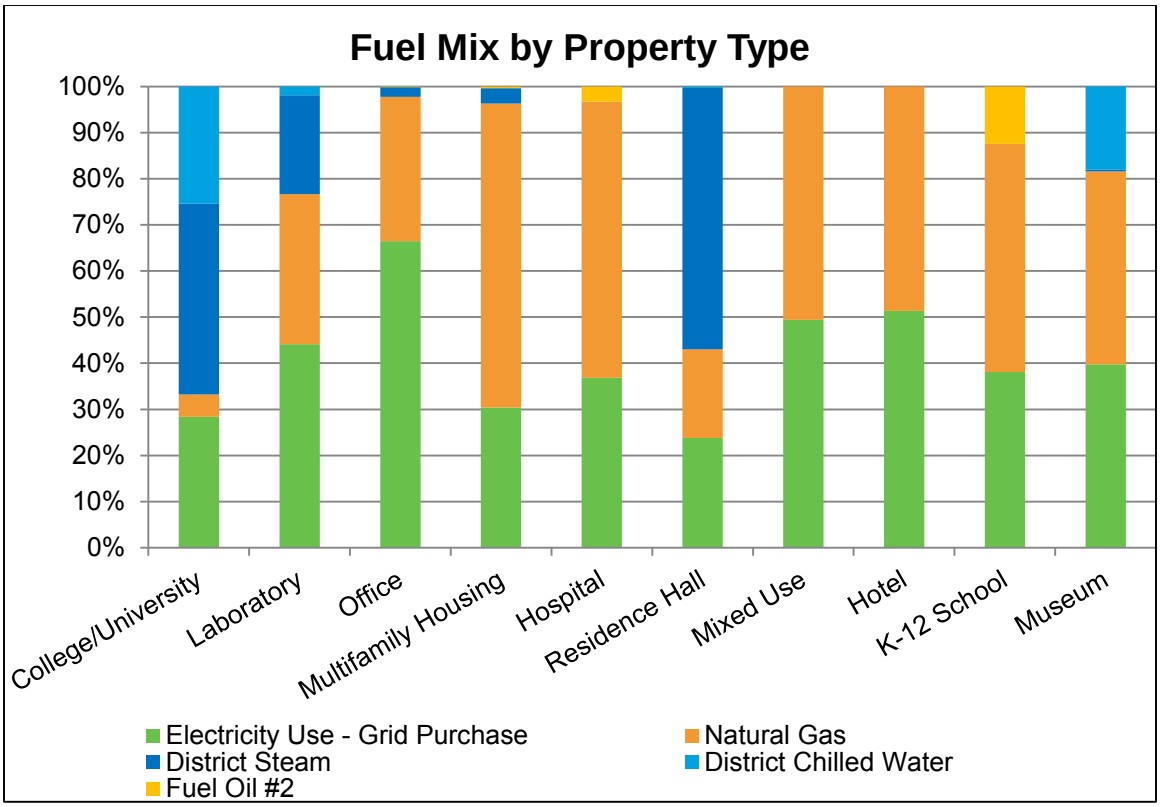

Figure 4.3: Fuel Mix by Property Type

V. Water Consumption

The 2016 BEUDO dataset for water consumption included both indoor and outdoor water use. 615 out of 702 properties included water data. After filtering for data quality, 441 properties (72%) of properties on 47.4 million square feet submitting water data were included in this analysis (Figure 5.1). 1.9 out of 11.7 billion gallons of water reported are included in this analysis (Figure 5.2)

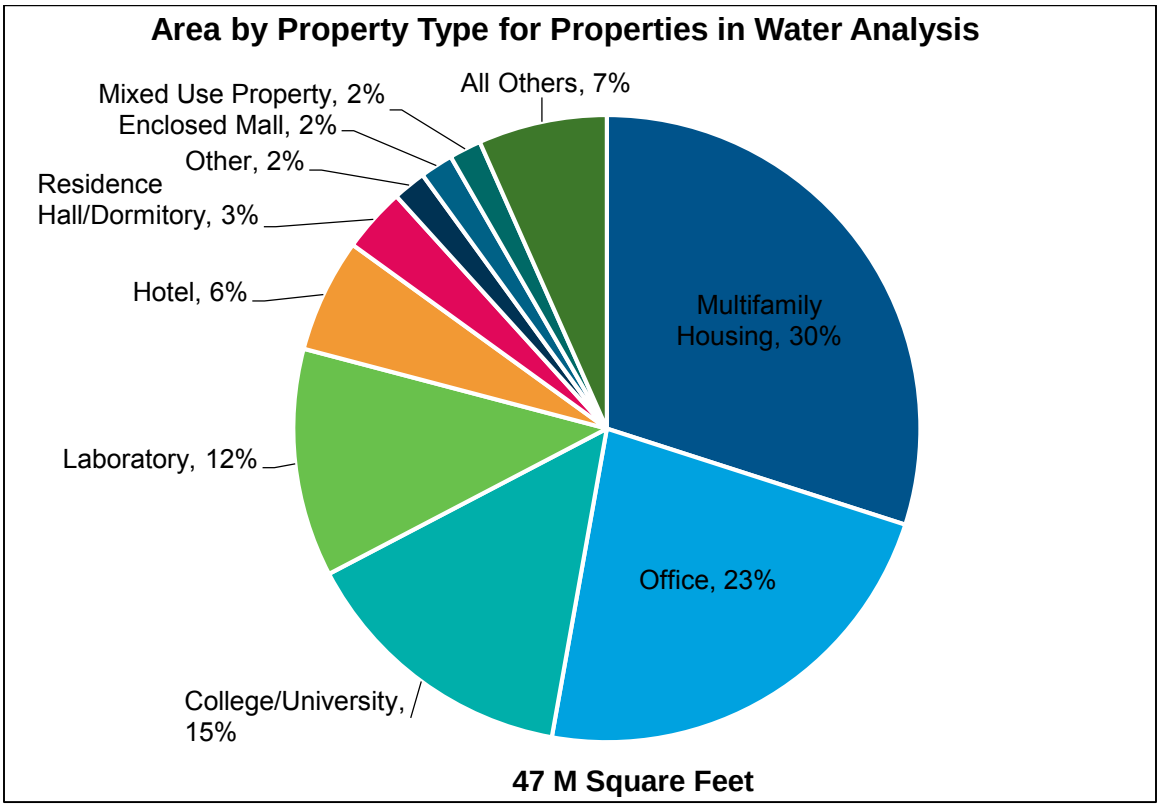

Figure 5.1: Area distribution of properties included in water analysis

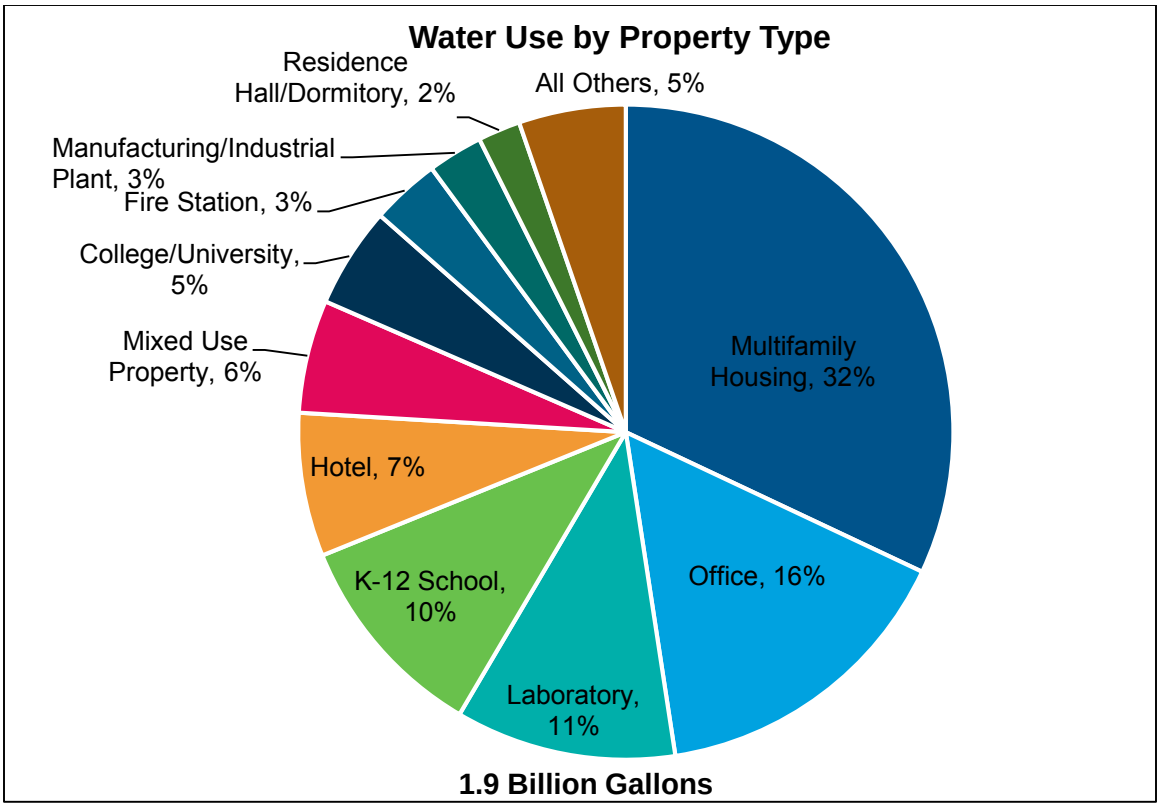

Figure 5.2: Water use distribution by property type

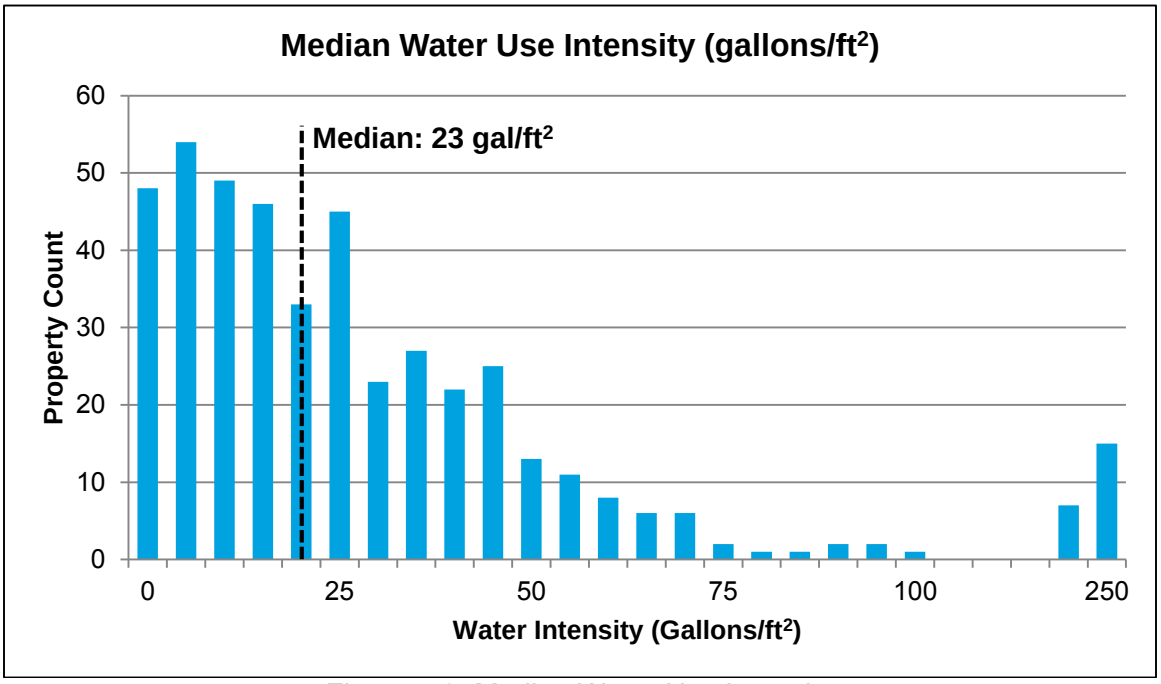

Figure 5.3: Median Water Use Intensity

The median water use intensity was 23 gal/ft^2 among BEUDO properties (Figure 5.3). Most properties had a median water use intensity between 3 and 96 gal/ft^2. Water use varies drastically by property type. Figure 5.4 shows the median water use intensity by property type. Fire stations had the highest water use intensity (780 gal/ft^2), followed by a vocational school (644 gal/ft^2) and manufacturing/industrial plants (183 gal/ft^2).

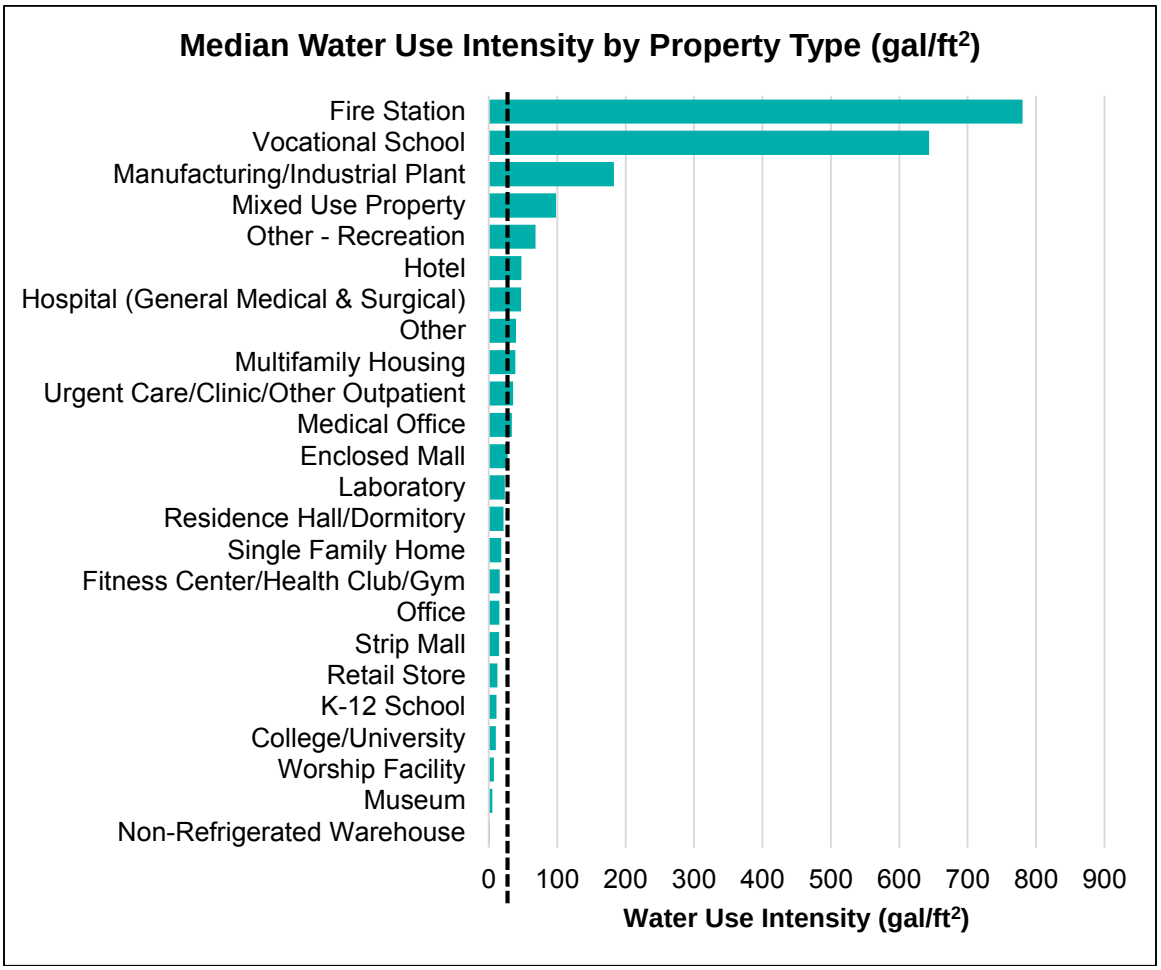

Figure 5.4: Median Water Use Intensity by Property Type

VI. Trends

From 2015 to 2016 the properties subject to BEUDO expanded to include nonresidential parcels with 25,000 ft^2 or more of building floor area. This added almost 150 buildings to the dataset. These buildings-mostly offices, laboratories and college/university properties-resulted in an increase in total energy use reported in the BEUDO dataset, although the median site EUI decreased. In order to compare the 2015 data to the 2016 data, this section compares only data from the cohort of properties that first began reporting in 2015.

Figure 6.1 shows the distribution of area in 2015 and 2016 among properties that began reporting in 2015. Among this group of properties, there were more reports received in 2016 than in 2015. The median area for these properties decreased slightly to 82,481 ft^2 in 2016 compared to 2015.

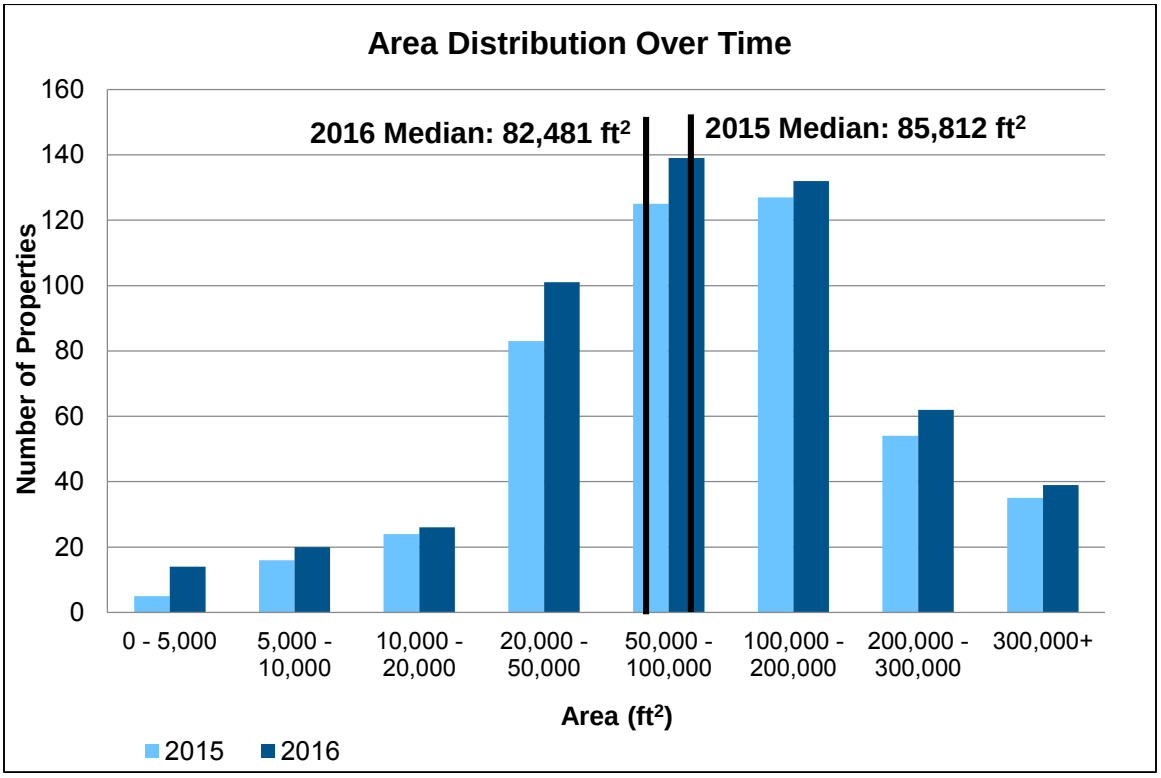

Figure 6.1: Area Distribution among Reports over Time

Figure 6.2 shows the median site EUI over time for BEUDO properties in 2015 and 2016, in comparison to the national median for each property type (2003). Median site EUI decreased from 2015 for college/university, multifamily housing, office and hotel property types. Residence halls/dormitories, laboratories and k-12 schools increased median site EUI.

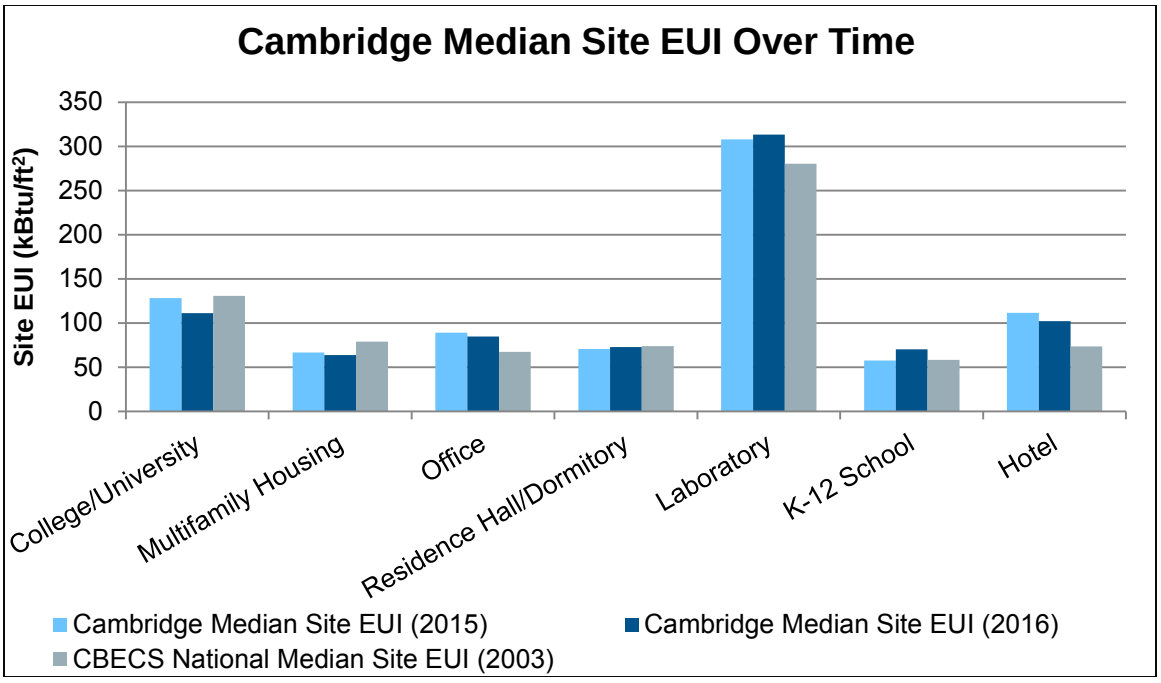

Figure 6.2: Cambridge Median Site EUI over Time

The variation in site EUI for each property type is shown in Figure 6.3. There was greater difference between the 5th and 95th percentiles for all property types except hotels. The variation in site EUI for laboratories and k-12 schools were consistent.

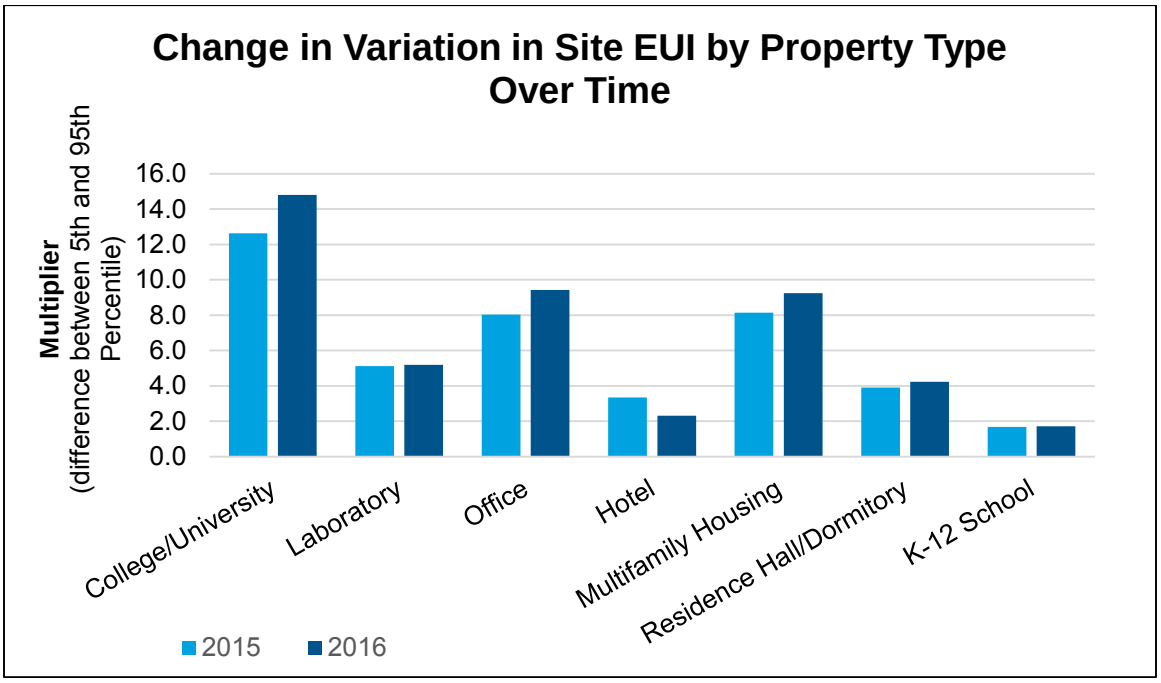

Figure 6.3: Change in Variation in Site Energy Use Intensity by Property Type: 2015 vs 2016

Figure 6.4 shows the total energy use between 2015 by fuel source. While overall the total amount of energy among properties increased, district steam and district chilled water use

decreased. A comparison of weather normalized site energy use between 2015 and 2016 shows an increase in total weather normalized energy use (Figure 6.5), while weather normalized site EUI decreased (Figure 6.6).

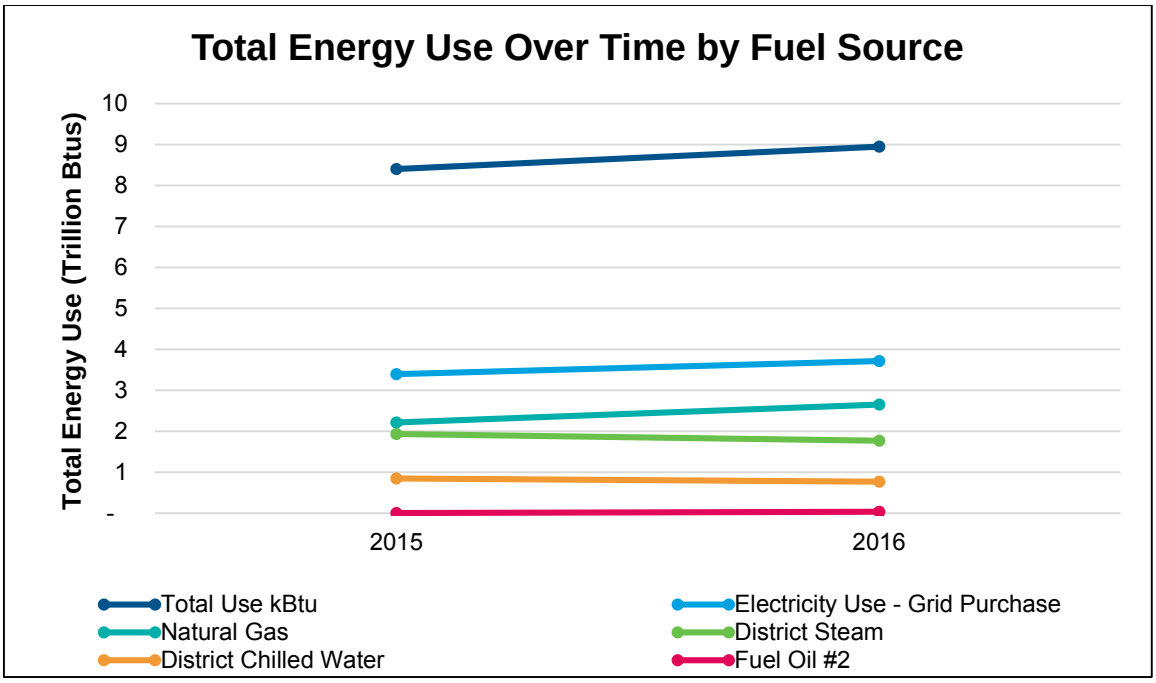

Figure 6.4: Total Energy Use Over Time by Fuel Source

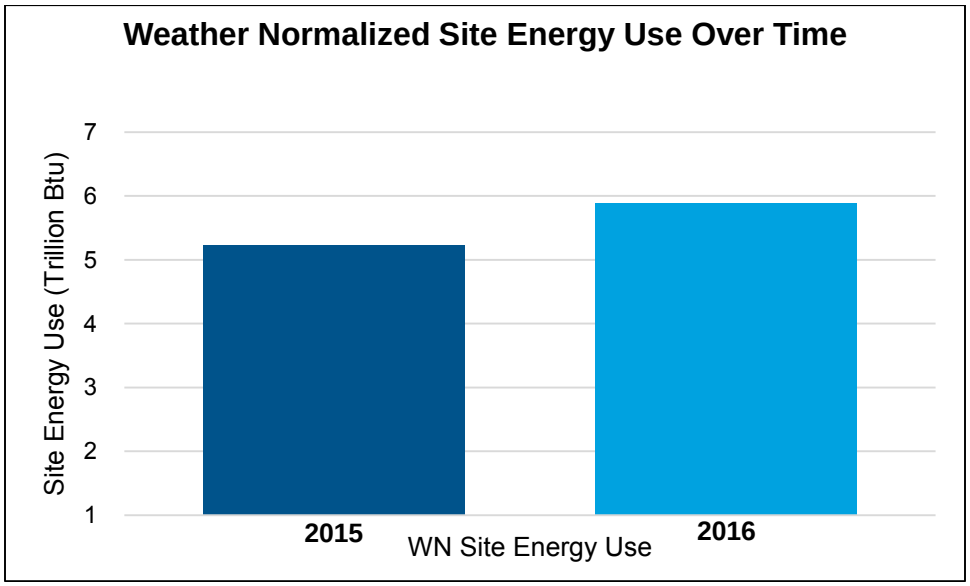

Figure 6.5: Weather Normalized Site Energy Use Over Time

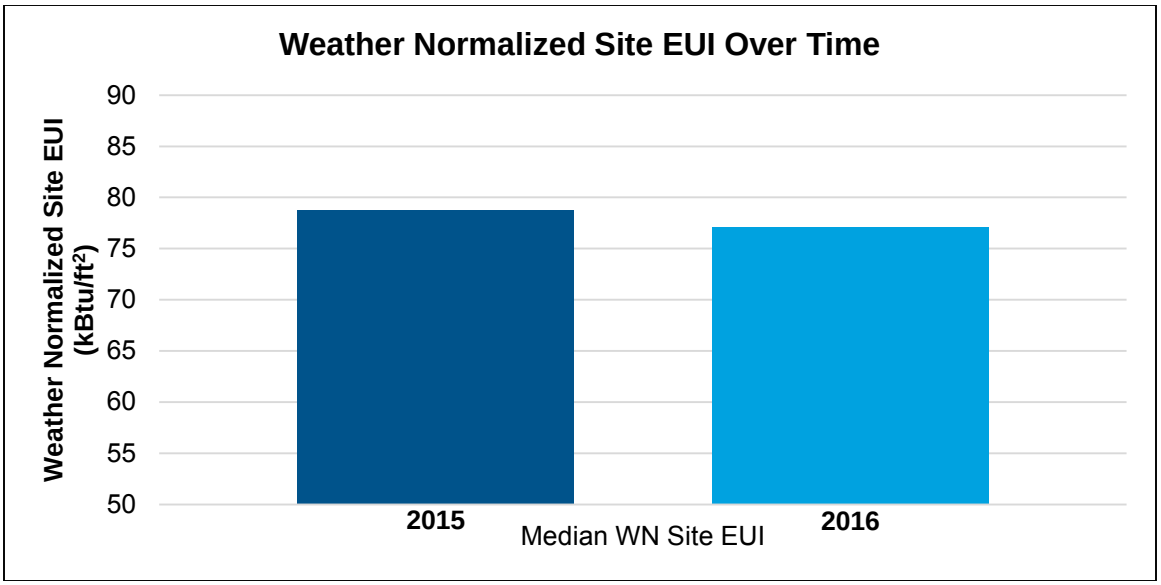

Figure 6.6: Weather Normalized Site EUI Over Time

Overall, ENERGY STAR scores increased from 61 to 65 from 2015 to 2016 (Figure 6.7). Figure 6.8 shows ENERGY STAR scores by property type over time. Among the property types eligible to receive a score, all scores increased from 2015 to 2016, with the most significant improvements in offices and multifamily housing.

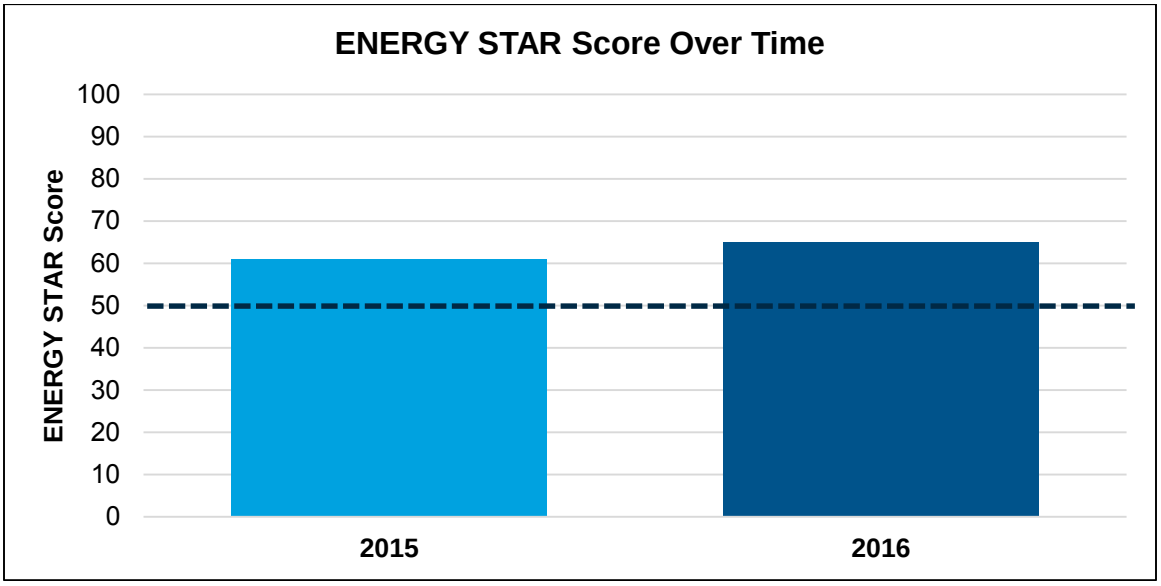

Figure 6.7: Median ENERGY STAR Score Over Time

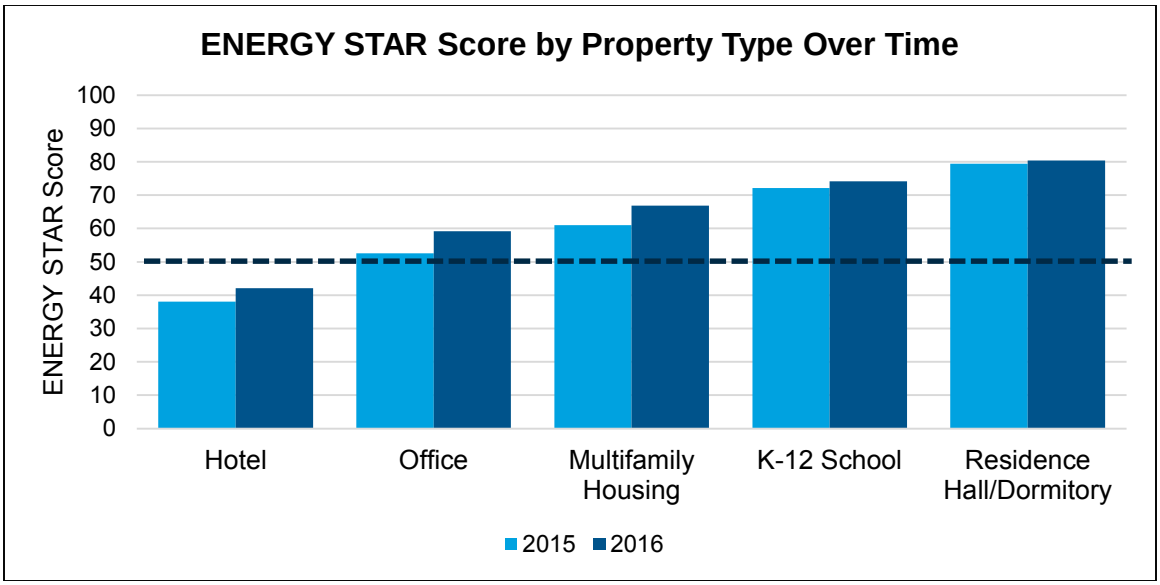

Figure 6.8: ENERGY STAR Score by Property Type Over Time

VII. Data Quality & Filtering

There were three data sets created from the 2016 data submissions submitted to the City of Cambridge through ENERGY STAR Portfolio Manager. One data set removed properties with flagged data for energy use, data set for water use, and an additional data set which included only properties that were subject to BEUDO beginning in 2015.

Data filters are used to ensure accurate data is used in analyzing the data for trends in energy and water use. An initial filter removes any duplicate reports (both properties submitted in a parent-child property relationship and identical reports for a single property), reports for properties not in Cambridge, reports that cover new construction (incomplete year), and reports that do not have area information. Then, the energy data filters remove any data that is not whole-building, estimated data and/or has an especially high or low source energy use intensity. If a filtered property's data was confirmed accurate by the property owner or manager, the property was added back into the dataset. For example, laboratories and data centers often have very high EUIs, which are typically filtered by the data quality process, but are usually added back into the dataset because they accurately reflect energy use at the property. Altogether, this method removed 111 reports from a total of 702 reports received. 591 properties were included in the 2016 BEUDO dataset.

For the water analysis, the same initial property-level filters were applied, and then water-specific filters were applied. The water data filters removed any reports that did not have whole-building water data, estimated data, and especially high or low water use intensity. Altogether, this method removed 255 reports from a total of 702 reports received. 447 properties were included in the 2016 BEUDO dataset.

For the energy trend analysis, properties reporting for the first time in 2016 were removed from the filtered energy dataset.