CITY OF CAMBRIDGE
COMMUNITY DEVELOPMENT DEPARTMENT

2015 BUILDING ENERGY & WATER USE REPORT

ACKNOWLEDGEMENTS

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For more information about BEUDO, please visit cambridgema.gov/beudo.

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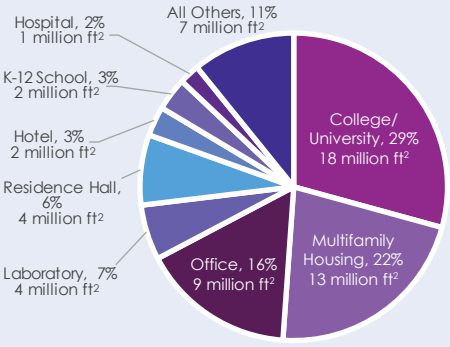
2015 BUILDING ENERGY USE DISCLOSURE ORDINANCE SUMMARY

980 buildings

95% reported



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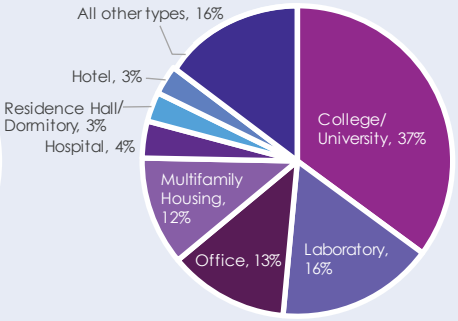
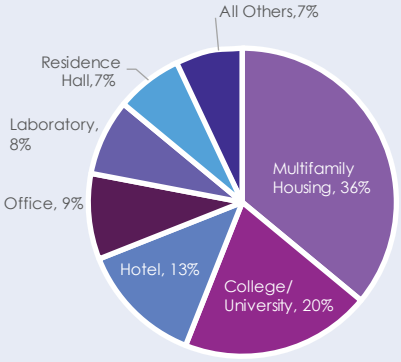


Energy Use by Property Type

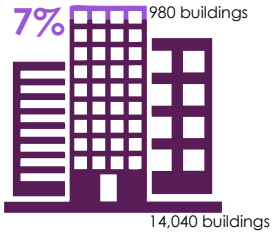


Water Use by Property Type

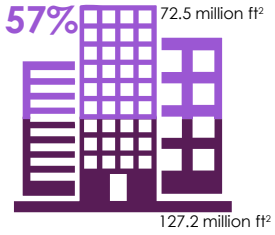
BEUDO Properties vs. Cambridge Building Inventory

BEUDO Cambridge

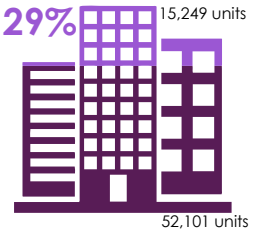
61 Average ENERGY STAR Score



Number of Buildings



Area



Residential Units

For more information, visit www.cambridgema.gov/beudo

INTRODUCTION

BACKGROUND ON THE ORDINANCE

Energy use in buildings are estimated to account for about 80% of greenhouse gas (GHG) emissions in Cambridge, with two-thirds of the total related to commercial, institutional, and large multifamily buildings. Efforts to improve the energy performance of our building stock is hampered by the invisible nature of energy use. The Building Energy Use Disclosure Ordinance (BEUDO) is intended to address this problem by requiring owners of larger buildings to track, benchmark and report annual energy and water use to the City. The City will begin to publicly disclose the data in the second reporting year, after building owners have had a chance to understand the benchmarking process and to work towards improving data quality in order to produce an accurate representation of building energy and water use.

Disclosure places the information in the marketplace, where various users such as potential property buyers, tenants, realtors, energy service providers, and others can use the data to better understand energy and water use in Cambridge buildings and to help create value for higher energy performing properties. The data will also aid the City and others in planning for higher energy performance in our building stock.

The ordinance is a foundational strategy for various community sustainability initiatives including the Community Compact for a Sustainable Future, Kendall Square Ecodistrict and efforts to move the community toward net zero GHG emissions.

2015 REPORTING CYCLE

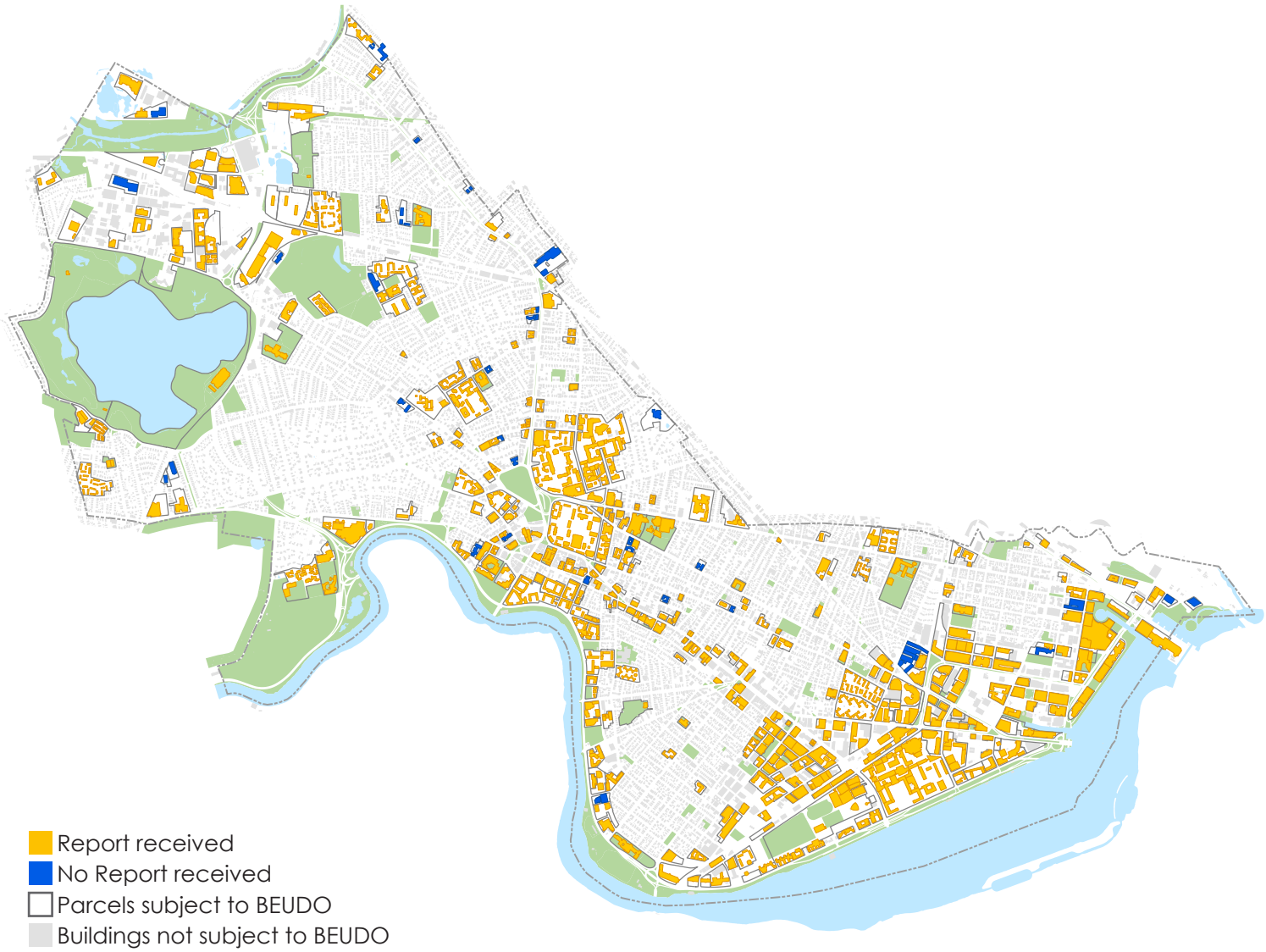
This report presents a benchmarking analysis for the 2015 reporting cycle, which covers energy and water use data for calendar year 2014. For this first year of reporting, nonresidential parcels with buildings that singly or together contained 50,000 ft^2 or more of living area and parcels with residential buildings that singly or together contained 50 or more units were required to submit building energy and water use data to the City. The City also reported on its municipal buildings 10,000 ft^2 and greater. The initial deadline for submitting building energy and water use data to the City was May 1, 2015. However, given this was the first year of reporting in Cambridge, additional effort was made to extend deadlines and provide support to as many of the BEUDO-subject properties as possible.

The result of these efforts was a 95% compliance rate based on the number of buildings that reported. Figure 1 shows the compliance status of every parcel and building that was subject to the Ordinance in 2015. Notification letters were sent to all owners of parcels subject to the Ordinance in December 2014 and final covered properties lists were published on January 15, 2015. Throughout the 2015 reporting cycle, the Energy Help Desk provided assistance with benchmarking in ENERGY STAR Portfolio Manager and submitting reports to the City.

NOTES ON DATA ANALYSIS IN THIS REPORT

The analysis presented in this report is based on data submitted as of July 2, 2015. As of this date, the City received 605 unique Portfolio Manager reports ("properties"). 538 properties are included in this analysis after filtering reports for data quality, representing 89% of submissions. The procedure used for filtering is documented in the Appendix. This data sample represents 746 out of 980 buildings subject to the Ordinance and covers 60.5 million ft^2 of 72.5 million ft^2 in the 2015 BEUDO database.

FIGURE 1: COMPLIANCE STATUS OF BUILDINGS SUBJECT TO BEUDO IN 2015

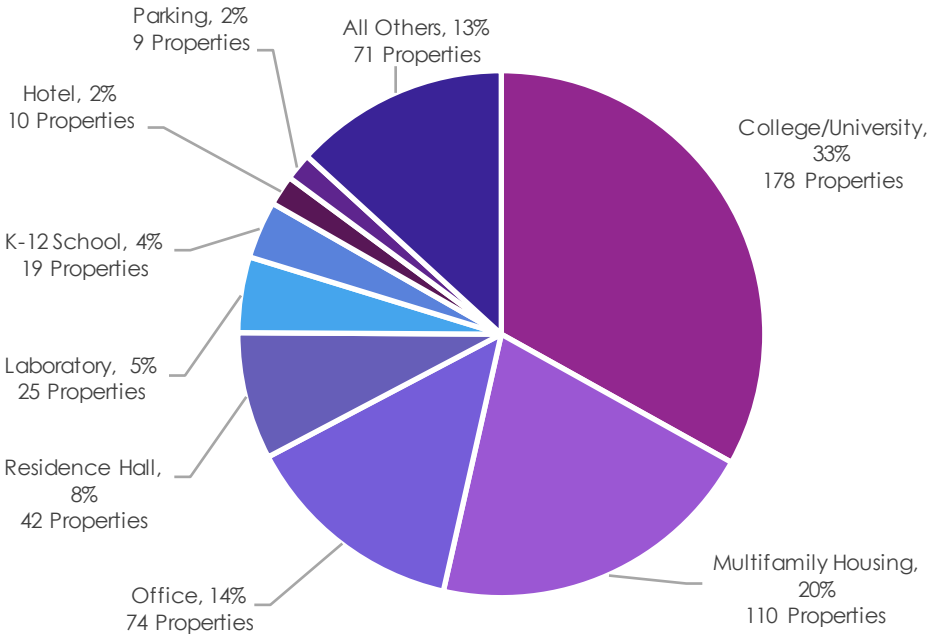


BUILDING CHARACTERISTICS

Parcels are subject to the Ordinance based on the area and number of units thresholds they trigger, depending on whether they are residential or nonresidential properties. Reporting is done at the building scale. Every report submitted through ENERGY STAR Portfolio Manager contains data for at least one building. In the case of shared meters, property owners had the option of proportionally allocating data for buildings with similar uses, allowing them to be reported separately. Reports covering more than one building include cases where energy and/or water use meters are shared across multiple buildings and could not be separated. As a result, we refer to each report as covering a "property" instead of a building. *Property type* is intended to describe a property's actual space use, rather than its affiliation. Therefore, residence halls, laboratories and office buildings may be associated with universities, but are categorized as their respective property types.

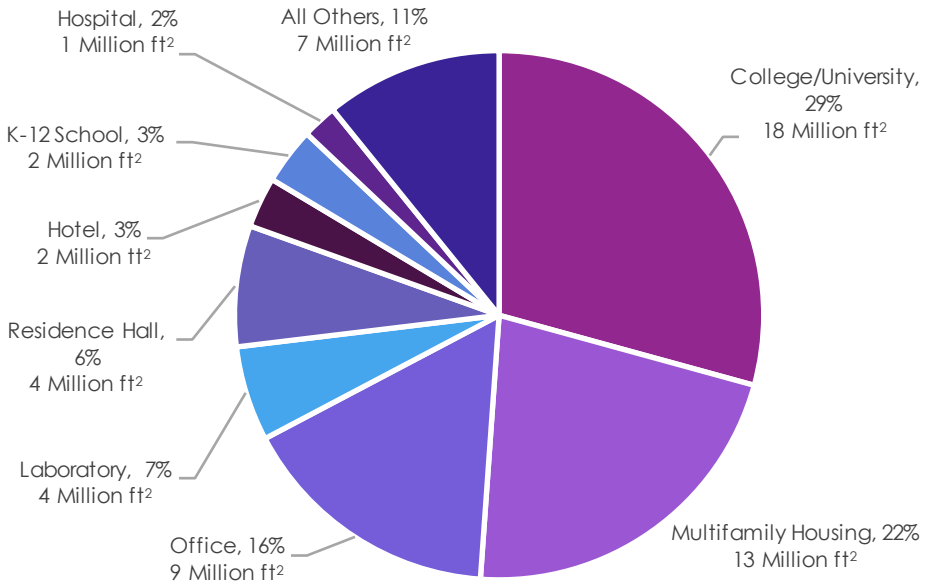
The BEUDO building inventory is described in the following two graphs. Figure 2 shows that a third of reports were for college/university properties, which

FIGURE 2: TOTAL REPORTS BY PROPERTY TYPE



Total Number of Properties in Analysis: 538

FIGURE 3: TOTAL AREA BY PROPERTY TYPE (FT^2)



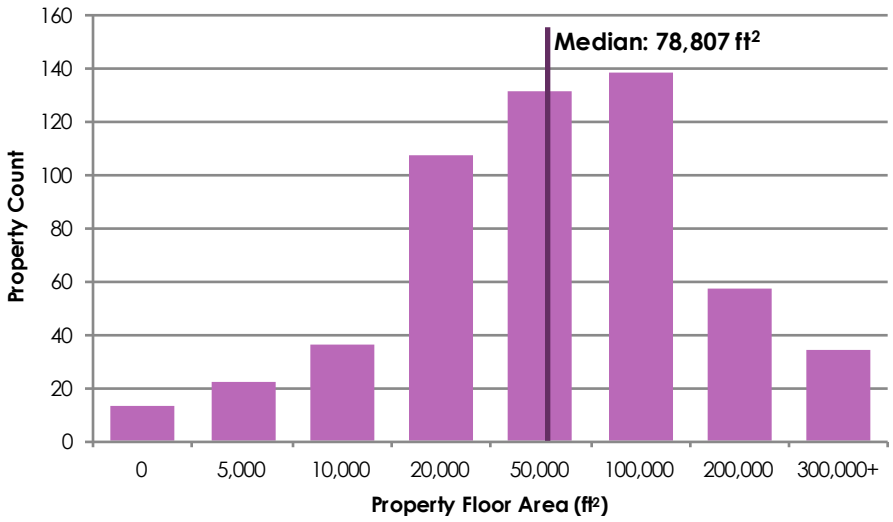
Total Area of Properties in Analysis: 60 million ft^2

include administrative and classroom buildings for universities. Another twenty percent of reports were for multifamily housing properties. These two property types make up more than half of the properties analyzed in this report, covering 30 million ft^2.

Altogether, buildings subject to BEUDO cover 72.5 million ft^2, with 60.5 million ft^2 included in this analysis broken down into twenty-five different property types. Offices (9 million ft^2), residence halls (4 million ft^2), and laboratories (4 million ft^2) round out the top five largest property types.

While college/universities comprise 33% of all reports, they represent 29% of the total area in the dataset. This discrepancy suggests that reports designated "college/university" are smaller, on average, than other submitted property types. Similarly, 9 reports characterized as parking make up 1% of total area. By contrast, hospitals have a large average area: two hospital properties comprise over a million square feet and 2% of the total area in the dataset.

FIGURE 4: PROPERTY FLOOR AREA DISTRIBUTION



As a result of the parcel-level thresholds for the Ordinance, some smaller buildings were also captured. This is because multiple buildings on a parcel together met the threshold even though each building did not meet the threshold by itself. The size of properties reported ranged from single buildings under 5,000 ft² to large complexes spanning hundreds of thousands of square feet. In general, area was most frequently between 20,000 and 200,00 ft² , with a median area of 78,807 ft² (Figure 4).

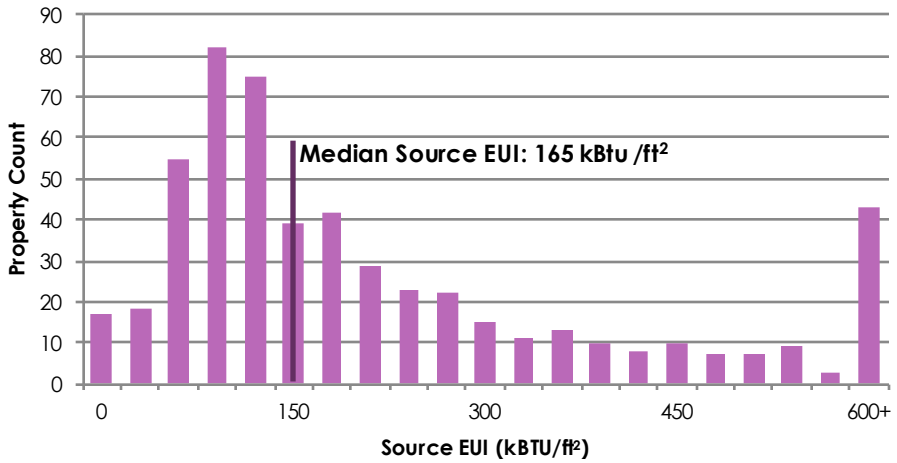
BUILDING ENERGY PERFORMANCE

Energy use data is entered into Portfolio Manager in monthly intervals and received by the City as a yearly aggregate for each fuel type, including electricity, natural gas and oil. Energy use is reported as both site energy and source energy. Source energy includes the amount of energy used in transmission. These numbers are used to calculate the total amount of energy used by a property, the site and source energy use intensity (EUI) and an ENERGY STAR score. Definitions for each of these metrics is included in the glossary.

Each of these metrics helps to understand energy use in a building. The EUI, for example, is a ratio of energy to area that helps compare energy use across buildings because it is based on how much energy is used per square foot (kBtu/ft^2), where lower values indicate better energy efficiency assuming the buildings are similar. The ENERGY STAR score takes into consideration factors that can impact the building energy use, like how many computers are used in a building and the hours of operation. The 1-100 scale compares a building to similar buildings nationwide. Weather normalized metrics mean that a value is adjusted for regional weather patterns that might have influenced the amount of energy used.

Energy consumption varies significantly with the way a building is used,

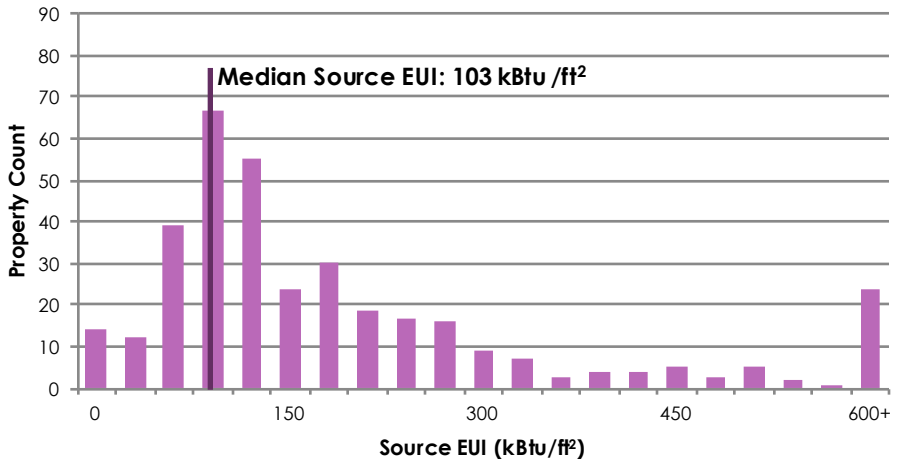
FIGURE 5: SOURCE EUI DISTRIBUTION FOR ALL PROPERTIES



from warehouses using very little energy to hospitals and laboratories that typically conduct energy-intensive activities. Many Cambridge properties used between 60 and 150 kBtu/ft^2 source energy, with a number of very energy-intensive properties at 300 to 600 kBtu/ft^2 and above. The median source EUI for the entire BEUDO dataset was 165 kBtu/ft^2. Energy-intensive properties in this data set are likely to be laboratories or offices with data centers. It should be noted that a high EUI does not by itself indicate inefficiency.

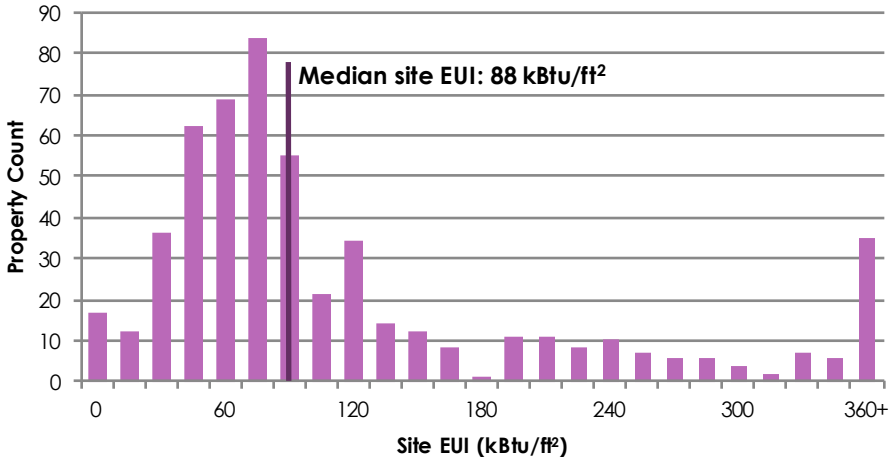
Source EUI for properties with on-site utility plants may be inaccurate, given that source values are estimated on regional data by ENERGY STAR Portfolio Manager, rather than on calculations by the utility plants real efficiency data. Figure 6 shows a source EUI histogram, with university and college properties removed. Removing the college/university property type brings the median source EUI for all properties to 105 kBtu/ft^2.

FIGURE 6: SOURCE EUI DISTRIBUTION-ALL PROPERTIES EXCEPT UNIVERSITIES



Cambridge buildings tend to use between 45 and 90 site kBtu/ft^2 (Figure 7), which is roughly consistent with the 60-120 source kBtu/ft^2 concentration seen in Figure 6 above.

FIGURE 7: SITE EUI DISTRIBUTION



In order to contextualize the results of the Cambridge analysis, median energy use intensities for various property types included in the Cambridge data are compared to the median energy use from the most recent Commercial Building Energy Consumption Survey (CBECS). Differences in median EUI may be due to more intensive activities, different climate and weather patterns, or differences in energy performance.

The Commercial Building Energy Consumption Survey provides a comprehensive and statistical sample of energy usage across regions and property types. The last CBECS was completed in 2003. Because building energy usage patterns may have changed since 2003, the reference numbers above may not accurately represent the 2015 national median. The Energy Information Administration is currently working to update the ENERGY STAR metric with the latest CBECS 2012 data. The 2003 CBECS data did not cover laboratories in sufficient detail to use as an accurate benchmark. Therefore, the reference data for the laboratory property type in the following graphs (Figures 8 and 9) were taken from benchmarking laboratories from 2003-2014 in the 6A climate zone of the Laboratories for the 21st Century (Labs21) data set.

FIGURE 8: MEDIAN SOURCE EUI VERSUS NATIONAL MEDIAN BY PROPERTY TYPE

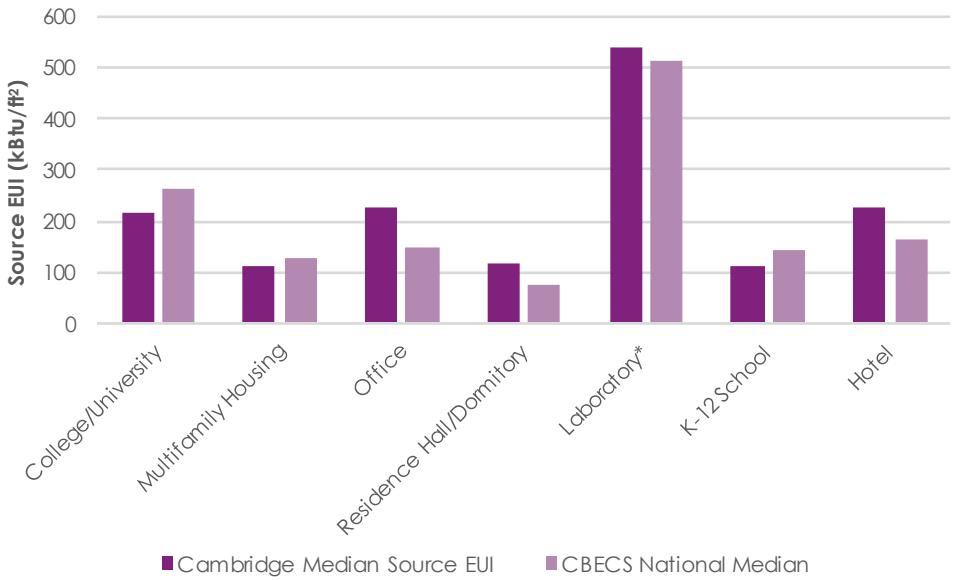
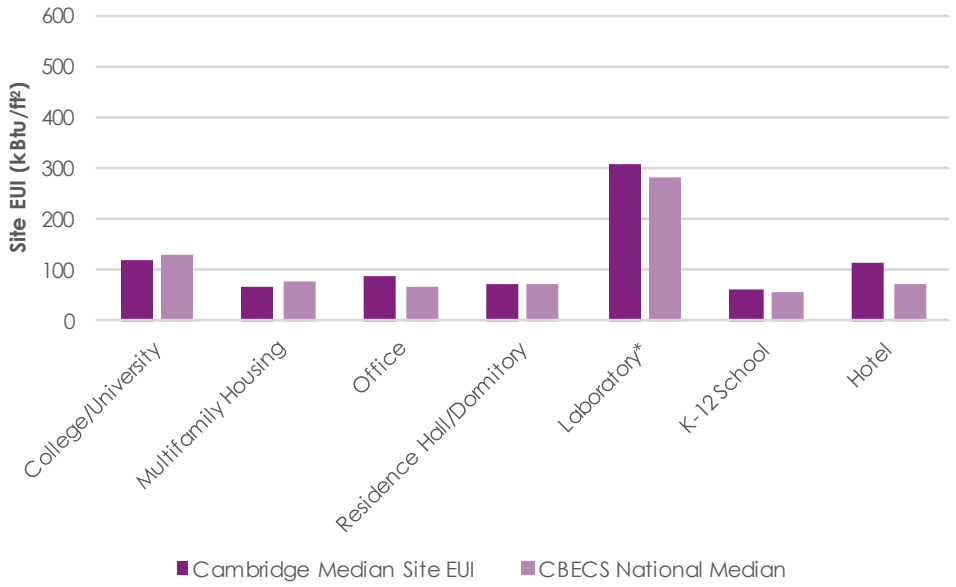


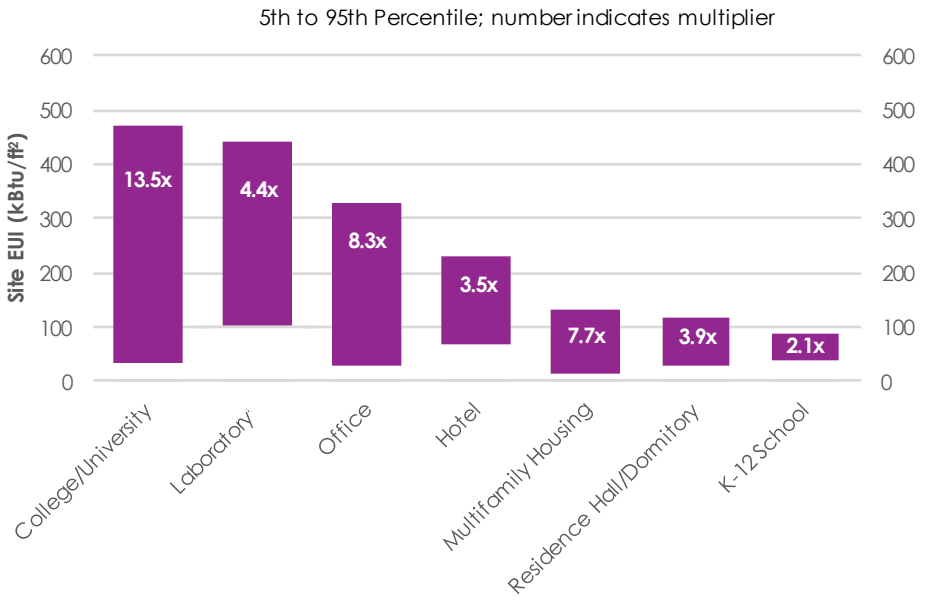
FIGURE 9: MEDIAN SITE EUI VERSUS NATIONAL MEDIAN BY PROPERTY TYPE



*The last CBECS survey did not cover laboratories in sufficient detail to use as an accurate benchmark; the reference data for the Laboratory property type was taken from laboratories in the 6A climate zone of the Labs21 data set, with energy use data ranging from 2003 to 2014.

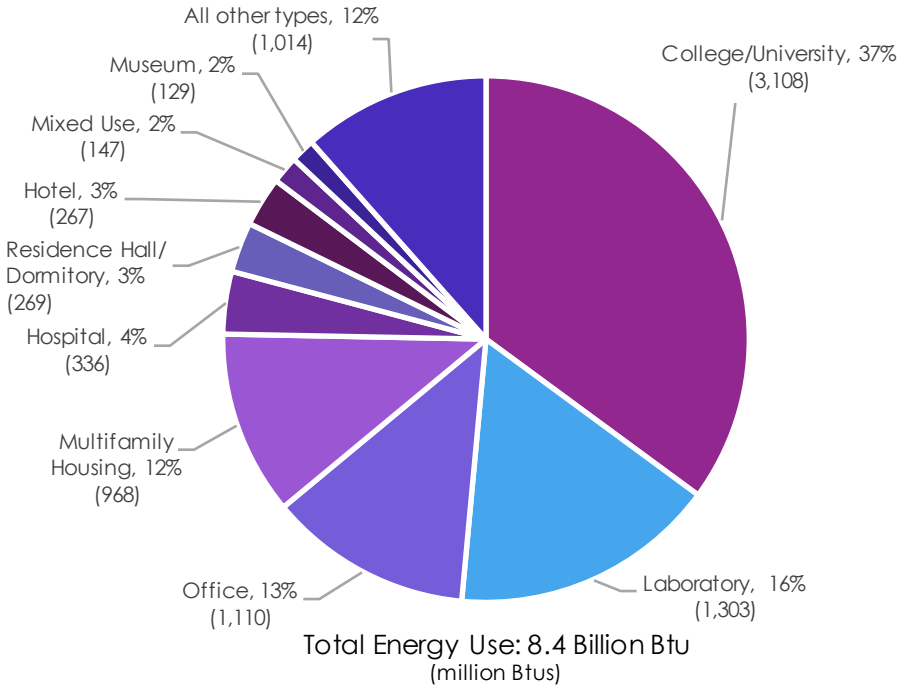
Figure 10 shows the 5th to 95th percentile of site energy use intensity in the most common property types in the data set. The variance between the lowest and highest energy users differs by property type; K-12 Schools show a relatively small difference and college/university buildings show a large variance. Energy-intensive buildings in property types with a high energy variance may be able to achieve substantial savings with appropriate energy conservation measures. The variance in the site EUIs for laboratories reflects some of the range in activity for different types of labs.

FIGURE 10: VARIANCE IN ENERGY USE BY PROPERTY TYPE



While the total share of energy use (Figure 11) is generally correlated with share of total properties and the total floor area, property types with unique energy patterns may use a significantly different proportion of energy usage compared to their square footage. In particular, the "Laboratory" property type occupies 7% of the total floor area of this data set, but uses 16% of total site energy. In comparison, "Multifamily Housing" occupies 22% of the total floor area of this data set, but only uses 12% of total energy.

FIGURE 11: SHARE OF TOTAL ENERGY USE BY PROPERTY TYPE



The 1 – 100 ENERGY STAR score is a screening tool that helps property owners and managers assess how a building is performing. A score of 50 is the median; if a building scores below 50, it means it's performing worse than 50 percent of similar buildings nationwide, while a score above 50 means it's performing better than 50 percent of its peers. A score of 75 or higher means it's a top performer and may be eligible for ENERGY STAR certification.

Out of the 538 reports included in this data set, 225 (41%) are eligible for an ENERGY STAR score. Figure 12 shows the distribution of ENERGY STAR scores for these properties. Across all eligible properties, Cambridge buildings tend to perform better than their peers, with an average score of 61. The graph also shows a significant amount of properties with an ENERGY STAR score of zero, which may be due to incomplete information or a mixed use (such as a laboratory in an office building). Twenty eight properties are eligible for ENERGY STAR certification.

FIGURE 12: DISTRIBUTION OF ENERGY STAR SCORES

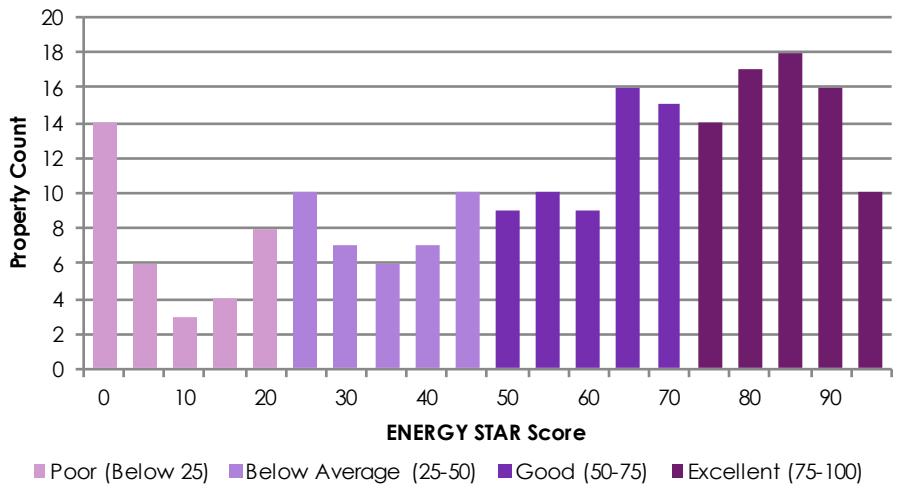


FIGURE 13: ENERGY STAR SCORE DISTRIBUTION BY PROPERTY TYPE

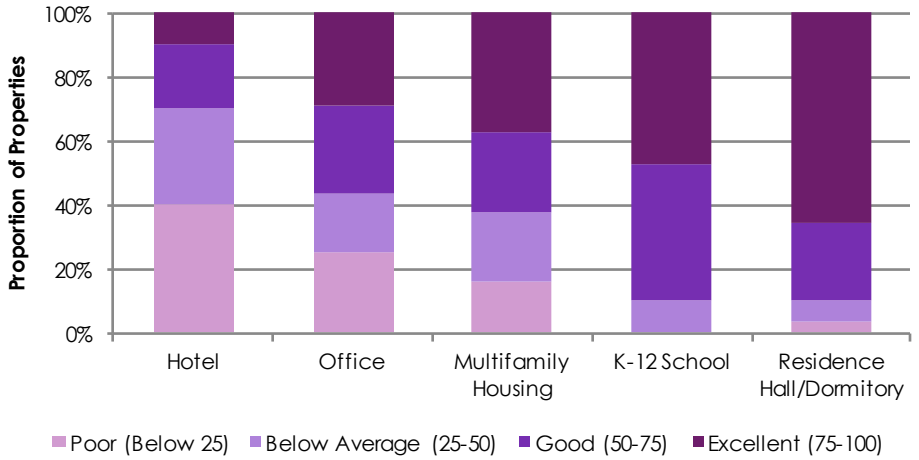
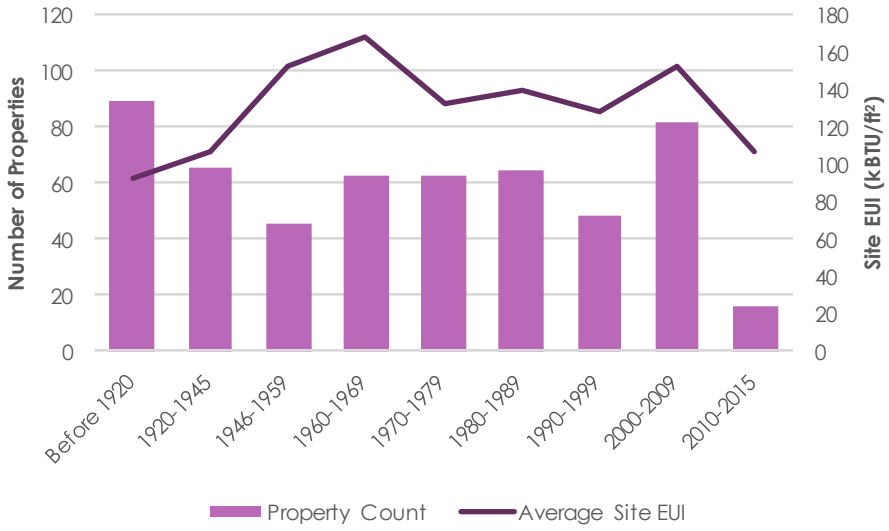


Figure 13 above shows the ENERGY STAR score distribution for five property types that are able to earn a score. While "hotels" has a roughly even distribution of scores, "multifamily housing," "K-12 school," and "residence hall/dormitory" tend to have higher scores. Schools in the Cambridge data set have a higher EUI than the national median, and also have high ENERGY STAR scores. This indicates that the schools may have more energy intensive activities than the national median, but are using that energy more efficiently, thus giving them a higher energy performance score.

FIGURE 14: ENERGY USE INTENSITY AND CONSTRUCTION YEAR COMPARISON



As Figure 14 shows, the age of a building is not necessarily tied to its energy performance. The oldest buildings in Cambridge have some of the lowest site EUIs among BEUDO buildings, while some of the highest site EUIs are characteristic of buildings constructed in the 1960-1969 range. Most recently constructed buildings show lower site EUIs than in the preceding decade, but there is also a smaller stock of buildings at this age to make the comparison.

Properties directly associated with the operation of local universities are the single largest energy users of the City of Cambridge. As a result, a comprehensive energy efficiency strategy should work to include university actions.

Mixed and combined-use properties in the Cambridge portfolio may make property-type analysis difficult. For instance, many office buildings may contain energy-intensive equipment that might be more commonly seen in a lab, and the college/university designation can include offices, classrooms, laboratories, maintenance facilities, arts facilities, athletic facilities, residential areas, etc.

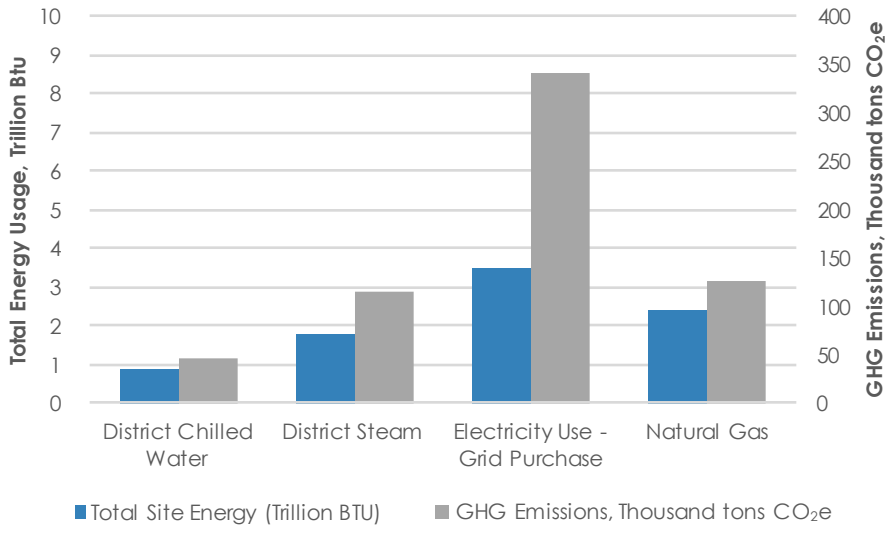
As expected, laboratories are significant contributors to total energy usage in this data set. Although there were only 25 reports from laboratories, they represented 21% of total energy use among all BEUDO buildings.

FUEL MIX AND EMISSIONS

Greenhouse gas emissions are determined by the total energy usage and the mix of fuel types used at each property. By benchmarking building energy usage, building owners and managers can also determine their contribution to global greenhouse gas emissions. Figure 15 shows total usage of the four most commonly used fuel types in Cambridge, along with their attendant greenhouse gas emissions, in tons of carbon dioxide-equivalent. While the use of electricity at a property does not directly emit greenhouse gases, the use of fuels at power plants to generate electricity produces a substantial amount of greenhouse gases.

Figure 15 shows these indirect emissions (associated with electricity purchased from the utility), as well as the direct emissions caused by combustion of fossil fuels (e.g. fuel directly burned at property). As illustrated in the graph, grid-purchased electricity accounts for a higher amount of greenhouse gas emissions than natural gas and oil. This is due to both the higher use of electricity compared to natural gas, oil and chilled water, and also higher carbon emissions per Btu created from electricity compared to natural gas, oil or chilled water.

FIGURE 15: TOTAL ENERGY USE AND GREENHOUSE GAS EMISSIONS BY FUEL TYPE



GHG emissions for electricity are calculated using eGRID emissions factors, which are based on older 2009 data and do not account for energy supply that has lower carbon emissions. For electricity produced by an on-site combined heat and power/cogeneration plant, the electricity emissions factor from eGRID is even less accurate because it does not reflect the specific fuel mix used to fire the cogeneration plant that produces the electricity. In addition, electricity has a higher potential for lower emissions, as electricity can be generated by renewable sources with zero emissions, while the emissions from natural gas and oil remains relatively constant and cannot be lowered.

Figure 16 shows the share of total emissions contributed by each property type. Notably, the office property type contributes more greenhouse gases than the laboratory property type, despite using less total energy. This is because the office property type's fuel mix has more electricity than laboratories, which tend to have proportionally higher natural gas usage. Offices then, have greater potential to reduce GHG emissions since electricity can be produced with renewable sources of energy, but natural gas is not a renewable source of energy.

FIGURE 16: TOTAL GREENHOUSE GAS EMISSIONS BY PROPERTY TYPE

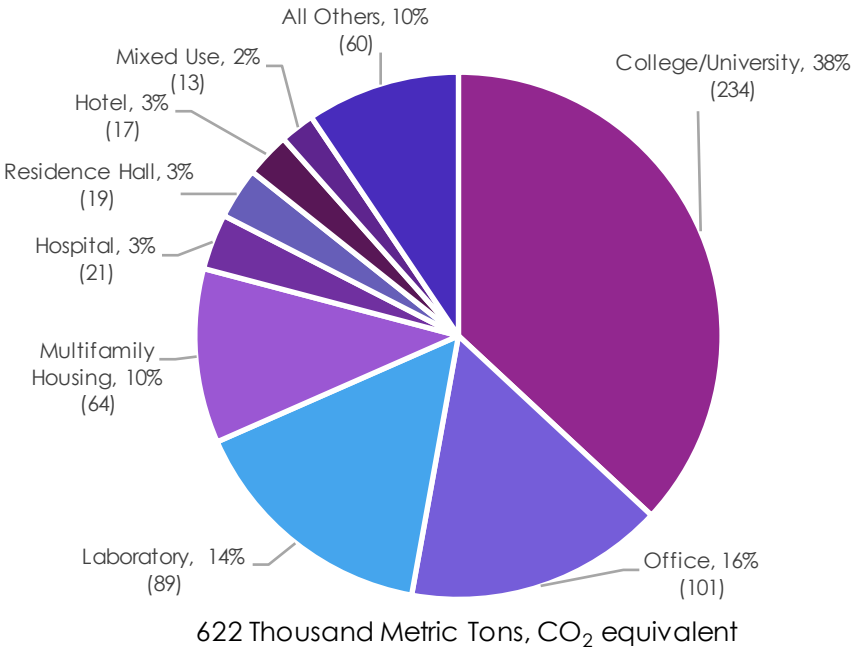


FIGURE 17: FUEL MIX BY PROPERTY TYPE

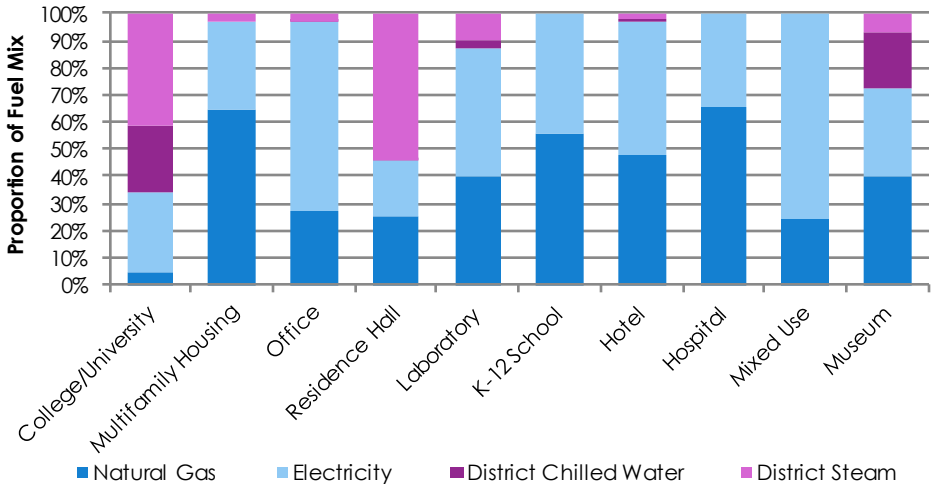
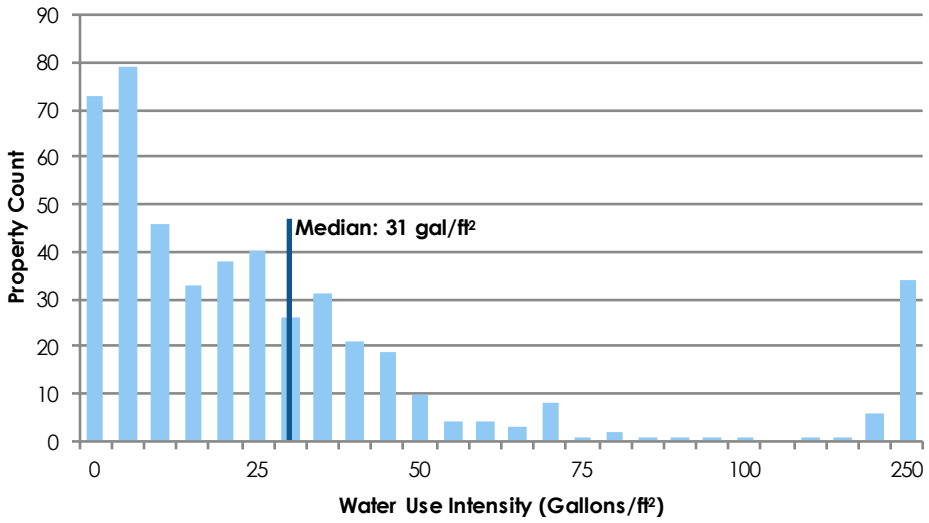


Figure 17 shows a comparison of fuel mix across property types. Multifamily housing, k-12 schools, hospitals and hotels have a higher proportion of natural gas use compared to offices and mixed used properties, which have a higher proportion of electricity use. Colleges and universities along with residence halls have a higher proportion of chilled water and steam use.

WATER CONSUMPTION

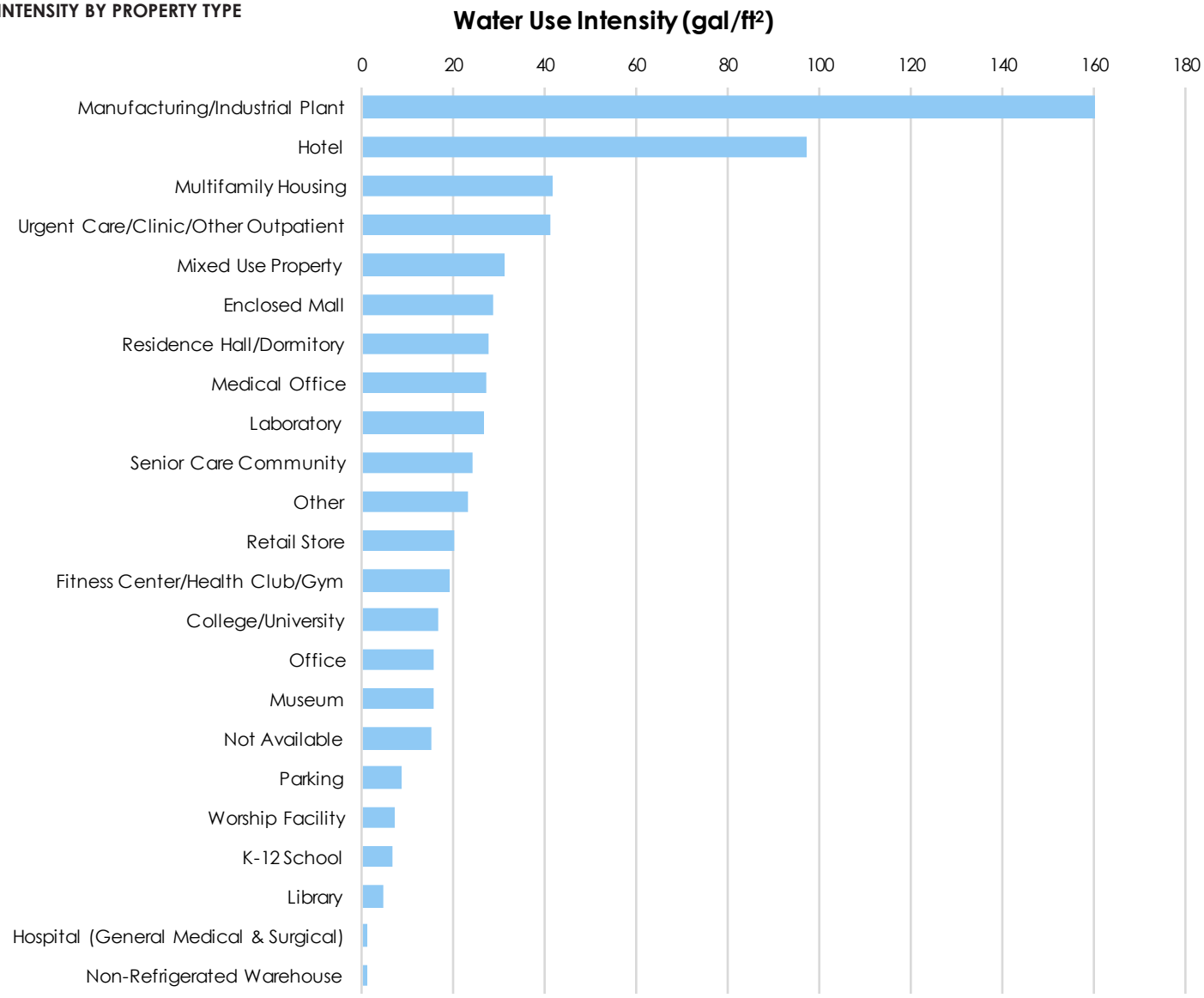
Benchmarking water consumption in Cambridge is useful in understanding typical usage patterns and resolving problems when the data shows usage outside of the expected range. Identifying opportunities for simple improvements can result in significant savings. The analysis covers total water use in buildings, including both indoor and outdoor water use. A total of 512 properties reported water consumption as of July 2, 2015. This analysis is based on the 441 properties that remained after filtering for quality control. The median water use intensity was 31 gallons/ft^2 with additional peaks at 5 and 250 gallons/ft^2 (Figure 18).

FIGURE 18: WATER USE INTENSITY DISTRIBUTION



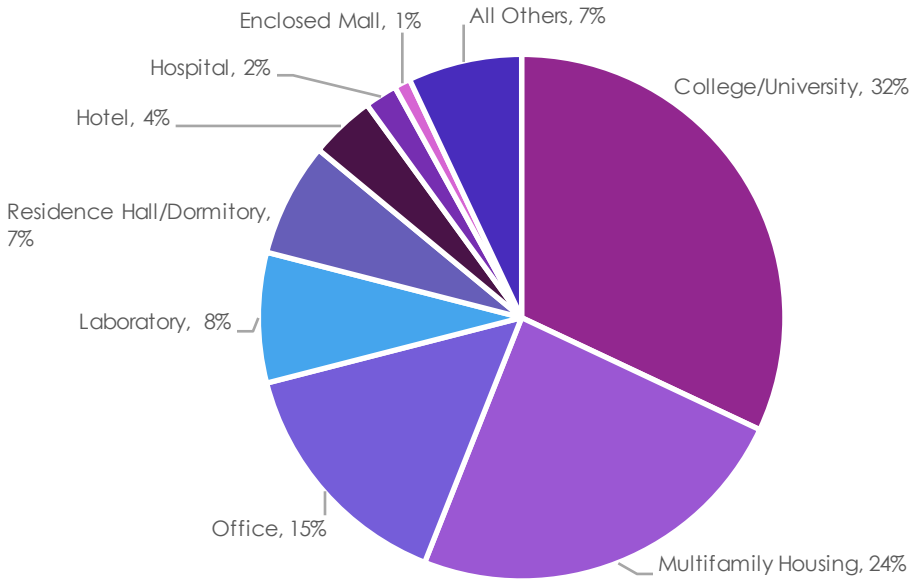
Water use varies drastically depending on the property type and how people use the building. Figure 19 shows the water use intensity by property type among BEUDO buildings. Manufacturing/industrial plants had the highest water use intensity by far, at 160 gallons/ft^2, followed by hotels, multifamily housing, and urgent care/clinic/other outpatient buildings. Figure 20 shows the area breakdown for properties analyzed and Figure 21 shows their water use breakdown.

FIGURE 19: MEDIAN WATER USE INTENSITY BY PROPERTY TYPE



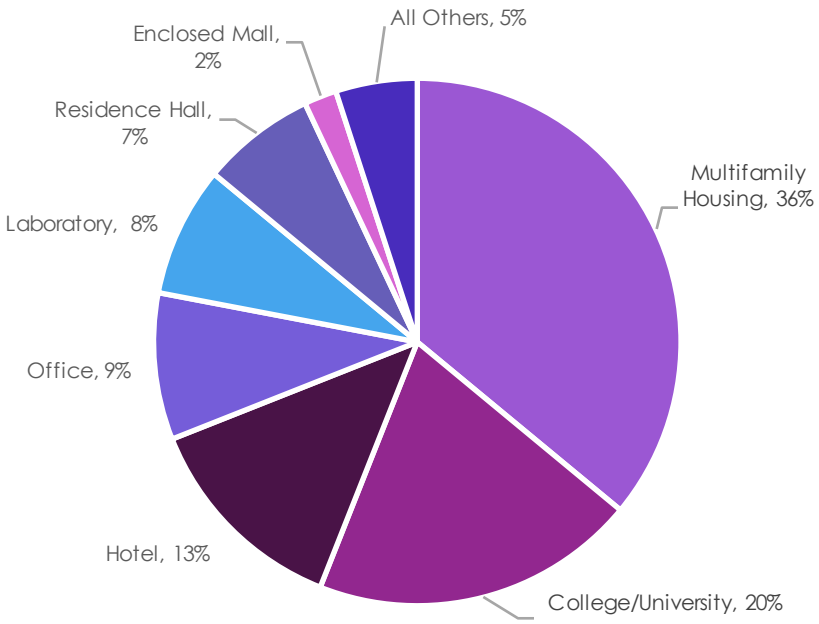
While colleges/universities and multifamily housing made up a majority of the area (Figure 20) and total water use (Figure 21), multifamily housing used 36% of the total water use with 24% of the area while college/universities used 20%.

FIGURE 20: AREA BY PROPERTY TYPE FOR WATER ANALYSIS



Total Area of Properties in Water Analysis: 61 million ft^2

FIGURE 21: WATER USE BY PROPERTY TYPE



Total Water Use: 14.6 trillion gallons

WHAT'S NEXT?

Achieving a compliance rate of 95 percent in the first year of reporting involved the cooperation and efforts of many stakeholders and staff involved in implementing the Ordinance in Cambridge. Insights into energy and water use among different property types gives us the opportunity to more deeply understand energy and water demand in the City and to set goals for efficiency that are particular to Cambridge's context. The City will continue to build on these efforts for the second year of reporting, when additional nonresidential properties with 25,000 ft^2 and greater will report their energy and water use for the first time. With data disclosure in 2016, the City is enthusiastic about the new ways in which the data can be used to further community sustainability.

APPENDIX: REVIEW OF FILTERING AND OUTREACH

Filters were applied to identify reports with unusual characteristics or indicators that energy data might be inaccurate or incomplete. This data quality review process is integral to ensuring accurate analysis of the data set. A summary of the filters applied, along with the number of properties identified, follows.

TABLE 1: SUMMARY OF FILTERS

FILTER NAME	FILTER MAX	FILTER MIN	REPORTS IDENTIFIED
Report is a duplicate of another submission	n/a	n/a	2
Address is not in Cambridge	n/a	n/a	5
Indicated partial-building energy use	n/a	n/a	130
Constructed or renovated in 2014	n/a	n/a	2
Square footage reported is unusual	1,000,000	1,000	4
Source energy use intensity (kBtu/ft^2) is unusual	1,000	1	54
Energy usage values are indicated as estimated	n/a	n/a	159
Total Reports Identified	**n/a**	**n/a**	**203**

Note: In total, 203 reports from 28 organizations were identified by the filter set.

Reports identified through the above filters have unusual characteristics, but may not necessarily be invalid submissions. Reports were individually evaluated to determine whether they should remain in the data set. Reports that explained unusual behavior in the property notes (such as an energy-intense building that indicated 'laboratory' as the primary property type) were marked as 'Keep'. Reports that fall outside of the scope of this analysis, such as buildings constructed in 2014 or with addresses outside of Cambridge, were marked as 'Remove'.

Outreach was conducted to gain more information when issues were identified but information was not immediately available to determine if the report could be included in the analysis. In many cases, this extra information validated the report, but a substantial amount of users indicated that energy data was not available or there were other issues with the submission.

TABLE 2: OUTREACH SUMMARY

CATEGORY NAME	RESULTS OF OUTREACH	INCLUDED IN DATA SET?	NUMBER OF REPORTS
Include – No outreach required	n/a	Yes	9
Remove – No outreach required	n/a	No	8
Conduct outreach to user	Outreach complete -Property should be included	Yes	125
	Outreach complete - Property should be removed	No	61

As a result of the filtering process and outreach to Cambridge property owners and managers 538 reports out of a possible 607 were included in this analysis (89% of total submissions), comprising 60.4 million square feet and 746 buildings. The number of buildings in this data set is self-reported through ENERGY STAR Portfolio Manager and may not accurately reflect the number of buildings covered. For example, in some cases where a single report contained data for multiple buildings, the building count reported was one. Additionally, because energy systems are often shared across buildings, some reports submitted in Portfolio Manager cover multiple physically separate buildings. As a result, some Portfolio Manager reports may cover multiple buildings on a single parcel, rather than individual buildings.

GLOSSARY

Btu: British thermal unit, the amount of heat it takes to raise the temperature of one pound of water by one degree Fahrenheit.

Direct Emissions: Emissions from fuel that is directly burned at your building, for example natural gas that may be combusted to heat your property (energystar.gov).

ENERGY STAR Score: EPA's 1-100 ENERGY STAR score is an external benchmark for assessing the performance of commercial buildings. The ENERGY STAR score, expressed as a number on a simple 1 - 100 scale, rates performance on a percentile basis: buildings with a score of 50 perform better than 50% of their peers; buildings earning a score of 75 or higher are in the top quartile of energy performance (energystar.gov).

Energy Use Intensity (EUI): The total amount of energy used per square foot in a building. The energy is a sum of all the fuel types used in the building, including electricity, natural gas, fuel oil and steam. The higher the EUI, the more energy is used per square foot of space.

Indirect Emissions: Emissions associated with energy purchased from a utility, for example emissions associated with the generation of electricity or district steam (energystar.gov).

Portfolio Manager: An online tool developed by the U.S. EPA that is used nationwide to measure and track energy and water consumption, as well as greenhouse gas emissions.

Site EUI: The units for site EUI are site kBtu per square foot. This metric includes all fuel types used across all uses at each building, which are converted to kBtu, summed together, and then divided by the total square footage of the property.

Source EUI: Accounts for differences among fuels in terms of inefficiencies as well as losses from generation and transmission. Each fuel type's use is multiplied by a source-site factor and the resulting sum after these source-site factors are applied is called the source energy. Because of this equitable comparison of fuels, source energy usage may be used for analyzing energy usage and calculating greenhouse gas emissions impacts.