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Guide to Contents

This package contains the results from an analysis of Cambridge's BEUDO ordinance. These inputs will be used to inform future stakeholder meetings, which will explore the possible inclusion of a performance-based element in the Building Energy Usage and Disclosure Ordinance (BEUDO). The memos are organized based on Tasks, which were originally described in an RFP issued by the City of Cambridge in April 2017.

- Includes benchmarking analysis of energy performance data of peer cities with reporting ordinances
- Describes best practices and benchmarks Cambridge's existing energy disclosure policy against other U.S. cities
- Provides an assessment of performance requirements in other reporting and disclosure ordinances

- Provides summary statistics on the impacted buildings under three different performance threshold scenarios based on ENERGYSTAR score, energy use intensity (EUI), and greenhouse gas (GHG) Performance
- Analyzes the Cambridge BEUDO dataset, and recommends adjustments needed to administer performance thresholds
- Details impacts for building owners under each of these threshold requirements

- Describes policy and administrative considerations for prescriptive requirements, specifically the implications and costs of energy audits, retro-commissioning and operations & maintenance (O&M) plans
- Analyzes policy, financial and administrative implications for the implementation of performance thresholds, exemptions, and prescriptive requirements within the City of Cambridge
- Outlines potential next steps for consideration by City staff and real estate stakeholders

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To: City of Cambridge
From: Institute for Market Transformation
Date: July 12, 2017
RE: **Best Practices Research on Performance-Based and Prescriptive Requirements in Benchmarking and Transparency Ordinances (Task 2)**

I. EXECUTIVE SUMMARY

The City of Cambridge is considering adopting provisions that would supplement its existing Building Energy Use Disclosure Ordinance by requiring building owners to meet certain performance thresholds or take actions to improve their buildings' energy performance. This memorandum analyzes the requirements of 10 other U.S. cities' building performance ordinances to identify common trends.

These beyond-benchmarking requirements can be viewed two ways. First, they can be viewed as performance thresholds that buildings are required to meet, with those that fail to meet them required to undertake prescriptive actions, such as energy audits or retrocommissioning. Second, they can be viewed as requirements to take prescriptive actions, for which high-performing buildings are exempt. High performance may be measured in a number of ways: earning a certain ENERGY STAR score; achieving specific improvements in a building's ENERGY STAR score or energy use intensity; or certification under a green building rating system. This memorandum adopts the former framework and discusses minimum performance thresholds that buildings are generally required to meet in multiple cities, followed by performance-based and prescriptive exemptions.

Furthermore, this memorandum compares Cambridge's building stock to the performance thresholds that other U.S. cities have typically considered, and describes key considerations for cities when creating beyond-benchmarking requirements. These include the need for technical assistance and the usefulness of establishing different approaches to compliance for different-sized buildings. Cambridge's building stock performs comparably with other cities based on overall ENERGY STAR scores, but demonstrates lower performance in office buildings and higher performance in residence halls, suggesting those areas may be potential foci for developing performance tiers.

II. INTRODUCTION AND PURPOSE OF MEMORANDUM

The City of Cambridge ("Cambridge" or the "City") first enacted a Building Energy Use Disclosure Ordinance ("BEUDO") in July 2014. At the time, Cambridge did not include any additional requirements beyond benchmarking and disclosure of energy and water usage data. Based on recommendations by the Net Zero Energy Task Force,[1] Cambridge is considering amending the BEUDO to add requirements that would lead to higher levels of energy and carbon savings. Cambridge is evaluating a range of options, including performance-based triggers that would require building owners to take a range of actions (such as energy assessments, retrocommissioning, and operations and maintenance plans). These options are being evaluated with consideration of potential benefits and costs to the City and building owners.

The Institute for Market Transformation ("IMT") compared the beyond-transparency requirements of U.S. cities to ascertain major trends. Of the 24 cities that have implemented benchmarking and transparency ordinances that affect commercial and/or multifamily buildings, 10 require building owners to take additional actions. **Error! Reference source not found.** compares the building types and sizes regulated by those 10 cities. The majority of these cities require building owners to conduct energy assessments and/or retrocommissioning. However, they also allow building owners to exempt themselves from these requirements based on building performance, as demonstrated through ENERGY STAR certification, Leadership in Energy and Environmental Design ("LEED") certification, or similar alternatives.

Section III of this memorandum summarizes the performance-based and prescriptive requirements that U.S. cities have considered or implemented that go beyond benchmarking and transparency, and looks at some high-level results. Section IV compares the performance of Cambridge's building stock to that of other cities that have released public datasets. Section V describes variations that cities have implemented when they add performance-based or prescriptive requirements, and summarizes the advantages and disadvantages of those variations. Appendix 1 references the ordinances, regulations, and data portals that were used to inform this analysis. Appendix 2 summarizes the various performance-based and prescriptive requirements of all the cities that IMT reviewed.

[1] Summary of Proposed Actions (2015) 4-5, *available at* http://www.cambridgema.gov/cdd/projects/climate/~/media/BF531928BB7D4526AE2D8538E025E0BA.ashx.

Table 1: Building Stock Regulated by Cities with Benchmarking and Transparency Programs

	Public/Government	Non-Residential	Multi-Family
CAMBRIDGE	**>10,000 SF**	**>25,000 SF**	**>50 dwellings**
Atlanta	>10,000 SF	>25,000 SF	>25,000 SF
Austin	>10,000 SF	>10,000 SF	>5 dwellings
Berkeley	ALL	ALL	ALL
Boston	ALL	>35,000 SF	>35,000 SF or >35 dwellings
Boulder	>5,000 SF	>20,000 SF	N/A (SmartRegs)
Los Angeles	>7,500 SF	>20,000 SF	>20,000 SF
New York City	>10,000 SF	>25,000 SF	>25,000 SF
Orlando	>10,000 SF	>50,000 SF	>50,000 SF
San Francisco	>10,000 SF	>10,000 SF	N/A
Seattle	>20,000 SF	>20,000 SF	>20,000 SF

III. OPTIONS FOR PERFORMANCE-BASED AND PRESCRIPTIVE REQUIREMENTS

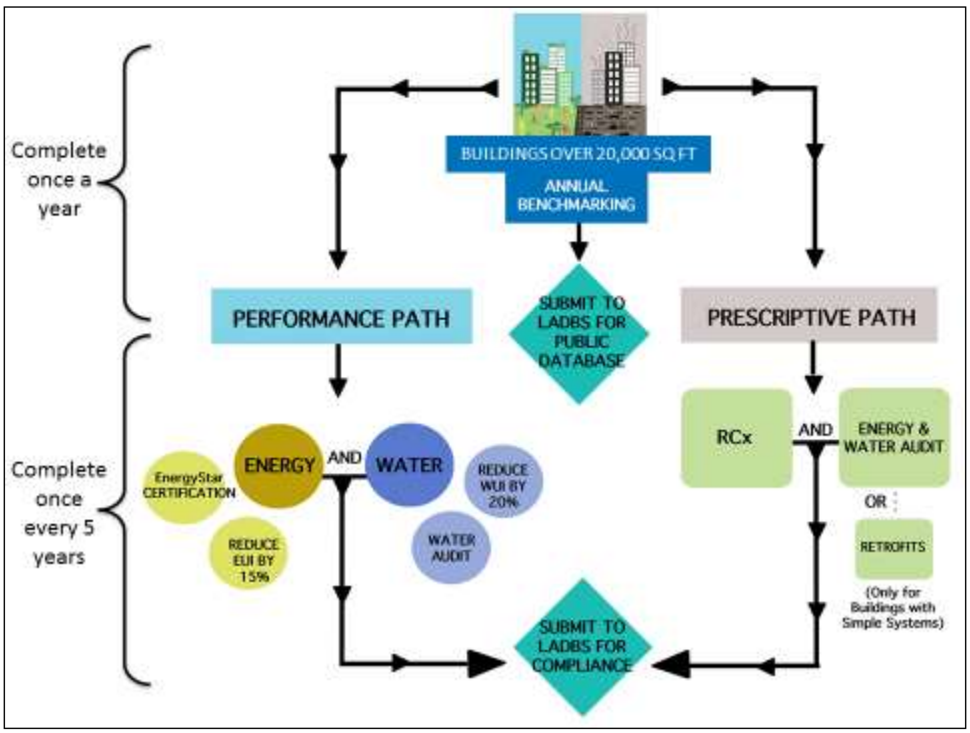
Performance-based or prescriptive requirements are designed to help building owners identify specific energy efficiency improvements, or to require them to act on those improvements, with the goal of increasing energy and carbon savings beyond those that can be achieved from benchmarking and transparency alone. Cities can implement four general categories of additional requirements: performance thresholds, energy assessments,[2] retrocommissioning requirements, and mandatory energy upgrades. The latter three categories are considered "prescriptive" as they require building owners to take specific actions or invest in specific upgrades. These requirements often work in concert, as demonstrated by the flowchart used by Los Angeles to show performance and prescriptive alternatives (see **Error! Reference source not found.**). However, —cities generally treat performance paths as "exemptions" and focus more on required prescriptive steps. Appendix 2 summarizes the different performance and prescriptive paths cities have adopted. While energy and carbon savings from cities that have implemented these requirements are not yet widely available, this Section also summarizes some initial findings.

a. Performance Exemptions

[2] This will be variously called energy assessments, energy audits, or simply audits.

Cambridge is considering requirements for building owners to take action based on performance thresholds. All cities that have included prescriptive requirements have authorized exemptions for high-performing buildings that receive a particular certification or demonstrate their energy performance in some other way. Performance-based exemptions can provide building owners with maximum flexibility to achieve the best combination of measures that are cost-effective for them.[3] There are two major tracks that cities have used to allow compliance based on proven performance: using an existing rating or certification system, or demonstrating performance through reduced energy use intensity ("EUI") or similar metrics.

Figure 1: Compliance Flowchart for the City of Los Angeles Benchmarking Program[4]



i. Performance Demonstrated by Existing Rating or Certification System

Most cities allow exemptions from audit and/or retrocommissioning requirements for completing a recognized building rating system, which may include certification under the U.S. Green Building Council's LEED for Existing Buildings: Operations & Maintenance ("LEED-EBOM")

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[3] Zachary Hart et al., ACEEE Summer Study, Building Performance Policies: A Comprehensive Approach (2016) 3, *available at* http://aceee.org/files/proceedings/2016/data/papers/9_955.pdf.

[4] Los Angeles Department of Building and Safety

system or ENERGY STAR. For example, Boston and Seattle both set specific requirements for LEED-EBOM: Boston requires Silver level certification with at least 15 points in the Energy & Atmosphere category, and Seattle requires at least Gold level certification with 17 points if the building owner is using LEED v4. Additionally, LEED-EBOM buildings must be recertified every five years, so buildings must demonstrate ongoing performance. For example, Boston's ordinance states that to be exempt, a building must have been certified or re-certified under LEED-EBOM within the 5-year compliance period. Berkeley and Seattle allow for exemption based on certification under the International Living Future Institute Living Building Challenge, and Orlando allows exception for buildings certified under the state-specific Florida Green Lodging standard.

A number of cities exempt buildings with very recent ENERGY STAR scores from requirements to conduct energy audits or retrocommissioning. ENERGY STAR scores are calculated by benchmarking a building's performance against a national peer group of buildings of the same primary use. ENERGY STAR Portfolio Manager selects each peer group from the Commercial Building Energy Consumption Survey (CBECS), which is conducted every four years.[5] ENERGY STAR scores are assigned on a 1-100 scale, with 50 the set as the peer group median. A building receiving a score of 75 or higher is considered "high-performing" compared to its peers and is eligible to receive ENERGY STAR certification. One nuance to policy implementation is that national peer groups can shift with CBECS updates. This means that building that is ENERGY STAR certified one year, and therefore exempt from prescriptive City requirements, may fall below the performance threshold in a subsequent year and be required to comply with city building efficiency ordinance.

Cities typically apply an absolute threshold for exemption based on ENERGY STAR scores. 75 points is common. Seattle bases its ENERGY STAR score thresholds on the performance of its existing building stock, and has set the exemption threshold at 90 for buildings ≥100,000 SF and 85 for smaller buildings. Seattle chose these thresholds to exempt the top 20 percent of buildings from tune-up requirements. In Seattle, buildings greater than 100,000 SF generally perform better than smaller ones. For non-residential buildings of 100,000 SF or larger, an ENERGY STAR score of 90 or above captures 20 percent of buildings and 24 percent of square footage, based on 2015 energy benchmarking data. For buildings 50,000 – 99,999 SF, an ENERGY STAR score of 85 captures 20 percent of buildings and 20 percent of square footage. In a staff memo, Seattle noted that its exemption is "specifically oriented towards those buildings that have achieved superior performance, whose operating efficiency is in the top 20 percent of the market."[6]

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[5] ENERGY STAR, How the 1-100 ENERGY STAR score is calculated, *available at* https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/how-1-100 (last visited June 14, 2017).

[6] Seattle Office of Sustainability & Environment ["OSE"], Response to Comments on OSE Director's Rule 2016-01 (2017) 3, *available at* http://www.seattle.gov/Documents/Departments/OSE/OSE_2016-01_Comments_Responses_on_Proposed_Rule.pdf.

Other cities focus specifically on low-performing buildings or demonstrated improvements. Orlando requires low-performing buildings with ENERGY STAR scores $\leq$50 (i.e., below the median) to complete auditing or retrocommissioning every 5 years until the building performance improves above 50.[7] Atlanta and Boston allow buildings to meet performance requirements if they can demonstrate a 15-point improvement in their ENERGY STAR scores, and Orlando allows buildings to demonstrate a 10-point improvement.

The number of buildings demonstrating compliance through certifications may be significant, depending on the city. From 2010-2014, 35 percent of covered floor area in San Francisco complied by attaining LEED-EBOM or ENERGY STAR certification, in lieu of conducting energy audits.[8] This result suggests that cities should develop clear and standardized guidelines for building owners to submit documentation about performance and any applicable exemptions.

ii. Performance Demonstrated by EUI or Other Improvements

Cities have also allowed building owners to demonstrate that they are reducing the EUI of their buildings over time. This may be generalized to any demonstrated improvement, in the case of Boulder, or a specific target, as in the case of Atlanta, Boston, New York City, and Seattle, which selected variations on the requirement that building owners demonstrate a 15 percent cumulative reduction in EUI over 2 to 5 years prior to the compliance year. Los Angeles, for example, requires a 15% reduction in weather-normalized source EUI within its 5-year compliance period. Specific site or source EUI thresholds may be beneficial in promoting energy savings; however, cities have not generally set requirements to meet a specific EUI threshold (as opposed to demonstrating progressive EUI improvement) due to the complexity of establishing thresholds for different building types that could move every few years. For example, Seattle does set a general site EUI threshold, and allows buildings with a site EUI less than 20 kBTU/SF/year for at least two of the three calendar years prior to compliance to be exempt from tune-up requirements.

A small number of cities allow building owners to demonstrate performance in other ways. In Boston, building owners can elect to take a series of "energy actions" in lieu of an audit, which could include a combination of energy efficiency measures, cogeneration, or on-site renewable energy. Boston also allows exemptions for buildings that can demonstrate they are “net zero” on an annual basis, either by generating more renewable energy than they consume, or by using sufficient renewable energy such that they generate no net greenhouse gas emissions. Provided the building owner retains the renewable energy credits, using on-site renewable energy such as rooftop solar will not affect a building’s site EUI score, but it will

[7] This obligation does not set in until 2020.

[8] San Francisco Department of the Environment & ULI Greenprint Center [“SFE & ULI Greenprint”], San Francisco Existing Commercial Buildings Performance Report, 2010-2014 (n.d.) 24, *available at* https://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_performancereport.pdf.

improve a building's source EUI score and reduce its associated greenhouse gas emissions (off-site green power purchases will only reduce emissions associated with the building).[9]

b. Energy Assessments

Some cities require that building owners conduct an energy assessment every few years as a condition of compliance. Most often, this takes the form of an American Society of Heating, Refrigeration, and Air Conditioning Engineers ("ASHRAE") audit. There are three ASHRAE audit levels, which are progressively more detailed (see **Error! Reference source not found.**). Cities generally require energy assessments that are at least as stringent as an ASHRAE Level II audit. There are two significant benefits associated with energy assessments. For building owners, they provide information and a roadmap they can use to identify improvements to building systems, or O&M to improve energy efficiency. For the implementing city, they can provide baseline information about the quality of existing building stock and the kinds of measures or operational changes that might improve its efficiency. Detailed information may also be useful in creating regulatory or incentive programs that are closely aligned to the specific needs of the jurisdiction's buildings.

The potential drawbacks of requiring energy assessments include high costs, compliance difficulties, and lack of direct energy savings. Building owners in some cities are required to seek outside auditors, and some building owners may need to undergo competitive processes to contract for auditor services. Cities may need to take affirmative steps to standardize audit filings so they can be effectively compared for compliance purposes. Another significant drawback of an audit-only requirement is that building owners do not have to act on the information they receive. Finally, some studies suggest that auditors tend to focus on easily implementable "low-hanging fruit," and accordingly their recommendations may understate the actual savings that can be obtained within a building.[10]

Table 1: Summary of ASHRAE Audit Types[11]

Level I	Preliminary or site assessment that identifies "low-hanging fruit" (e.g., no-cost options to increase energy savings)
Level II	An energy survey and engineering analysis audit, which may include more in-depth review

[9] ENERGY STAR Portfolio Manager, Technical Reference: Green Power (July 2013), *available at* https://portfoliomanager.energystar.gov/pdf/reference/Green%20Power.pdf.

[10] *See, e.g.*, Urban Green Council et al., New York City's Energy and Water Use 2013 Report (2016) 7, *available at* http://www.nyc.gov/html/gbee/downloads/pdf/nyc_energy_water_use_2013_report_final.pdf.

[11] Pacific Northwest National Laboratory ["PNNL"], A Guide to Energy Audits (2011) 2, *available at* http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-20956.pdf.

	of energy costs, usage, and building characteristics
Level III	A detailed, "investment grade" energy analysis designed to make recommendations about major capital investments

c. Retrocommissioning Requirements

Some cities go beyond auditing to require that building owners retrocommission[12] their buildings. Commissioning ensures that new buildings operate in accordance with design requirements and verifies that systems are working correctly[13]; retrocommissioning applies that quality assurance to existing buildings. Though retrocommissioning typically addresses issues of degradation, it can also improve a building's performance over its current baseline. It can both resolve problems that occurred during design or construction, and it can address problems that have developed during the building's operation. Typically, an energy assessment reveals some of the activities that would be conducted during retrocommissioning. Few cities require retrocommissioning, but some allow building owners to conduct it in lieu of, or in addition to, an energy assessment. The major benefit of retrocommissioning is that it leads to cost-effective energy savings implementation projects, with a median payback period of just over 1 year.[14] Relatively simple repairs, and recalibration of building systems, can lead to a significant amount of energy savings for most buildings. They can also increase occupant comfort by ensuring that climate control and other systems function properly. As the savings associated with retrocommissioning can degrade over time, cities with requirements tend to mandate retrocommissioning on five- to ten-year cycles.

As with audit requirements, the primary drawbacks to retrocommissioning requirements relate to compliance and costs. First, retrocommissioning requirements may not be standardized between providers, which can create market confusion for customers and challenge city staff attempting to determine which buildings are compliant. As we discuss below, some cities have addressed this by working with experts to standardize the retrocommissioning process. Second, retrocommissioning can increase costs and obligations to building owners, despite its short payback period. This can make it politically unpalatable. Atlanta's city council, for example, rejected a proposal that would have required retrocommissioning, but retained the provision as a voluntary option in its ordinance.

d. Mandatory Energy Upgrades

[12] Retrocommissioning may also be known as recommissioning.

[13] NIBS Whole Building Design Guide ("WBDG"), *available at* https://www.wbdg.org/building-commissioning.

[14] Evan Mills, Building Commissioning: A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions (2009), *available at* http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf.

In some cases, cities have set requirements that building owners complete specific, prescriptive actions. Often these requirements are designed to raise existing buildings to a base level of code compliance. For example, within five years of the first reporting requirement, Boulder will require building owners to demonstrate compliance with the current version of the International Energy Conservation Code ("IECC") for interior and exterior lighting fixtures, occupancy sensors, illuminated exit signs, and a few other prescriptive requirements. New York City's Local Law 88 will require building owners to upgrade lighting systems to comply with the city's IECC code by 2020, as well as to install submetering for tenant spaces by 2025. Since these requirements apply to equipment in both common and tenant occupied spaces, the lengthy lead periods before the compliance deadlines allow sufficient time for at least one renewal of all existing tenant leases, which typically run 10 years or less. This allows these upgrades to be implemented as part of tenant improvements which can occur as part of a new lease agreement. These requirements are specific and measurable, which makes compliance more straightforward. In New York City's case, the requirement to install submetering in applicable tenant spaces will provide the benefit of additional information to both building owners and tenants. However, some cities have rejected fully prescriptive approaches--both Berkeley and Boulder cite the fast-moving nature of building science and technology as a reason to shy away from a fuller list of prescriptive measures.

Few cities require building owners to invest in energy upgrades that go beyond basic code compliance. Boulder requires that, within two years of submitting a retrocommissioning report, building owners implement any recommended measure with a payback period of two years or fewer. Austin requires that "high-use" properties consuming more than 150 percent of the average multifamily energy usage[15] must reduce their usage by 20 percent within 18 months, by implementing a package of retrofits in consultation with Austin Energy. Austin Energy has not reported on the program's impact, but explains that the most frequently implemented measures are air duct sealing, attic insulation, and solar screens or film for windows. The anticipated cost to building owners from setting additional requirements is always of concern to cities, and most have rejected mandatory upgrades. Denver and Seattle both originally proposed that building owners be required to install cost-effective energy efficiency measures identified through energy assessments or retrocommissioning[16] but ultimately rejected these proposals.

e. Results of Beyond-Benchmarking Requirements to Date

Most cities with additional requirements implemented these rules recently, and there is little publicly available data on their impact. According to a recent meta-analysis by Lawrence Berkeley National Laboratory ("LBNL"), benchmarking and transparency ordinances correlate

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[15] Average multifamily energy usage is recalculated annually. *See* Austin Energy, FAQs: ECAD for Multifamily Properties, *available at* http://austinenergy.com/wps/portal/ae/energy-efficiency/ecad-ordinance/for-multifamily-properties/faqs/.

[16] Denver proposed implementation of measures with a 2.5-year payback and Seattle proposed a 2- to 3-year payback. Boston also seems to have rejected the idea of requiring cost-effective energy actions at this time.

with cumulative 1.6-14 percent decreases in energy usage, depending on the city.[17] However, LBNL did not specifically isolate cities that have implemented additional requirements for energy assessments or retrocommissioning. New York City and San Francisco are the only cities that have collected and publicly produced some degree of data on the impact of improvements recommended during energy assessments.

San Francisco's benchmarking and transparency ordinance was phased in from 2010-2013. According to 2010-2014 data, energy audits from 800 buildings revealed opportunities for $60.6 million worth of upgrades that have a $170 million net present value.[18] San Francisco estimated that these improvements, which were recommended by energy auditors and have not necessarily been implemented by building owners, would save 150 GWh and 1.4 million therms of natural gas. A smaller group of 176 buildings that have complied every year since 2010 decreased their energy use by 8 percent and their carbon emissions by 17 percent.[19]

Similar to San Francisco, New York City found that for 3,000 large buildings that complied with its benchmarking and transparency ordinance from 2010-2013, energy use decreased by 6 percent and carbon emissions by 8 percent.[20] New York City also collects and aggregates data about specific energy improvements recommended by energy auditors. According to 2013 data, the most commonly recommended energy conservation measures ("ECMs") for office buildings were lighting upgrades, and HVAC controls and sensors.[21] Auditors most frequently recommended lighting, domestic hot water, and envelope upgrades for multifamily housing. If implemented, the recommended ECMs could save 22 billion kBTU, or about 0.0183 percent of New York City's total consumption from reporting buildings. However, the city believes this to be an understatement as auditors focus on more practical measures, and may not be recommending deep retrofits.[22]

While Boulder has not released detailed results – its prescriptive requirements related to energy assessments and retrocommissioning have not yet come into effect – it initially estimated that benchmarking and transparency could save up to 38,000 metric tons of carbon dioxide emissions ("MTCO2e") per year, with up to 125,000 MTCO2e additionally possible by adding efficiency requirements over 10 years. This represents a decrease of 6 to 33 percent from

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[17] Natalie Mims et al., Lawrence Berkeley National Laboratory ["LBNL"], Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts, and Best Practices (2017) 56-62, *available at* https://emp.lbl.gov/sites/default/files/lbnl_benchmarking_final_050417.pdf.

[18] SFE & ULI Greenprint at 24-26.

[19] *Id*. at 14-15. These buildings are ≥50,000 SF due to San Francisco's phased ordinance implementation.

[20] Urban Green Council at 4.

[21] *Id*. at 26.

[22] *Id*. at p. 5, 26-28 (estimating that the 10,000 properties that submitted complete data in 2014 used approximately 120 trillion BTUs of energy).

covered buildings, using a 2005 baseline.[23] Boulder adopted a slightly stronger version of what it modeled, suggesting that emissions reductions may actually be higher.

III. BUILDING STOCK COMPARISON

Because Cambridge is considering whether to establish beyond-transparency requirements based on the performance thresholds of different building types, Section IV looks at the relative performance of Cambridge's building stock compared with that of other cities that have publicly released data. While IMT generally focused on two other "peer" cities, we also looked at EPA-calculated data (EUIs and ENERGY STAR scores) reported by several other cities that have implemented benchmarking and transparency ordinances, with and without additional requirements such as audits or retrocommissioning.

a. High-Level Building Stock Comparison

Nine other cities provide public data downloads or summary reports that can be compared to Cambridge's publicly available data on building performance.[24] **Error! Reference source not found.** indicates that Cambridge falls roughly in the middle, outperforming cities like Chicago, the District of Columbia, New York City, and Philadelphia. This does not control for variations in building stock that may affect ENERGY STAR scores.

Table 2: Reported Median ENERGY STAR Scores by City[25]

	ENERGY STAR Score	Properties Analyzed[26]	Year of Data (Reporting Year)
Boston	72	868	2015 (2016)
Boulder	70	143	2015 (2016)
Cambridge	***69***	***259***	***2015 (2016)***
Chicago	59	1,867	2016 (2017)

[23] City of Boulder Staff Memorandum, Study Session – Proposed Commercial and Industrial (C&I) Energy Efficiency Ordinance (May 12, 2015) 25, *available at* https://documents.bouldercolorado.gov/WebLink8/0/doc/129024/Electronic.aspx.

[24] Boston, Chicago, District of Columbia, Minneapolis, New York City, Philadelphia, San Francisco, and Seattle. *See* IMT, BuildingRating.org, http://buildingrating.org/graphic/us-benchmarking-data-and-data-visualization-links (last updated July 7, 2016).

[25] Links to data downloads are included in Appendix 1. For Boulder, Chicago, Minneapolis, and Philadelphia, the data comes from the city's own analysis. All other cities are based on analysis of open datasets (buildings with null ENERGY STAR scores were removed).

[26] This column references the number of buildings for which an ENERGY STAR score was calculated, which is fewer than the number of buildings which complied with local ordinances.

District of Columbia	67	1,155	2015 (2016)
Minneapolis	71	417	2015 (2016)
New York City	63	9,535	2015 (2016)
Philadelphia	59	1,921	2014 (2015)
San Francisco	83	788	2015 (2016)
Seattle	76	2,560	2015 (2016)

b. Methodology for Peer Cities Building Stock Comparison

Based on discussions with Cambridge and IMT's review of cities with similar building types and climate zones, we focused on Boston and Seattle as peer cities to compare specific building types more closely.[27] This building stock comparison analysis includes two steps.

First, we looked at the performance of the five largest categories of buildings that Cambridge has benchmarked, as measured in square feet. These building types are college/university, multifamily housing, office, laboratory, and residence hall/dormitory. Boston's building stock is the closest in comparison to Cambridge's, with a mix that includes laboratories and higher education in addition to multifamily and office buildings.

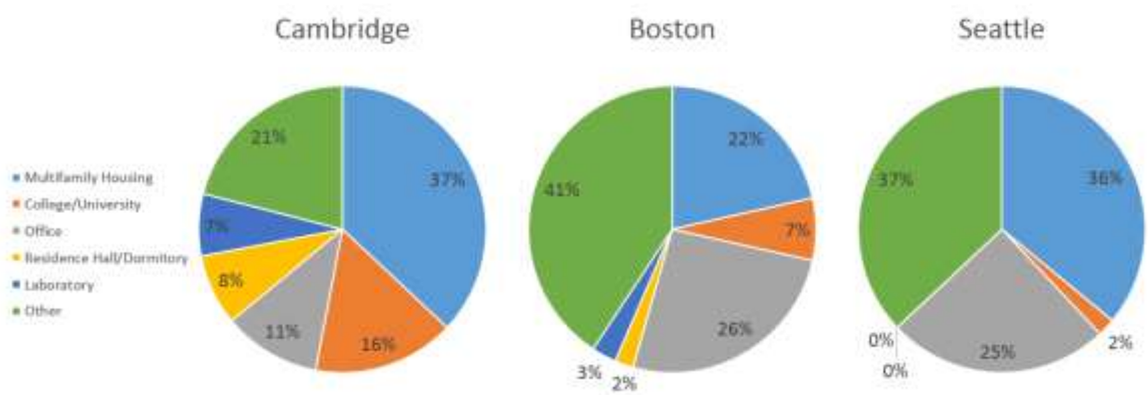

Figure 1: Comparison of Buildings Reporting by Square Footage

Second, to provide a comparison between cities based on building stock performance, we selected four metrics: building or property type, site energy use intensity ("EUI"),[28] source EUI, and ENERGY STAR rating. Building type may be self-reported or selected by Portfolio Manager, but the building types are standardized across cities. The Environmental Protection Agency ("EPA") recommends source energy to account for the total life cycle of fuels, and we also provided site energy to focus on the building stock itself and eliminate the effects of

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[27] While Boston's ordinance applies to parcels, like Cambridge's, Seattle's ordinance applies only to buildings.

[28] We used weather-normalized source and site EUI for Cambridge and Seattle.

transmission and distribution losses.[29] Finally, ENERGY STAR rating--which is not available to universities or laboratories[30]--has been used by cities as a performance threshold. ENERGY STAR ratings group buildings into similar categories and accounts for their operating hours and number of workers, in addition to normalizing for weather.[31] Because the cities selected have different practices for cleaning their data prior to publication, this comparison is intended to be suggestive rather than precise.

c. Results of Building Type Comparison

Based on **Error! Reference source not found.** above, Cambridge's buildings have lower overall median ENERGY STAR scores than those of Boston or Seattle. Differences emerge when looking more granularly at building types, summarized in Table 3 below. With regard to ENERGY STAR scores, multifamily housing in Cambridge is generally comparable to that of the other cities, although its office buildings perform generally lower (despite a large range of EUIs for Boston office buildings). Cambridge fares well with regard to residence halls and college/university buildings, with a significantly higher ENERGY STAR score for residence halls and a median site EUI for universities that outperforms Boston. While we have not specifically examined this possibility, the higher performance of Cambridge's residence halls compared to other multifamily housing in the city may be related to university management and sustainability plans. These data suggest that to the extent Cambridge considers performance requirements based on ENERGY STAR thresholds, residence halls would be the type of building most likely to exceed the requirements set by other cities.

	Cambridge			Boston			Seattle		
	Site EUI	Source EUI	ENERGY STAR	Site EUI	Source EUI	ENERGY STAR	Site EUI	Source EUI	ENERGY STAR
College/University	74	129	N/A	103	Unavail.	N/A	74	170	N/A
Multifamily Housing	78	116	73	68	Unavail.	76	34	94	79
Office	81	201	69	72	Unavail.	81	56	156	78
Laboratory	255	580	N/A	344	Unavail.	N/A	266	552	N/A
Residence Hall	70	95	88	76	Unavail.	78	70	128	71

[29] ENERGY STAR, The difference between source and site energy, *available at* https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/difference (last visited May 24, 2017).

[30] ENERGY STAR, Property types eligible to receive a 1-100 ENERGY STAR score, https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/identify-your-property-type-0 (last visited May 24, 2017).

[31] EPA, ENERGY STAR Portfolio Manager: Technical Reference (2014) 2, *available at* https://portfoliomanager.energystar.gov/pdf/reference/ENERGY%20STAR%20Score.pdf.

Table 3: Results of Building Stock Analysis[32]

IV. PRACTICES FOR IMPLEMENTING PERFORMANCE-BASED AND PRESCRIPTIVE REQUIREMENTS

While benchmarking and transparency ordinances are not themselves new, few cities have more than a couple of years of experience at implementing additional requirements. For example, the first year in which New York City required owners of covered buildings ≥50,000 square feet ("SF") to submit audit and retrocommissioning reports was 2013.[33] Given this lack of data, it is too early to identify best practices. However, cities have made unique decisions about how to implement additional requirements for practical, technical, and political reasons. We have identified the following eight practices that Cambridge may want to consider should it implement additional requirements:

- Varying requirements due to building size or complexity;
- Varying requirements due to industry;
- Creating common understandings of expectations;
- Setting staggered compliance schedules;
- Providing technical and financial assistance;
- Selecting appropriate reporting requirements and standardizing data collection practices;
- Establishing qualifications for service professionals; and
- Balancing costs for building owners with benefits for tenants.

a. Varying Requirements Due to Building Size or Complexity

The majority of cities that have established additional requirements vary those requirements based on the size of the building, or its complexity. Larger and more complex buildings are required to adhere to more stringent requirements. This benefits smaller buildings, which often have simpler systems (such as fewer stories and no elevators) and are less likely to have on-staff energy managers. Initial analysis from Boston supports this approach, finding higher levels of

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32 This data set compares 2015 reports by building type using medians, and requires two qualifications. First, Cambridge's data comes from the Task 3 "cleaned" data set except for site EUI, and site/source calculations may not be precisely comparable. Second, Boston does not release source EUI or weather-normalized data, although both Cambridge and Seattle data points have been weather-normalized.

33 New York City Mayor's Office of Sustainability, Covered Buildings (Buildings Required to Benchmark), *available at* http://www.nyc.gov/html/gbee/html/plan/ll87_covered_buildings_list.shtml (last visited May 24, 2017).

compliance for larger buildings and higher education buildings, compared to lower levels of compliance for smaller buildings and building owners in retail.[34]

Some cities have varying requirements based on building size and complexity for energy assessments and retrocommissioning. For example, the City of San Francisco requires Level II audits for buildings ≥50,000 SF, but allows buildings between 10,000-49,999 SF to receive audits that are at least as stringent as Level I. Not all cities vary this requirement. Atlanta's ordinance requires Level II audits for buildings ≥25,000 SF every 10 years.

Los Angeles and New York City exempt "simple" buildings from some requirements. Los Angeles defines simple buildings as buildings without central cooling systems. Simple buildings are exempted from audits and retrocommissioning requirements if they complete four of six prescriptive measures, including achieving code compliance for common area and exterior light fixtures; insulating exposed pipes; installing a cool roof; participating in a utility demand response program; installing a solar water heating system; or installing a new water heater. New York City defines simple buildings as those that do not have central cooling or chilled water systems; they can qualify for exemption from the first cycle of audit reports by completing six of seven retrofit measures.[35] These measures are similar to those required by Los Angeles, and include individual heating controls, common area and exterior lighting In compliance with local code, insulated pipes and hot water tanks, low-flow fixtures and front-load washing machines, and installing a cool roof.

b. Varying Requirements Due to Industry

Some cities vary their additional requirements for particular industries or building types. Some make unique provisions for local industries. Los Angeles has exempted movie studios, and Orlando has exempted theme parks from audit and retrocommissioning requirements. Boston heard comments on, but rejected, a proposed exemption for condominiums due to concerns regarding the need for unit owners to sign off on any energy investments.[36] However, the most common variations beyond these unusual commercial operations are for industrial or institutional entities with campuses.

In Boulder, stakeholders from large manufacturers raised concerns that regulations on a per-building basis might preclude them from making investments with larger paybacks in energy

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[34] City of Boston, Energy and Water Use in Boston's Large Buildings, 2013 (2015) 9, *available at* https://www.cityofboston.gov/images_documents/BERDO_rprt_webfinal_tcm3-52025.pdf (this was prior to energy assessment requirements setting in).

[35] They are required to complete subsequent audit reporting cycles.

[36] Condominium associations are considered within the definition of "owner." City of Boston, Summary of Comments Received on Draft Regulations (2014) 7, https://www.cityofboston.gov/images_documents/Draft%20Response%20to%20Public%20Comments%201%2031%202014_tcm3-42246.pdf.

savings and cost elsewhere in their portfolio.[37] Boulder responded by creating a "large industrial campus" exemption for multiple buildings served by a central plant or single utility meter.[38] The exemption requires large industrial campuses to submit annual narratives on their energy reduction goals and verbal reports on their energy savings. They have slightly lower requirements, and must perform ASHRAE Level II or equivalent audits every 10 years (in lieu of retrocommissioning), with the requirement to implement recommended measures with a payback period of 1 year (instead of 2 years).

Similarly, university stakeholders in Boston raised concerns with the city that their existing institutional energy management plans, unique buildings (laboratories), and unique usage patterns (dormitories) should exempt them from typical requirements. Boston responded by creating ordinance with a specific exemption from the audit requirement for covered building that are included in an institutional master plan with an energy management component, that would reduce energy use or greenhouse gases by 15 percent over 5 years across the institution. This compromise allows universities to manage their building portfolios in different ways. Boston's advisory group also took comments arguing that highly intense sectors like laboratories should be allowed to pursue alternative compliance approaches, like Labs21. This approach was rejected, but laboratories were still the only sector with 100 percent compliance in the first year of Boston's benchmarking ordinance.[39]

c. Creating Common Understandings of Expectations

While ASHRAE sets guidelines for energy assessments and retrocommissioning (though the retrocommissioning guidelines are not as fully developed as energy assessment guidelines), some cities opt to set their own community-specific requirements to ensure that every service professional uses roughly the same practices. These practices create consistency between providers and ensure equity between customers. Cities sometimes have difficulty articulating the specific practices that need to be conducted. New York City offers an example of an inconsistently interpreted requirement. While it excludes tenant systems and equipment from audit and retrocommissioning requirements, ambiguities in how energy auditors interpreted this caused some to submit information about tenant-owned systems.[40] Still, city-specific requirements can make compliance much more straightforward by clarifying the steps to take and documents to submit. The process can be managed by seeking expert advice through stakeholder working groups.

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[37] City of Boulder Staff Memo, Second Reading on Ordinance No. 8071, (Sept. 29, 2015) 6, *available at* https://documents.bouldercolorado.gov/weblink8/0/doc/130442/Electronic.aspx.

[38] In Boulder, this applies to a few large customers, including IBM and Ball Corporation.

[39] City of Boston at 9.

[40] Urban Green Council at 6.

Some cities define the systems and equipment that they want building owners to prioritize. New York City is typical of most cities in that it requires building owners to receive audits and retrocommissioning for "base building systems," which include the building envelope, heating, ventilating, and air conditioning ("HVAC") systems, conveying systems, domestic hot water systems, and electrical and lighting systems. Los Angeles has a similar requirement to focus on "base building systems," to which it adds renewable energy systems. These cities exclude tenant equipment from their requirements, with Seattle being an outlier in that it requires tenants to provide reasonable access to tune-up specialists.

Other cities develop specific lists of actions that they want energy services professionals (auditors or retrocommissioning agents) to take. This is more strongly associated with retrocommissioning requirements. While Los Angeles adopts by reference the ASHRAE Guideline 0.2, Atlanta, Boulder, and New York have all developed detailed requirements for what they expect the retrocommissioning process to cover. Both New York City[41] and Seattle[42] require building owners to make certain corrective actions as part of retrocommissioning. New York City's administrative regulations lay out specific, corrective steps, like calibrating HVAC sensors or ensuring appropriate lighting levels. Seattle's "tune-up" program includes an inspection of energy and water systems every 5 years, with recommendations for improvement of operations, as well as implementing low-cost adjustments and minor repairs. Seattle requires building owners to take a series of specific, corrective actions as part of the tune-up that are designed to reduce energy usage by 10-15 percent on average, a 2-3 year payback. Building owners must file the recommendations they receive and the adjustments they make.

d. Setting Staggered Compliance Schedules

Cities generally vary the frequency with which they require energy assessments, generally at five-, or 10-year intervals. Berkeley's compliance schedule is different. The city requires a five-year compliance interval for buildings greater than 50,000 SF, an eight-year interval for buildings smaller than 50,000 SF but larger than 5,000 SF, and a 10-year cycle for buildings less than 5,000 SF. This schedule was likely chosen to reduce burdens on the owners of smaller buildings. However, Berkeley staff also considered the importance of providing a longer phase-in for the policy to help build a well-trained workforce and allow service providers to foster deeper relationships with building owners.[43]

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[41] City of New York Department of Buildings, Local Law 87: Final Audits and Retrocommissioning Rule (September 5, 2012) 7, *available* at http://www.nyc.gov/html/gbee/downloads/pdf/energy_audits_and_retrocommissioning_final_rule.pdf

[42] Seattle Office of Sustainability & Environment, Director's Rule 2016-01 (2017) 2, *available* at http://www.seattle.gov/Documents/Departments/OSE/OSE_DIRECTORS_RULE_2016-01.pdf

[43] Berkeley Staff Memo.

Cities also tend to stagger the compliance schedule for additional requirements. Atlanta, Los Angeles, and San Francisco all stagger audit requirements for covered buildings over 5-10 years. In these cities, a building's compliance year is assigned based on building identification number.[44] Berkeley also requires building owners to submit Energy Reports (which summarize recommendations for energy efficiency measures, payback periods, and opportunities for incentives or financing) at time of sale, if they have not yet been required to comply under the current schedule. Unfortunately, the approach of staggering compliance means that these requirements have not yet come due for many cities, meaning there is little information available on the impacts of these additional requirements.

e. Providing Technical and Financial Assistance

Cities frequently provide building owners who are undergoing energy assessments or retrocommissioning with technical assistance. Financial assistance is less common, although cities do tailor their requirements to capitalize on existing incentives offered by local electric utilities or other entities.

The most common type of technical assistance cities provide is a help center, with customer service representatives trained to answer building owner questions, and connect building them with resources. Help centers may be staffed in-house, through nonprofits, or with external consultants.[45] New York City and Seattle have also developed accelerators that provide more targeted assistance. New York City's Retrofit Accelerator has a team of energy efficiency advisors that connect building owners to qualified contractors, train their staff, and help them identify incentives and financing. Similarly, Seattle's DOE-funded Tune-Up Accelerator will provide specific incentives and technical support to a limited number of building owners. Other common practices include posting guides and checklists with detailed compliance instructions on a designated website.

In rare cases, cities have provided or considered targeted financial assistance. For example, Boulder uses its Climate Action Plan ("CAP") Tax, a tax on electricity usage within the city, to fund sustainability staff and programs. Boulder has dedicated $250-300,000 of CAP Tax funding to provide incentives for energy audits and rebates through existing programs as well as boosts to electric energy efficiency rebates offered by Xcel Energy.[46] Berkeley has considered an alternative approach to offering financial assistance in the form of tax rebates. Its current Seismic Retrofit Program allows for a dollar-for-dollar refund of the transfer tax assessed at the

[44] Specifically, last digit of year to last digit of number.

[45] There does not appear to be a correlation between the number of FTEs required and whether the city has implemented additional requirements. LBNL at 25-26 provides a comprehensive list of staffing.

[46] Partners for a Clean Environment and EnergySmart, the latter of which is now operated by Boulder County.

sale of residential or mixed-use properties for seismic improvements, and it has considered (but not approved) implementing a similar refund for energy improvements.

Finally, cities sometimes leverage existing programs. For example, the City of Boulder allows buildings 10,000-49,999 SF to receive free energy audits that are approximately equivalent to ASHRAE Level I audits. These are provided by the local EnergySmart and Partners for a Clean Environment ("PACE") programs. Similarly, the City of Orlando allows building owners to comply with its energy audit requirement by completing the Orlando Utility Commission's free energy audit program. This assistance was politically critical to Orlando passing ordinance with an audit requirement, as the ordinance does not increase costs to building owners. Seattle allows buildings undergoing their "tune-up" to complete the Seattle City Light retrocommissioning incentive program as an alternative.[47] Lastly, New York City has successfully leveraged funding from the New York Energy Research and Development Authority ("NYSERDA") to direct building owners toward incentives for specific measures, verified energy savings, and energy audits. These activities are summarized in Table 5 below.

City	Required Prescriptive Action	Leveraged Programs for Compliance Alternatives	Program Administrator
Atlanta	Energy Audit	As determined by the Department, no-cost/reduced cost energy audits provided for commercial customers qualify for compliance.	N/A
Boulder	Energy Audit	Buildings < 50,000 SF may complete the free Energy Assessment offered by the City's Partners for a Clean Environment; Buildings ≥ 50,000 SF may apply for rebates from the City to offset audit costs.	Utility
	Retrocommissioning	Buildings < 50,000 SF may complete the Xcel Energy Building Tune-Up Program; Buildings ≥ 50,000 SF may complete the Xcel Energy RCx Study Program.	Utility
Orlando	Energy Audit	The free commercial audit offered by Orlando Utility Commission qualifies for compliance.	Utility

[47] Natural Resources Defense Council ["NRDC"], Putting Your Money Where Your Meter Is: A Study of Pay-for-Performance Energy Efficiency Programs in the United States (2017) 54, *available at* https://www.nrdc.org/sites/default/files/pay-for-performance-efficiency-report.pdf.

Seattle	Building Tune-Up	Seattle City Light (SCL) Retro-Commissioning incentive program plus Puget Sound Energy's Comprehensive Building Tune-Up if using natural gas heating qualifies for compliance.	Utility
		SCL whole-building Energy Analysis Assistance for Existing Buildings including receipts for implementing all measures with a 2.5 year payback or less qualifies for compliance.	Utility
		City of Seattle's Building Tune-Up Accelerator Program qualifies for compliance.	City of Seattle

Table 5: Leveraged Programs for Compliance Alternatives

f. Selecting Appropriate Reporting Requirements and Standardizing Data Collection Practices

Most cities have made intentional decisions about the information they will require building owners to report, and the documentation and tools they will use to collect that data. Building owners may be concerned about the disclosure of reporting certain aspects of their buildings' operation, although conversely, creating a more transparent market is often why cities implement benchmarking programs. Requiring more complete information on energy audit or retrocommissioning results benefits cities by providing a more complete perspective on local building stock. However, cities must consider privacy laws that apply to collection of detailed building data, and the possibility that a public information request would force the city to release sensitive data about buildings' internal system conditions and upgrade costs to the public.

To address privacy concerns, some cities only require filing of summary audit and/or retrocommissioning reports, while others require building owners or their energy auditors to file information that is more detailed:

- Orlando requires a "summary audit report" that only discloses to the city basic building data and the date the audit was completed.
- San Francisco requires that auditors provide building owners with a list of all retrofit measures available to them, highlighting those with a payback period <5 years. Building owners must then submit to the city a summary of available measures, their total associated energy and cost savings, and list of implemented measures.
- Boulder, Los Angeles, and New York City require building owners to submit a complete list of practical measures recommended by audits, the anticipated energy savings, and the payback period. Los Angeles requires a list of completed retrocommissioning measures. To the extent cities release this data to the public, they do so in summary.

New York City has created customized, highly tailored spreadsheet templates to ensure that providers lay out information consistently. Building owners are required to submit populated spreadsheets ("Data Collection Tools") for audits and for retrocommissioning as part of their Energy Efficiency Reports. This practice allowed the city to release a detailed analysis of audited square footage from the first two compliance years (20 percent of the city's total square footage), which identified significant opportunities for energy savings from increasing heating efficiency, more insulated window and wall air conditioning units, and upgrading lighting and lighting controls.[48] However, the reporting creates complexities in data management by increasing the potential for errors in data entry, creating a need to develop additional databases and to clean and analyze more data. Recognizing this challenge, the Department of Energy has been developing an Asset Score Data Reporting Template tool that collects standardized data on building systems and operations and recommends energy efficiency measures that may be cost-effective. So far, no cities have adopted this tool for compliance, although some are considering it for their 2018 reporting cycles.

g. Establishing Qualifications for Service Professionals

Another action cities have taken is setting baseline requirements for qualified service professionals who provide energy assessments, retrocommissioning, and other mandated actions. The primary benefits to this approach are the standardization of services professionals provide within the local market, and the increased likelihood of building owners having a positive experience working with those service providers. No cities recommend specific service providers, but many list those who have provided services in previous compliance cycles. Cities have generally established rules related to the independence of the service provider and their combination of certifications and experience.

Some cities require that service providers be independent of the building owner. For example, New York City requires independent energy assessors, in order to prevent conflicts of interest. However, Boston, Orlando, and Seattle all allow building owners to use existing staff to perform energy assessments or retrocommissioning, if the staff members meet certification and experience requirements. Boston stakeholders specifically raised this issue, arguing that using qualified internal staff is less expensive than hiring alternative providers.[49] This also encourages building owners to retain qualified in-house staff, which may lead to greater ongoing attention placed on energy efficiency in building operations.

All of the cities IMT reviewed have established some combination of certification requirements and experience levels for energy assessment and retrocommissioning personnel. Most cities require at least two to three years of experience with performing the specific requirements for the specific type of regulated building. In addition, cities tend to require certification, including professional accreditation (e.g., professional engineer or registered architect), energy

[48] Urban Green Council at 7. New York City's first year for requiring audits was 2013.

[49] Stakeholder comments.

accreditations (e.g., Association of Energy Engineers Certified Energy Manager or Auditor; ASHRAE Building Energy Assessment Professional or Design Professional), or commissioning accreditations (e.g., through the Associated Air Balance Council). This approach can cause friction if the local utility offers energy assessments or retrocommissioning incentive programs provided by professionals with different qualifications. While a number of cities offer trainings, Berkeley actually requires service providers to register and attend an orientation.

h. Balancing Costs for Building Owners with Benefits for Tenants

Some cities have considered the landlord-tenant relationship in setting requirements. For example, when Boulder set requirements that building owners make cost-effective energy upgrades, the city prohibited building owners from passing those costs directly on to tenants all at once. The city's administrative rules specify that building owners must amortize the costs of the measures recommended by the retrocommissioning agent over their lifetime prior to passing costs on to tenants. However, Boulder is the only city that has taken that action.

V. Conclusions

Cambridge is considering joining 10 other U.S. cities that have adopted requirements that go beyond benchmarking and transparency. Cities that have taken this step generally incorporate performance thresholds using LEED-EBOM or ENERGY STAR certification, with some adding options to comply through demonstrated improvement of EUI or another metric. Compared to peer cities, Cambridge's higher education buildings and residence halls perform well; its offices and multifamily housing compare less favorably. This suggests Cambridge may want to factor in the varying performance of building types should it set performance thresholds.

Many cities direct significant focus to developing auditing, retrocommissioning, and sometimes other prescriptive requirements, while treating performance requirements as more of an exemption. While there are significant trends in how cities have designed these prescriptive actions—such as the prevalence of ASHRAE Level II audit requirements and specific retrocommissioning actions where that is required—many cities make variations to meet their local needs, including tailoring programs to leverage utility financial incentives or exempting certain industries from requirements. Cambridge may want to integrate these lessons learned should it add to its benchmarking and transparency requirements.

APPENDIX 1: SOURCES

Boston, MA

- Ordinance, https://www.cityofboston.gov/images_documents/Signed%20Ordinance_tcm3-38217.pdf
- Administrative Regulations, https://www.cityofboston.gov/images_documents/BERDO%20Regulations%20Approved%2018Dec2013_tcm3-42376.pdf
- Greenovate Boston BERDO Homepage, http://berdo.greenovateboston.org/

Boulder, CO

- Ordinance No. 8071, https://www2.municode.com/library/co/boulder/codes/municipal_code?nodeId=TIT10ST_CH7.7COINENEF
- Administrative Rules, https://www-static.bouldercolorado.gov/docs/CMRs_FINAL_for_posting-1-201607131200.pdf
- Boulder Building Performance Homepage, https://bouldercolorado.gov/sustainability/boulder-building-performance-home
- City of Boulder, Boulder Building Performance Program 2015/2016 Report (2017), available at https://www-static.bouldercolorado.gov/docs/Buildings-Performance-Report-Boulder-FINAL-1-201704281010.pdf

Chicago, IL

- Energy Benchmarking Homepage, https://www.cityofchicago.org/city/en/progs/env/building-energy-benchmarking---transparency.html
- Data Portal, https://data.cityofchicago.org/Environment-Sustainable-Development/Chicago-Energy-Benchmarking/xq83-jr8c
- City of Chicago, City of Chicago Energy Benchmarking Report 2016 (2017), *available at* https://www.cityofchicago.org/content/dam/city/progs/env/EnergyBenchmark/2016_Chicago_Energy_Benchmarking_Report.pdf

District of Columbia

- 2015 Energy Benchmarking Dataset, https://doee.dc.gov/node/1203042

Minneapolis, MN

- Minneapolis Commercial Building Benchmarking and Transparency Homepage, http://www.ci.minneapolis.mn.us/environment/energy/.
- City of Minneapolis, 2015 Energy Benchmarking Report (2017), available at http://www.minneapolismn.gov/www/groups/public/@health/documents/images/wcmsp-194743.pdf

New York City, NY

- Greener, Greater Buildings Plan Homepage, http://www.nyc.gov/html/gbee/html/plan/plan.shtml
- Local Law 84: Benchmarking, http://www.nyc.gov/html/gbee/html/plan/ll84.shtml
- Local Law 87: Audits and Retrocommissioning, http://www.nyc.gov/html/gbee/html/plan/ll87.shtml
- Local Law 88, Lighting Upgrades & Sub-metering, http://www.nyc.gov/html/gbee/html/plan/ll88.shtml
- Data Portal, http://www.nyc.gov/html/gbee/html/plan/ll84_scores.shtml
- Urban Green Council, New York City's Energy and Water Use 2013 Report (2016), available at http://www.nyc.gov/html/gbee/downloads/pdf/nyc_energy_water_use_2013_report_final.pdf

Philadelphia, PA

- Philly Building Benchmarking Homepage, http://www.phillybuildingbenchmarking.com/
- Data Portal, https://www.opendataphilly.org/dataset/large-commercial-building-energy-benchmarking
- City of Philadelphia, 2016 Energy Benchmarking Report (2016), available at http://www.phillybuildingbenchmarking.com/wp-content/uploads/2016/04/2016-Benchmarking-Report.pdf

San Francisco, CA

- San Francisco Benchmarking Homepage, https://sfenvironment.org/energy/energy-efficiency/commercial-and-multifamily-properties/existing-commercial-buildings-energy-performance-ordinance/benchmarking
- San Francisco Environment Code Chapter 20, http://library.amlegal.com/nxt/gateway.dll/California/environment/chapter20existingcommercialbuildingsener?f=templates$fn=default.htm$3.0$vid=amlegal:sanfrancisco_ca
- Data Portal, https://data.sfgov.org/Energy-and-Environment/Existing-Commercial-Buildings-Energy-Performance-O/j2j3-acqj
- City of San Francisco, San Francisco Existing Commercial Buildings Performance Report 2010-2014 (n.d.), available at https://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_performancereport.pdf

Seattle, WA

- Seattle Building Tune-Ups Homepage, https://www.seattle.gov/environment/buildings-and-energy/seattle-building-tune-ups
- Director's Rule 2016-01, https://www.seattle.gov/Documents/Departments/OSE/OSE_DIRECTORS_RULE_2016-01.pdf
- Data Portal, https://data.seattle.gov/dataset/2015-Building-Energy-Benchmarking/h7rm-fz6m/data

APPENDIX 2: TABLE OF PERFORMANCE AND PRESCRIPTIVE ALTERNATIVES

	Minimum Performance Threshold	Performance-Based Exemptions to Minimum Performance Threshold		Prescriptive Actions Required if Not Exempt Due to Performance	
		Existing Rating or Certification	Improvement Requirements	Energy Assessment (Audit)	Retrocommissioning
Atlanta	• ENERGY STAR certification, or • Energy performance is at least 25 points better than an average building	• LEED EBOM certification	• Improved ENERGY STAR score by 15 points or reduce EUI by 15%	• ASHRAE Level II (every 10 years)	• No
Austin	• Multifamily properties must retrofit if their energy consumption is 150% greater than average	• N/A	• Completion of various Austin Energy Utility programs	• Audit prior to sale (every 10 years)	• No
Berkeley	• Building Energy score or Green Building rating demonstrating an effective level of efficiency as determined by the city	• N/A	• Completion of a multi-measure energy improvement project with minimum improvement as determined by City, or • Completion of an income-qualified Weatherization Assistance project	• Point of sale or every 5 years (large), 8 years (medium), 10 years (small)	• No
Boston	• ENERGY STAR certification	• LEED Silver Certification, or • Net zero energy, or • Net zero GHG emissions, or • Included in institutional master plan that has reduced GHGs by 15% over 5 years	• Improved Energy Star Score by 15 points within previous 5 years • Reduced annual EUI 15% over 5 years • Reduced annual GHG emissions by 15% • Increased renewable energy by 15% of annual energy consumption	• ASHRAE Level II (every 5 years)	• No
Boulder	• ENERGY STAR certification	• LEED EBOM certification	• Pattern of significant energy improvement	• ASHRAE Level II (every 10 years)	• Every 10 years; implement cost-effective measures within 2 years
Los Angeles	• ENERGY STAR Certification; Energy performance is 25% better than the median energy performance of similar buildings by comparing against the national source energy data provided in CBECS	• N/A	• 15% reduction of weather normalized source EUI; • 20% reduction of water use intensity	• ASHRAE Level II (every 5 years)	• Every 5 years for key building systems

New York City	• ENERGY STAR certification, or • Energy performance is 25 points or more better than the performance of an average building	• LEED EBOM certification	• N/A	• ASHRAE Level II (every 10 years)	• Every 10 years
Orlando	• ENERGY STAR Score of at least 50, or • EUI equivalent to median performance of all covered buildings of type	• Certification under Florida Green Lodging, LEED EBOM, or other comparable system	• ENERGY STAR Score improvement of at least 10 points or EUI reduction of at least 15%, or • Continuous commissioning	• ASHRAE Level II (every 5 years)	• No (but may substitute for audit)
San Francisco	• ENERGY STAR certification	• LEED Gold EBOM certification, or • Net-Zero Energy Certification from International Living Future Institute, or	• Energy savings of at least 15 percent, or • Active monitoring and continuous commissioning	• Level II ASHRAE for buildings >=50,000SF; Level I for buildings 10,000-49,999SF; every 5 years	• No (but may substitute for audit)
Seattle	• Certified ENERGY STAR Score of at least 90 for buildings 100,000 sf or greater; Certified ENERGY STAR Score of at least 85 for buildings less than 100,000 sf	• LEED Gold or Platinum certification with at least 15 Energy and Atmosphere credits, or Net Zero Energy certification from International Living Future Institute, or • Completion of a Tune-Up Equivalent Process as defined in regulations	• 15% reduction in weather-normalized site EUI relative to prior two-year average site EUI	• No	• Tune-up every 5 years for nonresidential buildings >=50,000SF

To: Nikhil Nadkarni & Seth Federspiel, City of Cambridge
From: Meister Consultants Group
Date: June 16, 2017
Subject: Task 3: Evaluate performance tier options from BEUDO data

OVERVIEW

This memo provides considerations for how the City of Cambridge could set performance tiers for buildings that are subject to BEUDO. As outlined in the project proposal, the purpose is to inform potential requirements to be implemented by BEUDO and analyze the impact of performance tiers on different segments of buildings. Based on discussions with the City of Cambridge, this memo focuses on three proposed thresholds, which use the EPA Portfolio Manager scores, greenhouse gas emissions, and Source EUI as performance criteria.

The memo is organized into four primary sections: (1) methodology, (2) a summary of trends in the data analysis, 3) the results of the application of the thresholds to Cambridge's reporting properties under BEUDO, and 4) considerations for future work or implementation.

METHODOLOGY

MCG performed its initial threshold analyses of the BEUDO data based on the reported Portfolio Manager score, GHG intensity, and Source EUI from the 2016 reporting cycle. The following section discusses our methodology and data selection.

POTENTIAL THRESHOLD METRICS

Cambridge proposed two main metrics for the development of thresholds that would trigger action by entities reporting to BEUDO: the facility's EPA Portfolio Manager Score, and ranking buildings by absolute performance (whether on an EUI basis or a greenhouse gas basis). The EPA Portfolio Manager Score is a robust and well-known metric that controls for operational schedules, occupant load, equipment load, and more to facilitate the comparison of buildings in a true peer group[50]. The score represents the building's percentile rank in terms of source EUI among its group of peer buildings as modeled through the CBECS dataset. In some ways, it represents the "go-to" datapoint for evaluating building performance though it is not comprehensive of all building types. Scores were also only available for approximately half of the reporting entries.

[50] Additional information available at: https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager/understand-metrics/how-1-100

An additional consideration is Cambridge's stated emissions reduction goal outlined by its Getting to Net Zero Task Force. Since the Net Zero Action Plan is focused on greenhouse gas performance, greenhouse gas intensity is another logical performance metric to test, as it is ultimately the most directly tied to Cambridge's goals. GHG intensity also has the benefit of having the broadest selection of actions available to address it (e.g. it also allows for fuel switching or purchasing RECs as a way of improving performance)[51].

Given the limited number of BEUDO facilities in each building classification with Portfolio Manager scores, this analysis was also completed based on EUI and on GHG intensity. A table showing the percentage of each type of building that had Portfolio Manager scores is included as an appendix to this memo. Overall, less than 46% of the BEUDO buildings that reported in 2016 had scores.

DATA SELECTION

The first step in conducting the analysis was to select the data source and remove problematic data that could bias the results. The project team obtained the filtered dataset that was used for the *2016 Cambridge Building Energy and Water Use Report* and used the same filters for consistency. These included the removal of any duplicate reports covering the same property (e.g. parent-child and identical reports), removal of properties outside of Cambridge, removal of data representing an incomplete year, removal of reports without square footage information, the removal of reports with poor quality energy reporting (e.g. estimated data, partial building, or unrealistic EUI). The 2016 data was used for the analysis because it covers a wider range of Cambridge buildings than 2015 data.[52] 569 buildings met the criteria applied in these filters and are included in this analysis.

The MCG team completed its analysis by building type. Initially, only building types with 10 or more reporting properties were included. Upon request, the summary tables been expanded to include the GHG and square footage of all reporting property types below the performance tier threshold.

SELECTED DATA ANALYSIS METHODS

For each of these building types described above, two primary analyses were completed to characterize the data before introducing performance thresholds. First, buildings were ranked and described by GHG intensity and EUI. Second, buildings were plotted on cumulative quantile plots, which shows the amount

[51] Using GHG intensity to set a performance threshold brings up a number of considerations, including whether to allow property owners to count RECs to improve their GHG performance. If this is allowed, opportunities to improve the fuel consumption of buildings with poor energy performance could potentially be foregone because they would not be caught by the threshold. This is likely a rare case because many property owners who decide to buy RECs may also be working to reduce their energy expenses.

[52] In order to smooth noise and have a more representative measure of building performance, the team attempted to take an average of the 2015 and 2016 values reported by each building that reported in both years. The team quickly found that less than 60% of the buildings could definitively be linked between the two years using the primary key ("custom.id.1"). Because degree day normalization would be needed to compare buildings across calendar years, it did not make sense to average the performance of *only* the buildings that *could* be linked. Therefore, the team used 2016 data only.

of square footage that would need to be subject to Cambridge's BEUDO action requirements to address any given percentage of BEUDO building emissions.

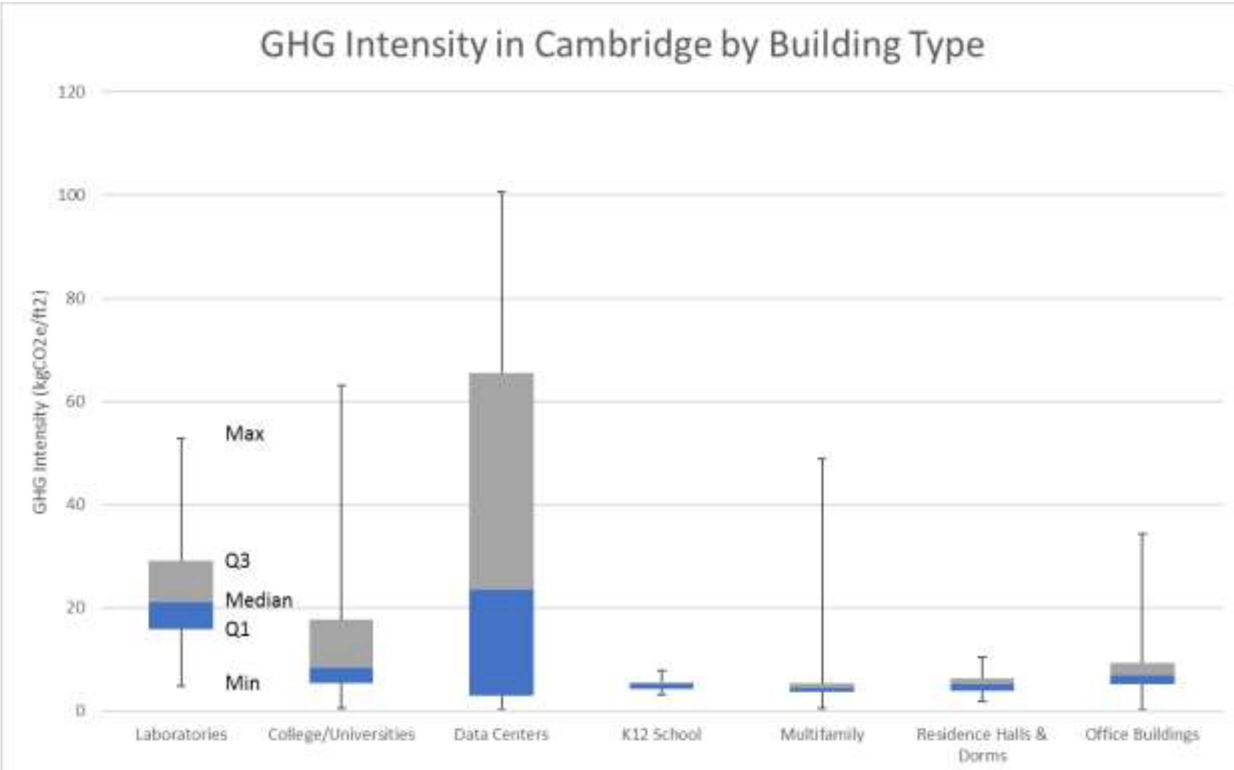
It is important to note that the building types as self-reported by the property owners are not perfect, nor are they consistent. Prior to the official determination of a threshold that varies by building type, effort should be invested in more thoroughly defining the eligibility of any given building to be considered part of a building type. It is likely, for instance, that the thresholds for performance for laboratories and data centers will be higher than the thresholds set for other building types. As a result, property owners could theoretically select a building type that worked to their advantage when reporting. For instance, a building may be primarily comprised of offices, but may contain a few server closets and/or a teaching lab. If the property owner is allowed to self-report, they may argue that they are a data center or a lab, so that they would not need to take action if they are under the more lenient threshold that would be applied to one of those sectors.

DATA SUMMARY

While redefining the building types is outside of the scope of this exercise, it should be noted that MIT and Harvard both reported some of their lab facilities and their office buildings under the umbrella category "College/University." These buildings could be more accurately reclassified based on their function to give a better indication of the spectrum of performance of each building type. As can be seen in Figure 1 below, the highest GHG intensity among buildings described as "college/university" was somewhat higher than the highest GHG intensity among labs. The college/university building that gained this distinction was Building 39, which houses 6,500ft^2 of clean room facilities, which is one of the most energy intensive lab facility types[53]. Based on a limited review of the MIT and Harvard campus maps, it appears that 9 of the 10 highest GHG intensity college/university facilities should be reclassified as laboratories in order to match their usage. As noted above, the classification of Harvard and MIT's buildings is not consistent – in some cases they are classified as other building types and in other cases simply "college/university." This challenge will need to be addressed before proposing thresholds by building type to Cambridge stakeholders.

[53] Additional information available from MIT at: http://web.mit.edu/annualreports/pres03/08.22.html

Figure 2 - GHG Analysis of Common BEUDO Reporting Property Types (Defined as 10 properties or more in the dataset)

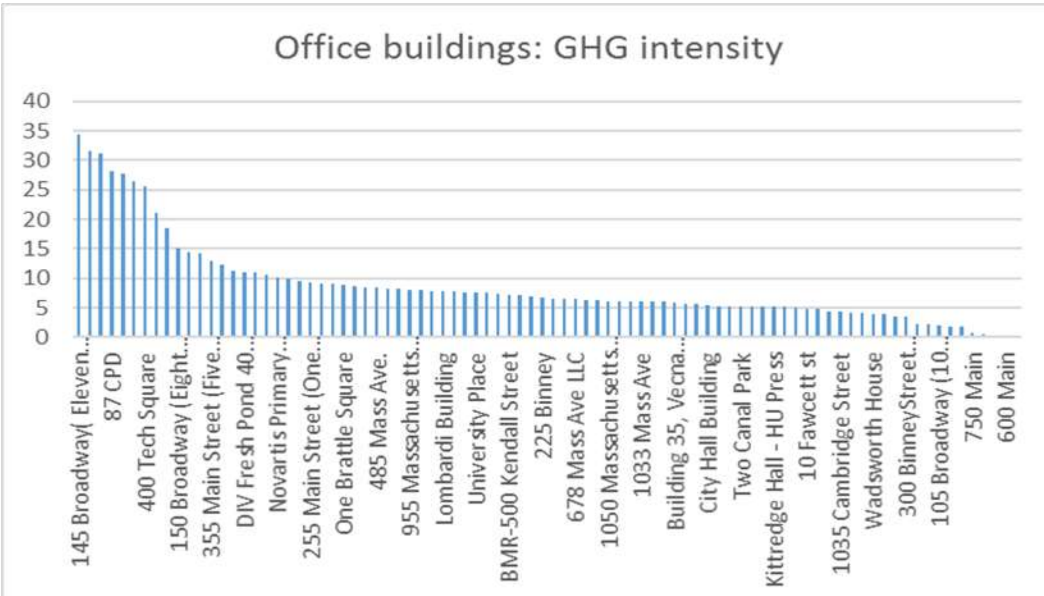


The team proceeded to analyze the dataset with this caveat in mind. Figure 1 shows that, as expected, there is significant variation in the GHG intensity of laboratories, college facilities, and data centers. This can be seen from the broad interquartile ranges shown by the grey and blue portions of the chart. The highest GHG intensity and the lowest GHG intensity are depicted by the bars above and below the interquartile range, respectively. The spread of performance in the multifamily building type is a function of one specific outlier, which was more than three times the GHG intensity of the second worst performing multifamily building. On the other hand, the spread of performance in the office building type, while similarly broad, was not driven by one outlier, but rather a sizeable number of buildings performing at significantly higher GHG intensities than the rest.

The team also evaluated the distribution of buildings based on their GHG intensity by building type. This was to determine if there were logical breakpoints to implement a performance threshold. While minor variations exist, EUI is a good proxy for GHG intensity and vice versa. GHG intensity data was also available for 99% of the filtered buildings in the dataset (565 of the 569 buildings).

The performance of buildings in each typology fell relatively evenly along a spectrum declining from the highest emitters to the lowest emitters, with almost none of the sectors displaying clearly defined tiers of comparable GHG intensity. Therefore, no natural threshold emerged from the data. The exception to this pattern was office buildings, where a large minority of the buildings had significantly higher GHG intensity than their peers. Again, these findings must be caveated by the fact that the building types could be refined, as it appears some of these higher energy consuming "office" buildings may actually contain lab space (e.g. 87 Cambridgepark Drive, which belongs to a pharmaceutical company).

Figure 3 - 2016 performance of office buildings (Provided as a reference for outliers)



Given the lack of intuitive breakpoints in the data, the team applied thresholds based on the Cambridge Net Zero Action Plan, and best practices from peer cities, such as the use of Portfolio Manager scores. For each proposed threshold, several factors will require additional consideration:

1. What percentage of emissions from Cambridge's BEUDO-reporting buildings does the City want to regulate, over what timescale? (Additional analysis in support of this question appears in Appendix I)
2. What is the quality of the data available to support each threshold?
3. What are the political and stakeholder implications of the threshold? What are the implications for the trajectory of development in Cambridge?
4. What type of data collection systems and process will need to be in place to assess building performance and provide increased accuracy from current self-reported categories?

This memo focuses on the impacts of applying three thresholds. The Task 4 memo will further explore the policy and administrative implications of these three threshold types.

THRESHOLD ANALYSIS

MCG conducted an analysis on three thresholds – Portfolio Manager score, EUI performance, and GHG performance. In these scenarios, buildings which performed below the performance requirement(s) would be required to complete prescriptive actions (e.g. retro-commissioning or audits), or demonstrate that their building has completed an exemption (e.g. the building achieved LEED Silver or higher). The costs and benefits of different prescriptive actions and appropriate exemptions will be further explored in the Task 4 memo. The purpose of this section is to show how many buildings would be affected and what share of GHG emissions they account for, for each of the three options.

PORTFOLIO MANAGER THRESHOLD

In the analysis, buildings were analyzed based on their Portfolio Manager score. Based on the Net Zero Action Plan, the performance threshold was based on a score of 60.

Limitations of Approach

As aforementioned, Portfolio Manager scores are not available for all property types or buildings within the dataset. Across the dataset, Portfolio Manager Scores were only available for 46% of the entries. This is detailed further in the table below.

Figure 4 - Availability of Portfolio Manager Scores

Building type	Number of buildings	Percent with Portfolio Manager Score in 2016	# of buildings with a Portfolio Manager Score in 2016
College/University	155	1%	1
Multifamily Housing	128	85%	109
Office	87	86%	75
Laboratory	40	3%	1
Residence Hall/Dormitory	34	68%	23
K-12 School	23	91%	21
Parking	10	10%	1
Hotel	9	100%	9
Other	9	0%	0
Mixed Use Property	7	14%	1
Worship Facility	7	86%	6
Data Center	6	0%	0
All remaining buildings	54	28%	15
Total	569	46%	262

Figure 5 - Summary Results for Portfolio Manager Threshold

Building Typology	Number of Buildings					Square Footage			GHG Emissions (Metric Tons CO2e) and Intensity (kgCO2e/ft2/yr)					Source EUI, Weather Normalized	
	Total in typology	...with PM scores	% of all buildings in typology with PM scores	...with PM scores below 60	% of all buildings in typology with PM scores below 60*	Total square footage in typology	Total for buildings with scores below 60	% of square footage that is in buildings with PM below 60*	Total GHG Emissions in typology	Total GHG emissions of buildings below 60 PM	% of GHG Emissions that are from buildings with PM below 60*	Average GHG Intensity of buildings below 60 PM*	Average GHG Intensity of all buildings in typology	Average Source EUI of buildings below 60 PM	Average Source EUI of all buildings in typology
K-12 School	23	21	91%	4	17%	1,940,180	374,322	19%	9,026	2,090	23%	6.0	4.8	169	121
Multifamily Housing	128	109	85%	37	29%	14,492,144	4,793,895	33%	69,881	32,288	46%	7.5	4.9	187	123
Office	87	75	86%	32	37%	11,155,437	3,353,300	30%	103,028	54,287	53%	13.1	8.7	371	250
Residence Hall/Dormitory	34	23	68%	3	9%	2,845,098	122,903	4%	16,872	1,188	7%	7.7	5.2	187	111
Other**	297	34	11%	22	7%	32,663,653	2,999,333	9%	477,715	34,444	7%	Spurious comparison***	Spurious comparison***	Spurious comparison***	Spurious comparison***
Total	**569**	**262**	**46%**	**98**	**17%**	**63,096,512**	**11,643,753**	**18%**	**676,522**	**124,297**	**18%**	Spurious comparison***	Spurious comparison***	Spurious comparison***	Spurious comparison***

*Note that only 46% of the reporting buildings have Energy Star scores. For each of these columns, the numerator is the total for the buildings with scores below 60, and the denominator is the total in the building typology, not the total among the buildings that have scores. This is the percentage of buildings, square footage, and GHG emissions that would be subject to the action requirement.

**For this table, "other" includes all building typologies with 10 or fewer reporting buildings in 2016 and all typologies that have 5% or lower prevalence of Energy Star scores. Overall, 46% of the reporting buildings have Energy Star scores.

***High GHG intensity building types in this dataset (like labs and data centers) do not have Energy Star scores with rare exceptions. Therefore, the average GHG intensity and source EUI of buildings with PM below 60 in the "Other" category could be lower than the average GHG intensity of all buildings in that category.

Figure 4 provides summary statistics on the impact of the Portfolio Manager score threshold on BEUDO reporting properties. This analysis also compares buildings above and below the threshold. A limitation of this analysis is that only 46% of all buildings reported in 2016 have Energy Star scores. As expected, the buildings below the threshold have higher EUIs and GHG intensities than buildings above the threshold. In some categories, the metrics almost double. The high magnitude of these differences could be partially accounted for by the classification of buildings with different use types in a sector (e.g. laboratories classified as office buildings). In Figure 4, the “Other” category encompasses building typologies with ten or fewer buildings reported in 2016, and typologies that have 5% or fewer Energy Star scores.

BOTTOM QUINTILE OF GHG PERFORMANCE

In alignment with the City of Cambridge’s greenhouse gas reduction targets and net zero action plan, a GHG-based threshold was examined. Reporting properties were ranked based on their GHG emissions, and the bottom 20% of performers within each sector was identified. Thus, in the table below each sector has a different target GHG intensity.

Limitations of Approach

In many cases, buildings are included in the bottom quintile of GHG intensity because a significant portion of the building's usage is not be aligned with its self-reported sector. These facilities may need an appeals process or exemption pathway, if such a threshold were implemented.

Results

Figure 6 - Summary Results for GHG Performance Thresholds

Building Typology	Number of Buildings			Square Footage			GHG Emissions (Metric Tons CO2e) and Intensity (kgCO2e/ft2/yr)					Source EUI (kBtu/ft2)		Energy Score Data
	Total in typology	In lowest 20% by GHG Intensity	% subject to action requirement (at or below bottom 20% by GHG intensity) (by building type)	Total square footage in typology	Total for buildings in lowest 20% by GHG Intensity	% of square footage subject to action requirement (by building type)	Total GHG Emissions in typology	Total GHG Emissions for buildings in lowest 20% by GHG intensity	% of GHG emissions subject to action requirement (by building type)	Average GHG Intensity of buildings in lowest 20% by GHG intensity**	Average GHG Intensity of all buildings in typology**	Average Source EUI of buildings in lowest 20% by GHG intensity	Average Source EUI of all buildings in typology	# of Buildings that are Energy Star certifiable (score >75) that rank in the lowest 20% by GHG intensity per typology
College/University	155	31	20%	14,843,959	3,410,947	23%	199,980	101,010	51%	29.8	12.6	705.0	301.4	0
Data Center	6	1	17%	299,360	28,100	9%	4,887	2,828	58%	100.6	37.2	3264.3	1207.1	0
K-12 School	23	4	17%	1,940,180	296,834	15%	9,026	1,744	19%	6.2	4.8	153.2	122.3	0
Laboratory	40	8	20%	6,849,995	1,447,943	21%	164,766	57,596	35%	38.3	22.7	974.4	607.4	0
Multifamily Housing	128	25	20%	14,492,144	3,408,782	24%	69,881	26,357	38%	8.9	4.9	210.5	124.4	1
Office	87	17	20%	11,155,437	2,152,452	19%	103,028	45,159	44%	19.7	8.7	587.6	257.2	1
Residence Hall/Dormitory	34	6	18%	2,845,098	750,309	26%	16,872	6,246	37%	8.5	5.2	198.9	121.3	0
Other*	96	N/A	N/A	10,670,339	N/A	N/A	108,082	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**569**	**92**	**16%**	**63,096,512**	**11,495,367**	**18%**	**676,522**	**240,939**	**36%**	**30.3**	**13.7**	**870.5**	**391.6**	**2**

*The "other" category includes a wide diversity of building types that have very different performance characteristics. As a result, it would not be easy for Cambridge to set a fair performance threshold for buildings in this category. Therefore, a threshold was not proposed.

**None of these averages are weighted.

A similar performance differential on GHG intensity can be seen for buildings above and below the threshold, as with the proposed Portfolio Manager score threshold. In Figure 5, the "Other" category encompasses all other building typologies reported in 2016. Because of the wide variety of building typologies and characteristics in this category, a threshold was not recommended.

BOTTOM QUINTILE OF SOURCE EUI

Lastly, the BEUDO dataset was evaluated on a performance threshold based on source EUI. Reporting properties were ranked based on their Source EUI, and the properties with the highest energy intensities were identified within each sector. Thus, in the table below each sector has a different threshold Source EUI.

Limitations of Approach

Weather-normalized Source EUI data was only available for 80% of entries (456 buildings). Source EUI was used instead since it was available for all buildings. For future analyses, the weather normalized metrics would be preferable, particularly for year-over-year comparisons.

Results

Figure 6 - Summary Results for Source EUI Performance Thresholds

Building Typology	Number of Buildings			Square Footage			GHG Emissions (Metric Tons CO2e) and Intensity (kgCO2e/ft2/yr)					Source EUI (kBtu/ft2)		Energy Score Data
	Total in typology	In lowest 20% by Source EUI	% subject to action requirement (at or below bottom 20% by Source EUI) (by building type)	Total square footage in typology	Total for buildings in lowest 20% by Source EUI	% of square footage subject to action requirement (by building type)	Total GHG Emissions in typology	Total GHG Emissions of buildings in lowest 20% by Source EUI	% of GHG emissions subject to action requirement (by building type)	Average GHG Intensity of buildings in lowest 20% by Source EUI**	Average GHG Intensity of all buildings in typology**	Average Source EUI of buildings in lowest 20% by Source EUI**	Average Source EUI of all buildings in typology**	# of Buildings that are Energy Star certifiable (score >75) that rank in the lowest 20% by Source EUI per typology
College/University	155	31	20%	14,843,959	3,491,276	24%	199,980	102,243	51%	29.7	12.6	705.0	301.4	0
Data Center	6	1	17%	299,360	28,100	9%	4,887	2,828	58%	100.6	37.2	3264.3	1207.1	0
K-12 School	23	4	17%	1,940,180	278,452	14%	9,026	1,597	18%	6.1	4.8	153.2	122.3	0
Laboratory	40	8	20%	6,849,995	1,446,245	21%	164,766	54,773	33%	36.8	22.7	974.4	607.4	0
Multifamily Housing	128	25	20%	14,492,144	2,615,333	18%	69,881	21,575	31%	8.9	4.9	210.5	124.4	0
Office	87	17	20%	11,155,437	2,483,005	22%	103,028	48,611	47%	19.7	8.7	587.6	257.2	1
Residence Hall/Dormitory	34	6	18%	2,845,098	798,114	28%	16,872	6,576	39%	8.4	5.2	198.9	121.3	0
Other*	96	N/A	N/A	10,670,339	N/A	N/A	108,082	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total	**569**	**92**	**16%**	**63,096,512**	**11,140,525**	**18%**	**676,522**	**238,203**	**35%**	**30.0**	**13.7**	**870.5**	**391.6**	**1**

*The "other" category includes a wide diversity of building types that have very different performance characteristics. As a result, it would not be easy for Cambridge to set a fair performance threshold for buildings in this category. Therefore, a threshold was not proposed.
**None of these averages are weighted.

Sector-specific thresholds may be skewed by the presence of outliers within their category. Notably, the bottom quintile for GHG intensity and the bottom quintile for Source EUI have remarkably similar total GHG emissions (240,000 and 238,000 metric tons CO2e, respectively). This is not unexpected because EUI typically correlates strongly with GHG intensity. The thresholds are likely selecting the same buildings, with a few exceptions, and therefore the impact of setting a GHG intensity threshold versus a Source EUI threshold is likely to be the same. In Figure 6, the "Other" category encompasses all other building typologies reported in 2016. Because of the wide variety of building typologies and characteristics in this category, a threshold was not recommended.

As illustrated above, there are advantages and disadvantages to each proposed threshold. These should be considered further in stakeholder conversations and prior to implementation. The advantages and limitations of each option are summarized in Figure 7.

Figure 7 - Summary of Advantages and Disadvantages of Each Threshold Option

Threshold	Advantages	Disadvantages
Portfolio Manager	• Nationally recognized program • Built into Portfolio Manager, which many properties use to report to BEUDO	• Does not include all building types • Gaps in data availability within the BEUDO set
Lowest Quintile GHG Performance	• Available for all property types • Aligned with policy objectives	• Potential discrepancies due to outliers within sectors • May need appeals process or additional requirements
Lowest Quintile EUI Performance	• Source and Site EUI available for all properties • Easily align with net zero or near net zero objectives	• Weather normalized EUI not available for all entries • May need appeals process or additional requirements.

IMPACT ANALYSIS OF THRESHOLD REQUIREMENTS

These estimates were created using scaled building-level results, which were calculated based on the implementation of actions of a typical audit (see the prescriptive requirements analysis in Section II of the Task 4 memo for per building information, and methodological details). These estimates state potential citywide impacts that would occur if all BEUDO-affected buildings that did not meet established energy performance targets were to conduct a comprehensive building energy retrofit resulting from an audit. It is not anticipated that the enforcement of a BEUDO performance threshold would trigger comprehensive retrofits in all affected buildings, but this exercise provides a useful conceptual upper limit on the types of impacts that may occur through the establishment of BEUDO energy performance thresholds

As discussed above, three separate building performance thresholds were considered in this analysis:

1) Buildings with an EnergyStar score under 60.
2) Buildings in lowest quintile of typology GHG intensity.
3) Buildings in lowest quintile of typology source EUI.

Due to the building-level nature of this analysis, the impacts of the latter two approaches are identical as the same number of buildings would be affected. These two threshold options are treated as one in this assessment.

Table 1 below shows the number of buildings impacted by a BEUDO performance threshold set at an EnergyStar score of 60, as well as the costs, lifetime savings, and GHG emissions reductions that would occur if all affected buildings were to undergo a comprehensive energy retrofit.[54] Because EnergyStar scores are not available for laboratory buildings, only multifamily and commercial buildings are included.

Table 1: Buildings with an EnergyStar Score Under 60

Building Typology	Number of buildings	Total upfront costs	Total lifetime savings	Total lifetime GHGe reduction (tons CO2)
Multifamily	40	$11,751,642.50	$29,311,350.83	105,646
Commercial	58	$8,607,614.59	$21,512,222.13	111,891
Lab	0	$-	$-	-
Total	98	$20,359,257.10	$50,823,572.96	217,537

Table 2 shows the same results, but assumes that the lowest-performing quintile of buildings within each building category would undergo a retrofit. This option would cover a smaller number of multifamily and commercial buildings, but would include laboratories, leading to a larger overall potential GHG impact.

Table 2: Buildings in Lowest Quintile of Typology GHG Intensity, Buildings in Lowest Quintile of Typology Source EUI

Building Typology	Number of buildings	Total upfront costs	Total lifetime savings	Total lifetime GHGe reduction (tons CO2)

[54] For the purposes of this discussion, a comprehensive energy retrofit is one which evaluates and acts on opportunities to achieve energy savings across a range of energy conservation measures and end uses. In this analysis, it is assumed to have the same level of rigor as a typical participant in MassSave's commercial or multifamily building retrofit programs.

Multifamily	31	$9,107,522.94	$22,716,296.89	81,876
Commercial	53	$7,865,578.85	$19,657,720.22	102,245
Lab	8	$5,555,040.00	$33,895,085.03	201,847
Total	92	$22,528,141.79	$76,269,102.15	385,968

The Task 4 memo includes additional information on this analysis and its methodology is in Task 4. Generally, the analysis evaluates the costs and savings from a typical building retrofit, using MassSave data for multifamily and commercial buildings, and scales these results up to the number of buildings impacted under a given performance threshold (assuming that all affected buildings would undergo a retrofit). The retrofit opportunity in laboratory buildings is much more variable and less standard than those in multifamily or commercial buildings, and is based on typical reference installation data from Sandia National Laboratory. These results should be viewed as having a wider potential for variance than those in the multifamily and commercial space.

CONSIDERATIONS AND CAVEATS

Several outstanding issues must be addressed before Cambridge puts forth a proposal to its stakeholders and property owners for BEUDO compliance.

1. If Cambridge is to use a threshold methodology, it must carefully think about how it defines building types and how this would impact the challenge of any particular building achieving the threshold. Data exists within BEUDO that defines the number of square feet of each building dedicated to parking, offices, and other major uses. As noted above, there is potential for building owners to "game the system" if a more robust structure for classifying buildings is not defined. If a sector-by-sector threshold approach is applied, there could be an opportunity for buildings to self-correct if there is an appeals process, where they could suggest the use of another performance pathway for a sector which more accurately reflects their building's usage.
2. Cambridge must also address data quality issues, particularly for campuses and buildings with shared metering. One possible solution, identified in the Task 2 memo, is to apply requirements on a portfolio basis for property owners that own more than one building in the city. In this way, the property owners could invest their resources in pursuing the energy conservation and emissions reductions strategies that will have the greatest payoff per unit of resources invested (subject, of course, to the constraint that the portfolio must meet a performance level that is sufficiently robust to achieve Cambridge's goals).
3. As noted in the Task 2 memo, it is necessary to consider the feasibility of measuring compliance when designing a threshold system. The more complex the compliance requirements are and the more exemptions are considered, the more staff time will be required to manage the program. The City will need to evaluate the effectiveness of the required actions, as well as benefits and costs for citizen and property owners alike, when

deciding how often to adjust the thresholds and compliance requirements. If requirements are strengthened over time, the concept of grandfathering must be discussed. The City must ask itself how much effort it will invest in data quality, verification of self-reported data, and enforcement.

4. Finally, determining the "action baseline" for energy and emissions performance is of primary importance. Some buildings may perform poorly because they have plenty of energy conservation opportunities yet to be tapped. Other buildings may appear to be poor performers, but their high GHG intensity or high EUI may instead be the result of being highly utilized across long operating hours, by large occupant populations, or by users with efficient but highly energy-intensive equipment. Some of these buildings may have taken extensive actions to reduce their energy consumption and emissions (e.g. Harvard's building portfolio under their 2016 goal of 30% emissions reductions). Determining what actions have already been taken and whether these actions should exempt buildings from further required action (and over what timeframe this exemption should last) will be a challenging stakeholder discussion. The amount of actions recently taken to reduce energy consumption will have strong implications for the cost-effectiveness of complying with the BEUDO action requirements, and program design should consider the fact that the cost-effectiveness will vary substantially from one stakeholder to the next. Task 4 addresses this question, but there are still many contextual factors relevant to each building's energy performance that cannot be fully known by the City. The City should carefully consider when to allow exemptions and what burden of proof should be applied on the property owner to show that the exemption is warranted. However, if Cambridge expects to achieve net zero emissions, prior action should not be a blanket exemption, and high energy productivity cannot be an excuse for high energy consumption. Still, these factors must be considered when determining where to apply limited resources. Refer to the Task 2 memo for more in-depth discussion.

APPENDIX A

WHAT GHG SAVINGS MIGHT BE LIKELY FROM DIFFERENT THRESHOLDS?

This analysis was completed using property data within BEUDO, and is a supplement to the threshold analysis provided above. It considers the impacts of GHG performance requirements which are lower and higher than the lowest quintile analysis discussed in the body of the memo. This analysis was completed by ranking the all BEUDO buildings by GHG intensity. The resulting table considers emissions reductions by buildings to meet the imposed GHG emissions requirement, assuming that not all possible actions building can use to reduce GHG emission are cost-effective or feasible. Because it was beyond the scope of this analysis to assess whether it would be feasible for each of the buildings that failed to meet the threshold to reduce its emissions to the threshold level, this table is presented with multiple levels of building-level GHG reductions and multiple performance tiers.

In order to quantify the impacts of applying different thresholds, Table 1 shows the percentage reduction in total emissions that could be achieved in various threshold scenarios. Given the diversity of building programming and the diversity of energy productivity/energy efficiency baselines across the stock of BEUDO buildings, it is unlikely that all of the buildings regulated by BEUDO could actually reduce emissions to the threshold level. Therefore, the columns in Table 1 on the following page discount the potential GHG reductions by various percentages.[55]

Table 4 - Percentage reductions in the total emissions across all BEUDO buildings as a function of the threshold set for action (rows) and the assumption that is made about how much of the reduction required will actually be achieved by each building.

		Assume that each building can achieve _x_% of the difference between their current GHG intensity and the threshold GHG intensity			
		20%	40%	60%	80%
Assume that Cambridge places the requirement on the bottom _x_% of performers by GHG intensity	20%	5%	10%	14%	19%
	30%	8%	16%	23%	31%
	40%	9%	19%	28%	37%
	50%	11%	21%	32%	43%
	60%	12%	23%	35%	47%
	70%	13%	25%	38%	50%

[55] To read the chart: suppose Cambridge applied a threshold requiring all buildings to take action until they achieve GHG emissions performance equivalent to the current 50th percentile building. If each of these buildings can feasibly reduce emissions intensity by 20% of the difference between its current performance and the threshold, overall BEUDO emissions fall by 11% by the time every regulated building implements all feasible reductions. If each of these buildings reduces by 40% of that difference, overall BEUDO emissions fall by 21%, and so on.

80%	13%	27%	40%	54%
90%	15%	31%	46%	62%

To: City of Cambridge
From: Meister Consultants Group, Inc. and Institute for Market Transformation
Date: July 14, 2017
Re: **Policy and Impact Analysis of Potential BEUDO Program Modifications**

At the request of the City of Cambridge, the Project Team analyzed the potential impacts of BEUDO performance thresholds on large building owners. These approaches were analyzed quantitatively and through a policy analysis. This memo focuses on the building blocks of creating performance requirements through BEUDO, which are analysis of three performance thresholds, exploring performance exemption options, and prescriptive requirements and technical assistance. These building blocks can be used by the City during Phase II of its BEUDO analysis with stakeholders. The potential performance thresholds are:

- ENERGY STAR Portfolio Manager Score of 60 or lower;
- Bottom quintile of GHG performance; and
- Bottom quintile of Source EUI performance.

This memo:

- Provides an overview of the policy analysis and discusses suggested packages for the BEUDO ordinances in Section I;
- Details the cost and savings impacts of the use of prescriptive requirements in Section II;
- Suggests recommendations for policy requirements and provides considerations for successful administration of performance requirements and exemptions in disclosure ordinances in Section III.

SECTION I. OVERVIEW OF POLICY COMPONENTS

Research into cities that have implemented requirements beyond benchmarking and transparency revealed significant commonalities, but also some variations that create an extensive list of policy design alternatives.[56] Should Cambridge implement building performance thresholds, it should consider offering multiple options that allow building owners to improve buildings cost-effectively, while providing a comprehensive package of technical assistance and resources to support implementation. Accordingly, Cambridge should consider including the following four elements within its beyond-benchmarking policy:

- **Performance Thresholds.** Performance thresholds create a standard by which reporting properties are evaluated. Thresholds could be applied on a sector-by-sector or portfolio-wide basis. Thresholds are discussed in further detail in the Task 3 memo. A number of cities have included performance-based exemptions for buildings that do not meet the performance threshold but have shown significant improvement in performance or have achieved a certification under a city-recognized standard of performance. These exemptions can take the form of increases in ENERGY STAR Score, reductions in EUI, LEED certification, or documented use of renewable energy.
- **Prescriptive requirements.** These are required actions that building owners must take if they fail to meet the performance threshold or any other exemption. Prescriptive requirements could include energy assessments, retrocommissioning, development of an energy management plan, or some combination of these. Not all prescriptive requirements lead directly to energy

[56] The Task 2 memo discusses other cities' policies and practices more comprehensively.

savings (e.g., energy assessments provide detailed energy efficiency information but do not by themselves reduce energy consumption), but they are considered best practices in energy management (See Section II).

- **Industry-based exemptions.** Some cities have exempted particular industries from performance thresholds, or modified their requirements, due to technical, practical, or political reasons (discussed in Task 2).
- **Administrative implementation considerations.** Implementing a beyond-benchmarking ordinance may require coaching building owners, providing financial assistance, and establishing clear procedures for submitting and tracking data. Establishing a clear compliance cycle that is manageable both for owners of covered buildings and for city staff (discussed further in Section III) is also important.

SECTION II: COSTS AND ANALYSIS OF PRESCRIPTIVE REQUIREMENTS

OVERVIEW OF ENERGY PLANNING OPTIONS AND APPROACHES

Building owners can take several approaches to plan for energy savings. This document describes three: energy audits, retrocommissioning (RCx), and operations and management (O&M) plans, which have been observed in other cities' prescriptive requirements and/or requested for review by the City of Cambridge. Each approach is defined below. This section then examines these approaches and a few supplemental options in the context of Cambridge's planning process. This table summarizes the methods and costs typical of each approach:

Table 5- Summary of Costs

Type of Effort	What's Involved?	Indicative Cost Range	Potential Subsidies
Audit (virtual)	Analysis of meter data, weather data, and comparisons with similar buildings to identify energy savings opportunities. Low upfront costs, low to medium savings.	$8000/building	Mass Save provides no-cost facility assessments (may be less rigorous than a Level II ASHRAE Audit), and subsidizes up to 70% of eligible energy conservation measures. For more complex buildings that participate in the Mass Save Custom program, up to 50% of a technical consultant's time can be covered by Mass Save.
Audit (in person)	Energy use analysis, building walk through analysis, implementation financial analysis to identify energy savings opportunities. High upfront cost, high savings.	$0.10-0.20/square foot	
Retrocommissioning	Assessing and adjusting building equipment and systems to optimize performance. Low	$0.15-0.30/square foot	Mass Save Pay for Performance Program ($0.12/kWh and $1.20/therm)

	upfront costs, low to medium savings.		
O&M Plan	Regularly updated energy efficiency policies, action plan, and implementation.	Depends on scope.	It may be possible to subsidize up to 50% of consultant costs for energy planning through the above Mass Save Custom program.

ENERGY AUDITS

Before making energy efficiency upgrades, it is considered best practice for large building owners to conduct an energy audit to determine the cost and potential savings of different upgrade options. Audits can be conducted in-person or virtually. These two audit types have different costs and provide different information to building owners.

While there are many types of in-person audits ranging in cost and comprehensiveness, the ASHRAE[57] Level 2 audit is widely accepted as adequate for the needs of most building owners preparing to make energy efficiency upgrades. The cost of performing an ASHRAE Level 2 audit can vary depending on building complexity and other factors. One general estimate projects costs to average around $0.15 per square foot for commercial, industrial, and residential buildings larger than 25,000 square feet. Audits for low-complexity buildings such as warehouses can cost less than $0.10 per square foot, while high-complexity buildings such as laboratories can cost more than $0.20 per square foot.[58] In-person audits tend to become less expensive per square foot for larger buildings. Certain lower-cost single-family energy audits may be used for smaller multifamily building analyses, as determined by the U.S. Department of Energy on a case-by-case basis.[59] ASHRAE Level 2 audits include a preliminary energy use analysis and building walk-through analysis. These analyses identify areas where the building can improve its energy use efficiency, which can include equipment upgrades and changes to operational and management practices, among other recommendations. The audit results in a detailed financial analysis of proposed measures.

Virtual audits are a relatively recent innovation, which were developed to reduce the cost of building energy audits. The growing list of companies offering virtual audit services includes FirstFuel, Autodesk Sustainability Solutions, and Ecova. Finding precise per-square-foot costs for virtual audits is difficult, but studies do show lower costs on a per building basis. In a recent study conducted by the Massachusetts Department of Energy Resources and Northeast Energy Efficiency Partnerships, virtual audit methodologies provided Boston-area building owners with actionable energy-saving strategies at a fraction of the cost of a traditional walk-through audit (a cost of $8,000 for a virtual audit compared to an average of $25,000 for an in-person audit).[60] Some reports indicate that virtual audits can cost around one-tenth of in-person

[57] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is a member organization that has developed standardized audits for different building types. There are three audit levels, 1, 2, and 3, which are progressively more comprehensive in their analysis and recommendations. Professionals who meet specified qualifications can become certified to conduct ASHRAE audits. For more information, see: https://www.ashrae.org/resources--publications/bookstore/procedures-for-commercial-building-energy-audits
[58] https://www.cesmechanical.com/hubfs/Orlando_City_Energy_Project/Audits101FactSheet.pdf
[59] http://www.waptac.org/Energy-Audits/Multifamily-Audits.aspx
[60] http://www.neep.org/initiatives/energy-efficient-buildings/building-asset-rating

audits.[61] Virtual energy audits do away with the walk-through analysis and in-person interviews with building operations and management, and instead make an analysis using meter data, weather information, and comparisons with similar buildings, among other information. This means that the cost of a virtual audit is not dependent on the building size, while in-person audit costs can become expensive for large buildings. However, virtual energy audits are typically viewed as less detailed than ASHRAE Level 2 audits and, while virtual audits have been shown to reliably identify major opportunities for improving a building's energy efficiency, they are less effective at identifying deep savings potential for complex buildings.[62]

RETROCOMMISSIONING

Whereas commissioning is the process of ensuring a new building operates as designed with respect to energy use, retrocommissioning is the process of investigating how a building's equipment and systems interact and making simple repairs as well as recommendations for how to optimize the building's operation. Because retrocommissioning is an optimization process for existing building systems, its savings are based on meeting the building's original design objectives, but do not increase efficiency beyond that. Ongoing retrocommissioning is important to keep the building operating at optimal efficiency; however deeper energy savings would require investment in more efficient equipment and systems.

Most studies on retrocommissioning costs do not separate the necessary pre-implementation study from implementation and maintenance costs. An ACEEE study reports that retrocommissioning costs can range from $0.15-0.20 per square foot,[63] while a 2007 EnergyStar study reports median costs at a much higher $0.27 per square foot, with typical energy savings of 15% and a simple payback period of only 0.7 years.[64] Similarly, a 2009 LBNL report found median costs of $0.30 per square foot, energy savings of 16%, and a simple payback of 1.1 years.[65]

OPERATIONS AND MANAGMENT

There is no single framework for the creation of operations and management (O&M) plans for facilities, as the scope of such a plan would greatly vary from one type of building to another. Organizations such as the ISO (50001), EPA's ENERGY STAR, ASHRAE (Guideline 32), and USGBC (LEED) have all provided guidance on elements of O&M. Common elements of these guidelines include: developing organizational commitment and policies promoting energy efficiency, assessing performance and creating objectives, applying data to develop action plans, implementing improvements, and measurement and verification (M&V) efforts followed by refinement of the plan. As such, an O&M plan can and should be regularly updated as new low-cost and no-cost efficiency opportunities emerge and as facility usage evolves. Energy planning as part of the O&M process can happen at a central level (for many campuses) or at a distributed level by each building's facility manager (or team). The degree of sophistication among facilities management personnel varies widely within the commercial real estate sector, from teams that barely turn their attention to energy (and that may have little motivation to do so due to split incentives), to teams that are staffed with energy managers with years of experience in energy conservation and who hold credentials such as LEED AP O&M and Certified Energy Manager. Large property owners may have in-house national teams that provide energy expertise and provide standards, while other large property owners may contract with providers of Building

[61] https://microgridknowledge.com/big-federal-building-owner-chose-virtual-energy-audit/
[62] http://www.abettercity.org/docs/Virtual%20Energy%20Assessments%20for%20web%2002.25.14.pdf
[63] http://aceee.org/files/proceedings/2010/data/papers/2248.pdf
[64] https://www.energystar.gov/sites/default/files/buildings/tools/EPA_BUM_CH5_RetroComm.pdf
[65] http://cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf

Automation Systems (e.g. Siemens, Honeywell, Johnson Controls) and ESCOs to incorporate energy management into facility management plans.

The line between O&M, energy conservation measures, and retrocommissioning can be blurred at times. Typically, O&M measures for energy efficiency are focused on low cost and no-cost interventions that require little sophisticated analysis to authorize. O&M plans may require retrocommissioning studies at a certain frequency and/or energy audits at a certain frequency. Often O&M actions can include evaluation of thermal setbacks, lighting schedules, proper function of occupancy sensors and demand controlled load (e.g. ventilation, lighting, and thermal). These same topics may also be explored in retrocommissioning, but typically with more sophistication and with more rigorous project-level or measure-level M&V. The cost of requiring O&M plans will depend on a number of factors including:

1) the scope required by Cambridge,
2) the frequency of updates,
3) the baseline status of energy efforts conducted to date in the building,
4) the organizational capacity to produce a plan in-house,
5) whether the property owner has created similar O&M plans in past years and whether the property manager already has informal O&M practices that simply need to be codified, and
6) the amount of customization required for existing O&M plans to conform with Cambridge's template.

This could range from essentially zero dollars to a modest sum that would need to be calculated based on the amount of time required from staff members to develop a plan and customize it for reporting and the cost and scope of needed upgrades. The benefits of O&M plans likely also correlate with the scope and level of effort invested, but can be difficult to disentangle from the effects of other efforts implemented simultaneously such as retrocommissioning measures and energy conservation investments, particularly given noise in the data, weather fluctuations, occupant fluctuations, limited submetering, and data that typically has low temporal resolution.

Several parameters that Cambridge might consider include:

1) whether to require a full O&M plan or an energy management plan, as O&M plans could be much broader and more time intensive;
2) what type of consumption to include in the requirement (e.g. electric, delivered fuels, purchased thermal energy, water);
3) the level of granularity (e.g. should it cover lighting, HVAC, plug load, etc.);
4) whether the requirement includes plan creation only or also plan implementation;
5) which buildings and property owners could be exempted based on institutional goals and actions; and
6) quality control standards - who can create and submit an O&M plan to Cambridge - will they need a formal facilities manager role? An engineering credential? An O&M credential as described above?

Given the wide range of possible scope and levels of effort required of diverse actors, estimating the "cost" of an O&M plan is not recommended until Cambridge begins to narrow down the answers to some of the questions above. Generally, O&M planning can be considered low-cost and high-benefit because it can involve more than just energy savings (e.g., operational co-benefits such as occupant comfort, labor savings, better visibility in to future facility needs, and discussions that enable property management teams to agree upon priorities). However, even without formal O&M plans that conform with Cambridge's future guidelines, it is also possible that some property owners have already reaped some of the low hanging fruit associated with better O&M.

ENERGY SAVINGS IMPACT ANALYSIS FOR PRESCRIPTIVE REQUIREMENTS

This section discusses the potential impacts that could result at a building and citywide level if BEUDO-affected buildings with poor energy performance were to conduct a whole-building retrofit in order to comply with BEUDO performance thresholds. Such a comprehensive retrofit would involve a range of potential energy saving measures, including both process-based improvements and capital improvements.

While potential energy savings will be specific to each individual building, this analysis considers the impacts of a typical representative whole-building energy improvement effort, evaluated using state energy efficiency program data and prior studies of building-level energy savings.

METHODOLOGY

Using the methods described below, MCG projected the building- and portfolio-level impacts of comprehensive building energy retrofits for commercial, multifamily, and laboratory buildings, such as those that might be triggered by a BEUDO prescriptive standard, such as an audit.

Installed participant costs for electricity and gas upgrades for multifamily residential buildings and commercial (non-laboratory) buildings were obtained from Mass Save program data, taking into account the average participant costs (before and after Mass Save incentives) for participants in Mass Save C&I retrofit and multifamily retrofit programs.[66] Laboratory retrofit cost data was obtained from an in-depth U.S. EPA and DEP Labs 21 analysis of energy efficiency upgrades at Sandia National Laboratories.[67] The same data sets are used to obtain annual and lifetime electricity (MWh), natural gas (therms), and heating oil (MMBTU) savings for the three building typologies.

MCG estimated utility bill savings by applying the energy savings data described above to appropriate tariff information. For each building, the annual utility bill savings associated with that building's electricity and natural gas savings were calculating using the Eversource supply charges and delivery service tariffs applicable to that building.[68] Fuel oil cost savings from 2016-2017 heating season pricing data available from the US Energy Information Administration (EIA).

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[66] As square footage estimates are not available through MassSave, this analysis was conducted at the building level of analysis, rather than on a per square foot basis.

[67] Given the wide variability of energy use and energy savings opportunities in laboratory buildings, it is likely that the costs and savings potential at a particular laboratory building in Cambridge will vary significantly from this reference project. Still, this data provides useful reference data regarding the potential magnitude of energy savings that might be achieved in a laboratory setting.

[68] Commercial and laboratory building impacts were calculated using the Eversource General Commercial electric tariff and Low Load Factor General Service gas tariff. Multifamily building impacts were calculated using the Eversource Residential electric tariff and Residential Annual gas tariff.

To account for seasonal changes in electricity supply charges and natural gas prices, and to calculate non-residential electric demand charge reductions, building energy consumption was mapped over weather-normalized commercial building hourly load profile data provided by the U.S. Department of Energy (US DOE) and National Renewable Energy Laboratory. This data was used to estimate monthly demand charge reduction for commercial electric buildings, and to estimate the share of electric and gas savings occurring in the summer and winter seasons (which have different supply charges and delivery tariffs for some buildings).

Greenhouse gas savings were calculated using natural gas and fuel oil emissions factors available from the US EIA, and the annual electricity emissions factor for ISO New England (grossed up to reflect transmission and distribution line losses).

The per-building data was then applied to the building sets identified for each threshold set in Task 3. This calculation estimates the city-wide cost and savings that would occur in Cambridge if buildings falling below a given performance threshold were required to undergo a comprehensive building retrofit. This projection groups the more granular building typologies described in Task 3 into commercial, multifamily, and laboratory building typologies. Laboratories in Task 4 are laboratories in Task 3; multifamily buildings in Task 4 includes multifamily buildings and dormitories from Task 3; and commercial buildings in Task 4 includes all other buildings considered in Task 3.

BUILDING-LEVEL RESULTS

The per-building data described above shows the following cost and savings for multifamily, commercial, and laboratory building typologies.

Table 2 shows per-building cost to implement electricity and natural gas energy efficiency upgrades recommended by an energy audit. Upgrades are a onetime cost. Note that the laboratory data is not from Mass Save, and therefore does not include state incentives. Confidence in laboratory data as descriptive for a Cambridge laboratory's cost and savings should be qualified by the great variety in energy use and building complexity across this building type.

Table 6: Typical Building-Level Energy Efficiency Implementation Costs

Building Typology	Total Upgrade Cost	Cost After Incentive
Multifamily	$293,791	$70,748
Commercial	$148,407	$77,025
Laboratory	$694,380	n/a

Table 3 shows annual and lifetime projected energy savings resulting from these typical building energy retrofits, based on reported energy savings and current retail energy prices. A typical Mass Save multifamily building undergoing both an electric and natural gas retrofit is projected to experience $85,000 in annual energy savings (exceeding the after-incentive cost of the initial retrofit) while commercial buildings are projected to save an estimated $40,000 per year. Laboratory savings are projected to be substantially higher based on the reference data used in this analysis, but will have a far greater degree of variability in potential savings due to inconsistency in the building stock.

Table 7: Utility Bill Savings

Building Typology	Electricity		Gas		Oil[69]		Total	
	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime	Annual	Lifetime
Multifamily	$66,103	$774,238	$20,881	$271,454	$(1,471)	$(19,117)	$85,513	$1,026,575
Commercial	$32,952	$432,593	$7,743	$94,747	$(656)	$(8,032)	$40,038	$519,308
Laboratory	$223,543	$2,971,102	$78,407	1,960,164	$-	$-	$301,949	$4,931,266

On average, annual GHG emissions from multifamily and commercial buildings are projected to range from 150 – 250 tons CO2. Laboratory savings have the potential to be far greater, but will vary much more significantly across buildings depending on the unique energy profile of the laboratory building. Across the building lifetime, a commercial building will prevent almost 2,000 tons of lifetime carbon dioxide emission (CO_2) by making upgrades. Multifamily buildings will prevent more than 2,500 tons of CO_2. Emissions reductions from laboratories are an order of magnitude higher, with lifetime savings exceeding 25,000 tons of CO_2.

Table 4: Typical GHG Savings

Building Typology	Tons CO2	
	Annual	Lifetime
Multifamily	216	2,641
Commercial	151	1,929
Laboratory	1,280	25,231

Without incentives, these typical building retrofits would provide simple paybacks of between 2 and 4 years depending on the building sector, as illustrated in Table 5, with substantial (undiscounted) lifetime net savings experienced in all cases. With the state incentive accounted for, payback decreases to less than two years for both commercial and multifamily buildings, providing substantial value to building owners and tenants that conduct such retrofits.

Table 5: Lifetime per Building Payback Periods and Net Savings

Building Typology	Without Incentives		Including Incentives	
	Payback (years)	Lifetime Net Savings	Lifetime Net Savings	Lifetime Net Savings
Multifamily	3.44	$732,783	0.83	$955,826
Commercial	3.71	$370,900	1.92	$442,282
Laboratory	2.30	$4,236,885	N/A	N/A

END-USE COMPARISON

While this analysis focuses on building-level energy savings rather than measure-level or end use-level savings, Cambridge building owners and tenants should be aware of the wide variety in energy savings opportunities. To demonstrate the range of potential energy savings, this report utilizes data from the "New York City's Data Energy and Water Use 2013 Report" (published in

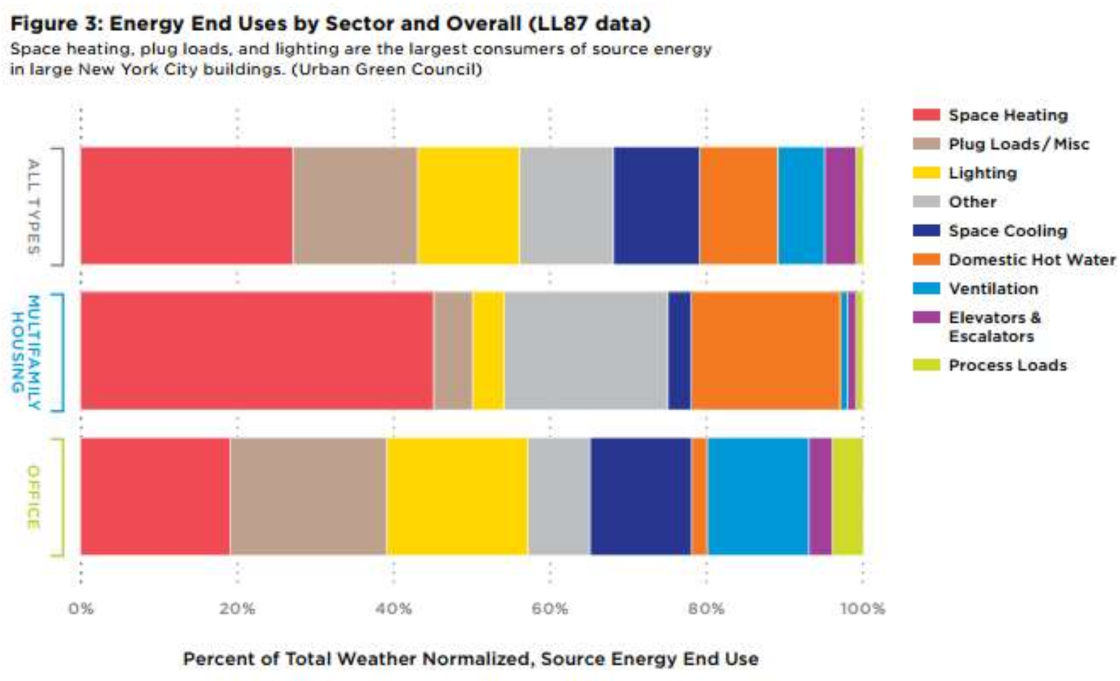
[69] Due to a substantial increase in lighting efficiency, Multifamily and Commercial heat loads are expected to increase. Because energy savings for oil heat are not evaluated in MassSave, this analysis forecasts a minor increase in heating oil consumption as a result.

2016)[70] to demonstrate typical patterns in energy consumption and energy savings opportunities for buildings in the Northeastern United States.

Like Cambridge, New York City requires certain large buildings to report their energy use. As part of this effort, the City has analyzed trends in energy use, and in the effectiveness of different energy conservation measures (ECM). ECMs are the energy efficiency improvement recommendations made by auditors to building owners that are considered feasible and cost effective. Cambridge and New York have comparable building stocks and similar weather, and NYC's ECM analyses demonstrate the types of ECMs that may be attractive to building owners in Cambridge.

Figure 1 displays a typical breakdown of energy consumption in New York City multifamily and office buildings. These two building types have very different energy end uses. Almost 50% of multifamily energy use comes from space heating, with domestic hot water and "other" as the next largest end uses. Meanwhile, 20% of the energy use in a typical NYC office building comes from space heating, with 20% from plug loads and 20% from lighting. For comparison, in multifamily buildings only around 10% of energy use comes from plug loads and lighting combined. This breakdown indicates that ECM targeting space heating will create deep cost savings in multifamily housing, while ECMs targeting lighting and plug loads may better serve offices.

Figure 1: Breakdown of Energy Consumption in New York City Buildings by End Use

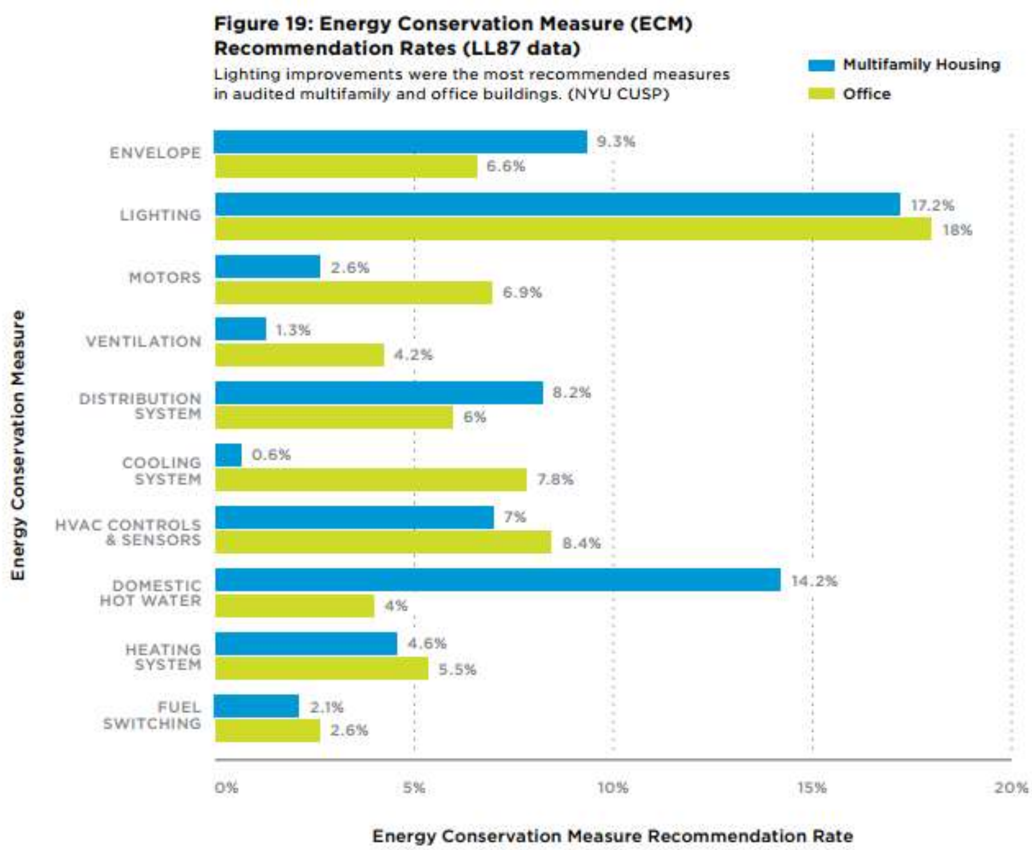


The report also aggregates and categorizes ECM recommendations made by auditors for NYC buildings. Lighting upgrades are the most common recommendation for both offices and multifamily buildings, despite the relatively low percentage of energy used by lighting in multifamily buildings. Domestic hot water improvements are highlighted as economically

[70] New York City ECM Analysis, available at: http://www.nyc.gov/html/gbee/downloads/pdf/nyc_energy_water_use_2013_report_final.pdf

attractive, and are a common recommendation for multifamily buildings, which is consistent with the high percentage of energy use dedicated to domestic hot water in this building type. The report stresses that the cost effectiveness of ECMs is a function of both the energy savings and the energy cost. ECMs that conserve electricity were far more cost effective than gas saving measures, because the price of gas was significantly lower than that of electricity in 2013.

Figure 2: Breakdown of Recommended Energy Conservation Measures in New York City Buildings



Given the broad similarities of building stock and energy consumption patterns between urban areas in Massachusetts and New York, these data provide general indications of the types of end-use ECMs that may be suitable and prioritized in BEUDO-compliant buildings. While the opportunity for energy savings will vary across buildings, these may provide useful starting points for building owners and tenants to consider as they begin to plan for energy improvements.

SECTION III. RECOMMENDATIONS AND ADMINSTRATIVE CONSIDERATIONS

The following section describes our recommendations for the City of Cambridge to consider as it works with stakeholders to design additional requirements to BEUDO. In addition to recommendations for legislation concerning prescriptive policy requirements and performance-based exemptions, we also discuss critical dimensions of policy administration. These include providing technical and financial assistance to building owners, and designing a data collection process that provides Cambridge with sufficient information to verify its progress toward a net zero built environment while balancing the demands on both City staff and building owners.

We recommend including all—or at least a large subset—of these recommendations as part of a comprehensive building performance policy that provides building owners with flexibility in complying, regardless of which performance threshold Cambridge selects.

ENERGY AUDIT POLICY OPTIONS FOR BEUDO

First, Cambridge should consider a requirement that building owners obtain Level II ASHRAE audits. Audits should occur at least every 10 years, and some cities have required them to occur every 5 years. An energy audit requirement provides owners with detailed information about their building's performance and specific capital measures they can take to improve their energy efficiency. This information includes estimates of cost-effectiveness and payback times for measures. However, for the energy savings identified in an energy audit to turn into realized energy savings, owners must implement some of the recommended measures.

A co-benefit of an energy audit requirement is that, depending on the extent of the audit data that the City collects, the City can use audit reports to gain a better understanding of the systems and equipment used in the City's building stock. This information can be valuable for designing other energy efficiency policies and incentives.

ENERGY AUDIT AND/OR RETROCOMMISSIONING FOR BEUDO

Second, Cambridge should consider pairing the energy audit with a retrocommissioning requirement. Cambridge may want to consider the following dimensions of implementation as part of this prescriptive requirement:

- **Pairing.** A retrocommissioning requirement could be paired with an energy audit in multiple ways: for example, the requirements could be alternated every 5 years; they could both be required together every 10 years; or the building owner could have the option to select between them. While Cambridge could implement a retrocommissioning-only requirement without the audit, we believe that there is valuable information to be attained from the audit requirement that would not necessarily come from retrocommissioning.
- **Clarity of requirements**. Cambridge may want to build off work in Seattle, Atlanta, and other cities by defining specifically what steps need to be taken to meet retrocommissioning requirements.
- **Alternative approaches.** To the extent Cambridge requires retrocommissioning, it may want to allow building owners who are performing ongoing commissioning of building systems (e.g., automated fault detection) to be exempt.

While no city has implemented this to our knowledge, Cambridge could also consider establishing a trigger to require retrocommissioning based on declining performance. For example, even if a building exceeds Cambridge's performance threshold, if it demonstrated a decline in performance across multiple compliance periods, it would have to engage in retrocommissioning. Cambridge would need to discuss with stakeholders the best way to administer this kind of requirement, given that some buildings will fluctuate in performance over time for many reasons including data entry,[71] so a trigger that considered multiple compliance periods or extreme declines would be more meaningful.

SPECIFIC REQUIRED MEASURES

Like New York City and Boulder, Cambridge could also require building owners to take specific required actions. These requirements do not necessarily depend on building performance, although they could be tied to building performance if preferred. There are two types of required actions that Cambridge may want to consider:

- **Submetering.** Submetering addresses split incentives by measuring the energy use of tenants, so that they can be billed for their individual energy consumption. This gives tenants a financial reason to reduce their energy use. If Cambridge has a significant amount of building stock that is not separately metered, it may want to phase-in a requirement that would provide this additional information over time. The requirement's compliance date should be set far enough in the future to allow existing tenant leases to renew, so that the submeter installation can occur during the tenant improvements that often accompany a new lease.
- **Lighting and Basic Code Upgrades.** Cambridge could consider requiring owners to upgrade their lighting systems to comply with the most current International Energy Conservation Code. If Cambridge chooses to pursue lighting upgrades, it should give owners enough time to fit lighting upgrades into their capital planning. A time period of 5 to 10 years in which to complete the lighting upgrades should be sufficient for buildings 50,000 SF and larger. For buildings 25,000 SF to 49,999 SF an additional 2-3 years should be considered.

REQUIRED ACTIONS BASED ON PAYBACK

Cities have often considered, but less frequently implemented, requirements that building owners invest in energy efficiency measures where they are cost-effective. The assessment for what measures are cost-effective would generally come from an energy audit (or maybe through retrocommissioning activities). Cambridge could consider the following prescriptive requirements:

- **Implement Cost-Effective Energy Upgrades.** If Cambridge requires an energy audit, it could require that building owners implement those energy upgrades deemed cost-effective. Boulder, for example, has required that building owners make upgrades discovered during audits or retrocommissioning where they have a payback period of less than 2 years. Other cities have considered payback periods of 2, 2.5, or 3 years. A component of this requirement is how the building owner passes through these costs to occupants or tenants, and Boulder paired this requirement with a requirement that the costs be amortized to tenants over time rather than passed through all at once.
- **Point-of-Sale Requirements**. Cities have only just started to grapple with the idea of requiring prescriptive actions to be taken at the time of sale. For example, a city could (hypothetically) require a building owner to conduct an energy audit, and then require cost-effective upgrades to be made (or specific measures to be installed) prior to the sale. There are practical and political challenges to implementing such a program. Cambridge is currently considering this option as part of the Net Zero Action Plan.

SIGNIFICANT IMPROVEMENT EXEMPTIONS

[71] http://midwestenergynews.com/2017/03/16/chicago-sees-progress-challenges-in-early-years-of-energy-efficiency-benchmarking/

The performance thresholds modeled—ENERGY STAR score, source EUI, and GHG emissions—are not perfectly fungible. While there is generally a correlation between "good" source EUI performance and a higher ENERGY STAR score, for example, the connections are not perfect. Moreover, there are a number of building types common to Cambridge, such as universities, which cannot receive an ENERGY STAR score. These considerations mean that some buildings may not have the ability to reach Cambridge's selected performance threshold, but they may still be able to improve their performance significantly.

We recommend that Cambridge offer the following three exemptions for significant improvement in performance:

- **Demonstrated ENERGY STAR score Improvement.** For buildings that are eligible to receive ENERGY STAR scores, Cambridge could consider exempting from performance or prescriptive requirements a building that achieves at least a 15-point increase in ENERGY STAR score from one compliance period to the next.
- **Demonstrated Source Energy Use Intensity ("EUI") Improvement**. Because only 46% of BEUDO-covered buildings are eligible to receive an ENERGY STAR score, Cambridge should consider adopting a performance exemption based on a reduction of weather-normalized source EUI. Cambridge could consider an exemption from prescriptive requirements for buildings that achieve at least a 15% reduction in weather-normalized source EUI from one compliance period to the next.
- **Demonstrated Greenhouse Gas ("GHG") Improvement.** No city, to our knowledge, has implemented an exemption that would allow buildings to meet performance requirements by demonstrating GHG savings—with the exception of Boston's campus-specific exemption (discussed below). Given the aggressiveness of Cambridge's climate goals, a high threshold in the range of 15-20% reduction in GHG levels between compliance years may be appropriate. Cambridge would need to make a series of administrative choices, such as whether off-site renewables could be used (e.g., green power purchases), and whether the metric would be based on GHG intensity as derived from ENERGY STAR Portfolio Manager,[72] or a different metric such as total emissions.

Determining the appropriate numerical values for these improvement exemptions is challenging. In our experience, numerical values are often set based on discussions with local stakeholders and energy efficiency experts. For purposes of this memo, we have recommended the highest improvement targets of those chosen by other cities with building performance policies, given the aggressiveness of Cambridge's climate goals. However, these numerical thresholds could be adjusted over time—either ratcheted up to increase the ability to meet goals sooner, or ratcheted down as overall building stock becomes more efficient. Cambridge may want to consider both costs to building owners and administrative complexity over time should it decide to modify these thresholds to provide continuous improvement.

HIGH PERFORMANCE BUILDING CERTIFICATION EXEMPTION

Certifying a building as high performance often requires it to take the kinds of prescriptive actions that cities require as an alternative to meeting performance thresholds. Accordingly, cities

[72] Portfolio Manager includes location-based (grid-average) Scope 2 indirect emissions and so appears to be consistent with the GHG emissions covered under Cambridge's net zero goal. See ENERGY STAR Portfolio Manager Technical Reference for Greenhouse Gas Emissions (2016) 2, available at https://portfoliomanager.energystar.gov/pdf/reference/Emissions.pdf.

generally provide an exemption from performance or prescriptive requirements where it is likely that the building would already meet them through that process.

We recommend that Cambridge offer the following exemption for high-performing buildings:

- **LEED-Existing Buildings Operations and Maintenance**. A large number of cities exempted from other performance or prescriptive requirements buildings that receive LEED-EBOM under LEED v4, provided they meet certain criteria. Currently, Cambridge requires new construction ≥50,000 square feet ("SF") seeking special permits to achieve at least LEED Silver while buildings 25,000-49,999 SF must achieve LEED Certified.[73] Cambridge should consider a compatible structure, with LEED Silver certification or higher required for any covered building under the revised BEUDO ordinance. Other cities have also required that buildings receive 15-17 points out of the 38 in the E&A category. Cambridge could set a more specific threshold for achieving E&A points in conversations with expert stakeholders.

Currently, about 90% of 240 LEED-certified buildings in Cambridge are at the Silver, Gold, or Platinum level, although this does not specify existing buildings from new construction.[74] Furthermore, a report from San Francisco indicated that 35% of covered floor area used a performance exemption, either ENERGY STAR certification or LEED-EBOM certification, to comply with their ordinance.[75] This evidence suggests that Cambridge could see a significant amount of buildings considering a LEED certification option.

DEMONSTRATED NET-ZERO EXEMPTIONS

Cambridge defines its net-zero goal to include reducing both Scope 1 and Scope 2 GHG emissions, which can be done through a mix of energy efficiency and renewable energy. In theory buildings that are moving toward net zero should be meeting Cambridge's performance thresholds, but it may be useful to allow them to demonstrate their net zero performance separately as an alternative.

We recommend that Cambridge offer at least one of the following exemptions for demonstrating net-zero performance:

- **Certification as a Zero Energy Building by the International Living Futures Institute.** To become certified as a Zero Energy Building, buildings must be efficient and meet their entire energy needs with renewable energy, criteria that are consistent with Cambridge's net zero goal.[76] Multiple cities allow this alternative. For Cambridge, it could serve as a permanent exemption from beyond-benchmarking requirements.
- **Demonstrated Net Zero Building Performance.** Cambridge could also follow Boston's lead and provide exemptions for buildings that demonstrate net-zero performance on an annual basis by either generating more energy than they consume or by using sufficient renewable energy

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[73] http://www.cambridgema.gov/~/media/Files/CDD/ZoningDevel/leeddocuments/LEED_GUIDELINE.pdf.
[74] http://www.gbig.org/collections/analyze_search?action=analyze&search%5Bflat_rating_program_ids%5D=Certification&search%5Bplace_ids%5D=3147
[75] San Francisco Department of the Environment & ULI Greenprint Center ["SFE & ULI Greenprint"], San Francisco Existing Commercial Buildings Performance Report, 2010-2014 (n.d.) 24, *available at* https://sfenvironment.org/sites/default/files/fliers/files/sfe_gb_ecb_performancereport.pdf.
[76] https://living-future.org/contact-us/faq/#net-zero-energy-building-certification

such that they generate no net greenhouse gas emissions.[77] Provided the building owner retains the renewable energy credits, using on-site renewable energy such as rooftop solar will not affect a building's site EUI score, but it will improve a building's source EUI score and reduce its associated greenhouse gas emissions (off-site green power purchases will only reduce emissions associated with the building).[78]

Selecting between these exemptions may require conversations with stakeholders. For example, Cambridge may want to discuss with stakeholders whether it would require on-site renewable energy, as opposed to off-site purchases. Additionally, if Cambridge wants to encourage building owners to avoid fossil fuels entirely, as opposed to netting out fossil fuel use through renewables on an accounting basis, it may want to consider implementing Zero Energy Building certification but not an accounting-based performance exemption. Finally, Net Zero approaches may create situations where a building could be inefficient, but fully powered by renewables. Cambridge would want to discuss the consequences of that choice with stakeholders (for example, if green power purchases are allowed to demonstrate Net Zero status, a new building owner may not continue them).

INDUSTRY-BASED EXEMPTIONS

Many cities include exemptions from performance or prescriptive requirements based on their local industries and the breakdown of their building stock. These should be developed based on direct discussion with impacted stakeholders. In general, we recommend crafting exemptions to support performance toward the city's goals, but without entirely eliminating requirements. Based on Cambridge's building stock and the experience of Boston, Cambridge may want to consider an exemption for universities and dormitories:

- **Universities and Dormitories.** Because Cambridge's building stock includes a significant number of university and dormitory buildings that are on campus systems, we recommend implementing an exemption similar to Boston's, and allow institutional building owners to comply by demonstrating that they have a campus master plan with a significant energy management component (e.g., it requires a 15% decrease in GHG emissions over 5 years). This exemption may be preferable when it is more cost-effective for buildings to be managed as a portfolio, rather than bringing every building up to the same level of performance immediately.

TIMING OF COMPLIANCE CYCLES

Generally, cities have implemented their performance-based and prescriptive programs across multiple years, to help them manage the volume of buildings that are required to comply in any given year. Cambridge may want to consider two factors in assessing how often performance requirements should be demonstrated: the cost to the building owner for meeting the obligation as discussed elsewhere in this memorandum, and the timeline to meet community Net Zero goals. For example, Cambridge may want to alternate a requirement that pairs audits and retrocommissioning so that one would come into play every 5 years, or it could require both every 10 years. However, this timeline could need to be shorter to meet the city's aggressive goals.

[77] Rules Sec. 1.08(c) at pp. 6-7, available at https://www.cityofboston.gov/images_documents/BERDO%20Regulations%20Approved%2018Dec2013_tcm3-42376.pdf.
[78] https://portfoliomanager.energystar.gov/pdf/reference/Green%20Power.pdf

TECHNICAL ASSISTANCE

Should Cambridge go forward with a performance threshold and beyond benchmarking requirements for building owners, it or its partners should provide robust technical assistance to the owners of covered buildings. Support for building owners is important not just for the purposes of attaining a high rate of compliance; it is also important for ensuring the realization of the intended energy performance improvements.

Establish Implementation Advisory Group. We recommend that Cambridge set up an advisory group of leading experts from relevant sectors such as real estate, energy efficiency companies, environmental nonprofits, utilities, and universities to help with implementation of the new requirements. Such a stakeholder group can help draft supporting regulatory language and provide training and building owner outreach. New York City relied on an implementation advisory group representing 30 organizations to lead industry assistance after the passage of its benchmarking and transparency, audits, retrocommissioning, lighting upgrade, and submetering requirements. Organizations from this advisory group, funded by NYSERDA and local utilities, led the formation of the City's outreach process to inform building owners of the new requirements, developed a benchmarking help center, and held trainings.

Conduct Outreach, Education, and Training. Cambridge should develop a plan for educating affected building owners and managers about the new policy requirements. Cambridge should develop guidance materials to help owners understand their responsibilities under the ordinance and how to meet them. These materials could include a short FAQ document explaining the purpose of the requirements, who must comply with them, how to comply, and available supporting resources; a longer compliance guide that takes an owner through the steps of policy compliance; and a brief compliance checklist to help owners and managers understand the high-level compliance process.

Boulder, Colorado has created a number of useful tools for managers and owners of its covered buildings. In addition to a detailed compliance guide, Boulder provides a cost estimation tool to help owners estimate the cost of hiring professional services for energy audits and retrocommissioning. They also provide guidance on local, state, and utility funded incentives, as well as a list of qualified service providers.

In addition to creating public guidance materials, Cambridge should work with partners from its implementation advisory group to develop a local community of practice within the Cambridge/Boston area real estate, energy efficiency, and sustainability industries. By coordinating energy efficiency-related training and networking events, Cambridge and its partners can prepare a community of building owners, property managers, energy professionals, and other interested parties to meet not only the requirements of the beyond benchmarking policy, but also the City's ambitious building performance goals.

An example of this is New York City's Building Energy Exchange. The Exchange is the most robust example of building owner outreach in the country, offering extensive support and educational enrichment for the New York building and energy efficiency communities. A less resource-intensive approach to this kind of stakeholder outreach is to host workshops on ordinance requirements as well as energy efficiency best practices. Salt Lake City connects building owners with local energy efficiency services and programs using workshops on energy efficiency-related topics such as tenant/manager collaboration on energy efficiency, available utility incentives, retrocommissioning, building automation systems, and low or no cost efficiency opportunities.

Expand the Energy Help Desk Capabilities. Cambridge should equip its Help Desk staff to assist building owners in meeting the new policy requirements in addition to benchmarking. Owners will need assistance understanding their responsibilities under the ordinance and having knowledgeable technical support will increase compliance rates. Ideally, Help Desk assistance would go beyond helping owners comply. Staff should be trained to connect building owners to utility rebates and incentives, making energy efficiency investments more likely. This would require the City to develop relationships that allow Help Desk staff to make direct connections between building owners and representatives of Mass Save or utility customer service staff.

Prepare Service Providers. In addition to requiring in ordinance language that energy assessments and retrocommissioning be conducted by qualified professionals. The City of Cambridge can help building owners receive quality professional services by providing training on the building performance requirements to local energy efficiency professionals and firms. The City of Boulder requires building owners to use service providers qualified by the city in order to meet the city's energy assessments and retrocommissioning requirements. To become qualified, a service provider must meet the minimum professional qualification requirements and complete a 30-minute online training session on the specifics of Boulder's Building Performance Ordinance. After passing this training, the city adds service providers to a publicly available list of qualified firms[79].

FINANCIAL ASSISTANCE

We recommend that Cambridge consider the following options for financial assistance:

- **Leverage Mass Save programs.** Continue to point owners to preexisting offerings from Mass Save, including free energy assessments for multifamily buildings and commercial facilities. The city is already providing this service for multifamily buildings by connecting them with free energy assessments through the Cambridge Energy Alliance. Educating building owners about the financial incentives available to them through local utilities is a common practice among cities with building performance requirements.
- **Consider City-Sponsored Incentives.** City governments rarely provide financial incentives for energy efficiency. Boulder is an exception. Its Climate Action Plan (CAP) tax applies to Boulder residents and businesses and is based on their electricity consumption. The tax generates roughly $1.8 million per year. These funds support energy efficiency programs, including rebates to residents and businesses through the EnergySmart program.[80] EnergySmart, which is now implemented by Boulder County, provides energy efficiency rebates that supplement those offered by the electric and natural gas utility that serves the area.
- **Consider Offering Green Business Loans.** The City of Seattle's Office of Economic Development offers low interest loans for energy efficient equipment upgrades that can be paired with incentives from Seattle City Light.[81]
- **Challenges and Competitions.** Some cities have hosted voluntary performance challenges that buildings can opt into or competitions that buildings can compete in. These optional programs provide recognition as a reward, and may or may not be paired with financial incentives. However, Cambridge could work with a foundation to develop a challenge or competition for high-performing or Net Zero buildings.

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[79] https://bouldercolorado.gov/sustainability/service-providers
[80] Boulder's Climate Action Plan Handout, 2015. https://www-static.bouldercolorado.gov/docs/CAP_document_FINAL-1-201603211302.pdf?_ga=2.38202915.1426847123.1497976703-879769645.1497976703
[81] City of Seattle http://www.seattle.gov/environment/buildings-and-energy/incentives-and-rebates#atwork

RECOMMENDED DATA COLLECTION AND MANAGEMENT PRACTICES

Cambridge should implement tailored data management practices that are appropriate to the types of data it wants to collect but not too onerous to either building owners or city staff.

- **Create Clear Data Collection Forms and Procedures.** Because of Cambridge's interest in better understanding its building stock, we recommend that it adopt comprehensive data collection practices. This means that, to the extent Cambridge requires buildings to undertake prescriptive actions, it should require building owners to report recommended or completed upgrades. To do this, it will need to design clear data collection forms. At a minimum, Cambridge will want to collect data on the types of recommended measures, the estimated one-year energy savings and lifetime of the measure, and the net present value as well as payback period.
- **Consider DOE's Asset Score tool as a data collection method.** The Department of Energy is developing its Asset Score Data Reporting Template tool that cities can use as a digital intake form to collect energy assessment information. The tool has data validation functions to address data quality problems and reduces cities' data management burden by allowing energy auditors to submit a building's audit report directly to the city. From there, a city can download buildings' reports in PDF or CSV format. The beta version of the tool has input fields for ASHRAE Level 2 audits as well as the custom data collection forms used by New York City and Atlanta. A production version of the Asset Score tool is scheduled to be ready for use in January 2018.

ADDITIONAL CONSIDERATIONS

The City of Cambridge will focus on stakeholder engagement on the BEUDO policy, and any potential enhancements in the coming months. The above analyses and previous assessments of the proportion of the building stock impacted by potential thresholds can inform future stakeholder conversations with landlords, tenants, facilities managers and the different reporting property types. Based on the data analysis and stakeholder feedback, the City of Cambridge will need to decide on an appropriate set of performance thresholds, property exemptions, and prescriptive requirements to balance the City's climate goals and the building industry's burdens and costs.

The goal of Phase I of the BEUDO Analysis project was to provide the City of Cambridge with data inputs on the implications of a series of policy options in order to provide the foundation for informative conversations with stakeholders. The impacts of these potential policies have been provided through the Task 3 and 4 memos, related to the cost, benefits, and GHG implications for Cambridge's reporting processes. Regardless of which policy options the data and stakeholder conversations lead the Environment Department toward, the City of Cambridge must consider:

- **Data Quality and Management.** As aforementioned in the Task 3 memo, some facilities' self-reported BEUDO property types differ from the primary use of the space. This could cloud or distort any sector-by-sector threshold approach, unless efforts are made for additional data quality control. The City will also need to examine its data collection system and administrative burdens associated with the application of certain performance exemptions or thresholds. An ENERGY STAR score exemption would have a low administrative burden, as scores are often included with reporting, but this would not cover all property types. Performance exemptions, which require demonstrated improvement in EUI or GHG emissions, would require properties to be clearly trackable in the BEUDO dataset over time. In the 2015 and 2016 datasets, it was only possible to match and pair half of the properties which reported in both years with the previous reporting year (see Task 3 memo for further details).

- **Appropriate Exemptions or Reporting Methodologies Based on Building Stock.** The Cambridge building stock contains a significant proportion of labs and university-owned buildings. Given the high EUI associated with labs and the complexity of the spaces, labs may struggle to comply with performance thresholds. They may also face high costs from prescriptive requirements. Universities, in addition to having lab spaces, likely have their own campus-wide energy management approaches. These approaches may not readily translate to building-by-building prescriptive requirements. In both of these cases, Cambridge must consider appropriate exemptions or alternative reporting pathways for these stakeholder groups.