19TH JUNE 2019

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Re: Washington DC Building Energy Performance Standard – C40 Technical Analysis

Dear Department of Energy and Environment (DOEE),

We are pleased to provide you with our final results from the C40 technical analysis for Washington, D.C. to support your efforts to develop a Building Energy Performance Standard (BEPS), one of the largest action items in the District's Clean Energy DC plan. As you are aware, this analysis was performed as a result of your application for technical assistance offered through your membership in C40's Private Building Efficiency (PBE) network. Working under direction from DOEE and the DC Sustainable Energy Utility (DCSEU), C40 PBE worked in partnership with Lawrence Berkeley National Laboratory (LBNL) to analyze the potential energy savings and greenhouse gas reductions, as well as the potential cost impacts, from the implementation of a BEPS policy in Washington, D.C.

Attached you will find a memo report summarizing our technical approach and key findings, with more details on the technical approach found in Appendix A. The results show that requiring all buildings over 10,000 square feet to meet the 50th percentile of ENERGY STAR scores in the District has the potential to reduce citywide energy usage by over 20%, which equates to 1.05 million tons of greenhouse gases annually.

Within the report, we note that there are some limitations to analyzing the cost impacts of implementing energy efficiency measures to meet the requirements of BEPS. Thus, our final report focuses on the actual project data provided by DCSEU to calculate the cost-effectiveness and simple payback for DCSEU projects. As we have discussed with you, we recognize that more work needs to be done in regard to the fiscal impacts of the BEPS policy, and we look forward to seeing more from DOEE on this topic in the near future.

Thank you for this opportunity to work with you on this project.

Sincerely,

Pegah Noori khah
Building Energy Data Analyst

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Washington DC
Building Energy Performance Standard: C40 Technical Analysis

Memo Report. June 19 2019

Introduction

This memo report summarizes the key findings of the C40 technical analysis conducted for Washington DC to support and inform its efforts to develop a Building Energy Performance Standard (BEPS). Washington DC has identified BEPS as an essential action in the CleanDC plan which lays out a path to achieving the city's interim target to reduce GHG emissions by 50% by 2032. Washington DC, as a member of the C40 PBE network, successfully applied for C40 technical assistance to analyze the potential energy savings and greenhouse gas reductions from a BEPS policy. The analysis was conducted jointly by the C40 Private Buildings Efficiency (PBE) network and Lawrence Berkeley National Laboratory. The Washington DC team - including the Department of Energy and Environment (DOEE) and the DC Sustainable Energy Utility (DCSEU) - identified objectives for the analysis, provided data, and reviewed interim and final results.

Objectives and Scope

Washington DC identified two main objectives for the analysis:

1. Determine the energy savings and GHG reductions from implementing a BEPS policy for a range of energy performance targets for different building types and sizes.
2. Assess the cost implications for building owners, and technology pathways to achieve such targets.

The scope of the analysis was all commercial and multi-family buildings over 10k sf floor area.

Technical Approach

Pursuant to the objectives of the analysis, our approach was to quantify the impacts of requiring buildings with Energy Star Score below a particular criteria (a percentile of the building stock) to implement energy efficiency measures until they have met the criteria. We completed the analysis using three alternative criteria: the 20th, 40th, and 50th percentiles of the Energy Star score for their respective sub group of building type and floor area range. We conducted the analysis for six building types (education, lodging, medical, multifamily, office, and other), and three floor area ranges (>50k sf, 25-50k sf, and 10-25k sf). We computed the following:

- the number and types of buildings affected;
- the amount they would need to improve their site and source energy use intensity (EUI) and Energy Star Score;
- the monetary cost required to implement the measures.

We used the Washington D.C. tax data to represent the entirety of the commercial and multifamily building stock. Federal buildings and embassies were excluded as they would not be covered by the policy. Since the tax data did not include information on energy consumption, we used two additional data sources: 1) the Washington D.C. benchmarking data for buildings >50k sf, and 2) the DOE Building Performance Database (BPD) data for buildings from 10-50k sf. We treated the combination of the benchmarking and BPD data as a representative sample of the building stock with respect to the quantities of interest (energy consumption, Energy Star Score, etc.). Lastly, we used the DCSEU data to estimate the cost of implementing energy efficiency measures.

Appendix A provides more details on the technical approach. Appendix B provides detailed figures and tables for each metric and building sub group.

Key Findings

The Building Stock

Table 1 shows the total number of buildings and total source energy use for each each floor area range. The total number of buildings considered for this analysis is 5593, almost half of which are in the 10-25k sf floor area range. The total estimated annual source energy use for these buildings is 86,521 billion Btu. Buildings greater than 50k sf account for 73,680 billion Btu of this total - about 85%.

Table 1. Total number of buildings and annnual source energy use for each floor area range.

Floor area range	Number of buildings	Source energy (Billion Btu)
>50k sf	1886	73,680
25-50k sf	1152	6,956
10-25k sf	2555	5,885
Total	**5593**	**86,521**

Energy Savings

Figure 1 summarizes the reduction in source energy savings from meeting the 20th, 40th and 50th percentile criteria, broken out by floor area range and building type. Figure 2 shows the cumulative percentage reduction in source energy for increasing stringency in the criteria for different floor area ranges. Figure 3 shows the number of impacted buildings for each criteria, broken out by floor area range and building type. Figures 4 and 5 show the reduction in site electricity use and site natural gas respectively from meeting the 20th, 40th and 50th percentile criteria, broken out by floor area range and building type (similar to Figure 1).

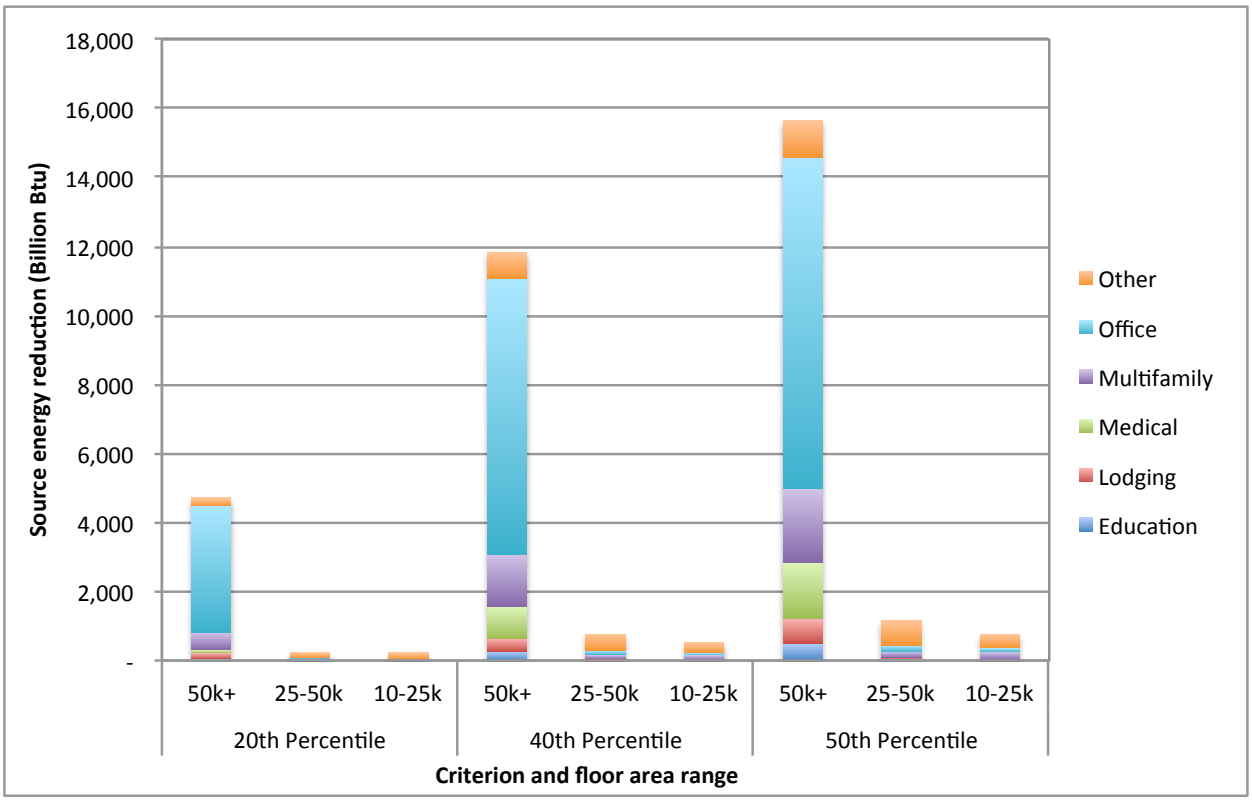

Figure 1. Reduction in annual source energy from meeting 20th, 40th and 50th percentile criteria, by floor area range and building type.

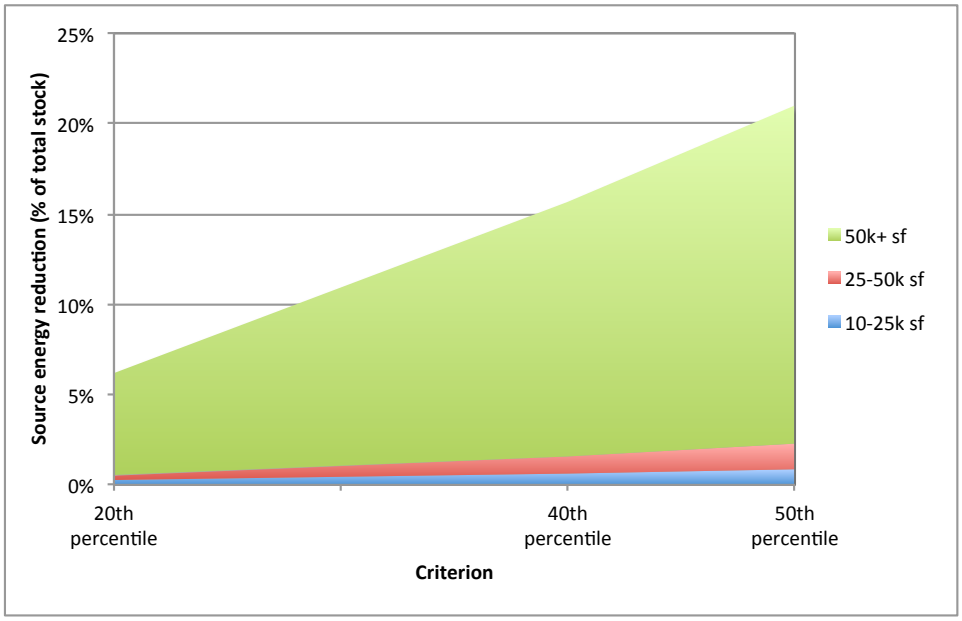

Figure 2. Cumulative percentage reduction is source energy for increasing stringency in criteria.

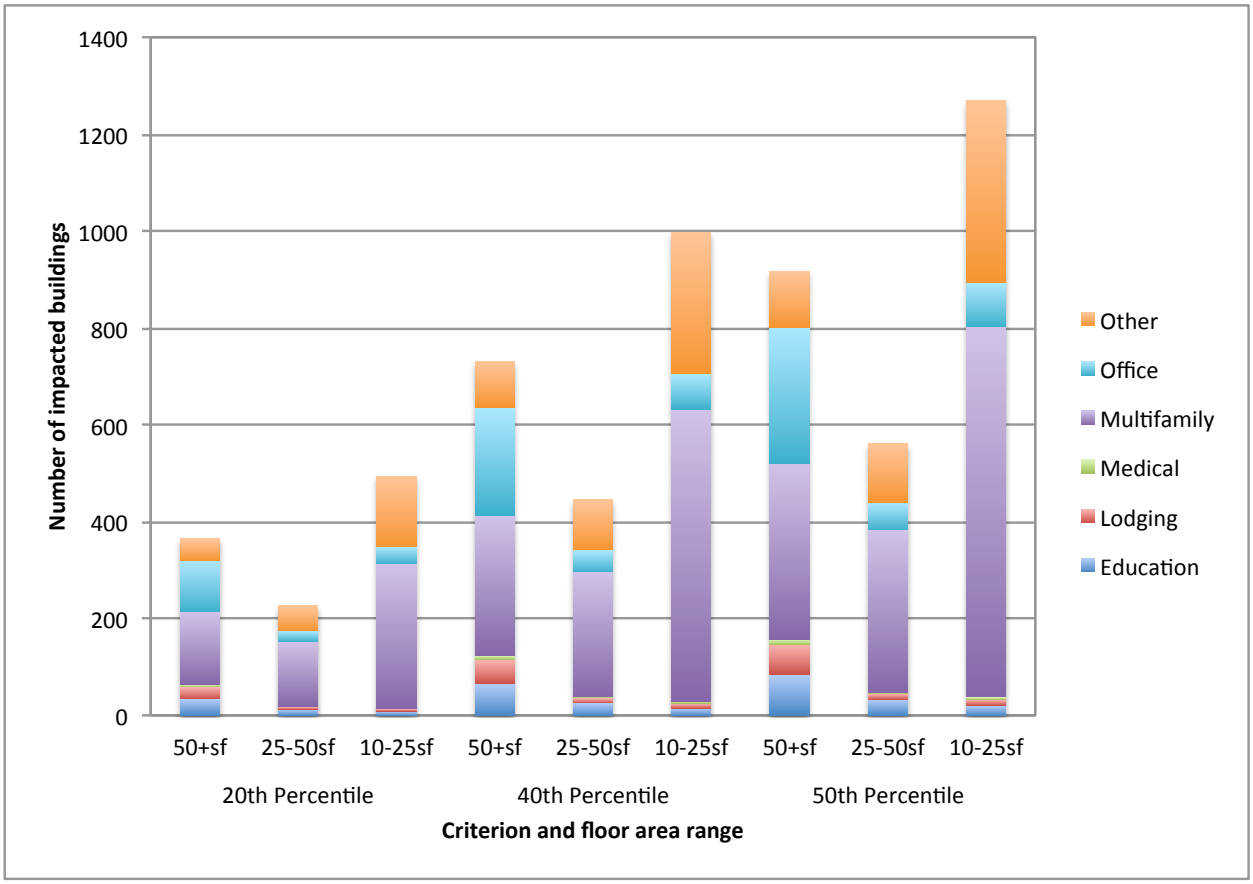

Figure 3. Number of buildings impacted by 20th, 40th and 50th percentile criteria, by floor area range and building type.

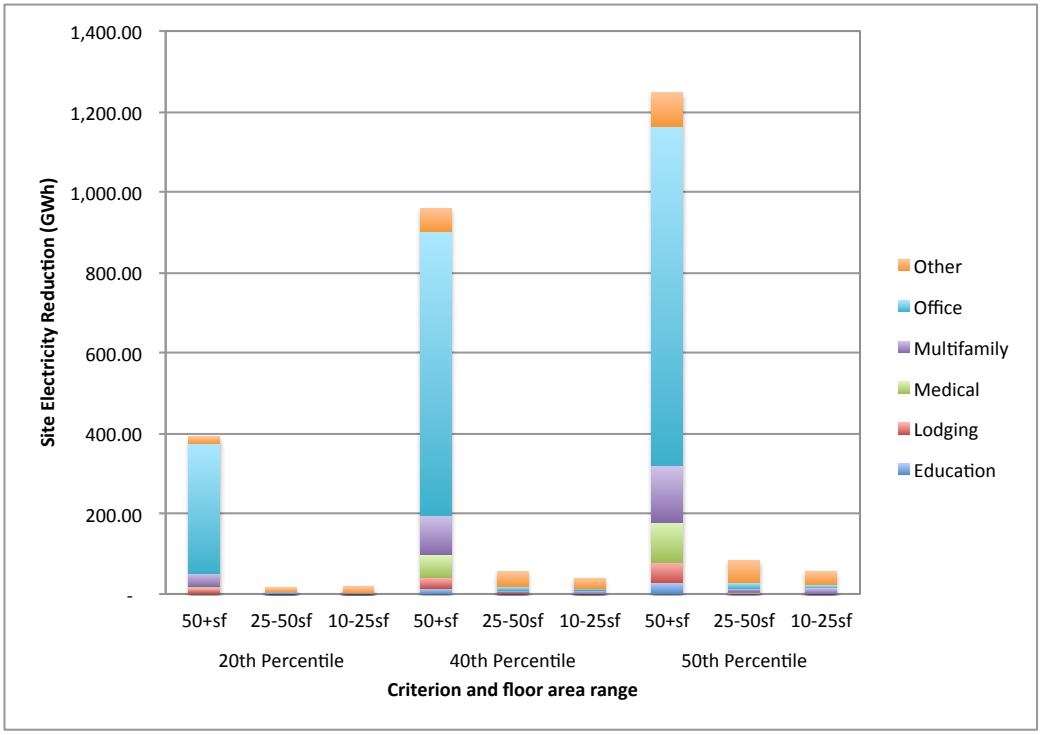

Figure 4. Reduction in annual site electricity from meeting 20th, 40th and 50th percentile criteria, by floor area range and building type.

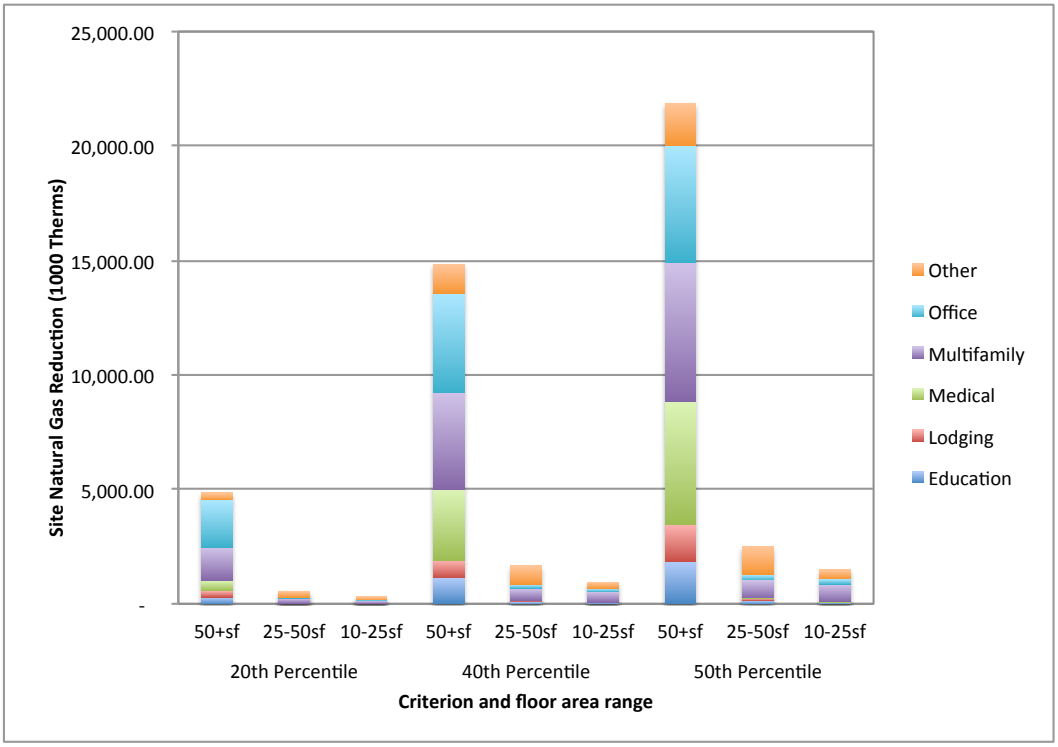

Figure 5. Reduction in annual site natural gas from meeting 20th, 40th and 50th percentile criteria, by floor area range and building type.

Major observations from our analysis:

- The most stringent policy implementation (50th percentile criteria for all buildings above 10,000 sf) will result in a total annual source energy reduction of 17,586 Billion Btu (21% of total stock).
- The vast majority of this reduction (18.7%) would come from buildings over 50k sf. Buildings in the 25k-50k sf range and 10k-25k sf range only contribute an additional reduction of 1.4% and 1% respectively.
- Total reductions scale linearly with the criterion stringency - 6.2%, 15.6%, and 21% for the 20th percentile, 40th and 50th percentiles respectively.
- Most of the savings come from offices, followed by multi-family housing and medical.
- The total number of buildings impacted by the 50th percentile criteria is 2746. Of these, 916 are in the 50k+ sf range, and 561 and 1269 in the 25-50k sf and 10-25k sf range respectively. As expected, the number of impacted buildings scales downward linearly with less stringent criteria.
- We also explored the relationship between energy use and building age as well as energy use and size. We did not find a significant relationship between these parameters (see figures in Appendix B), which is consistent with evidence from other data sources. This suggests that the policy does not necessarily need to differentiate the criteria based on building age and size.

GHG Reductions

We calculated annual CO_2e GHG reductions from the annual energy savings, using the following conversion factors provided by the Washington DC team:

- Electricity: eGRID subregion RFC-East non-baseload emission rates;
- Natural gas: ICLEI U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions.

Figure 6 shows the total annual GHG reductions from meeting the 20th, 40th and 50th percentile criteria, broken out by floor area range and building type. The most stringent policy implementation (50th percentile criteria for all buildings above 10,000 sf) will result in a total annual GHG reduction of 1.05 million tons of CO_2e.

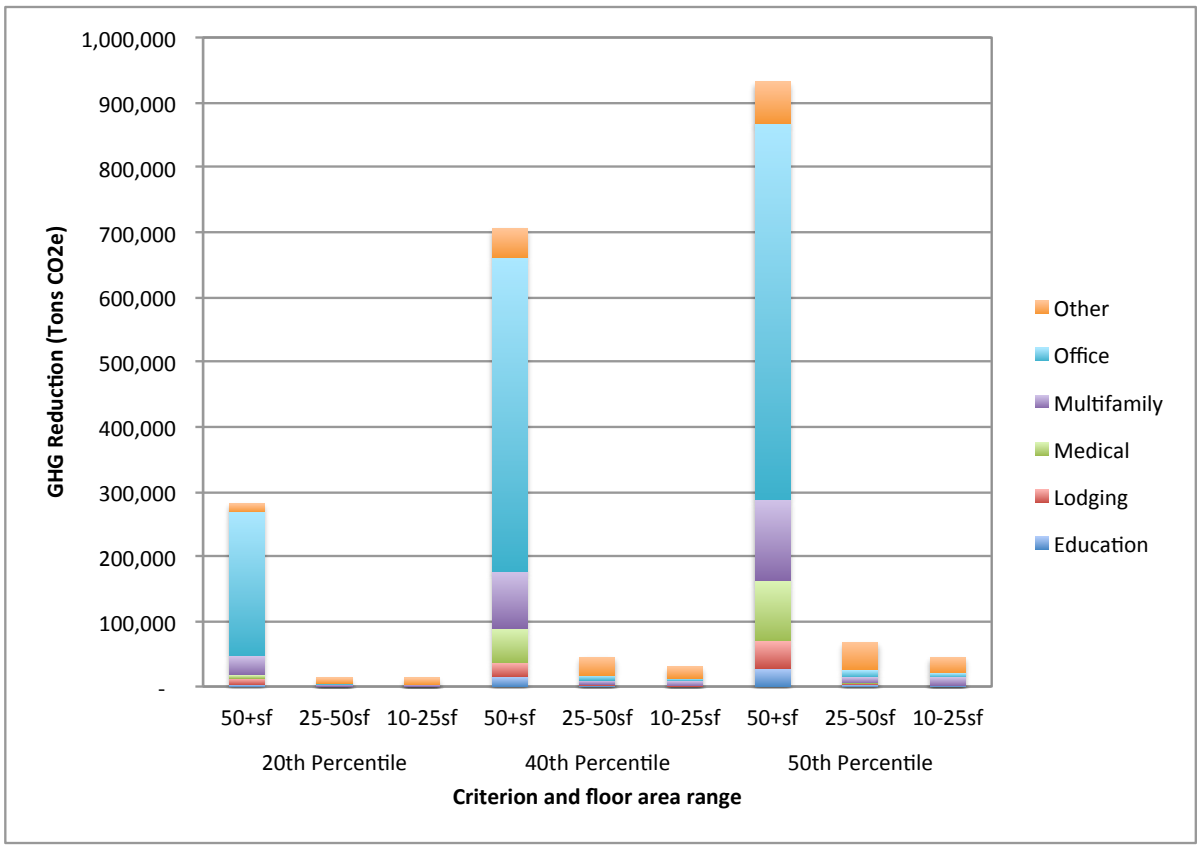

Figure 6. Reduction in annual CO_2e GHG from meeting 20th, 40th and 50th percentile criteria, by floor area range and building type.

Costs

First, it should be noted that the costs to implement efficiency measures are highly context specific and can vary significantly even for the same measure and building type based on the external factors such as the construction economic cycle, as well as site specific factors such as asbestos abatement, accessibility and security constraints, etc. The results below should be seen as "ball park" indicators.

We first analyzed the DCSEU measure data in terms of costs and savings at the building level i.e. project level costs and savings aggregated for each building. Table 2 shows the range of project cost per unit of site energy savings ($/kBtu saved). The median values for each building type vary from 0.06-0.12 $/kBtu saved. Table 3 shows the simple payback at the building level, assuming utility prices in Washington DC are about $0.04/kBtu for electricity and $0.01/kBtu for gas[1]. Median values for simple payback are 3 years or less.

[1] February 2018 data from https://www.bls.gov/regions/mid-atlantic/data/averageenergyprices_washingtondc_table.htm

Table 2. Aggregated building-level cost for DCSEU projects

	Implementation cost ($/site kBtu saved)				
Building Type	**10th percentile**	**25th percentile**	**Median**	**75th percentile**	**90th percentile**
Education	0.02	0.04	0.12	0.19	0.36
Multi-family	0.04	0.06	0.10	0.21	0.29
Office	0.01	0.05	0.10	0.18	0.49
Other	0.01	0.02	0.06	0.12	0.21

Table 3. Building-level simple payback for DCSEU projects

	Simple payback (years)				
Building Type	**10th percentile**	**25th percentile**	**Median**	**75th percentile**	**90th percentile**
Education	0.37	1.38	2.99	4.89	8.80
Multi-family	1.26	1.83	3.01	6.88	13.58
Office	1.09	1.44	2.59	4.83	14.39
Other	0.34	0.51	1.54	3.17	5.46

Figure 7 shows the total costs and savings across the portfolio of projects implemented by the DCSEU to date. It shows a wide array of measure types. As expected, the measures vary in their cost effectiveness. For example: Lighting fixture retrofits provided 18.5% of total portfolio savings at 22.2% of total costs; Space heating measures provided 32% of savings at 11% costs; and air conditioning provided 6.5% of total portfolio savings at 16% of costs.

We then tried to estimate the costs for each building affected by the criteria, by applying the DCSEU cost intensity ($/kBtu saved) data to the reductions required for each building that was below the criteria. We found that the range of costs for each building type and size category was very wide - with the 20th percentile at less than $1/sf and 80th percentile at more than $20/sf. These ranges were too wide to provide more specific conclusions about the costs for specific building types and sizes.

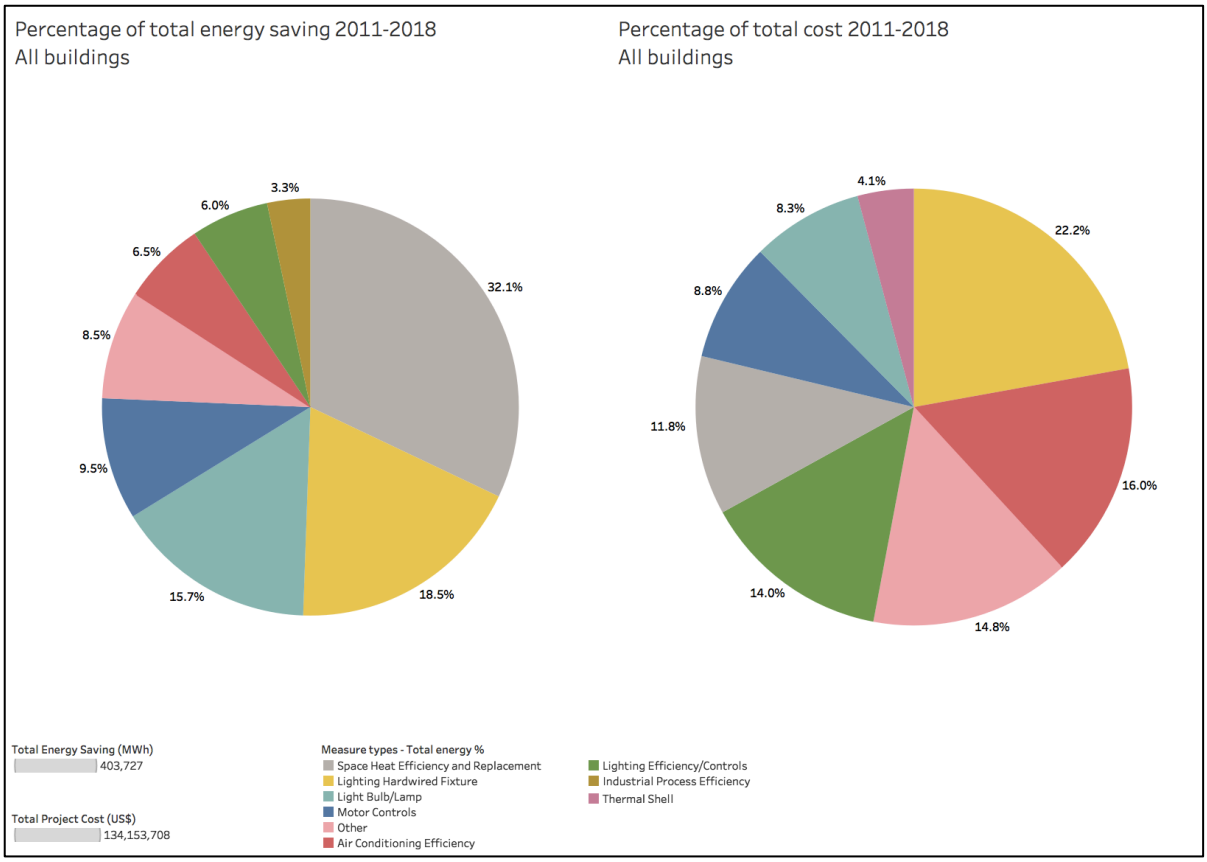

Figure 7. Total costs and savings for portfolio of DCSEU projects

Recommendation

This analysis suggests that a BEPS policy can provide significant savings towards meeting Washington D.C.'s climate goals. If all buildings over 10k sf were required to meet the 50th percentile criteria, it would reduce annual source energy use by more than 20%, equating to 1.05 million tons of CO_2e GHG annually. However, the savings vary widely by building type and floor area range. The vast majority of savings (over 18%) are from buildings over 50k sf. It is notable that the policy would impact 916 buildings over 50k sf and 1269 buildings in the 10-25k sf range, but with vastly different amounts of savings for those floor area ranges. The city should carefully consider the benefits of additional savings from smaller buildings against the transaction costs of implementing the policy for those buildings. Even if the city were to include all buildings, it may be advisable to start with buildings over 50k sf. Similarly, the city could also consider phasing the policy based on building types. Office, multi-family and medical are the most impactful of the six types we analyzed.

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