Boston Green Ribbon Commission

Health Care Working Group

Coordinated by Health Care Without Harm
Analytics by Environmental Health & Engineering

Metropolitan Boston Health Care Energy Profile for 2011-2013

December 11, 2014

This report summarizes an analysis of over 18,000 energy and green house gas records covering 22 million square feet of metro Boston hospitals, in a first-in-the-nation, metro sector-wide database. Developed for the Boston Green Ribbon Commission's Health Care Working Group (GRC-HC) by its coordinator, Health Care Without Harm, the data tracks the sector's collective progress towards the GRC's shared goals of a 25% reduction in greenhouse gas (GHG) emissions by 2020, and 80% by 2050.

SUMMARY

Metro Boston hospitals consume over 7 trillion British thermal units (BTU) of energy per year in their 22 million square feet of owned buildings. Hospitals routinely invest in energy efficiency projects, supported by utilities and other stakeholders, to tune and improve the performance of equipment and operating systems in their complex buildings that operate around the clock every day of the year.

Since 2011, the sector's weather and space adjusted energy efficiency efforts have saved 494 billion BTU[1], avoiding greenhouse gas emissions equivalent to 85 million miles traveled by an average passenger vehicle per year.[2,3] Absolute energy use decreased 6% (BAU) in 2013

[1] Without accounting for business as usual (BAU) of 1.5% and with weather and sq ft. adjustments, the total energy savings since 2011 would be 290 billion BTU. This is equivalent to 4% of absolute energy use of 2011.
[2] 353 billion BTU is equivalent to 4 million gallons of gasoline. http://www.epa.gov/cpd/pdf/brochure.pdf
[3] 4 million gallons of gasoline is equivalent to 35,560 Metric Tons of Carbon. http://www.epa.gov/cleanenergy/energy-resources/calculator.html

compared to 2011 (not normalized for weather or space). These achievements are impressive given that historically, Boston hospitals' energy use has grown about 1.5%/year, driven by new buildings, repurposing of spaces for more energy intensive clinical uses, growth in clinical equipment, increased numbers of patients served, and/or expanded research.

Source energy use intensity (EUI, kBTU/ft^2) for metro Boston health care decreased by 4% from 2011-2013.[4] About four-fifths (80%) of the reduction is attributable to simply using less energy overall (Site EUI) with the remainder arising from a more efficient mixture of source fuels as the sector increased its reliance on chilled water for cooling and steam for heating.

After normalizing for weather across the three years, EUI per heating degree day (kBTU/ft^2/HDD) for combined use of steam and natural gas (steam/gas) decreased by 11% for 2011-2013.[5]

Energy use by the metro Boston health care sector is impacted by the intensive care provided for critically ill patients from around the region, nation, and world. Because of the greater density of medical equipment, demand for electrical energy generally increases with the intensity of care required by patients. Patients requiring specialized imaging, transplants and other types of intensive care account for nearly 1 in 5 patient-days in metro Boston hospitals. Electricity demand for intensive care units is approximately two times greater than standard inpatient care. Metro Boston health care's energy use is also impacted by its millions of square feet of world-famous biomedical research laboratories, which typically use much more energy per square foot than even acute care hospitals due to special ventilation, safety requirements and equipment needs. Estimates vary, but laboratories likely comprise between 12% and 45% of metro Boston's total health care space. Some hospitals have as much as 50% of their floor space devoted to labs.

BACKGROUND ON THIS REPORT

Health Care Without Harm (HCWH) coordinates the Health Care Working Group of the Boston Green Ribbon Commission (GRC). The latter includes 33 executives from health care, higher education, commercial real estate, non-profits and hospitality in a cross-sector collaboration with the City to meet Boston's climate goals of a 25% GHG reduction by 2020, and 80% by 2050.[6] Twenty two hospitals, including all the major academic teaching hospitals participate in the Health Care Working Group (GRC-HC), which is co-chaired by Dr. Gary Gottlieb, President and CEO of Partners HealthCare, and Kate Walsh, CEO of Boston Medical Center. Environmental Health & Engineering (EH&E) was retained by HCWH to analyze energy information for metro Boston health care organizations for 2011-2013 because HCWH and the hospitals wanted to

[4] From 572 kBtu/ft^2 in 2011 to 547 kBtu/ft^2 in 2013
[5] From 0.0638 kBtu/ft^2/HDD in 2011 to 0.0654 kBtu/ft^2/HDD in 2013
[6] https://noharm-global.org/content/us-canada/boston-green-ribbon-commission

better understand how the sector's energy and GHG use are trending, and the key drivers of energy intensity across the sector. In addition, the effort sought to identify additional information that could enhance analysis and functionality of the health care sector energy data, and shared learning sector-wide.

Participating health care organizations entered over 18,000 records in the U.S. Environmental Protection Agency (EPA) Portfolio Manager®, which were then quality assured and standardized to include 39 buildings from 13 institutions.

SECTOR ENERGY USE

Source energy use intensity (EUI, kBTU/ft^2) for metro Boston health care decreased by 4% from 2011-2013.[7] About four-fifths (80%) of the reduction is attributable to simply using less energy overall (Site EUI) with the remainder arising from a more efficient mixture of source fuels as the sector increased its reliance on chilled water for cooling and steam for heating.

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The U.S. Department of Energy estimates that electric EUI in hospitals increases by approximately 1.5% per year in response to greater use of medical equipment and information technology. Local experience has found a similar 'business as usual' (BAU) increase in health care electricity use. Greater plug load increases electricity consumption directly and also raises internal heat load which in turn increases demand for chilled water or other means of cooling. The reverse effect would likely occur in the winter when increased internal heat load would lower demand for heating. The sector data available for 2011-2013 clearly fit this scenario; though additional data and analysis are needed to evaluate its validity and to characterize the effects quantitatively.

The relative amounts of grid electricity, chilled water, natural gas, steam and other fuels were generally consistent for 2011-2013.

An increase in operating hours across the health care sector could also drive the observed increase in EUI per cooling degree day (CDD). Annual data on sector-wide operating hours would be required to evaluate this possibility.

[7] From 572 kBtu/ft^2 in 2011 to 547 kBtu/ft^2 in 2013
[8] From 0.0638 kBtu/ft^2/HDD in 2011 to 0.0654 kBtu/ft^2/HDD in 2013

SECTOR GREENHOUSE GASES

Carbon dioxide equivalent (CO_{2eq}) emissions for the sector decreased by 2.9% from 2011-2013. Compared to BAU, CO_{2eq} emissions in 2013 were 5.7% lower than in 2011. Consistent with the modest adjustments in fuel mix, the largest decreases in CO_{2eq} were attributable to natural gas and electricity use, with comparatively small decreases in CO_{2eq} for chilled water and steam.

After normalizing the CO_{2eq} emissions for weather and space in each year, the sector-wide reduction of CO_{2eq} emissions from 2011 to 2013 is 6%. By extrapolating these results into the near future, we estimate that Metro Boston healthcare is on track to reduce greenhouse gas emissions of 27% by 2020 compared to a 2011 baseline and BAU annual growth of 1.5%. Analysis shows a sector-wide CO_{2eq} emissions reduction of 34% by 2020 could be possible given projected GHG reductions by leading institutions, certain targeted efforts, and assuming a constant rate of improvement.

SECTOR COST INFORMATION

The quality assured dataset contained information on energy costs for 9 of the 13 institutions that represent two-thirds of the corresponding gross floor area. Cost information was provided for the principal energy types including electricity, steam, and natural gas. The unit costs for energy were comparable among the institutions and therefore consistent with data of reasonable quality. In addition, the distribution of gross floor area was approximately equal for institutions that provided cost information compared to institutions that did not report cost information, which demonstrates that cost data are available for the range of organizations in metro Boston based on size. Overall we find that the dataset contains information of sufficient quantity and quality to undertake a detailed characterization of energy costs for the sector and among participants for 2011-2013.

As a preliminary effort, overall energy savings were attributed by 45% electric and 55% thermal savings, with an average cost of $36/MBtu and $14/MBtu, respectively. A weighted average energy cost of $24/MBtu, applied to the sector-wide energy savings of 494 billion btu between 2011 - 2013 (BAU adjusted) is equivalent to $11.9 million savings, enough to cover 1,055 Medicare enrollees in Massachusetts.

INSTITUTION ENERGY USE

The GRC-HC Energy Profile study conducted analysis of source EUI at the institution level to examine energy use in relation to characteristics other than weather.

The institutions included in the analysis are representative of the sizes of health care organizations in metro Boston and range in gross floor area from 269,000 to 5,500,000 ft^2 with a median of 1,200,000 ft^2. A notable feature of the size information is that one institution accounts for nearly 25% of the sector floor area and is more than twice the size of the next largest institution. In comparison, the smallest institution occupies only about one-fourth the gross floor area of the median institution in the sector. The larger institutions necessarily have the largest influence on energy performance of the sector.

Energy use at the institution level exhibits approximately the same degree of variability across institutions as gross floor area, with the single institution maximum of approximately 1.5 billion kBTU, slightly more than 20 times greater than the smallest energy consumption by an institution. Electricity and natural gas/steam each accounted for approximately one-half of the total energy use for most of the institutions, with some of the smaller institutions less reliant on electricity. Steam rather than gas is more common in the large institutions. The Medical Area Total Energy Plant (MATEP) data demonstrate the significant use of chilled water for many of the larger institutions.

Although absolute energy use varies directly with gross floor area, Source EUI is not associated with size of the institution. Source EUI is also less variable across institutions than absolute energy use with a 2.5-fold range from the minimum to the maximum (309 kBTU/ft^2 to 809 kBTU/ ft^2). The range of EUI is in part the result of differences in intensity of patient care and laboratory research.

Patient Care and Research Intensity

Patient Acuity. The intensity of care required by a patient is known as patient acuity. A recent study conducted in metro Boston hospitals found that plug load EUI increased two-fold in intensive care units compared to non-acute inpatient care areas.[9] Patients requiring specialized imaging, transplants and other types of intensive care account for nearly 1 in 5 patient-days in metro Boston hospitals.[10] Thus, we hypothesize that accounting for intensity of care is important for benchmarking energy use in metro Boston health care.

Source EUI decreased with increasing density of staffed patient beds among 10 metro Boston health care institutions.[11] The direction of this relationship is somewhat surprising given that EUI *increases* with patient bed density in the US EPA's Energy Star reference data set. The

[9] D'Antona J. and Messervy J. 2014. Quantifying cord-connected plug load in inpatient areas. ASHE Monograph, American Society for Healthcare Engineering.

[10] Based on specialty care inpatient bed days and routine care inpatient bed days for metro Boston hospitals downloaded from http://www.ahd.com.

[11] n = 13, Pearson correlation coefficient = -0.6, $p < 0.05$.

difference is likely attributable to confounding by research activity given that patient bed density is associated with both Source EUI and surrogates of research activity (see below).

To address the confounding between patient bed density and research activity, we also examined a measure of patient acuity as a substitute for patient bed density. We considered publicly available information on the percentage of inpatient bed days dedicated to intensive care as a surrogate of patient acuity.[12] Values ranged from 6% to 31%, indicating a wide range of patient acuity among institutions in the sector, with an average of 15%.[13] Using this information, we found that Source EUI is strongly associated with patient acuity as indicated by the percentage of inpatient bed days for special care.[14]

Biomedical Research. Turning now to the influence of space dedicated to research, we found that Source EUI is associated with two different indicators of research activity obtained from publicly available sources. First, we found that Source EUI increased with increasing extramural research funding from the National Institutes of Health (NIH).[15] This relationship was observed despite the inconsistencies in funding data arising from NIH's reporting of awards that have multiple principal investigators. Second, our analyses show that Source EUI also increases with increasing non-patient revenue as reported by the American Hospital Directory.[16]

Laboratories generally have substantially greater EUI than many other building uses because of safety requirements that require additional ventilation, as well as research effort's use of energy intensive equipment. We are not aware of a source of information on gross floor area dedicated to research in health care organizations, however non-patient revenue, a surrogate for research intensity, accounts for 1 – 19% of total revenue for individual metro Boston hospitals. This and other information suggest that a substantial amount of space, and therefore EUI, is associated with research activity in metro Boston health care. In consideration of this information, we hypothesize that accounting for research is expected to be important for future benchmarking energy use in metro Boston health care.

As hypothesized, Source EUI for metro Boston health care institutions appears to be positively associated with indicators of patient acuity and research activity. This finding is particularly notable given that the measures for intensity of patient care, federal research funding, and revenue unrelated to patient care were derived from different sources of information, prepared for different purposes, and that the analysis was performed at the institution level rather than for individual buildings.

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[12] See reference 8.
[13] An institution that accounted for 0.1% of the total inpatient bed days, had no special beds, and was highly influential was identified as an outlier based on rational and statistical grounds and omitted from the analysis.
[14] n = 13, Pearson correlation coefficient = 0.5, p = 0.09
[15] Data obtained from http://report.nih.gov/award/index.cfm; Pearson correlation coefficient = 0.2, p = 0.5
[16] Data obtained from www.ahd.com; Pearson correlation coefficient = 0.4, p = 0.2

To illustrate the utility of benchmarking based on determinants of EUI in Boston area hospitals, we fit Source EUI for institutions to measures of patient acuity and non-patient revenue. We found that sector EUI would decrease by 10% if the seven institutions with actual EUI greater than predicted EUI were able to lower their energy use to the level predicted by the model. This refined estimate is more realistic and attainable than an estimate of potential energy savings based on benchmarking with gross floor area alone.

CONCLUSION

The analysis of energy information provided by metro Boston healthcare organizations indicates that absolute energy use declined by 6% from 2011 through 2013 compared to BAU. Greenhouse gas emissions associated with the sector's energy consumption decreased by 2.9% in absolute terms and by 5.7% compared to BAU growth.

Non-weather adjusted source energy use intensity (EUI, kBTU/ft^2) for metro Boston health care decreased by 4% from 2011-2013.[17] About four-fifths (80%) of the reduction is attributable to simply using less energy overall (Site EUI) with the remainder arising from a more efficient mixture of source fuels as the sector increased its reliance on chilled water for cooling and steam for heating. After accounting for the influence of weather, EUI was relatively constant between 2011 and 2013, however improvements in efficiency outpaced BAU growth in consumption.

Hospitals have made significant energy reduction and GHG progress. From January, 2011 through the end of 2013, the sector has cut energy use by 6% equal to eliminating the GHG impact of an average car traveling over 85 million miles.

Notable areas of progress in energy efficiency, conservation and GHG reduction, include:

- The sector reduced absolute total energy use (electricity, gas, chilled water, oil and steam) by weather adjusted 227 billion Btu.
- Absolute electricity use dropped 25.4 million kWh, 6.47% BAU, or 6,797 metric tons of carbon dioxide equivalent (MtCO2e).
- Natural gas use dropped 1.2 million therms, 14.75% BAU or 6,367 MtCO2e.
- GHG reductions for all fuels equaled 14,286 MtCO2e.
- Cost savings are conservatively estimated at $11.9 million, enough to pay for healthcare for 1055 Massachusetts Medicare enrollees.

These achievements are impressive given that historically, Boston hospitals' energy use has grown about 1.5%/year, driven by new buildings, repurposing of spaces for more energy intensive clinical uses, growth in clinical equipment, increased numbers of patients served, and/or expanded research.

[17] From 596 kBtu/ft^2 in 2011 to 578 kBtu/ft^2 in 2013

EUI for metro Boston health care institutions appears to be strongly influenced by patient acuity and research activity. Publicly available information on patient density, frequency of intensive care, non-patient revenue, and research funding was associated institution-level source EUI.

These findings on trends and benchmarking of energy use are based on analysis of a quality assured subset of data from metro Boston health care that represents 87% of the institutions (13 of 15) input to Portfolio Manager by the participating health care organizations. [Institutions that started participating more recently in the GRC-HC energy data effort could not be included due to insufficient data for earlier years.]

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This report can be found on both the Green Ribbon Commission's and Health Care Without Harm's websites:
http://www.greenribboncommission.org/health-care
https://noharm-uscanada.org/content/us-canada/boston-green-ribbon-commission

About the Boston Green Ribbon Commission
The Boston Green Ribbon Commission www.greenribboncommission.org/ is a group of business, institutional and civic leaders in Boston supporting the implementation of the city's Climate Action Plan. The plan includes strong recommendations on how Bostonians can increase efficiency, reduce emissions and prepare for extreme weather and higher sea levels. Many cities have produced similar plans. But few have also enlisted the support and leadership of the local business community as effectively as Boston, to help reduce greenhouse gas emissions 25 percent by 2020 and 80 percent by 2050.

About Health Care Without Harm
Heath Care Without Harm (HCWH) https://noharm-uscanada.org/Boston / is an international coalition of hospitals, health care systems, medical professionals, community groups, health-affected constituencies, labor unions, environmental and environmental health organizations, and religious groups. The coalition seeks to transform the health sector worldwide, without compromising patient safety or care, to become ecologically sustainable and a leading advocate for environmental health and justice. HCWH-Boston leads some of its most ambitious efforts, covering toxic reductions, green building, energy efficiency, and climate change. As a result, Boston's health care sector is playing a leadership role in regional efforts to address climate change.

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