Boston Area Laboratory Energy Benchmarking Study

Year 2 Data Analysis Report: University Labs

A Report from the Higher Education Working Group
Boston Green Ribbon Commission

Prepared by kW Engineering
Managed by the Harvard Office for Sustainability
SEPTEMBER 2017

BOSTON Green Ribbon COMMISSION | Higher Education Working Group

HARVARD Office for Sustainability

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This report was produced for the Boston Green Ribbon Commission's Higher Education Working Group by kW Engineering. This report was made possible thanks to support from the Barr Foundation.

About the Author

kW Engineering is a nationwide energy engineering consulting firm specializing in saving energy and reducing utility costs. kW's mission is to make all buildings sustainable by improving operation while increasing building value and delivering energy and cost savings.

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About the Boston Green Ribbon Commission (GRC)

The mission of the GRC is to convene leaders from Boston's key sectors—business, education, health care, non-profit, finance, real estate, professional services, tourism and others—to support the outcomes of the City's Climate Action Plan. The GRC works on a network model and comprises a set of sector-based and initiative-based Working Groups. Together, participants focus on two key strategies: 1) Climate Ready Boston, to help the City become climate resilient and prepared for future impacts of sea level rise, more intense heat, and flooding, and 2) Carbon Free Boston, to develop policy and technology pathways that will enable Boston to reach its goal of net zero carbon by 2050.

About the GRC Higher Education Working Group

The GRC Higher Education Working Group represents the unique constituency of large research and residential campuses in Boston and neighboring cities. Lab facilities are often the source of the greatest energy use at large research institutions, disproportionate to the square footage they occupy, so they are a key area of focus for educational institutions. The Higher Education Working Group commissioned this data collection and analysis effort to better understand how Boston area lab buildings compare to each other and to lab buildings nationally.

The Higher Education Working Group is chaired by Harvard University and managed by the Harvard University Office for Sustainability.

Acknowledgment

Support for this report is provided by the Boston-based Barr Foundation as part of its Climate Program and efforts to advance clean energy in the region.

Boston Area Laboratory Energy Benchmarking Study

Supplemental Report: 2015 Data

Executive Summary

This report supplements the Green Ribbon Commission's Boston Area Laboratory Energy Benchmarking Study, which analyzed energy consumption data for calendar year 2014 from a sample of 121 academic lab buildings in the Boston area.

In this new work, calendar year 2015 energy usage data were obtained for the same set of buildings. The goal of this exercise was two-fold: to uncover data quality issues which could manifest themselves as otherwise unexplained variations between years; and to determine whether the conclusions of the original study (average energy consumption, energy score formulation, etc.) would hold over time.

The overall average energy use intensity was essentially unchanged between the two years, solidifying the energy baseline for Boston labs. However, given the known extent of weather variations between 2014 and 2015, many buildings showed unexpectedly large changes in energy usage: one third of the buildings showed source energy consumption changes of more than 10%, raising concerns about the effect of data quality issues on the results of the previous study. This led to the present report's focus on understanding the origin of the discrepancies between years.

Approximately 7% of buildings in the sample were reported to have undergone significant renovation projects or changes in research schedules between 2014 and 2015. For a further 15% of buildings, it was discovered that the 2014 energy usage data used in the original GRC study were inaccurate. Reasons for data inaccuracies included faulty meter data, accidental transposition of spreadsheet columns, omission of tenant usage data, and other reasons not known or reported. Where discrepancies were found to exist, this study's focus was on ensuring that the 2015 dataset included the corrected values.

The collection of a second year of data was ultimately a highly valuable exercise which resulted in a greater level of confidence in the integrity of the 2015 dataset. The issues detected via the two-year comparison could not have been (and were indeed not) identified with a single year of data without highly detailed auditing of the data submissions. It must be recognized, however, that additional data issues that did not manifest themselves as differences between years could still be present in the improved dataset.

When the draft energy score regression analysis was repeated using the 2015 dataset, energy score assignments changed for 40% of eligible buildings. While many of the score changes are seen in those buildings with large reported energy use changes between years, some buildings with consistent energy usage also experienced changes in ranking. It is recommended that the new draft scores are used in place of the scores developed using the 2014 data.

Looking ahead to the final phase of the GRC lab benchmarking study and beyond, this report also includes a discussion of the actionability of benchmarking exercises.

Contents

1. Introduction

This report supplements the Green Ribbon Commission's Boston Area Laboratory Energy Benchmarking Study (the "original study"), which analyzed energy consumption data for calendar year 2014 from a sample of 121 academic lab buildings in the Boston area. The original report was published on the Green Ribbon Commission's website in May 2017.

The original report made a number of recommendations as to next steps in the benchmarking exercise; one of these was to conduct a follow-up analysis using energy consumption data for at least one subsequent year. The reasons for this recommendation were two-fold: to uncover data quality issues which could manifest themselves as otherwise unexplained variations between years; and to determine whether the conclusions of the original study (average energy consumption, energy score formulation, etc.) would hold over time.

Data quality checks were built into the original study, but by necessity these extended only to verifying that overall energy use intensity lay in the (broadly defined) anticipated range for lab buildings; to identifying and querying buildings with unexpectedly large or small ratios between thermal and electrical energy consumption; to following up on particularly high or low reported lab area fractions; and to requesting clarification where building or system properties were irregular or unclear. These checks revealed a number of issues in the data submitted for the original study, and the majority of these were corrected by the submitting institutions following issue flagging. The scope of the benchmarking exercise did not extend to verifying all submitted data in full detail. For the energy usage data, arguably the most important data submitted, a comparison between two subsequent years is a promising avenue for the detection of additional data quality issues and thereby for improving data integrity and building greater confidence in the study's conclusions.

This report presents the methodology, results, and analysis of the follow-up work incorporating energy use data for calendar year 2015 and its comparison with the 2014 data from the original report.

Drivers of Differences between Years

Buildings are dynamic systems with many external and internal drivers of energy consumption; variations in energy use over time are of course expected, are routinely observed, and do not necessarily indicate data quality problems. Common reasons for real variations in lab building energy usage include:

- Weather differences between years
- Changes in occupancy level or occupancy patterns
- Renovation projects in progress
- Changes in space usage
- Changes in system operations, e.g. HVAC system setpoints
- Malfunction or repair of building systems
- Changes in experimental processes or equipment.

Without supplemental information, it is not possible to distinguish between possible reasons for reported variations in annual energy consumption or to determine whether the variations are real or the result of measurement or reporting errors.

Weather Comparison

While lab building energy consumption is typically fairly insensitive to envelope loads, it is still weather dependent because most laboratory buildings employ 100% outside air HVAC systems. Because building HVAC systems vary in physical and operational configurations, the effect of weather variations is expected to differ between buildings: while all buildings in the GRC dataset experienced the same weather in each year, the impact of weather variations on each building's energy use will differ. Weather variations are therefore expected to produce both shifts and scatter in energy consumption between the two years. Important factors affecting the specific weather response of lab buildings include (but are not limited to) supply air temperature and humidity controls, the presence of zonal cooling systems, and the use of exhaust air heat recovery systems.

In Boston, 2015 was on average warmer than 2014. Monthly heating and cooling degree day totals for 2014, 2015, and a typical meteorological year (TMY3 for Boston Logan) are shown in Figure 1 below.

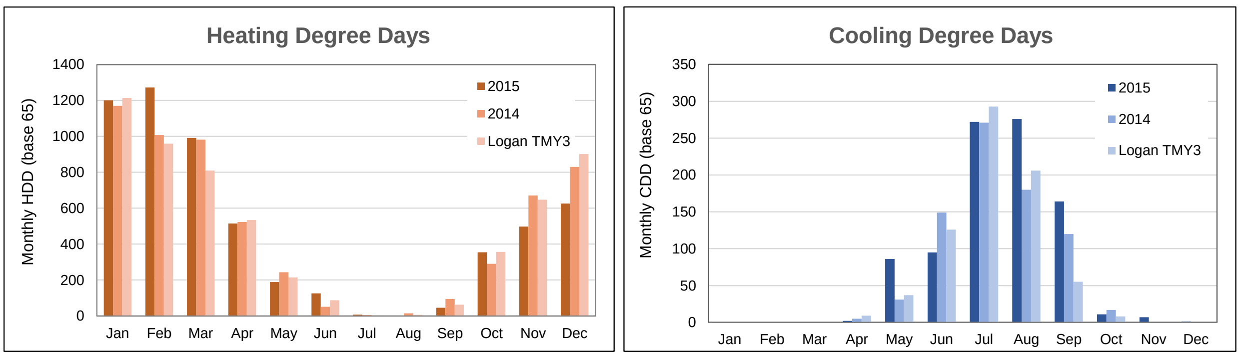


Figure 1: Monthly total heating degree days, base 65°F (left) and cooling degree days base 65°F (right) for Boston in 2014, 2015 and TMY (Logan Airport)

Overall, Boston experienced 18% more cooling degree days (base 65°F) in 2015 than in 2014 and 1% fewer heating degree days (also base 65°F). Reported cooling energy usage would therefore be expected to be somewhat higher in the 2015 dataset, while heating energy usage would to first order be expected to be similar.

Report Outline

In Section 2 we briefly describe the data collection process for the 2015 data, and in Section 3 highlight the (limited) changes in the sample population between 2014 and 2015. Section 4 presents a comparison of energy usage between years and explores the origin of the variations observed. In Section 5, the draft energy ranking system is recalculated using the new, higher quality dataset and changes in energy scores are discussed. Section 6 contains a discussion of the purpose and actionability of benchmarking, along with planned next steps and conclusions.

2. Approach

A new, customized data request was issued to the seven institutional participants in the original study. The request was limited to utility usage data for calendar year 2015, plus a record of any major changes in building operations or occupancy that could significantly alter energy usage compared with the previous year.

Source energy usage was calculated from reported thermal and electrical energy data for each building in the same way as in the original study, i.e. using the standard Energy Star site-to-source conversion factors.

Follow-up questions were asked of institutions where significant differences were found between 2014 and 2015 energy usage data.

Building Name	Calendar Year 2015 Site Energy Usage					Any Important Changes to Building since 2014
	Electricity	Natural Gas	Chilled Water	Steam or Hot Water	Data Type	
	kWh	Therms	Ton-hours	klbs or MMBtu		

Figure 2: Data collection spreadsheet for 2015 data

3. Results: Demographics

Data were again received from all seven participating institutions and for almost all buildings represented in the 2014 dataset. The few minor differences between the dataset populations in 2014 and 2015 are summarized in Table 1 below.

Table 1: Changes in GRC lab building dataset population between 2014 and 2015

	Change in # buildings (2015 vs. 2014)			
Description of change	**Total**	**Fully metered**	**Allocated usage**	**Missing data**
2015 utility usage was not provided for a group of three buildings for which usage data were judged to be questionable.		-3		+3
Two buildings which share systems were treated separately in the 2014 dataset but were combined in the 2015 dataset.	-1	-1		
One newly renovated building was added to the dataset in 2015, but utility data were not used because a complete year of data is not yet available.	+1			+1
One building's metering situation improved and was included as fully metered data in 2015 (but had missing data in 2014).		+1		-1
Totals	**0**	**-3**	**0**	**+3**

The overall dataset populations are shown in Table 2 below.

Table 2: Summary of 2014 and 2015 GRC lab building dataset populations

Year	**2014**	**2015**
Total # bldgs	121	121
Fully metered	82	79
Allocated usage	32	32
Missing usage data	7	10

For comparison purposes, this report chiefly focuses on the 110 buildings for which energy usage data (metered or allocated) were submitted for *both* years.

4. Results: Energy Usage and Data Quality Improvements

Initial Comparison

An initial comparison of building source energy usage in 2014 and 2015 (Figure 3) reveals a distribution centered on approximately equal energy consumption for the two years; given the relatively small weather variations described above, this is in line with expectations. However, the distribution is relatively broad and displays long tails of buildings whose reported energy consumption varies significantly between 2014 and 2015. For approximately one third of the buildings in the sample, reported energy consumption differs by more than 10% between the two years.

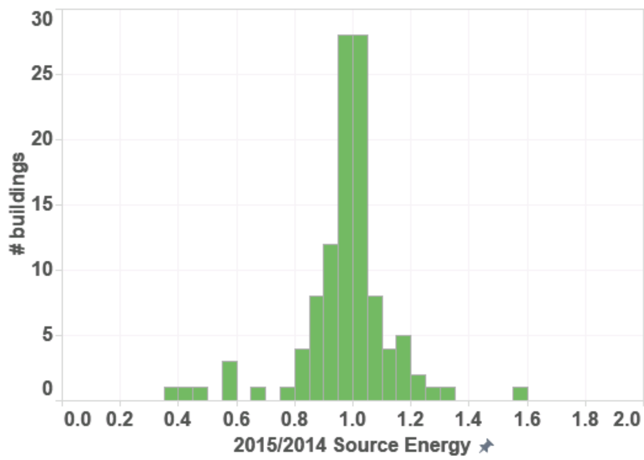


Figure 3: Distribution of ratio of source energy consumption (2015/2014)

This level of scatter between subsequent years was unexpected and is higher than can be explained by weather variations alone. Much of the work on the 2015 data was concerned with following up on the discrepancies to better understand their origins and to improve the integrity of the GRC dataset.

Follow-Up on Discrepancies

Buildings with significant discrepancies between years were flagged and follow-up questions were sent to the institutional representative for each affected building. In some cases, representatives were aware of data issues or major building renovation projects and reported these when submitting the 2015 data; in most cases of discrepancy, however, representatives were unaware of the issues before the follow-up questions were sent.

The discrepancies were found to have a variety of origins. A significant number of these related to data quality problems in the 2014 (or 2015) data; by themselves, these issues did not result in egregious overall energy consumption and were therefore not flagged in the 2014 data. Other reasons included renovation projects in progress and reported changes to experimental research schedules. The level of detail provided on these effects varied across the contributing institutions. The established reasons for discrepancies are summarized in Table 5 below as a function of lab type.

Table 3: Reasons for changes in energy usage between 2014 and 2015, sorted by lab building type

	Bio/Biochem	Chemistry	Physics/Eng	Other	Total
Error in 2014 data	14	1	2		17
Reported process change			5		5
Reported renovation project	1	1		1	3
No known changes	25	14	39	7	85
Total	40	16	46	8	110

As shown in the table, inaccurate energy usage data were provided and used for (at least) 15% of buildings in the original study.

Participants were asked about the origin of the data problems discovered. These included the following:

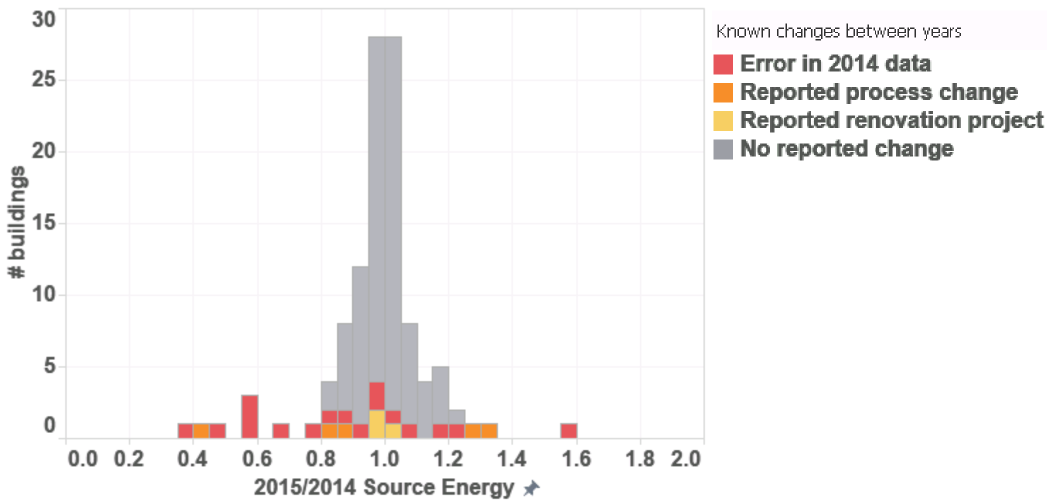
- Transposition of thermal and electrical data
- New metering installed since previous year
- Tenant energy usage data omitted in 2014
- Energy reporting system issues
- Other reasons not known or not reported.

Where discrepancies existed between 2014 and 2015, the focus of this study was on ensuring that the 2015 data were correct; correcting the full 2014 dataset was outside the scope of this work.

The collection of a second year of data was ultimately a highly valuable exercise which resulted in a greater level of confidence in the integrity of the 2015 dataset. The issues detected via the two-year comparison could not have been (and were not) identified with a single year of data without highly detailed auditing of the data submissions. It must be recognized, however, that additional data issues that do not manifest themselves as differences between years could still be present in the improved dataset.

Energy Consumption Differences Revisited

Revisiting the initial source energy comparison plot and flagging buildings with reported operational changes or data quality issues shows that the outliers seen in Figure 3 above are the result of known changes in data quality and/or building systems. The scatter in energy consumption between years is significantly smaller when these outliers (and allocated metering data) are removed from the sample (Figure 4): the ratio between 2015 and 2014 annual source energy consumption for fully metered buildings has a standard deviation of just 7% (versus 16% for the full sample).



	No known changes Metered	No known changes Allocated	All buildings
# buildings included	59	26	110
Median 2015/2014 ratio	0.99	1.01	0.99
StDev of 2015/2014 ratio	0.07	0.08	0.16

Figure 4: Distribution of source energy consumption ratio (2015/2014) with known changes highlighted

Breaking down the sample by building area (Figure 5) reveals that fractional energy use variations between years are typically greater for smaller buildings than for larger ones. This is in line with expectations: operational changes in individual labs within the building are more likely to average out for larger facilities.

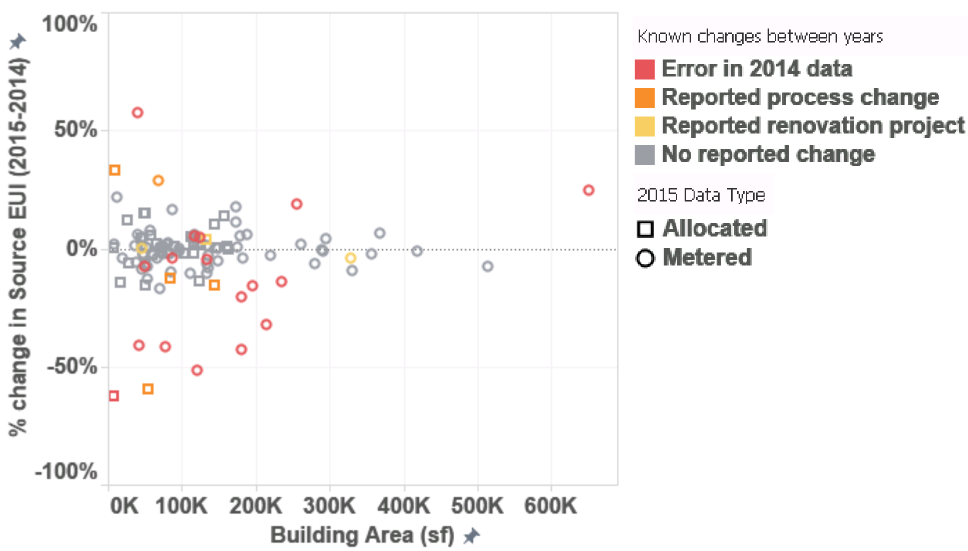


Figure 5: Percentage change in source energy consumption (2015-2014) vs. building area, with known changes highlighted

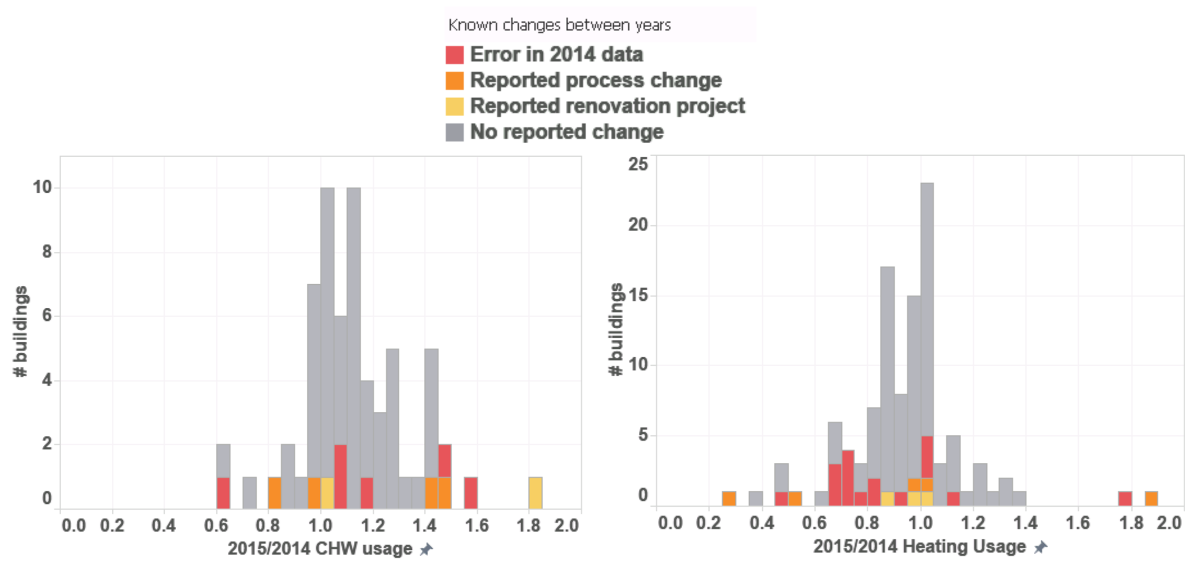
Including only the 85 buildings present in both samples for which no changes were reported in building operations or data quality, Table 4 below shows that there was no significant change in the overall energy intensity of the sample between years.

Table 4: Source EUI comparison 2014 vs. 2015, including only those buildings with no reported changes between years. All source EUI values are in kBtu/sf/yr.

	# of Buildings	2014 Average	2014 Median	2015 Average	2015 Median
Bio/Biochem	25	551	539	547	564
Chemistry	14	644	642	638	623
Physics/Eng	39	482	421	482	420
Other	7	656	594	691	588
Total	**85**	**543**	**529**	**544**	**544**

Weather Variations Revisited

The effect of weather variations on energy consumption can be assessed by examining heating and cooling energy consumption of buildings where these are available separately. For buildings with electric chillers, shifts in total electrical energy consumption are of course present but are expected to be fractionally smaller and were therefore not examined here. Comparisons of chilled water and hot water/steam consumption data are shown in Figure 6 below.



	No known changes Metered	Allocated	All bldgs with data
CHW: # buildings	31	20	63
CHW: median ratio 2015/2014	1.04	1.22	1.11
CHW: StDev of ratio	0.14	0.17	0.21

	No known changes Metered	Allocated	All bldgs with data
Heating: # buildings	57	26	108
Heating: median ratio 2015/2014	0.99	0.94	0.96
Heating: StDev of ratio	0.15	0.22	0.23

Figure 6: Distribution of ratios in chilled water usage (left) and heating source energy usage (right), with known changes highlighted

For both heating and cooling energy usage, the distributions in energy consumption ratio are narrower for the dataset including just buildings for which no known changes were reported (and are narrower still when only explicitly metered data are included). The median ratio between 2015 and 2014 cooling energy usage is 1.04 for fully metered buildings; for heating it is 0.99. In both cases, the data are consistent both with no change between years and with a change of the level expected due to weather variations.

With data for additional years (or monthly usage data, or data for different weather locations), the typical dependence of energy consumption on weather could be quantified and used as part of an energy score for lab buildings for locations or years other than those represented in the source dataset (as is done for Energy Star). Note that one of the major advantages of the GRC sample as a testbed for lab benchmarking is the (by design) relative absence of complications due to weather variations between sites.

5. Results: Energy Score Development

Note on Motivation

By assigning an energy score, we distill a building's energy performance into a single number (or letter) that can easily be tracked and communicated. The use of a regression analysis to develop the scoring system provides a means to compare a building not just with its immediate neighbors in parameter space but – because energy consumption depends in a somewhat predictable way on functional requirements – with the entire dataset of buildings. In this way, for example, buildings with few apparent peers in the dataset can still be assigned an energy score via extrapolation from the rest of the set. With a simple filtering system to look for near-match peer buildings, many buildings in sparsely populated areas of the space of functional requirements could extract little useful information from a benchmarking exercise; a regression-based energy score, however, can still be provided for these buildings.

Updating the Analysis

Because of the improved quality of the 2015 data, the regression analysis was repeated using the new dataset. As before, the analysis was limited to bio/biochem and chemistry buildings. The new analysis used the same independent variables as in the original report: % lab area (for bio/biochem buildings), % lab area (for chemistry buildings), weekly operating hours, and number of fume hoods per lab area.

The regression parameters from the two studies are compared in Table 5 below.

Table 5: Comparison of regression parameters for 2014 and 2015 datasets

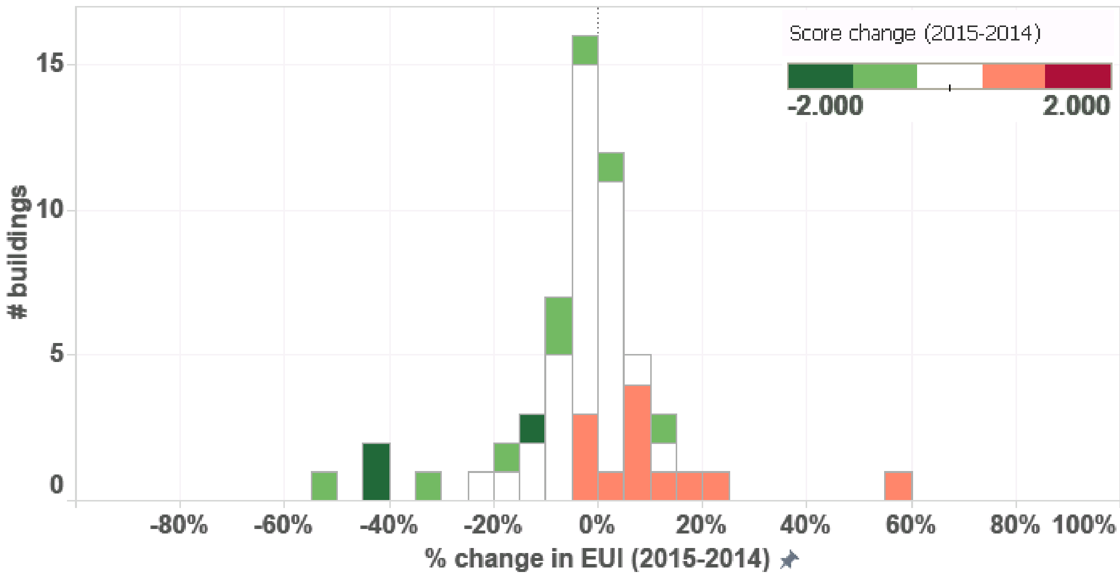
	2014			2015		
	Coefficient	**Stdev**	**Significant?**	**Coefficient**	**Stdev**	**Significant?**
% lab area (bio)	807	157	Yes	397	136	Yes
% lab area (chem)	800	190	Yes	551	168	Yes
Weekly operating hours	-1.8	1.4	No	0.5	1.3	No
Fume hoods/lab sf	45,494	48,900	No	21,166	41,763	No
Constant	380	159	Yes	305	139	Yes
R^2 (EUI)	**38%**			**27%**		
R^2 (source energy)	**79%**			**82%**		

Although the quality of data has undoubtedly increased, the R^2 value for the multilinear fit to energy use intensity has decreased slightly. The quality of fit is still in line with those used for Energy Star rankings of major building categories.

A notable change in regression parameters between the two years relates to the % lab area coefficient for bio/biochem and chemistry buildings. A significant fraction (35%) of bio/biochem buildings were found to have suffered data quality issues in 2014, and so a significant change in the regression results was anticipated for at least this lab type. In 2014 the two lab area % regression coefficients were nearly equal, while the 2015 regression results in a larger coefficient for the % chemistry lab area. The 2015 result is in line with expectations given the higher typical energy density of chemistry lab space versus biology space. (Note, however, that this assessment is complicated by the presence of fume hood density as an independent variable in the regression.)

Energy scores were assigned to each building as before, i.e. scores were assigned based on a quartile ranking of fractional regression residuals. Approximately 60% of the buildings (33 of 56) were assigned the same score in both years. Of the 23 buildings whose score changed, 10 were those known to have experienced operational changes or previous data issues. Where scores changed, almost all changed by a single quartile point; the three buildings whose rankings changed by two points were all buildings with data quality problems in 2014.

Figure 7 below shows that many of the score changes were experienced by buildings whose reported energy usage changed significantly between years.



Score change	Change or error reported	No known changes	Total
-2	3		3
-1	3	5	8
0	6	27	33
1	5	7	12
Total	17	39	56

Figure 7: Draft energy score changes sorted by % change in building source EUI between 2014 and 2015. Score decrease (green points) indicates apparent improvement in performance.

Because the new scoring system was constructed using the improved 2015 dataset, it is recommended that the new draft scores are used in place of the scores developed using the 2014 data.

Note on Alternative Statistical Analyses

While the present approach to building scoring (multilinear regression with quartile rankings based on the distribution of regression residuals) is attractive for its simplicity and because it follows the well-established procedure used by the EPA to construct Energy Star ratings, it is certainly not the only scoring methodology in use or with potential to inform building owners about energy performance.

The UK's Display Energy Certificate system uses a simpler approach: this system ranks buildings based on the percentage deviation of EUI from a standard value per building type (with the infrequently used option to exclude special process energy consumption from the analysis[1]). By avoiding the use of residual distributions, this system does not attempt to "grade on a curve" and focuses more directly and simply on energy consumption.

On the more complex side, other types of statistical analysis may provide a more direct route to a quartile ranking system: it is possible to fit directly to quantile band cutoffs, eliminating the intermediate linear regression step used here. This process is attractive because it is less influenced by outlier buildings in the population and because it directly provides the metrics of interest as well as their associated levels of statistical uncertainty. A disadvantage is that the approach is less familiar and less transparent to users.

In any system of public rankings, the details of the scoring system matter and will often become the subject of focus where building owners feel that a score does not fairly represent a building's true functional requirements, limitations, or the owner's energy efficiency efforts. The ranking method, however, is just one piece of a broader equation: efforts such as this should also focus on the capacity of benchmarking exercises and energy rankings to effect change.

[1] Bruhns et al., 2011, CIBSE Review of Energy Benchmarks for Display Energy Certificates – Analysis of DEC Results to Date

6. Discussion: Taking Action

Broadly defined, benchmarking (in any context) seeks to provide insight via a comparison against one's past self or with others. Benchmarking shows us where we stand; it provides a yardstick against which to gauge progress; and it can, sometimes, show us what is possible. However, without follow-up efforts, benchmarking exercises are not effective drivers of change. In this section we address (in outline) the actionability of the GRC lab benchmarking study.

The Original Goal

The GRC lab benchmarking study was primarily designed to address the group's concerns relating to the public disclosure of lab energy use data in the Boston area. To recap: when viewed as a group, and in the absence of any established way to objectively rank lab building energy usage (in the US), Boston's labs appear profligate relative to other building types. Relatedly, lab buildings are often granted a "free pass" for high energy consumption because they are perceived as challenging, unassailable targets for efficiency initiatives.

Perhaps ironically, it is lab buildings' high internal diversity relative to that of other building categories that leads to difficulties comparing like with like and therefore to the monolithic view of lab buildings as unavoidable energy hogs. By dividing the Boston dataset based on broadly defined functional requirements and developing a draft energy ranking system for some of the buildings in the sample, the GRC lab benchmarking study showed that it is feasible to identify buildings on the high- and low-efficiency ends of the lab building spectrum. The study advised that it would therefore be unreasonable for any ordinance to uniformly penalize lab facilities for high absolute energy consumption. In illustrating this point, and in demonstrating that the overall energy consumption of lab buildings in the Boston area is in line with that of labs in the rest of the country, the study met its original goals.

Actionable Insights from the GRC Dataset

While the original study was not designed to produce directly actionable recommendations, its results can be used both directly and indirectly to guide energy efficiency efforts at the participating universities.

With limited availability of time and attention on the part of building owners (or their sustainability departments), buildings receiving low draft efficiency rankings are promising targets for follow-up investigation. Figure 8 below shows an example of a possible selection process for further study: the circled buildings are those with both high overall energy consumption *and* high energy intensity relative to buildings with similar functional requirements. Because these buildings have the potential for high fractional and absolute energy savings, they are excellent candidates to receive energy audits.

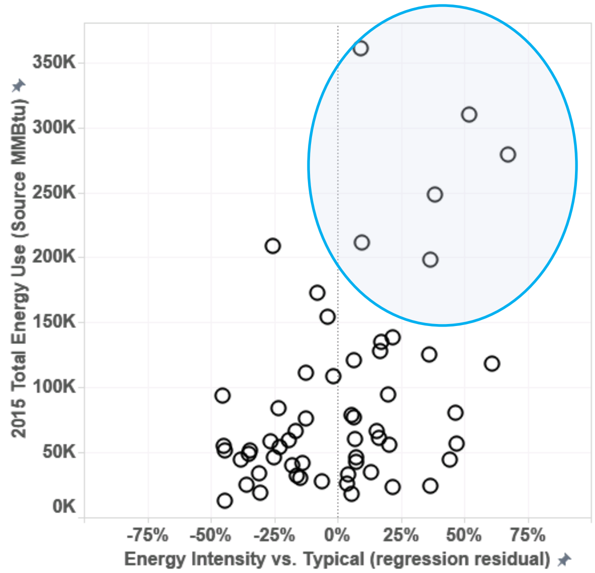


Figure 8: Total source energy use vs regression residual for all bio/biochem and chemistry buildings in the sample with energy scores. Promising audit candidates are circled (in blue).

The GRC dataset also contains some specific actionable insights at the system level. For example, Figure 9 below is the same as Figure 8 except that the circled buildings are now those with high overall energy consumption *and* high energy intensity relative to their peers *and* modern digital HVAC control systems *and* no night airflow setback in lab spaces. Night airflow setback should in principle be feasible for such buildings, and so those currently without it are good follow-up candidates for the implementation of night airflow setback controls.

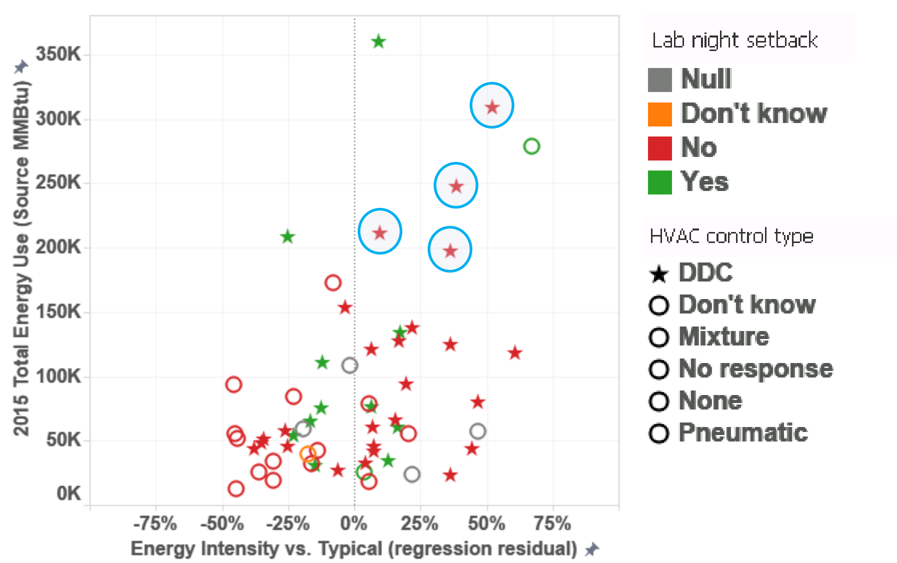


Figure 9: Energy use vs. regression residual, with candidates for lab night airflow setback circled in blue.

Non-Energy Metrics

Another source of actionable insights is the comparison of operational parameters between buildings or institutions, i.e. benchmarking using metrics other than energy consumption. Examples include HVAC control strategies, minimum air change rates, or space usage metrics; some of these were collected as part of the GRC effort, but for many buildings these data were not provided and so the study reports have not thus far explored these metrics in detail.

An institution discovering, for example, that its campus standard minimum lab ventilation rate is higher than all others in the group might be motivated to explore the reasons for its current policies with a view to reducing minimum ventilation rates while following consensus safety standards. This type of comparison can be particularly helpful when approaching institutional lab safety policies, e.g. fume hood minimum face velocities. By taking advantage of shared data that demonstrate industry norms, individual institutions can avoid beginning their own efficiency efforts from scratch. The GRC group has a distinct advantage over most fully anonymous benchmarking datasets: while only anonymized data has thus far been shared among the group, members have a ready-made venue to openly discuss issues raised in the benchmarking exercise and to share strategies for success. Again, it is in the follow-up discussions rather than in the benchmarking exercise itself that progress is made.

Allowing participants to explore and filter the dataset to identify close matches in building function and system type could also lead to useful insights if corresponding building staff are then also paired for discussions of operational and efficiency strategies (“benchmarking speed dating”).

The Purpose and Limitations of Energy Benchmarking

Energy benchmarking is the first, but certainly not the only, step in an energy efficiency program. Whether public or private, benchmarking comparisons and energy rankings help to focus and direct attention; they also provide useful metrics against which to gauge progress. Arguably the most useful function of any benchmarking exercise, however, is as a catalyst for conversation on the drivers behind the energy consumption of any given building. In this capacity, the precision of the energy comparison is of limited importance – a useful feature when data quality problems affect even studies with the most dedicated participants. For lab facilities, which have diverse and complex functional requirements, the investigation of energy drivers is a critical part of any energy assessment: understanding the true needs of a lab facility may be half the battle in the pursuit of efficiency gains.

Energy benchmarking says little to nothing about the technical feasibility or cost of potential efficiency projects, and may not provide precise estimates of savings potential. As a high-level exercise to direct attention and stimulate investigations, however, benchmarking is a valuable, economical, accessible, and quickly employed tool. Benchmarking results (energy usage, rankings, system-level comparisons, space-usage metrics, and operational metrics) should be used in concert with other resources such as case studies and energy audit reports to build a comprehensive efficiency action plan.

Next Steps for the GRC Study

The GRC study’s final phase of data collection will involve the request and processing of energy usage data for calendar year 2016; following the present efforts to improve data quality, it is hoped that the analysis of the 2016 data will show stabilization of energy data and rankings. Optional additional efforts for the final year include filling some of the remaining gaps in building system properties to allow better comparisons of hardware and operations across buildings, or assembling data on other parameters such as fume hood face velocity policies, space utilization, water usage, or a more detailed classification of laboratory type and function. The participating institutions are invited to direct the focus of the final GRC lab benchmarking report.