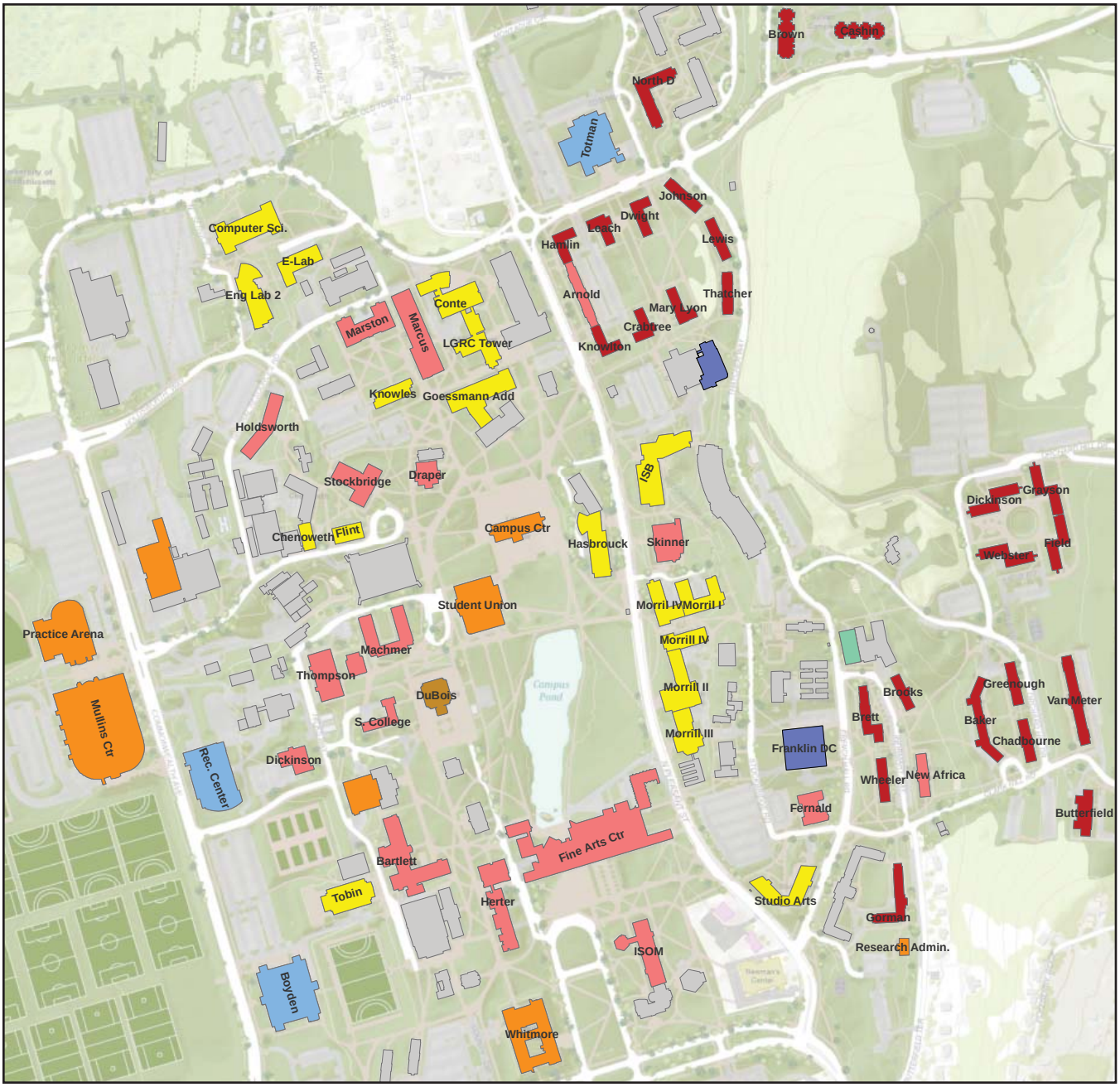
Measuring, Managing and Visualizing Building Energy Consumption & Carbon Emissions: Benchmarking at the University of Massachusetts Amherst



Measuring, Managing and Visualizing Building Energy Consumption & Carbon Emissions

Benchmarking at the University of Massachusetts Amherst

Masters Practicum Paper by

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Thanks!

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Introduction

"You can't manage what you don't measure."

How much energy do the buildings at the University of Massachusetts Amherst (UMA) consume? The answer to this question is of interest to those tracking energy efficiency and greenhouse gas emissions, those paying utility bills, those studying building performance and perhaps to occupants of buildings themselves. Answering this question is complicated and time-consuming because data on building-level energy consumption are not collected and reported in a consistent manner, in a central place, or often not collected at all. "Benchmarking", or measuring for the purposes of comparison, provides valuable information about building energy consumption and performance, and most importantly, carbon emissions.

UMA is committed to addressing climate change, and has established a carbon dioxide equivalent (CO_2E) emissions reduction goal. Because buildings (both their construction and operation) consume 40% of all energy, 72% of all electricity, and emit 39% of all CO_2E (USGBC) UMA's climate change mitigation strategy must address buildings. Having good data on energy consumption at the building level will allow UMA to make better strategic decisions about where to make the necessary energy savings, and to prove that the interventions have worked. Currently UMA reports data on campus-level energy consumption, costs and carbon emissions. UMA should also have a tool to benchmark its buildings' energy consumption and carbon emissions with interpretation designed for various campus stakeholder groups (students, the Sustainability Manager, Campus Planning, Physical Plant, Facilities Planning, etc.) to make the task of addressing building-level energy consumption easier.

The goal of this project was to establish a benchmarking methodology and tool to automate the tasks of measuring, managing and visualizing building-level energy data. This project concludes with a 3-year energy and carbon emissions comparison for all metered buildings (which amounts to 88% of the gross square footage of campus), a spreadsheet template to more easily do this work in an ongoing way, and several sample benchmarking reports. Designing a way to automate these tasks proved too difficult for the scope of this practicum project. However, it is possible to automate these processes in the near future because most of the necessary data exists on *Metasys*, the campus building automation software designed and installed in 2008 by Johnson Controls Inc., the company contracted by UMA to execute building energy efficiency measures. Metasys displays real-time outputs from every building utility meter and sensor (i.e.

chilled and hot water flow rates, occupancy sensors, lighting, dampers, temperature and humidity readings, etc.) With the aid of a computer programmer, the automation part of this tool could be achieved.

Energy, CO_2E emissions and Growth at UMA

383 buildings on the UMA campus equate to 10.7 million gross square feet (sf) accommodating 30,000 people: 84% students, 16% faculty & staff. Over the next 4-8 years UMA will grow by 17% to 12.7 million sf with an additional 4,000 students, faculty and staff. (UMass Amherst Campus Planning Division, 2012)

The Sustainability Manager, Ezra Small, recently wrote an update to the University's Climate Action Plan, *A Vision for 2020 & Roadmap towards Carbon Neutrality*, stating,

> "The Commonwealth of Massachusetts' Executive Order 484 "Leading by Example-Clean Energy and Efficient Buildings" mandates that by 2020 all state agencies must reduce overall emissions by 40%, reduce energy consumption of their buildings by 35%, and must obtain 30% electricity from renewable energy....The particular challenge that this mandate places before us is that the University expects to add almost 2 million square feet of state-of-the-art laboratories, residence halls, and learning spaces as well as enrolling an additional 3,000 students and hiring almost 1,000 new staff over the next 4-8 years. (EPAC, 2012)

This graph illustrates the dichotomous trajectories of campus emissions and growth goals:

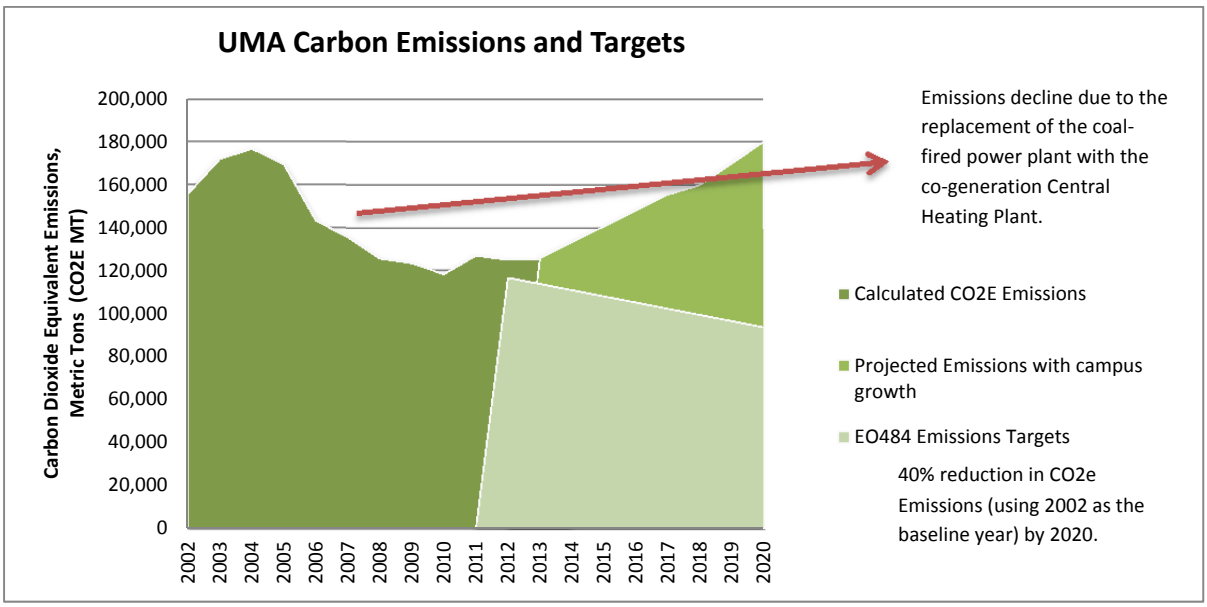


Figure 1. UMA Carbon Emissions and Targets

If UMA can decrease energy consumption in buildings by 35%, it will also achieve a 35% emissions reduction goal. The remaining 5% will need to come from other interventions such as renewable energy.

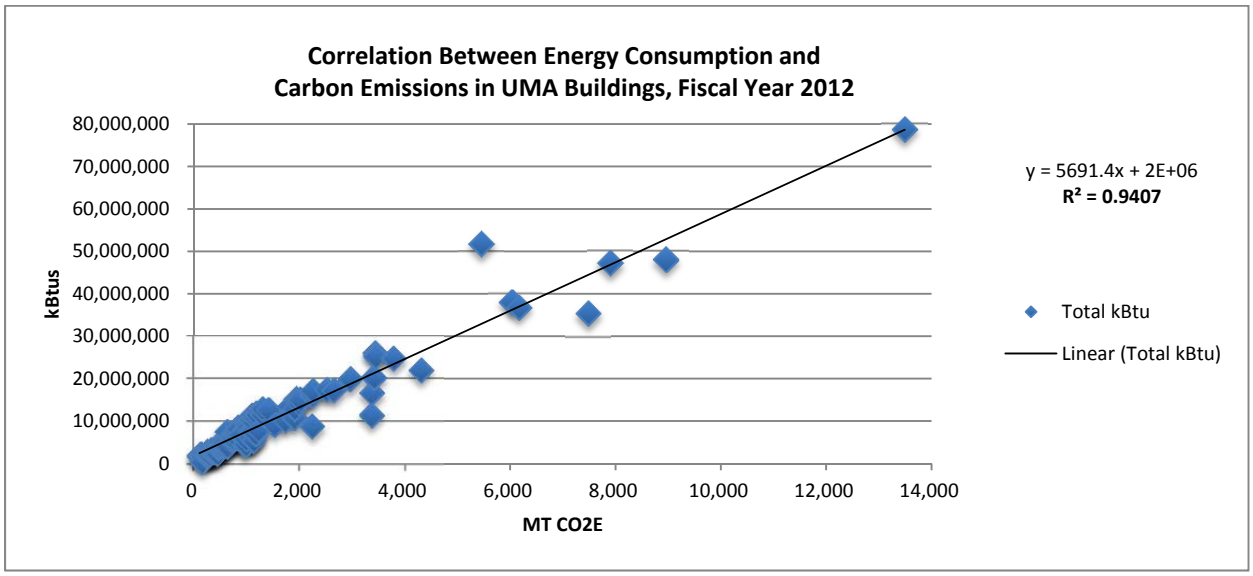


Figure 2. Correlation between Energy Consumption and Carbon Emissions is high, with an R^2 value of 0.94
Graph created from FY2012 UMA Benchmarking data

Benchmarking the energy consumption and carbon emissions of campus buildings is an important step in any strategy to reach energy and carbon reduction goals.

Existing Benchmarking Initiatives

The 2012 United Nations Conference on Sustainable Development, Rio+20, had a stated objective of doubling the global rate of energy efficiency by 2030. Addressing building energy consumption will play an important role in achieving this goal.

> "Energy use by buildings offers a tremendous opportunity for governments seeking to foster clean energy technologies. Sustainability-minded policymakers should focus on three interlinked policy approaches: 1) energy policy that favors energy efficiency and distributed renewable energy sources, 2) climate policy that recognizes and internalizes the cost of carbon pollution; and 3) standards and performance criteria for the building envelope and the building components." (Rio+20, 2012)

The UN's specific building initiative, titled *Driving Transformation to Energy Efficient Buildings, Policies and Actions*, outlines six policy categories which will help bring about these changes, including better building codes; energy improvement targets; awareness; incentives;

utility programs; and human and technical capacity building. The category most relevant to benchmarking is the awareness category:

> "Policies that increase awareness, information and market transparency, like competitions, audits, ratings and certifications**, energy performance disclosure**, and public awareness campaigns." (Rio+20, 2012)

The US Green Building Council and Johnson Controls are two of the four organizations creating this building initiative. According to the report, both "data collection and baseline development" and "building energy performance disclosure" are not properly supported by policy.

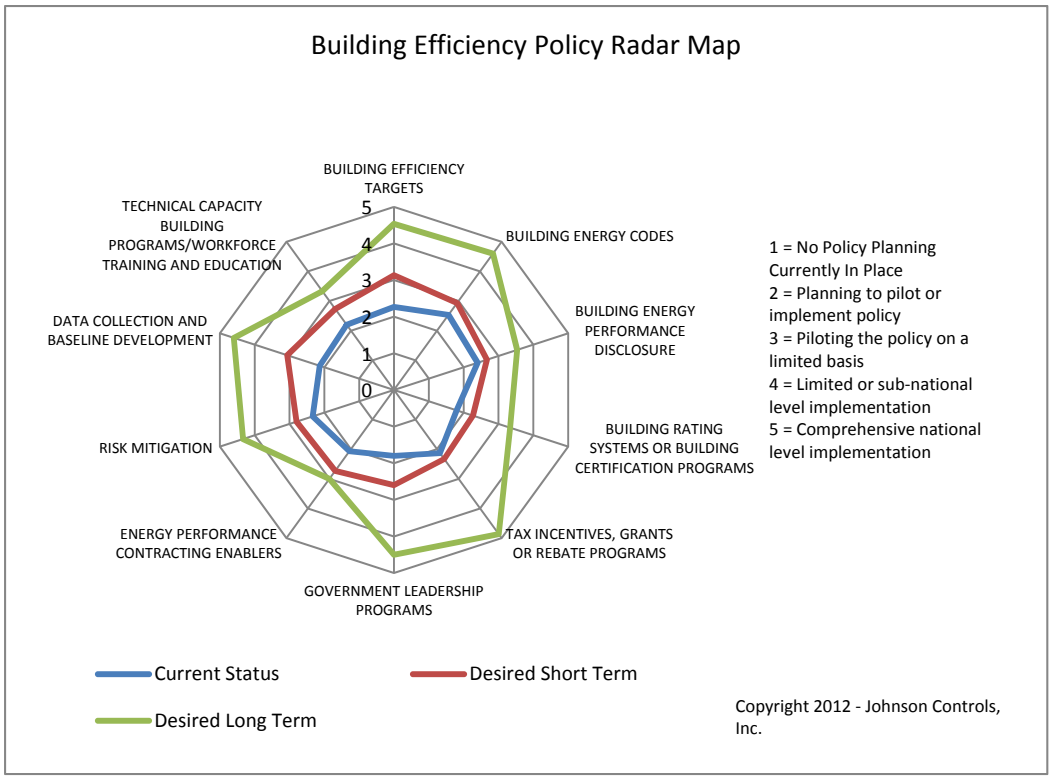


Figure 3. Building Efficiency Policy Radar Map (Rio+20, 2012)

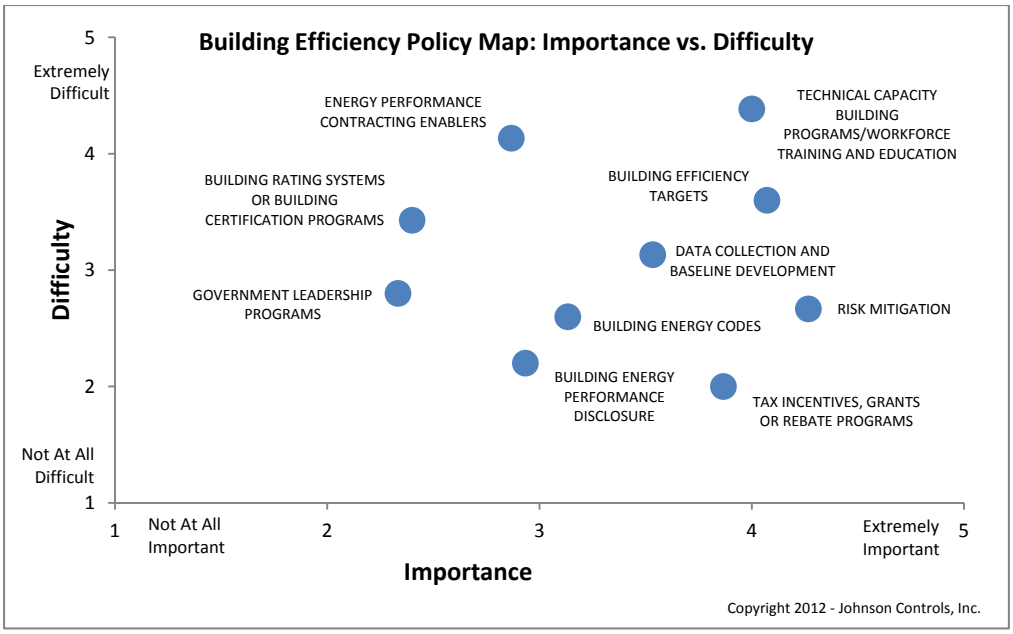


Figure 4. Building Efficiency Policy Map: Importance vs. Difficulty (Rio+20, 2012)

In the US, progressive city mayors are taking the policy lead regarding building energy consumption. Benchmarking has become law in New York City, Washington D.C., Seattle, San Francisco, Austin and may soon be required in Boston as part of the city's Climate Action Plan. (Boston Green Ribbon Commission, 2012)

The largest single effort is in New York City. The *Greener, Greater Buildings Plan*, specifically Local Law 84, requires public buildings over 10,000 square feet (sf), and private buildings over 50,000 sf to benchmark their energy usage. (Future reports will include other types and sizes of buildings.) Benchmarking is one of many strategies being implemented in the city to meet its goal of a 30% reduction in greenhouse gas emissions by 2017. The city expects 45% of these reductions to come from buildings. (PlaNYC, 2011)

In addition to learning which buildings are performing poorly, there is an expectation that making building energy scores public in and of itself will motivate building operators to improve energy efficiency.

> "Energy reporting mandates pick up where codes leave off. While energy codes mandate increasingly stringent levels of energy efficiency in new buildings and major renovations, they don't address existing buildings that are not otherwise being renovated, they don't ensure that the properties are managed for efficiency, and they don't encourage performance beyond the code minimum." (Malin et al., 2012)

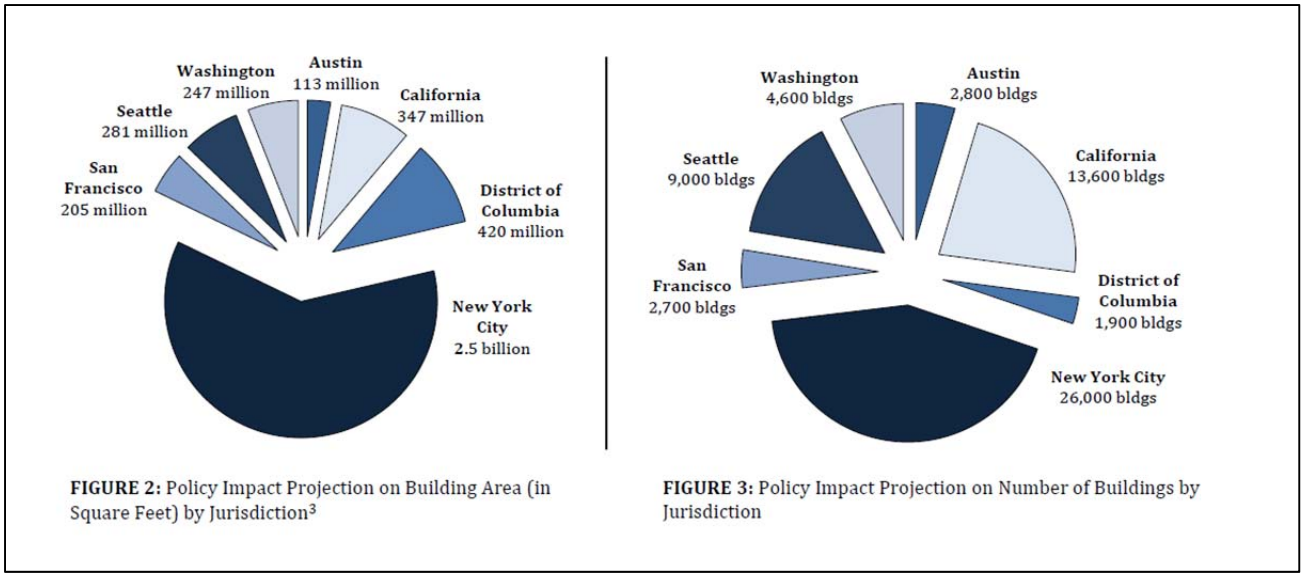


Figure 5. Impact of Building Benchmarking Policy in the United States (IMT, 2012)

The hope is that the market will drive energy efficiency through tenants deciding to rent space from a building with lower utility bills, or the motivation of bragging rights for building owners.

Building operators are often uncomfortable with these new energy disclosure laws. Not only are they seen as burdensome (Agrion, 2012), but there is concern over the fairness of the results. In Philadelphia, the president of the Building Owners and Managers Association protested against the city's energy benchmarking reporting laws explaining that a building owner could be unfairly judged due to a tenant's energy intensive behavior. (Malin et al., 2012)

The EPA (co-creators of the industry standard benchmarking tool and database: ENERGY STAR Portfolio Manager) claims building benchmarking has saved energy. The program database is quite large, now containing more than 250,000 buildings – an estimated 40% of the US commercial building market. (ENERGY STAR, 2012)

> "Over 35,000 buildings entered complete energy data in Portfolio Manager and received ENERGY STAR scores for 2008 through 2011, which represents three years of change from a 2008 baseline. These buildings realized savings every year....Their average annual savings is 2.4%, with a total savings of 7% and score increase of 6 points over the period of analysis." (ENERGY STAR, 2012)

Over 70% of buildings showed a reduction in energy consumption, with buildings in the retail, office and K-12 schools showing the greatest improvements.

> "If all buildings in the U.S. followed a similar trend, over 18 million metric tons of of CO_2E could be saved each year. Through 2020, the total savings could be approximately 25%." (ENERGY STAR, 2012)

Laws vary about how, when and to whom these data must be disclosed. NYC's project is precedent- setting both in scope (2,730 buildings thus far) and that the data have to be publically disclosed. In Seattle, Austin, California and Washington State, benchmarking data need only be shared during real-estate transactions (with buyers and whole building tenants). Trends are beginning to change. California will require public disclosure on commercial buildings over 50,000 sf starting in 2013 once privacy issues around the energy data are resolved. (Buonicore, 2010)

Additional initiatives that encourage energy efficiency through benchmarking include the Department of Energy's Better Buildings Challenge, launched in December of 2011, which seeks a 20% reduction in energy use in buildings by 2020. Thus far 100 organizations representing almost 2 billion sf have signed onto the program. Architecture 2030, an organization supported by several major US cities, the AIA, and the USGBC seeks carbon neutrality by 2030. An area of Seattle calling itself the *Seattle 2030 District* (25 million sf of the city) responded to the Architecture 2030 initiative by seeking energy efficiencies through district heating and cooling, heat recovery and renewable power generation. Site and source EUIs of buildings within this district are benchmarked and shared publicly through dashboards. The energy targets are a bit more modest with a 50-60% reduction in energy and water by 2030. Pittsburgh and Cleveland also have 2030 districts. The 2030 challenge has not had larger success in large part because of the challenges in tracking energy data and policies against public disclosure of these data. (Melton, 2012)

Honest Buildings is an emerging online network and database of 475,000 buildings from Texas, San Francisco, DC and NYC which share their green building status and data. Unfortunately, this data is not publicly available.

Benchmarking at other college campuses

Currently, the only sustainability rating system for college campuses, *The Sustainability Tracking, Assessment & Rating System* or STARS, run by the Association of the Advancement of Sustainability in Higher Education does not require individual building benchmarking, only aggregated energy and carbon emissions data for the entire campus.

The industry standard benchmarking tool is ENERGY STAR Portfolio Manager, an online program developed by the EPA and DOE. Portfolio Manager allows input of annual building utility data and generates an ENERGY STAR score based on the building's performance relative to the national average for the building type (retail, K-12 schools, food service, office building, etc.). The national median for a building type is determined by the *Commercial Building Energy Consumption Survey* (CBECS) database –also developed by the DOE. Unfortunately, there are not enough college and university buildings in this database to determine EUI averages for higher ed. buildings.

As a result, it is unclear how many other college campuses have benchmarked their buildings' energy consumption. While working on a different building energy project for Facilities Planning here at UMA, I contacted several campuses that have a studio arts building similar to our own, to compare energy usage intensities. Of the handful of schools I contacted, only two were able to report to me how their studio arts buildings were performing. In some instances the building wasn't metered, in others the meter readings weren't accurate enough to share.

Additionally, for this practicum project, I contacted several schools inquiring as to whether they had a benchmarking program. I suspect the response I received from Peter Cooper, Manager of Sustainable Engineering & Utility Planning at the Massachusetts Institute of Technology, is indicative of the current campus situation:

> "Previous attempts at benchmarking to the outside world have not been very successful. For instance DOE's Portfolio Manager or CBECS building database are mostly about commercial office buildings. Only a very small portion of our academic buildings look like these. The Lab21 benchmarking tool seems to be much more sophisticated and useful. We have accessed it for some specific purposes but not adopted it wholesale. Even comparisons to other universities has difficulties around whether there is district energy systems serving the building or stand-alone. Variations on electricity and chilled water production can skew performance indicators by a factor of up to 3X.
>
> We have found it most useful to benchmark against ourselves. We have over 130 buildings, which is a pretty good population. For many years we have created an annual cost distribution report which tallies annual use of each utility for each building. From that it is easy to calculate site and source energy use indices. We rank by energy intensity to prioritize our energy efficiency focus.
>
> Recently we have constructed two excellent buildings. One is offices and classrooms for the Sloan School of Management and the other is a cancer research lab building. Their energy use models are 46% and 35% below code

respectively. We plan to use these for benchmarking our other similar buildings." (personal email from Peter Cooper)

The Value of Benchmarking for UMA

Benchmarking can help decision makers determine where UMA should begin its building-related emissions and energy reduction work because it makes clear which buildings are the most energy intensive within any given category, and which buildings have had unusual changes in energy consumption year to year (or month to month, day to day, etc.). The most useful aspect of benchmarking is that it creates a baseline from which to measure change over time, either positive or negative, as the result of occupant behavior, building programming changes, or mechanical malfunction.

The Building Benchmarking Process

The most common metric in benchmarking is Energy Usage Intensity (EUI), the total energy consumed (in thousand British Thermal Units, kBtus) per building divided by the gross square footage. EUI numbers can be benchmarked to demonstrate a building's energy performance compared to similar buildings, a national average, or itself over time. The industry standard benchmarking tool is ENERGY STAR Portfolio Manager which uses the *Commercial Building Energy Consumption Survey* (CBECS) database –also developed by the DOE. The goal of the CBECS survey program was to publish results every four years, but the lastest available data are from 2003. The 2007 data were not released because they were not deemed statistically reliable, and the 2011 data were not released because of federal budget cuts to the program. (Roberts, 2011) Regardless, it is still the benchmarking standard.

The NYC benchmarking project results were graphed (Figure 6) such that buildings were ranked by EUI and color-coded based on whether the building performed worse (red) or better (green) than the national average.

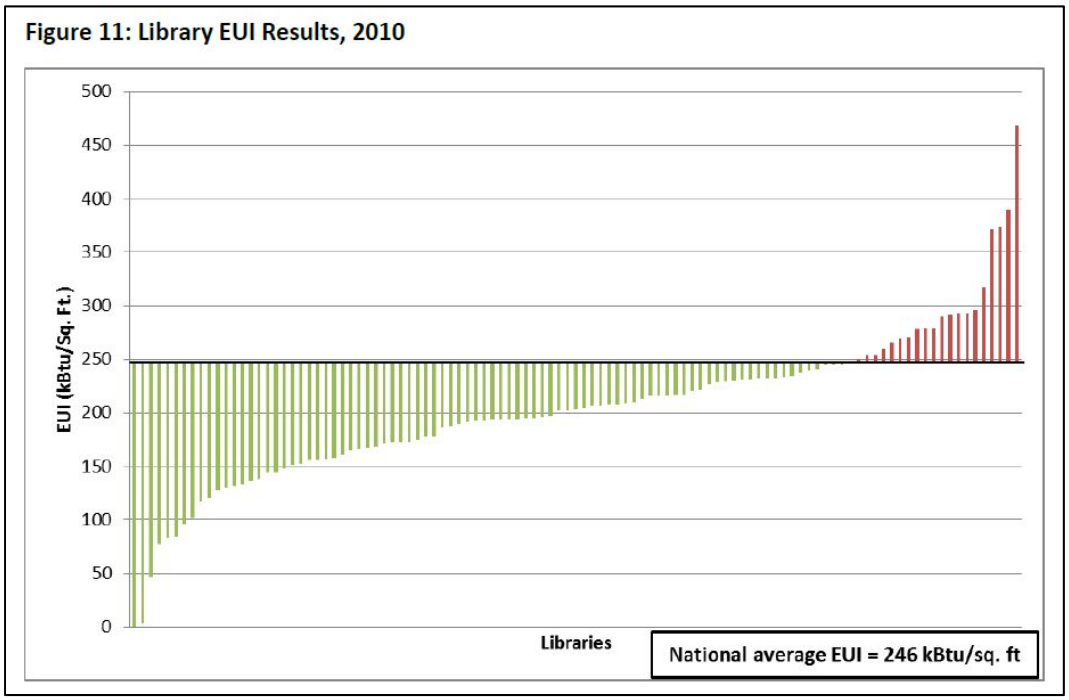


Figure 6. NYC Benchmarked Offices (PlaNYC, 2011)

CBECS does not have enough data to provide median energy scores for all commercial building types and unfortunately, higher education buildings are one such category therefore its scores are of limited value to UMA. However, UMA has the advantage of being large enough that it can benchmark against itself. There are enough buildings within most categories (administrative, residential, academic, dining, etc.) to make meaningful comparisons. UMA also has the advantage of having data on weather, occupancy, meals served in the dining halls, academic expertise on building science and architecture, a knowledgeable energy engineering staff, and graduate students eager to tackle projects which will improve the sustainability of campus. UMA has all the tools required to create meaningful internal benchmarks.

Project Description

All UMA buildings run on electricity and steam which together power the heating and cooling systems, mechanical ventilation systems, lights, heat water, and power the various equipment required for the mission of teaching and learning. To know how much steam and electricity is consumed per building requires building-level energy meters. Not all UMA buildings are metered. Not all metered buildings are metered completely (many have electricity meters only), and many buildings share meters. Additionally, although the raw data from these energy meters exists on Metasys, the current method of reporting energy consumption is for two staff members to take responsibility for steam and electricity separately. This has resulted in two completely distinct spreadsheets, using different building names and numbers that are challenging to combine. Chilled water data is not consistently metered so in several cases is not accounted for at all. Simply put, the data sets are incomplete, disparate and difficult to combine. Similarly, determining CO_2E emissions per building first requires an accurate measure of energy consumed per building. Calculations can then be made about emissions based on energy type.

A fellow graduate student, Zac Bloom, took a first pass at energy benchmarking at UMA using steam and electrical data from fiscal year 2011 (FY11, July 2010 – June 2011). He visualized the data and made a compelling presentation about how UMA buildings are performing. This project builds on that work, aiming to establish a methodology and ultimately a tool to automate calculating building energy usage and carbon emissions combining all energy sources, and normalizing for weather and occupancy.

Methods

A. Gathering Data on Electricity and Steam

Steam is the main energy source than runs the UMA campus. It is all generated at the Central Heating Plant (CHP) using oil and natural gas and a bit of electricity to run the steam turbines. Electricity is generated as a byproduct of the steam making process. Approximately 72% of the campus' electricity needs are generated at CHP with the remainder purchased from the Western Massachusetts Electric Company. Figure 7 illustrates the design of the CHP:

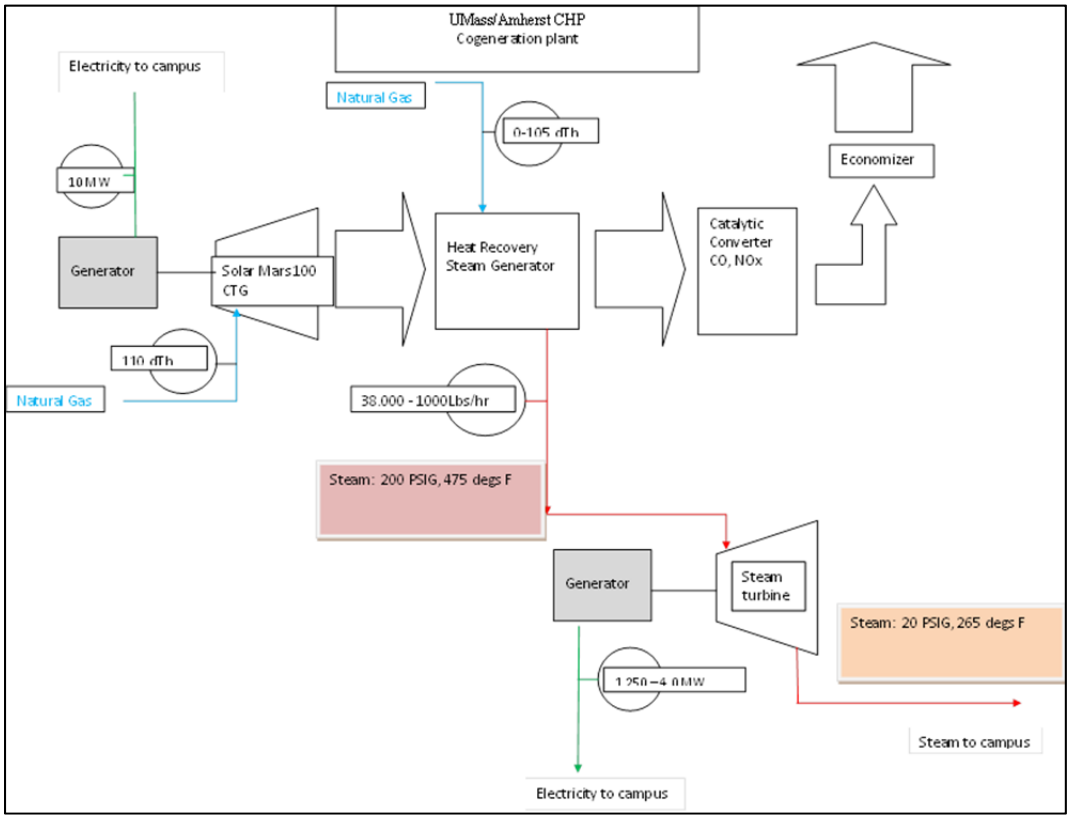


Figure 7. Central Heating Plant Diagram (UMA Physical Plant)

Meters for both electricity and steam exist on all larger campus buildings. Raw data from the electricity meters are gathered on the "PowerLogic" server (Schneider Electric metering software). Building-level kWhs are reported by Physical Plant staff on an Excel spreadsheet, on a monthly and annual basis. The raw data from steam meters exist on Metasys, the campus wide building automation software installed in 2008. Building-level steam usage, calculated in pounds, is reported by Physical Plant staff on a separate Excel spreadsheet on a monthly and annual basis.

Since the existing steam and electricity spreadsheets use different naming and numbering conventions, the first step in this project was to create a master Excel spreadsheet using official UMA building names, numbers and gross square footage. Two tabs were created to replace the steam and electricity spreadsheets. Aggregated data (when buildings shared a meter) was divided based on square footage proportions. A third tab was created for chilled water for the eleven buildings which make use of external unmetered chillers.

The calculation to determine the energy required (again, either electricity or steam) to chill water for these buildings was to first determine ton-hours (from 3 data points on Metasys: chilled water flow-rate; chilled water supply temperature; chilled water return temperature), then convert the ton-hours into kWh or lbs of steam, depending on the type of chiller equipment used. This formula was used:

> Ton-hours (at each 15 minute meter reading) = Flow Rate * 60 * 8.34 * (Return Temperature – Supply Temperature) / 12000
> Monthly ton-hours = Monthly average ton-hour * number of hours in the month

A few buildings were missing from the steam spreadsheets (South College and Mullins Memorial Center), so additional Excel tabs were made for these buildings and the raw data (pounds of steam) was extracted from Metatsys.

A final combined/total energy tab is automatically populated with data from the electricity, steam and chilled water tabs.

B. Converting Energy to a Common Unit

1 lb steam	1 ton-hour chilled water * 18
1 kWh electricity	1 ton-hour chilled water * 0.7
1 lb steam	1.194 kBtus
1 kWh electricity	3.413 kBtus

Figure 8. Calculations to convert to a common energy unit

The combined/total tab pulls in the electricity, steam and chiller data and converts kWhs, lbs of steam, and ton-hours of chilled water into a common energy unit – kBtus. (Note: 8/11 external chillers use both electricity and steam, the remaining 3 are 100% electricity.)

Final Benchmarked Building Set

The result was a complete energy picture for 100 campus buildings, representing 84% of the gross square footage (8,976,233 sf /10,700,000 sf) because all larger campus buildings have been metered. The energy consumption of this set of benchmarked buildings accounts for 80% of the total campus electricity produced or purchased, and 63% of its steam production. The remainder of the electricity and steam are used in non-benchmarked buildings; non-building uses (i.e. street-lights) or is lost in transmission or not used. (See graphics, including maps in the Appendix)

C. Normalizing for Weather

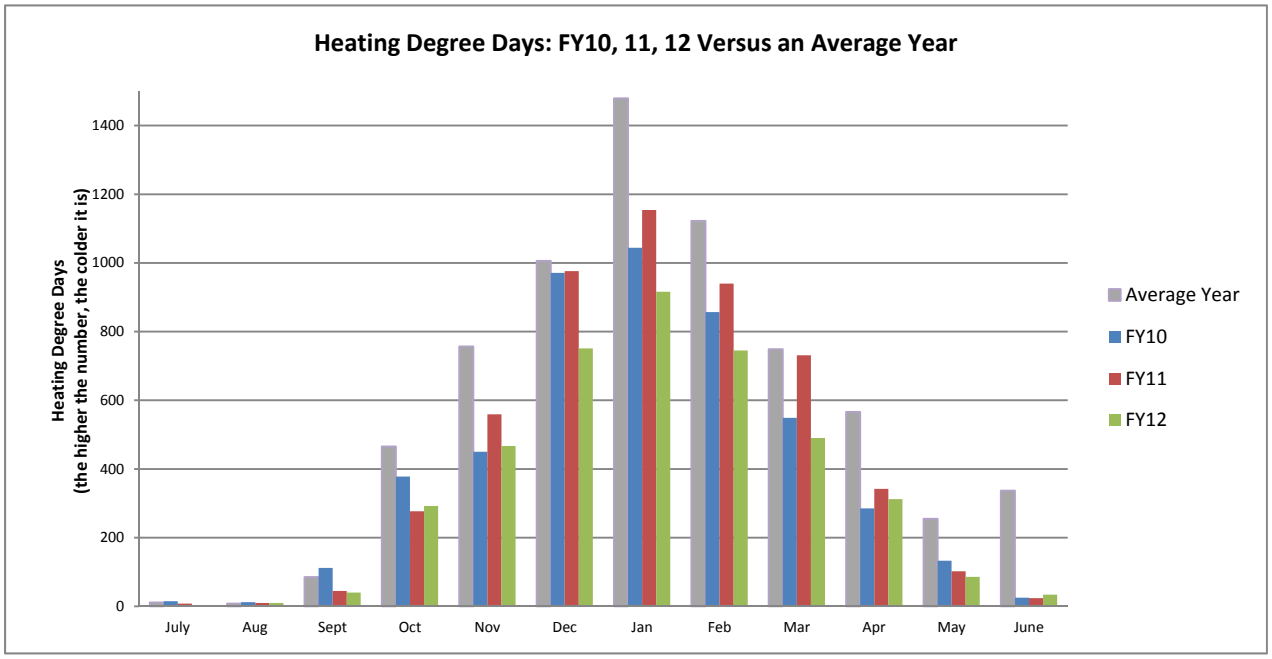


Figure 9. Heating Degree Days: FY10, 11, 12 versus Average Year

The next step was to weather normalize the data. Weather normalization eliminates any benefit or penalty in energy consumption data due to weather fluctuations. Weather normalizing in this case means calculating how much energy a building would consume if the weather were normal, as determined by a statistically average year. Degree day numbers are calculated, which represent how many hours per day heating or cooling is required based on a "balance point temperature". The baseline or balance point temperature of 60˚ was used to calculate Heating Degree Days (HDD) for this project. The choice of an appropriate balance point temperature depends on a variety of factors including how thermally resistant the building's envelope is, the

building's exposure to sun and wind, internal activities, people and equipment operating within the building, etc. There are calculations to determine a precise balance point temperature for an individual building, but for the purposes of this benchmarking tool, we choose an average for use for UMA as a whole.

HDD balance point = 60˚
60˚ – Daily average dry bulb temperature= HDD

HDDs for this area are available from the website DegreeDays.net, using the weather data from Westfield Barnes Airport in Chicopee, MA.

The statistically average year is determined using historical weather data files collected by the Department of Energy's (DOE) National Renewable Energy Laboratory, sometimes over a period as long as 30 years. The DOE publishes these weather files, *Typical Meteorological Year* files (the most recent being the third update or TMY3) for a variety of locations including Westfield Barnes Airport in Chicopee MA. Airports typically have more robust weather stations with wider range of meters and detail about weather. The TMY3 "normal year" is a construct of 12 statistically average months selected from the longer time period range, based on global horizontal radiation, direct normal radiation, dry bulb temperature, dew point temperature, and wind speed. (Wilcox and Marion, 2008)

Normal HDDs were calculated from this file by first converting the daily dry bulb temperatures from Celsius to Fahrenheit (9/5 * ˚Celsius + 32) then subtracting these temperature from 60˚, our selected balance point temperature. Monthly totals were then generated.

This benchmarking project normalized winter weather only by normalizing steam consumption for the seven heating months, October – April. (Summer weather normalization should be done in the future. It is a more complicated process because both electricity and steam are used for cooling, and humidity as well as dry bulb temperatures determine the need for cooling. Time did not allow me to do these calculations.) This approach is fairly rough and could be finessed in the future. In reality, for buildings with steam heat (over 95% of UMA buildings), steam is turned on and off at slightly different times of the year – often determined by the complaints of a building's occupants. The schedule is not predetermined and consistent, but again, for the purposes of this project the 5-month average was used for the calculation.

Not all steam delivered to buildings is used for heating purposes. Steam is also used for cooling, hot water and specialized equipment such as autoclaves and cage washers. A baseline of steam

usage that does not account for heating must be subtracted from the monthly steam totals for the weather corrected months before the normalization calculation is applied. The baseline is typically calculated with a regression analysis - an assessment of how closely related weather and steam usage are. If the statistical correlation between HDDs and steam use was higher than 0.7 it was used as the baseline figure. If the baseline figure determined by the regression analysis was negative, or if the correlation was lower than 0.7, the 15th percentile of the yearly steam data was used as the baseline instead. The 15th percentile is essentially an estimate of steam usage during the four "shoulder months", months when neither heating nor cooling is required and steam usage will be the lowest. Since four months represents 30% of the year, the median of those lowest four months is the 15th percentile. The steam data was weather normalized for 7 months, October – April using this technique:

> Baseline corrected steam usage for building = Regression analysis figure or 15th percentile figure
>
> Normalized Steam usage = ((Baseline corrected steam per month / HDD per month)) * HDD in a typical month TMY3

The following graph (Figure 10) demonstrates the impact of weather normalization on steam usage in one of UMA's buildings, the Integrated Sciences Buildings. The dotted lines represent the actual steam usage in the building associated with heating whereas the solid lines represents steam the building would have used (for heating) had the weather been normal. The non-weather-normalized steam consumption is lower because the winters have been atypically warm in the three benchmarked years.

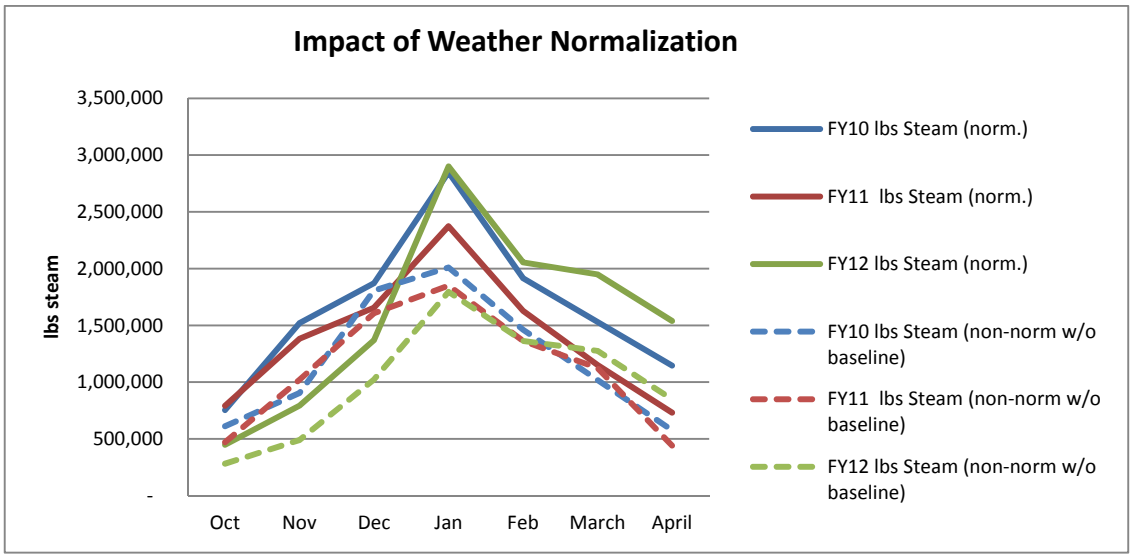


Figure 10. Impact of weather normalization on steam usage in the Integrated Sciences Building.

UMA collects weather data on campus and Metasys stores these data point. Going forward, Metasys could be programmed to calculate heating and cooling degree days, and eventually UMA's own statistically average weather data.

Note, we do not normalize steam for the CO_2E emissions calculations.

D. Normalizing for Size, Source and Site EUI

To compare buildings to each other building size is normalized by dividing the total energy usage by the gross square footage. This metric is called Energy Usage Intensity, or EUI (total kBtu/gross sf) and is the standard industry benchmarking metric. Both Site EUI and Source EUIs are reported and the difference between the two is important.

The sum total of all energy used in a building, as measured by the building meters, is called *site energy*. Site energy is easy to calculate and is a fairly accurate portrait of energy efficiency and building performance. However site EUIs do not tell the full story, as they do not account for energy required to generate and transmit the specific energy type.

A better assessment of the environmental impact of energy use is *source energy*, because it includes the energy required to produce and transport the energy to the building. Delivering electricity to a building is not comparable to delivering natural gas or steam because of the relative efficiencies in how these energy sources are generated and transmitted. Electricity generation and transmission is relatively inefficient. The ratio of energy needed at the power plant to delivered electricity in a building is greater than 3:1. Some of this energy is lost in transmission – within the electricity grid itself – but most is lost in the form of heat when electricity is being generated. Steam, fuel oil and natural gas, for example, are more efficient and have a site to source ratio closer to 1:1.

The DOE publishes national average multipliers to convert site energy to source energy. These are listed in Figure 11. (Uneo and Straube, 2010) Electricity generated at the UMA CHP is roughly 75% efficient so a multiplier of 1.33 was used. (as recommended by Jason Burbank)

Energy Type	Site to Source Multipliers:
Electricity from Grid	3.34
Electricity from onsite solar or wind	1.0
Natural Gas	1.047
Fuel Oil	1.01
Chilled Water	1.05
District Steam	1.21
District Hot Water	1.28
Electricity from UMA CHP	1.33

Figure 11. Site to Source Multipliers

Source EUI is the more conventional benchmarking metric and is used by EPA's Energy Star Portfolio Manager, LEED, the NYC building benchmarking project, and the Architecture 2030 Challenge. UMA's benchmarking tool will calculate both source

and site EUIs. Those interested in building performance will be interested in site EUI, those interested in carbon emissions overall energy consumption will be interested in source EUI. Those interested in improvement over time can refer to either.

Currently, the primary database building benchmarking data is CBECS which includes energy profiles for nearly 5,000 commercial buildings, provides national median EUI for a variety of building types. (EIA, 2008) Unfortunately, there are not enough college and university buildings in this database to determine EUI averages for UMA building types. One EUI is given for all college/university buildings but there is no differentiation between a cafeteria, a gym, a dorm, a science lab, etc. Figure 12 below includes the singular college/university average as well as other building categories (non-higher ed) UMA can use for benchmarking. The EPA and the DOE also

UMA Building Types	UMA Averages from FY12, Site EUI (kBtu/sf)	National Median Site EUI (kBtu/sf)	Source	Exemplary Buildings	Median Site EUI for Higher Ed. Buildings in the UK (kBtu/sf)*
Dining Hall	262	258.3	Food Service (CBECS)		
Residential	79	100	Lodging (CBECS)		103
Library	69	92	Public Assembly, Library (Architecture 2030)		63
Recreation Centers	74	93.9	Public Assembly (CBECS)		162
Academic, general	79	104	College/University (campus-level) Architecture 2030 & CBECS	UMA New Academic Classroom Building promises an EUI of **35 kBtus/sf**	55
Academic, lab	195	303	Labs21	Life Sciences Center at Dartmouth College **= 97 kBtu/sf**;	81
Administrative	113	90.2	Administrative/Professional Office (CBECS – Office Only Report)	National Renewable Energy Laboratory in Golden Colorado = **35 kBtus/sf;**	42
Administrative, health	83	94.6	Outpatient and Health Care, Clinic / Other Outpatient Health (CBECS)		

Figure 12. Site EUI National Averages for Building Types, CBECS Database October 2006 & Labs 21 & BRESCU
* UK Targets are reported in kWh/m^2. 1 kBtu/sf = 3.155 kWh/m^2

sponsor the Labs21 program, which benchmarks laboratory buildings in the nation. The database is currently small. In our geographic/weather area, there are only 13 research and teaching labs, but this is as a good a starting place as any. For comparison, included in the chart are the median EUIs for buildings in the United Kingdom. The UK's Building Research Energy Conservation Support Unit (BRESCU) has established a database for university buildings. (Sapri and Muhammad, 2010) By this comparison UMA's buildings perform similarly to national

averages with the exceptions of administrative buildings which are consuming more energy than the national average, and labs which are consuming much less energy than our regional peers.

E. Normalizing for Occupancy

Another way to benchmark building energy usage is to normalize for occupancy, or calculate total energy consumed in the building per person. This is a particularly interesting metric when considering a dining hall, which on average will use more energy per square foot than any other type of campus building; however, its function is not comparable to others. Occupancy for dormitories, capacity for academic and administrative buildings, and meals served for the dining halls have all been added to the benchmarking database.

F. Calculations for Carbon Dioxide Equivalent Emissions

- **CO_2E for kWh Electricity**:
  lb CO_2E for electricity generated by the CHP = kWh * .58 lbs
  lb CO_2E for electricity purchased from WMECO = kWh * .83 lbs
- **CO_2E for Pounds of Steam:**
  lb CO_2E = lb of steam *.17
- Metric Tons (MT) CO_2E = lbs CO_2E / 2204.6

Each year there is a slightly different mix of generated electricity to purchased:
FY10: 66% generated & 34% from WMECO
FY11: 72% generated & 28% from WMECO
FY12: 72% generated & 28% from WMECO

G. Visualizing these Data

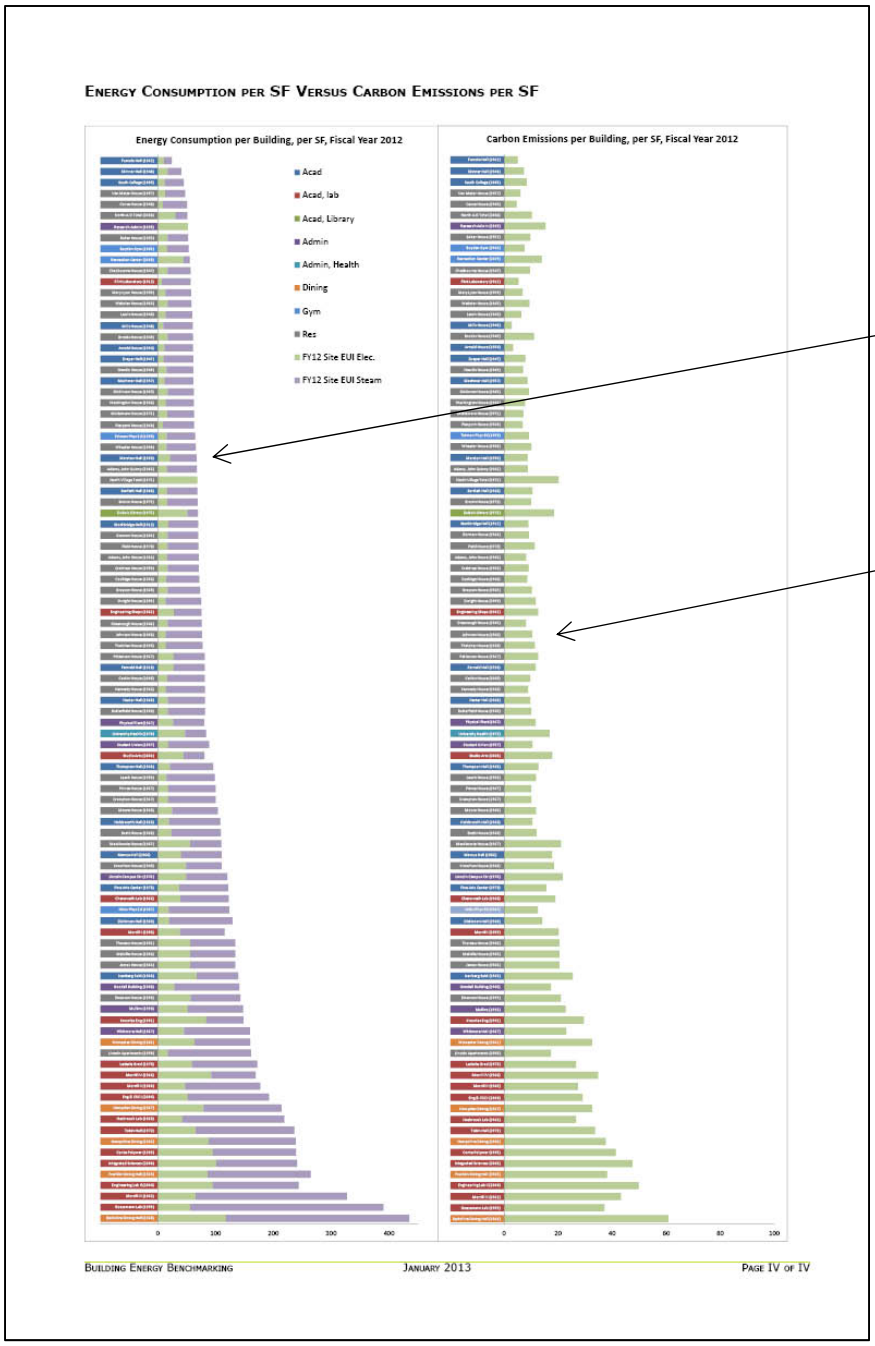
Once the building energy data was collected, the more interesting part of the project began. The following sample graphic reports can be found in the Appendix:

Overview of Benchmarked Building Set including campus maps
Academic Buildings
Administrative Buildings
Dining Halls
Residential Halls
One Building Analysis Example: Integrated Sciences Building
Spreadsheet Samples

Discussion

Initial Observations:

- Steam (versus electricity) is the dominant energy source for UMA buildings.
- Electricity usage drives CO2E emissions.



Green represents portion of total energy/sf that comes from electricity. Purple represents steam.

Carbon Emissions/sf roughly follows the electricity pattern on the EUI graph.

Note: This graph is included in the Appendix Section, in a larger more legible format.

Figure 13. Energy Usage Intensity (kBtu/sf) and Carbon Emissions/sf for UMA Buildings.

- Benchmarking graphs make it easy to see the buildings with unusually high or low energy usage, both compared to other buildings, and when there has been a dramatic change within the building over time. For example, Berkshire Dining Hall uses lots more energy per square foot than any of the other halls. With the exception of Hampshire, all dining halls used more energy (steam) in FY 2012 than in FY 2011. (See graphic reports in the Appendix for many more examples.)

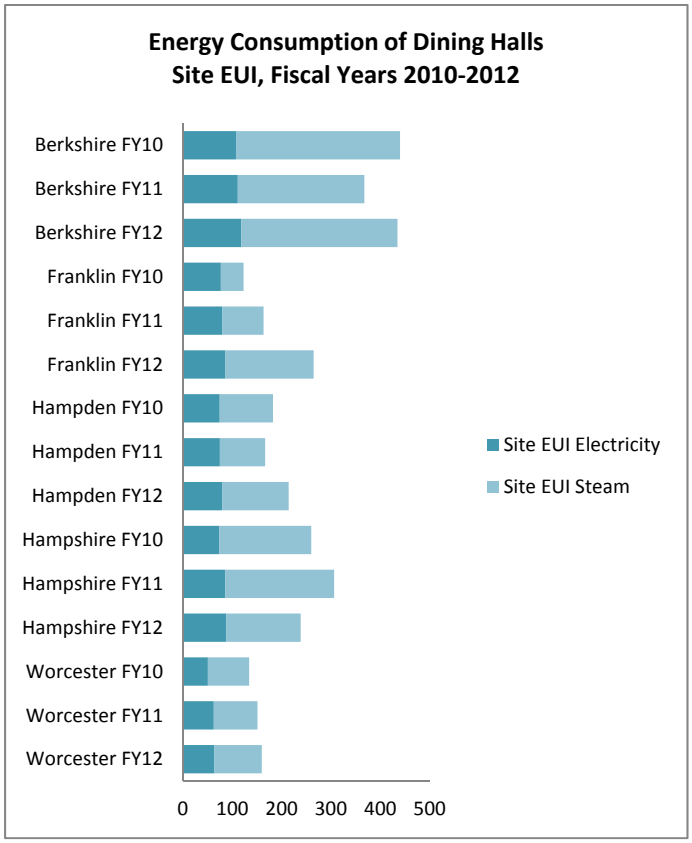


Figure 14. Site Energy Usage Intensity (kBtu/sf) for UMA Dining Halls.

- When unusual energy trends are made visible, building operators more quickly know where to investigate and which questions need to be asked. (i.e. Were the meter readings accurate; was new equipment installed in the buildings; did occupancy change; was there a malfunction of some kind?)

- Normalizing for size versus size and occupancy makes a huge difference. Figure 15 shows an interesting comparison between North Dorms and Southwest dorms. When energy is compared by size (Site EUI) Southwest dorms use much more energy than the North dorms. However when compared by occupancy, they are much closer to each other because there are more students per square foot in Southwest than North.

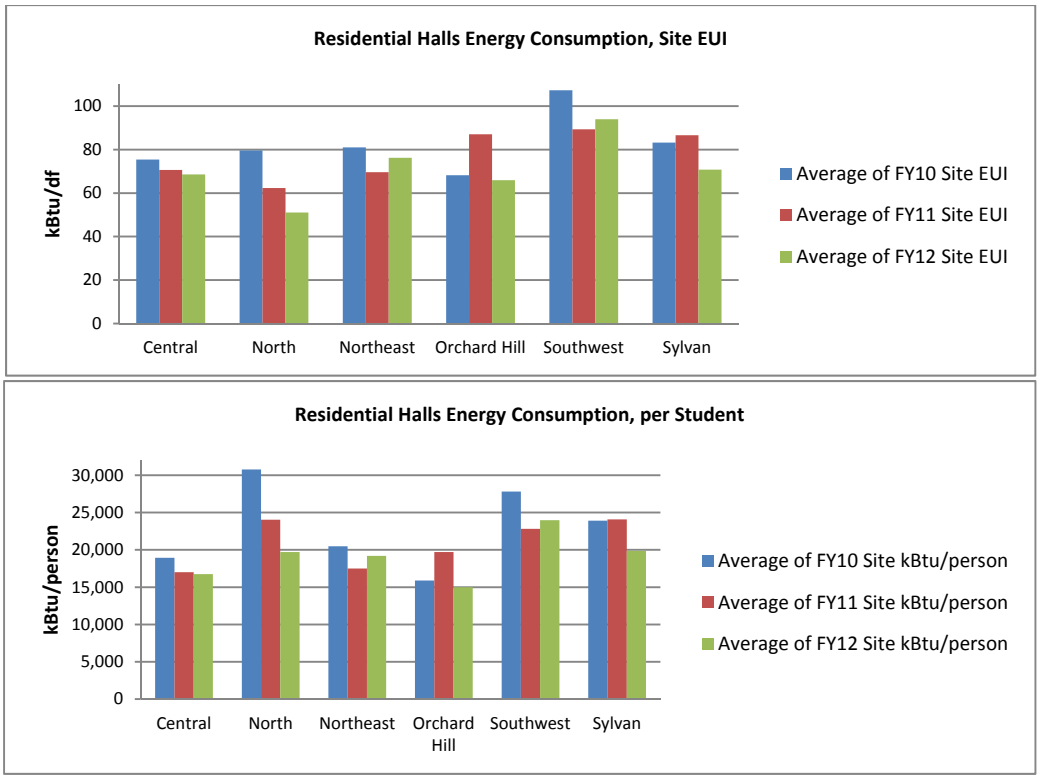


Figure 15. Residential Hall Energy Consumption normalized by size and occupancy.

- Sub-metering is really helpful to understanding what drives energy consumption. In the Integrated Sciences Building (ISB) lights and computer/office/lab equipment account for majority of the electricity consumption. Fiscal years 2010 and 2011 are more similar than 2012, when Jason Burbank led began retro-commissioning work on the building.

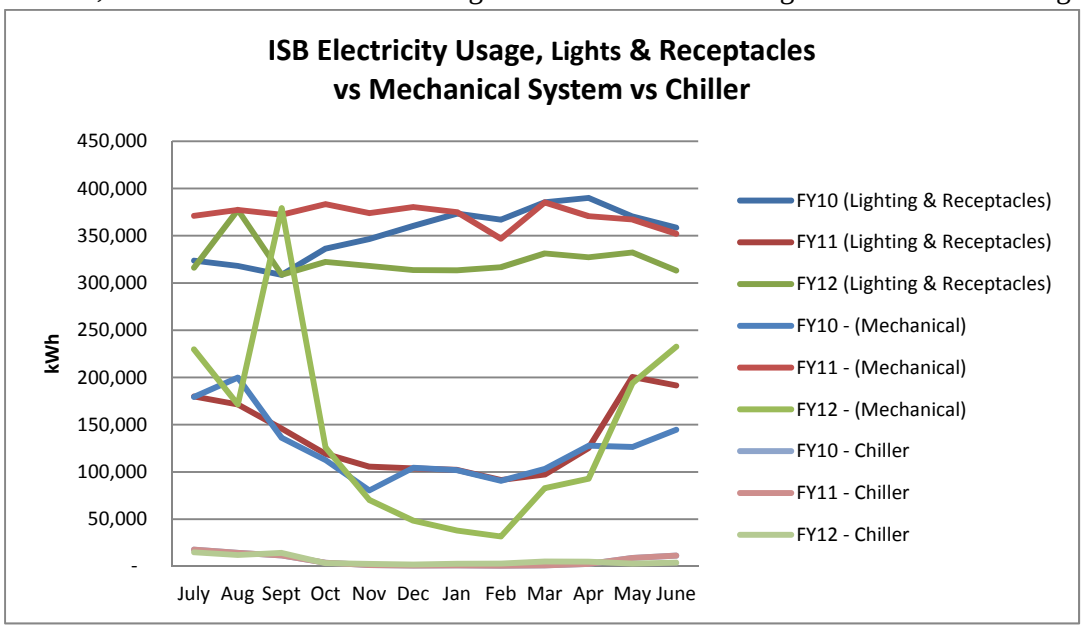


Figure 16. Integrated Sciences Building Electricity Consumption over 3 years.

- Benchmarking in and of itself does nothing to improve energy efficiency. However, as an aid to help decision makers determine where building interventions need to be made, it is a powerful tool because it makes clear where the performance outliers are. These data could be used:
    1. by a continuous commissioning team to determine where to begin energy work;
    2. to educate the campus about energy consumption through the use of dashboards;
    3. in classrooms to teach about buildings and energy –the campus as a lab concept;
    4. by building operators to learn how buildings are performing on a monthly, daily or hourly basis:

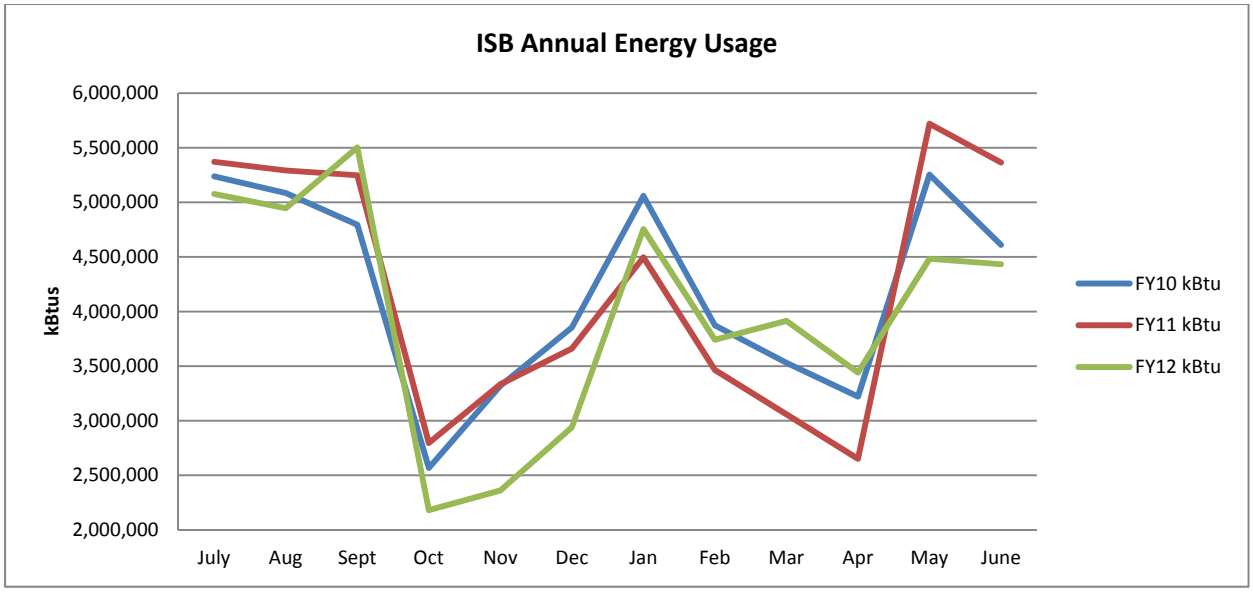


Figure 17. Integrated Sciences Building Total Energy Consumption over 3 years.

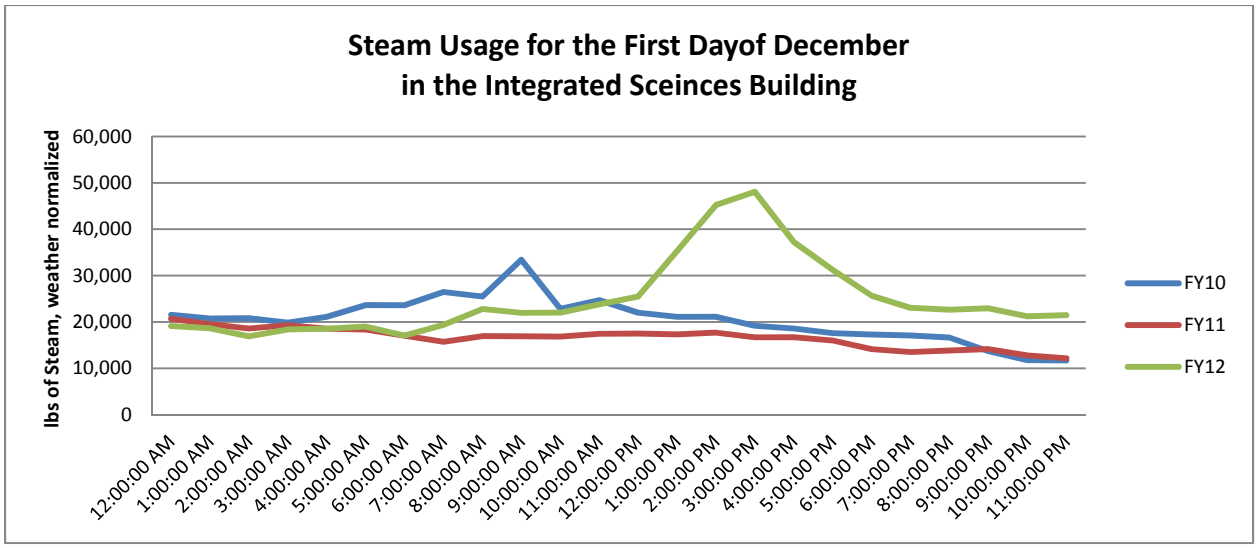


Figure 18. Integrated Sciences Building Hourly Steam Usage

- In general, UMA is not performing much worse that the national average for most building types, but there is certainly great room for improvement. One of the reasons attention hasn't been given to improving the performance of existing buildings is the Operations and Maintenance staff is undersized. De-facto, their management style is reactionary, or complaint-driven. None has time to take a proactive role is analyzing building performance. Adding this type of investigative work to the job descriptions of operations staff, or better yet hiring a Continuous Commissioning Team is an important next step. This benchmarking tool will save some time in the diagnostic process.

Recommendations & Next Steps

The following are recommendations to both improve the benchmarking tool itself and the energy efficiency of campus buildings:

A. Individually meter all residence halls.

There is great potential for energy savings and education about energy consumption and carbon emission via "green games" or other types of energy savings competitions. Other campuses have successfully demonstrated the positive impact of green games in residential hall energy consumption. The campus Sustainability Manager and the Eco-Reps would like to launch such an initiative at UMA but cannot until all the residential halls are individually metered. Currently the majority of the dorms (30) use group and/or virtual electricity meters. Nearly half as many use group steam meters.

B. Add condensate meters for steam.

The current UMA steam meters are *differential pressure* meters, using orifice plates to measure steam flow through pressure changes. This type of meter is notoriously inaccurate, especially during low-flow time times such as the summer. Condensate meters, which measure a liquid, are much more accurate. (Jason Burbank)

C. Finalize and Automate the benchmarking tool:

1. As an interim step, modify Metasys and the campus utility spreadsheets in the following ways:

- Use official building names and numbers throughout.
- Add Mullins Center and South College to Steam spreadsheet.
- Create a spreadsheet for Chiller Data for buildings with external chillers. Programming Metasys to calculate monthly ton-hours of chilled water.
- Consistently report chilled water flow-rates. Most of Metasys data is reported in 15 minute intervals but there are several exceptions in the chilled water data points – i.e. Conte Polymer Research Center reports chilled water flow and supply temperatures in 1 hour intervals, but return temperature in 15 minute intervals. Mullins Memorial Center chilled water flow is 30 minutes. All chilled water data points in the Engineering and Computer Science Center are 30 minute intervals.

2. ***Weather normalize energy data for summer or cooling months.***

3. ***Determine a consistent emissions factor for calculating CO2E Emissions.***

   The CO2E emissions total for these 100 benchmarked buildings is higher than the figure reported in the Climate Action Plan (CAP) report. For fiscal year 2012 the CAP reported 126,947 MT whereas this tool calculated 160,831 MT *and* excluded emissions from campus vehicles. The CAP figure comes from the Campus Carbon Calculator created by Clean Air Cool Plant, which uses emissions factors based on our fuel import region. The carbon emissions factors used in this benchmarking tool were provided to me by a staff member in the Environmental Health and Safety Department. He used ISO NEPOOL factor numbers to derive a more accurate calculation for our campus. Unfortunately this staff member has recently left the University, and I was not able to learn which emissions factors the Clean Air Cool Planet calculator used or how he derived the campus-specific factors.

   Additionally, UMA hires a consulting agency (Berkshire Environmental) to report emissions as required by the US EPA and the Mass DEP. The EPA report uses emission factors from 40 CFR 98, and the Mass DEP report uses factors from the Climate Registry, and they often differ from each other and from other campus calculations. For example, the Mass DEP report for FY2012 was 110,157 MT.

   Clearly one issue is that emissions factors differ from calculator to calculator. Another issue is that what gets reported for campus-wide emissions are derived from total fuels purchased to operate the CHP versus end use energy – the steam and electricity consumed/metered in the buildings. UMA should determine the most accurate methods and emissions factors and use them consistently.

4. ***Compare ENERGY STAR Portfolio Manager Source EUIs with the UMA benchmarking tool's Source EUIs.***

   ENERGY STAR Portfolio Manager does not have a pull-down menu option for district electricity (as they do with district steam). When we have used Portfolio Manager thus far we have entered all electricity consumption per building as if it

were all purchased from WMECO, so we have been given falsely high source EUI figures. An ENERGY STAR support person offered this instruction in an email correspondence:

> "If you are benchmarking a facility that has a combined heat and power plant, you are required to enter the input fuel into Portfolio Manager. That is, if you have a plant that takes natural gas as an input to produce steam and electricity, you would enter a meter to quantify all natural gas inputs to the CHP. You do not need to report the outputs (steam and electricity). When you enter the natural gas, you will be credited for the efficiency of the CHP because your plant will produce electricity and steam with greater efficiency than they could otherwise be purchased." (12/11/2012)

As a next step, data from a few benchmarked buildings could be entered into Portfolio Manager in this alternative way to see how close the EUI figures are. In addition, if UMA pursues LEED certification for any of its existing buildings, any differences will be important to understand as Portfolio Manager is the benchmarking tool used by LEED.

5. ***Add water consumption to the benchmarking tool.***

   UMA collects data on water consumption per building. This data set should be added to the benchmarking tool.

6. ***Automate the benchmarking process by using Metasys and some other database program, perhaps Tririga the campus facility asset management software which contains other important data sets such as capacity and space type allocations.***

   The benchmarking approach taken in this project should be seen as a first-step, not a final product. This approach is labor intensive with great possibilities for human error. A more accurate and efficient method for benchmarking energy usage and carbon emissions would be to automate the process with a computer database program. Currently Metasys collects granular data (at 15 minute intervals) on a variety of data points including energy, occupancy, weather, water and building mechanical systems. This granular data would allow the benchmarking tool to illustrate what's happening within a building on weekly, daily, or hourly, and 15 minute interval basis. It is a robust program with great potential that is poorly programmed and underutilized at UMA. Since its implementation in 2008, it has

been archiving data on all metered buildings. Metasys, not campus utility spreadsheets should be the source of energy data. If Metasys is paired with another database program such as Tririga, which would add data sets on occupancy, capacity, sf percentages within a building which are office space/classroom/lab, number of meals served in the dining halls, etc., the benchmarking tool would be very robust.

D. Set EUI targets for new construction.

It's always better to design efficiency into a building than retrofit an existing design. UMA is planning 2 million square feet of new building construction in the next decade. The EUI goals for this new construction should align with the best of design and construction practices. The National Renewable Energy Laboratory office in Golden Colorado has been operating for two years with a site EUI of 35 (and an EUI of 25 without the data center). The new Academic Classroom Building being built at UMA has a targete site EUI of 35. There are other exemplary buildings in the world from which UMA could establish targets based on building function. (See Figure 12)

E. Through commissioning and retro-fitting, find a 35% reduction in energy consumption (from 2002) by 2020 (the EO484 mandate).

UMA should use this benchmarking tool to document its own improvements in energy efficiency over time. To find a savings of 35% in energy consumption and reduce carbon emissions by 40% UMA will need to address the existing building stock strategically. Retro-commissioning (returning a building to its original performance intention or "re-tuning" the building), retro-fitting (making modification to the original design of the building), and behavioral change strategies will be required to meet these goals. UMA should establish a Continuous Commissioning Team of qualified building scientists and engineers to improve and maintain campus buildings from an energy point of view. The Green Building Committee wrote a proposal to do just this basing the projected savings on a Lawrence Berkeley National Laboratory study which determined a 16% median energy savings per building with retro-commissioning. The study also showed that buildings stop performing optimally after about 5 years – thus the need for continuously commissioning buildings. In addition, the Green Building Committee's commissioning proposal drew on the results of a retro-commissioning "light" pilot project (not all typical retro-commissioning tasks were performed), which proved this work pays off. The pilot project was conducted for 6 months on the Studio Arts Building and the Integrated

Sciences Building and resulted in a savings $76,770 total, 16% energy savings in the ISB, 6% in the SAB. (Contact the Green Building committee for a copy of the report.)

The impact of retro-fitting campus buildings has also been studied at UMA. Dr. Benjamin Weil led an independent study which analyzed Holdsworth Hall from an energy and occupant comfort point of view. A set of recommendations were proposed which would have a dramatic impact on the energy efficiency of the building, reducing its site EUI from 115 to 37! One key finding was if such electricity reductions were multiplied across all buildings of a similar type it would be possible to dramatically decrease if not eliminate the need to purchase electricity from WMECO. The CHP currently produces about 72% of the electricity used on campus, at a much cheaper rate than that purchased from WMECO. The financial benefit of decreased electricity consumption is significant. "....a 21% energy savings would gain a 46% financial savings. A goal of living within the energy means of the CHP should be seriously considered." (The Holdsworth Report is available from the Green Building Committee)

Conclusion

> "Global warming happens just slowly enough that political systems have been able to ignore it. The distress signal is emitted at a frequency that scientists can hear quite clearly, but is seemingly just beyond the reach of most politicians." (Remnick, 2012)

The Green Building Committee has identified four key strategies to meet carbon emissions reduction goals:

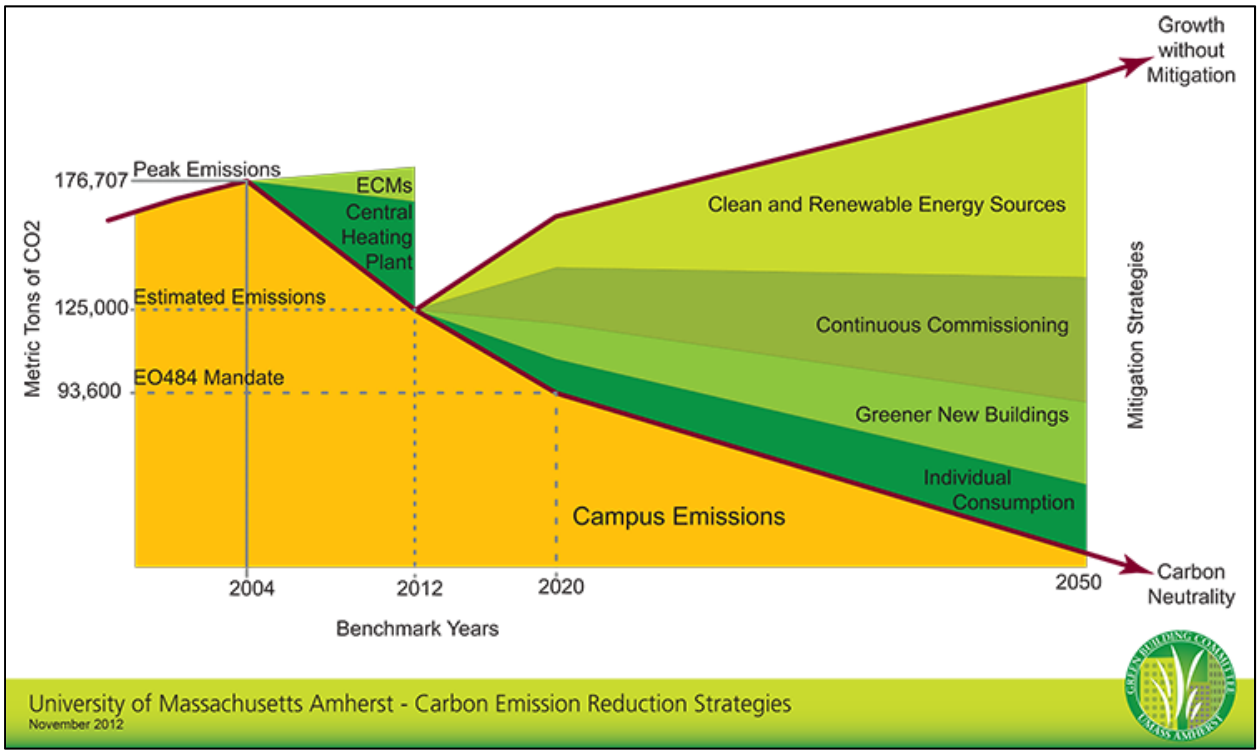


Figure 19. UMA Carbon Emissions Reduction Strategies (Lawson Wulson)

These strategies will come with a hefty price tag, which will engender criticism. Some will ask if UMA would be doing more than its fair share – working harder, and spending more money to achieve these energy and emissions goals than its peers. Some will be concerned that spending resources to meet the state emissions mandate would come at the expense of supporting UMA's educational mission, i.e. spending the financial resources directly on teaching and learning, which would risk UMA's competitive edge in the higher education market.

Fortunately, energy efficiency improvements and CO_2E reductions will also save money! To properly account for costs and benefits of energy efficiency work requires a shift in thinking about payback periods and the social/environmental values of UMA's investments. Traditionally

projects at UMA are funded if they can show a 7-year simple payback period. This approach is too simplistic because it doesn't compare the benefits of the work to the cost of the status-quo, nor does it allow a proper comparison between current university investments and energy efficiency investments.

When UMA is ready to seriously address unnecessary energy consumption in its buildings, an automated benchmarking tool will be very valuable.

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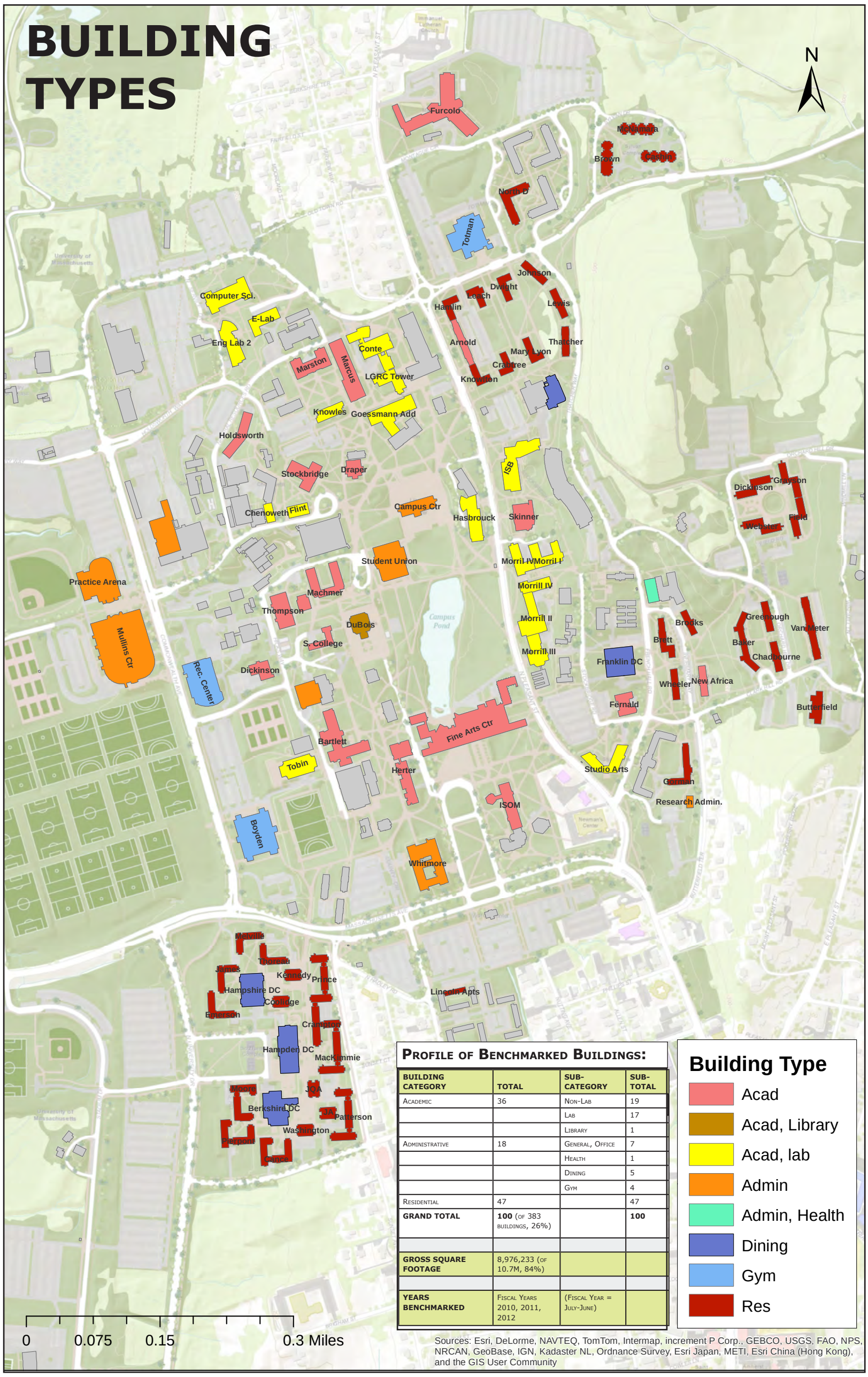
Building Energy Benchmarking Maps

BENCHMARKED BUILDINGS (FY 2012) BY BUILDING TYPE

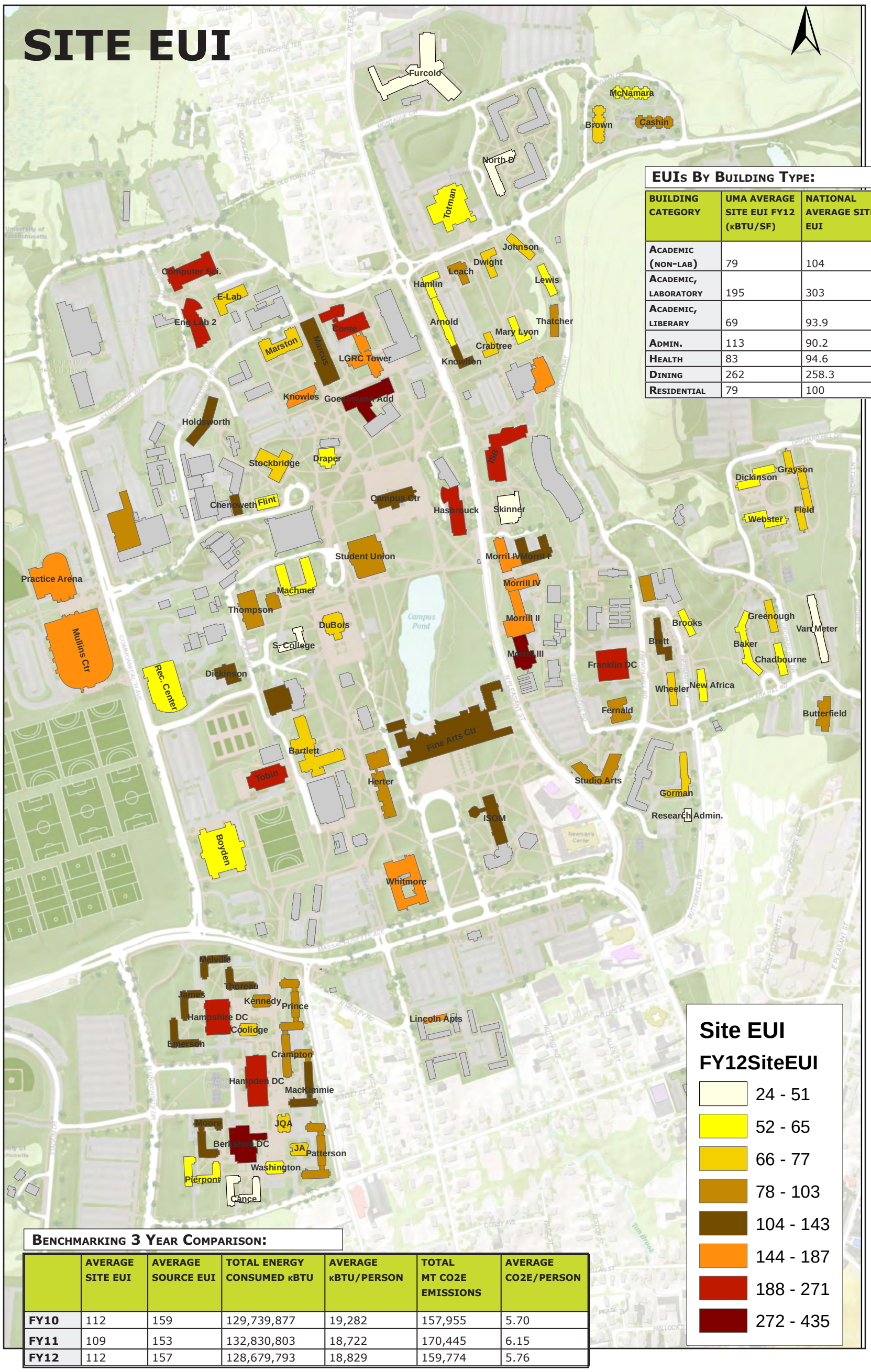


Profile of Benchmarked Buildings:

BUILDING CATEGORY	TOTAL	SUB-CATEGORY	SUB-TOTAL
Academic	36	Non-Lab	19
		Lab	17
		Library	1
Administrative	18	General, Office	7
		Health	1
		Dining	5
		Gym	4
Residential	47		47
GRAND TOTAL	**100** (of 383 buildings, 26%)		**100**
GROSS SQUARE FOOTAGE	8,976,233 (of 10.7M, 84%)		
YEARS BENCHMARKED	Fiscal Years 2010, 2011, 2012	(Fiscal Year = July-June)	

Building Energy Benchmarking Maps

BENCHMARKED BUILDINGS (FY 2012) SITE EUI PER BUILDING



EUIs By Building Type:

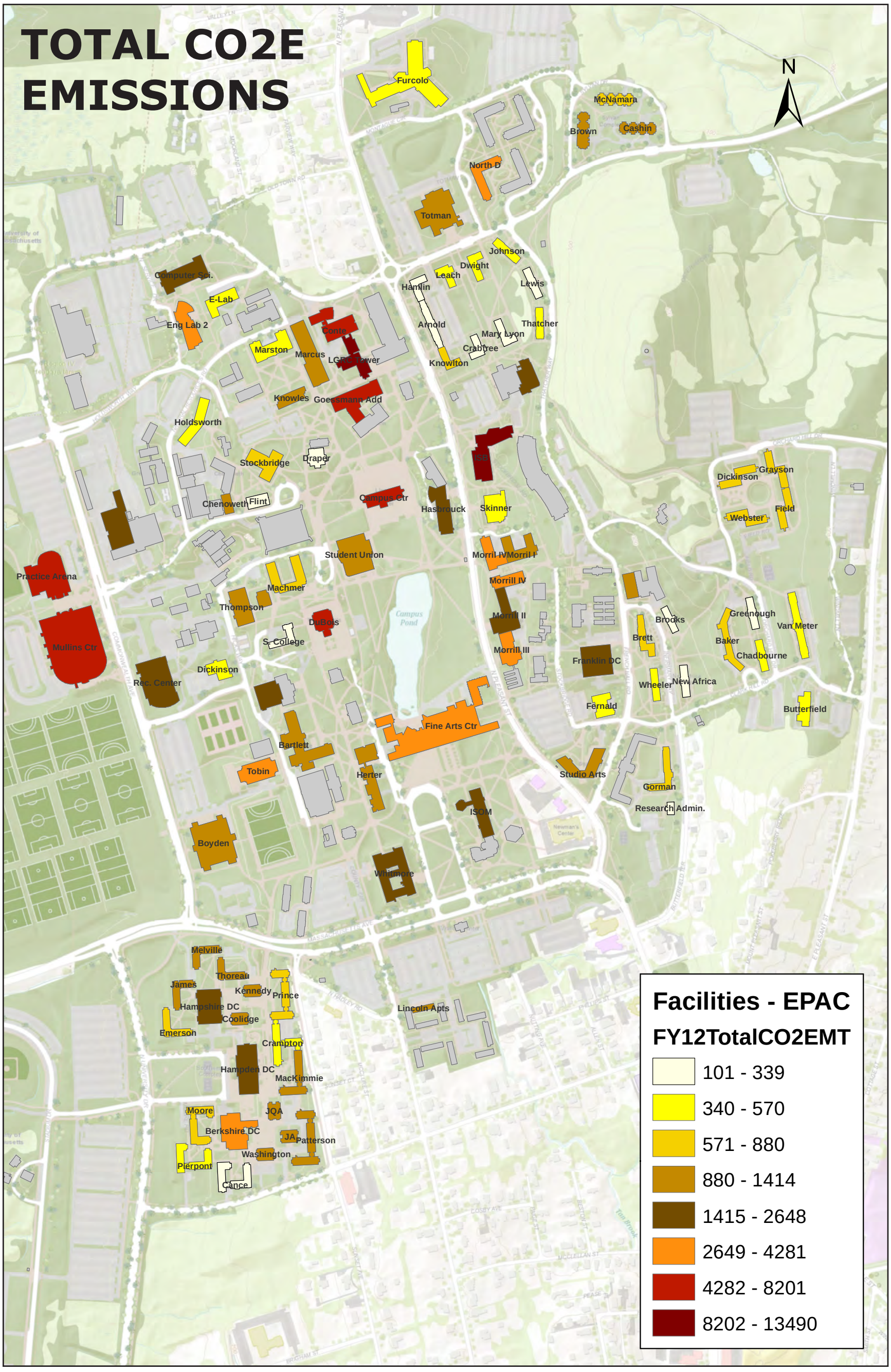
BUILDING CATEGORY	UMA AVERAGE SITE EUI FY12 (kBTU/SF)	NATIONAL AVERAGE SITE EUI
Academic (non-lab)	79	104
Academic, laboratory	195	303
Academic, liberary	69	93.9
Admin.	113	90.2
Health	83	94.6
Dining	262	258.3
Residential	79	100

Benchmarking 3 Year Comparison:

	AVERAGE SITE EUI	AVERAGE SOURCE EUI	TOTAL ENERGY CONSUMED kBTU	AVERAGE kBTU/PERSON	TOTAL MT CO2E EMISSIONS	AVERAGE CO2E/PERSON
FY10	112	159	129,739,877	19,282	157,955	5.70
FY11	109	153	132,830,803	18,722	170,445	6.15
FY12	112	157	128,679,793	18,829	159,774	5.76

Building Energy Benchmarking Maps

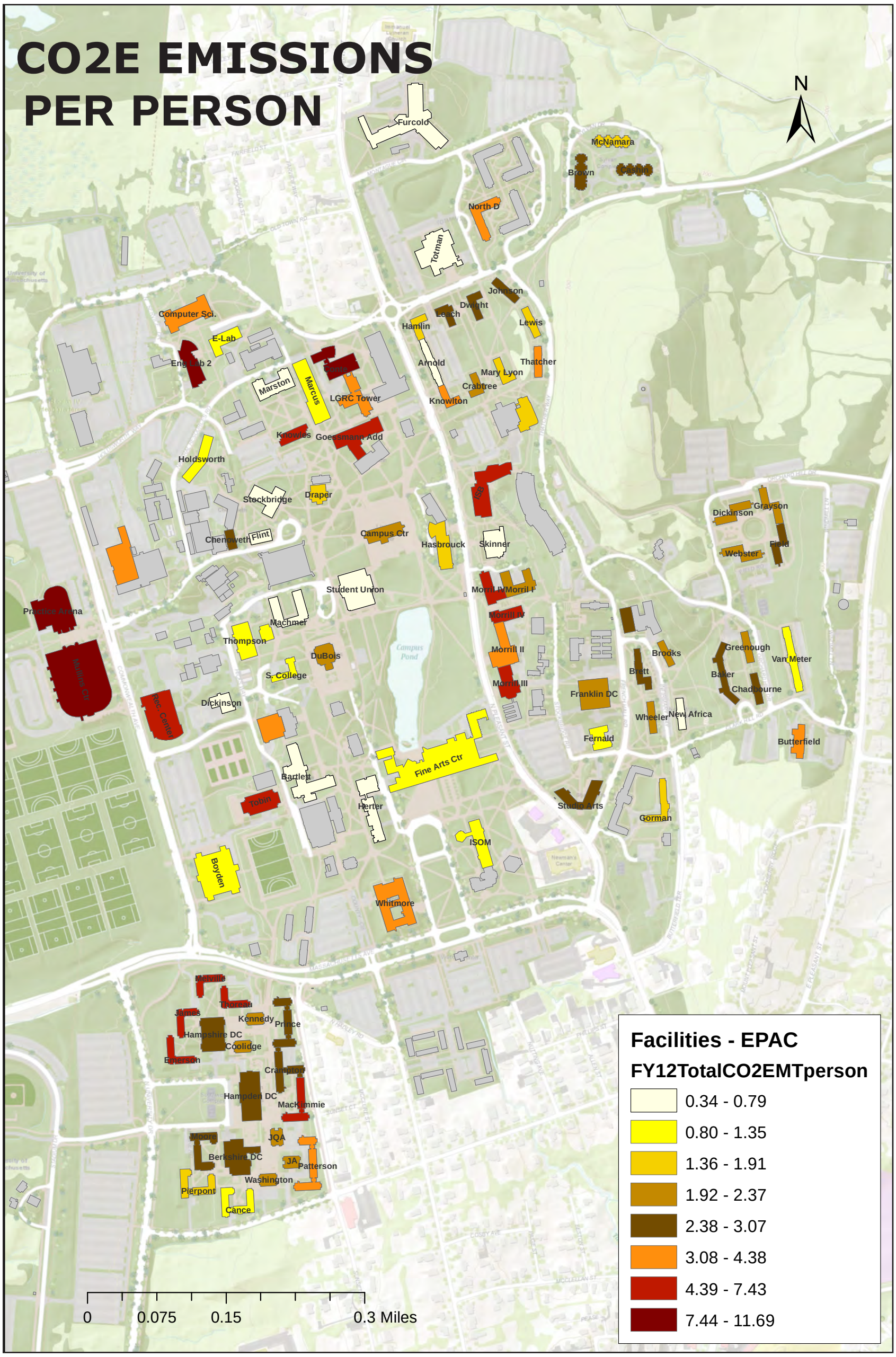
BENCHMARKED BUILDINGS (FY 2012) TOTAL CARBON EMISSIONS PER BUILDING



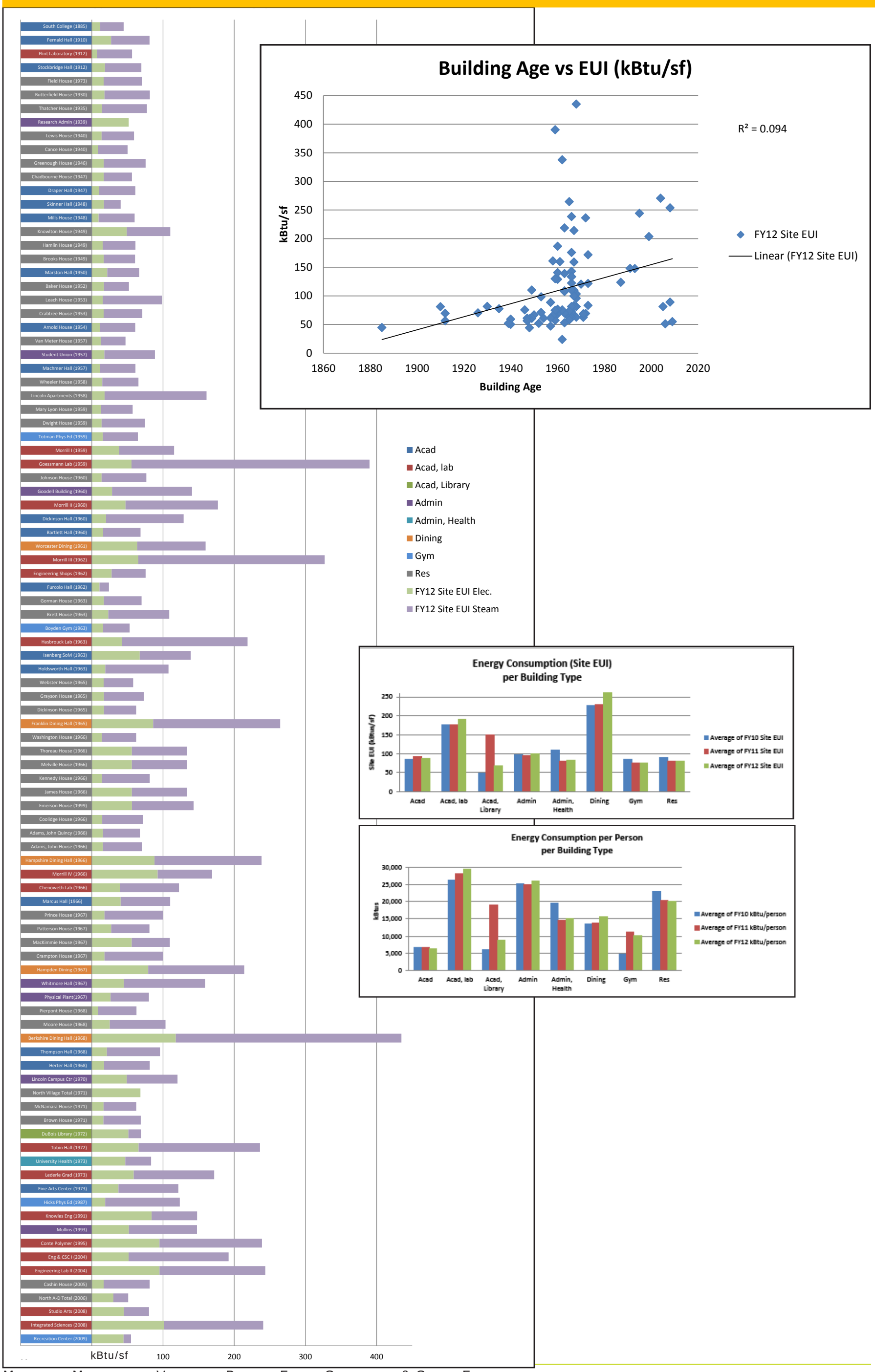
Measuring, Managing and Visualizing Building Energy Consumption & Carbon Emissions
Benchmarking at the University of Massachusetts Amherst
Katherine McCusker

Building Energy Benchmarking Maps

BENCHMARKED BUILDINGS (FY 2012) CARBON EMISSIONS PER PERSON PER BUILDING

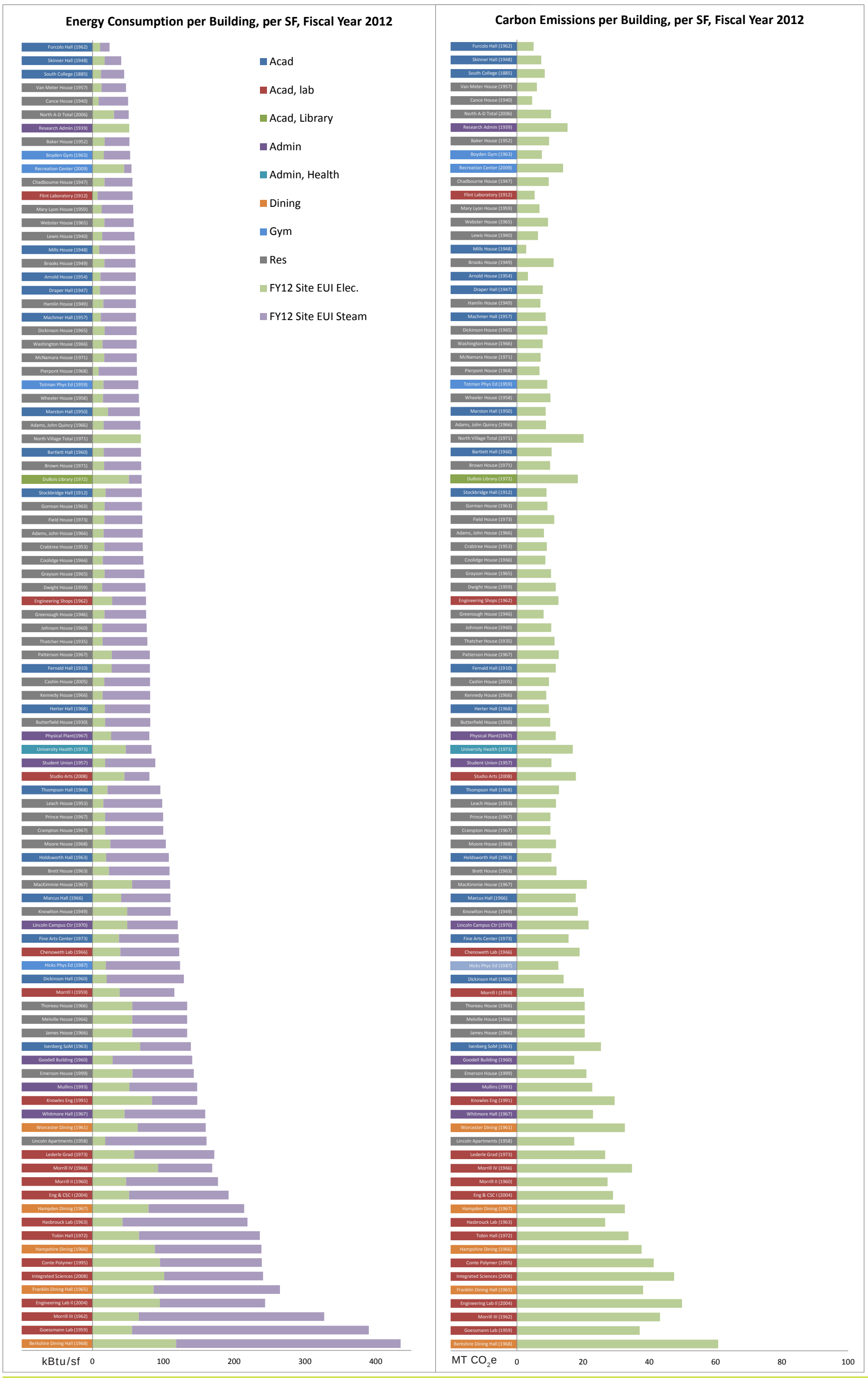


Building EUI and Age



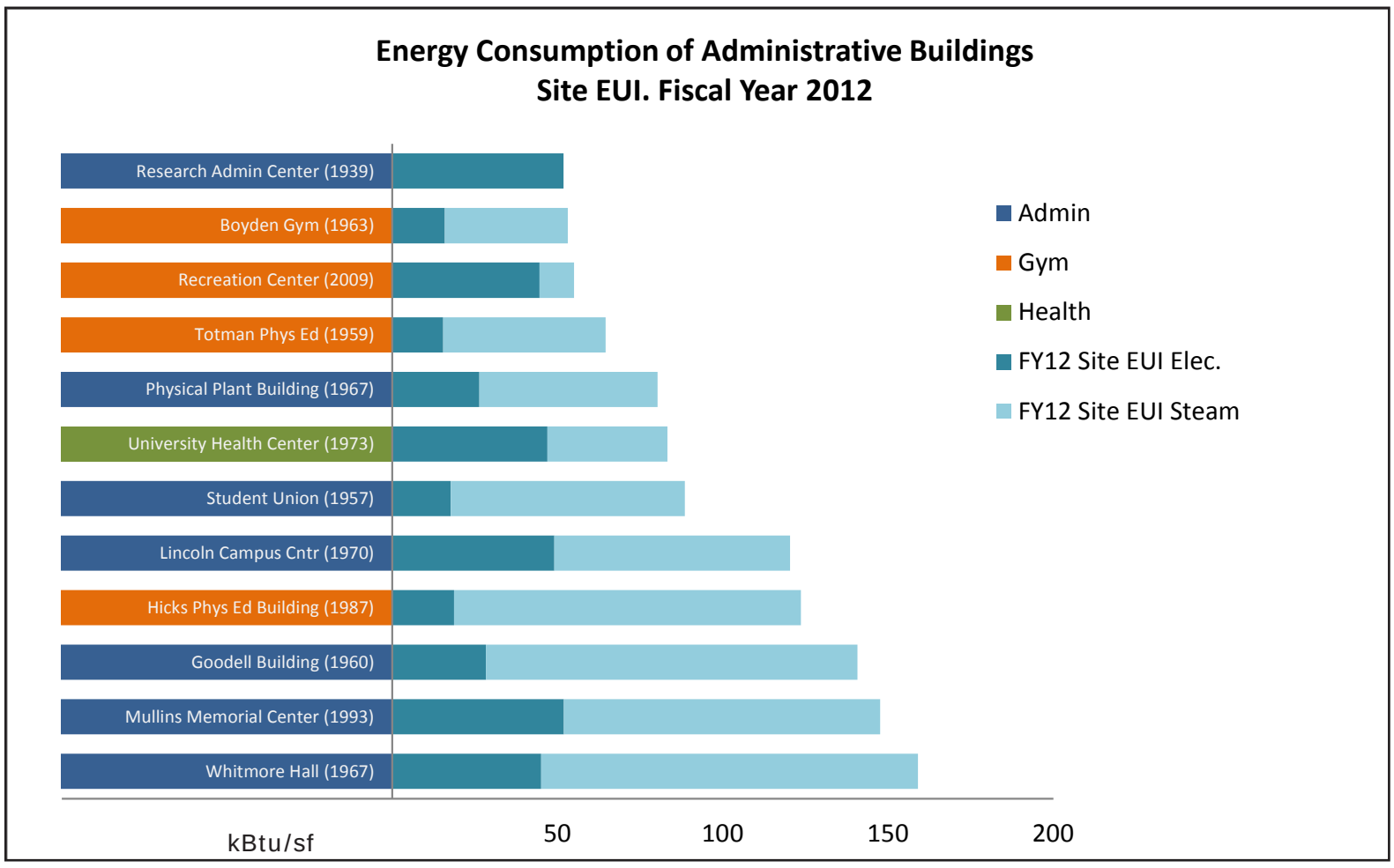
Measuring, Managing and Visualizing Building Energy Consumption & Carbon Emissions
Benchmarking at the University of Massachusetts Amherst
Katherine McCusker

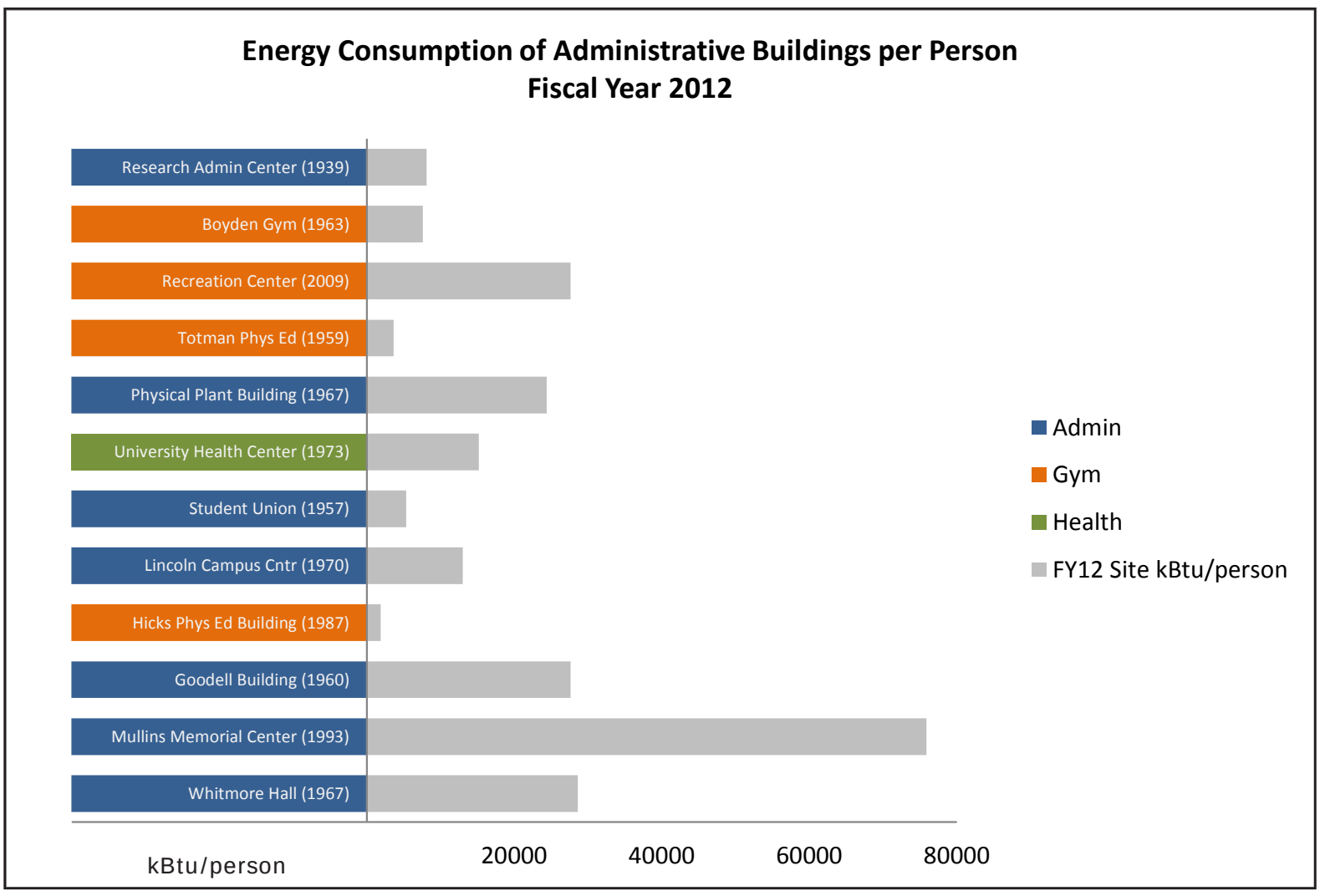
Building EUI versus Carbon Emissions



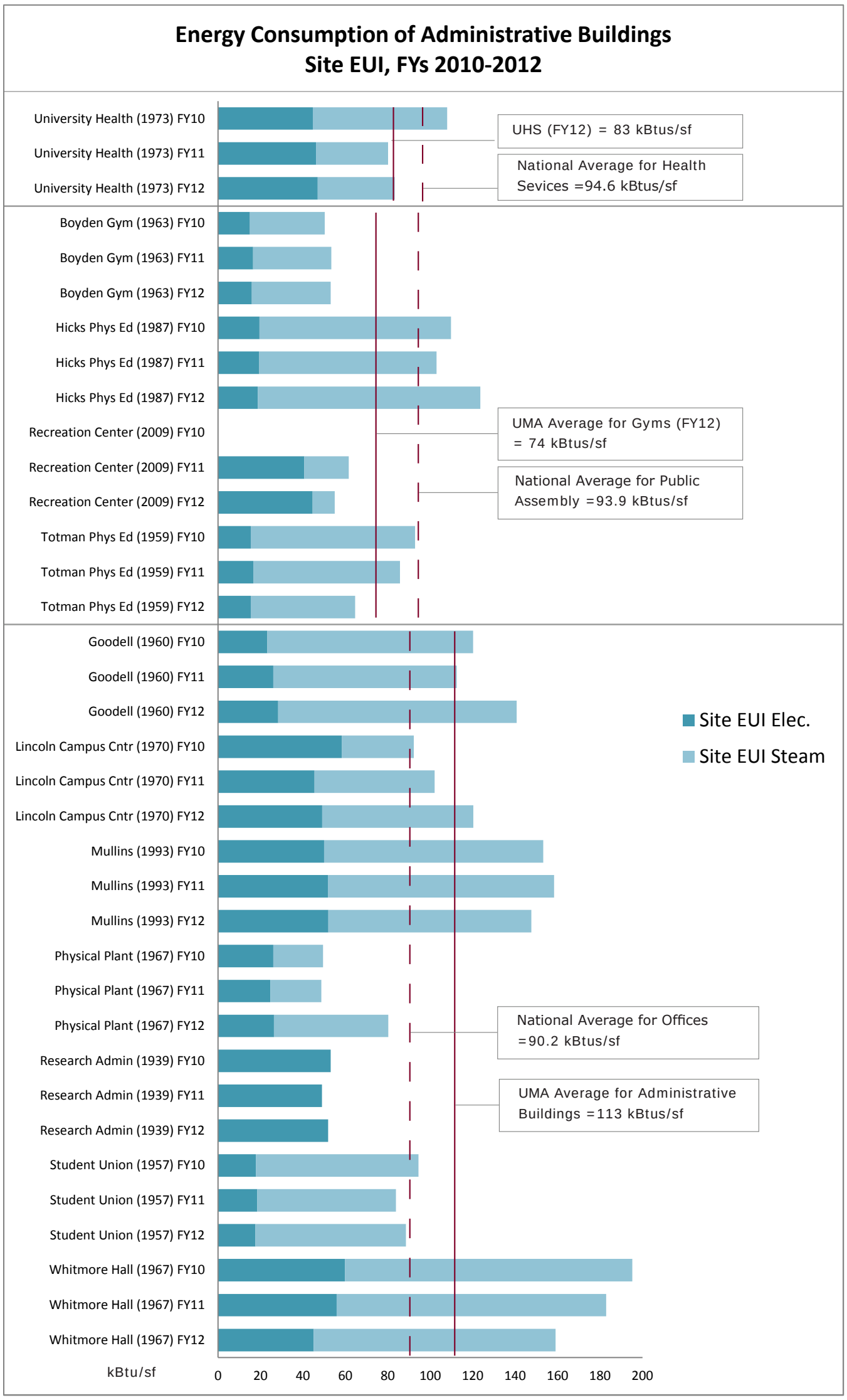
Measuring, Managing and Visualizing Building Energy Consumption & Carbon Emissions
Benchmarking at the University of Massachusetts Amherst
Katherine McCusker

Administrative Buildings

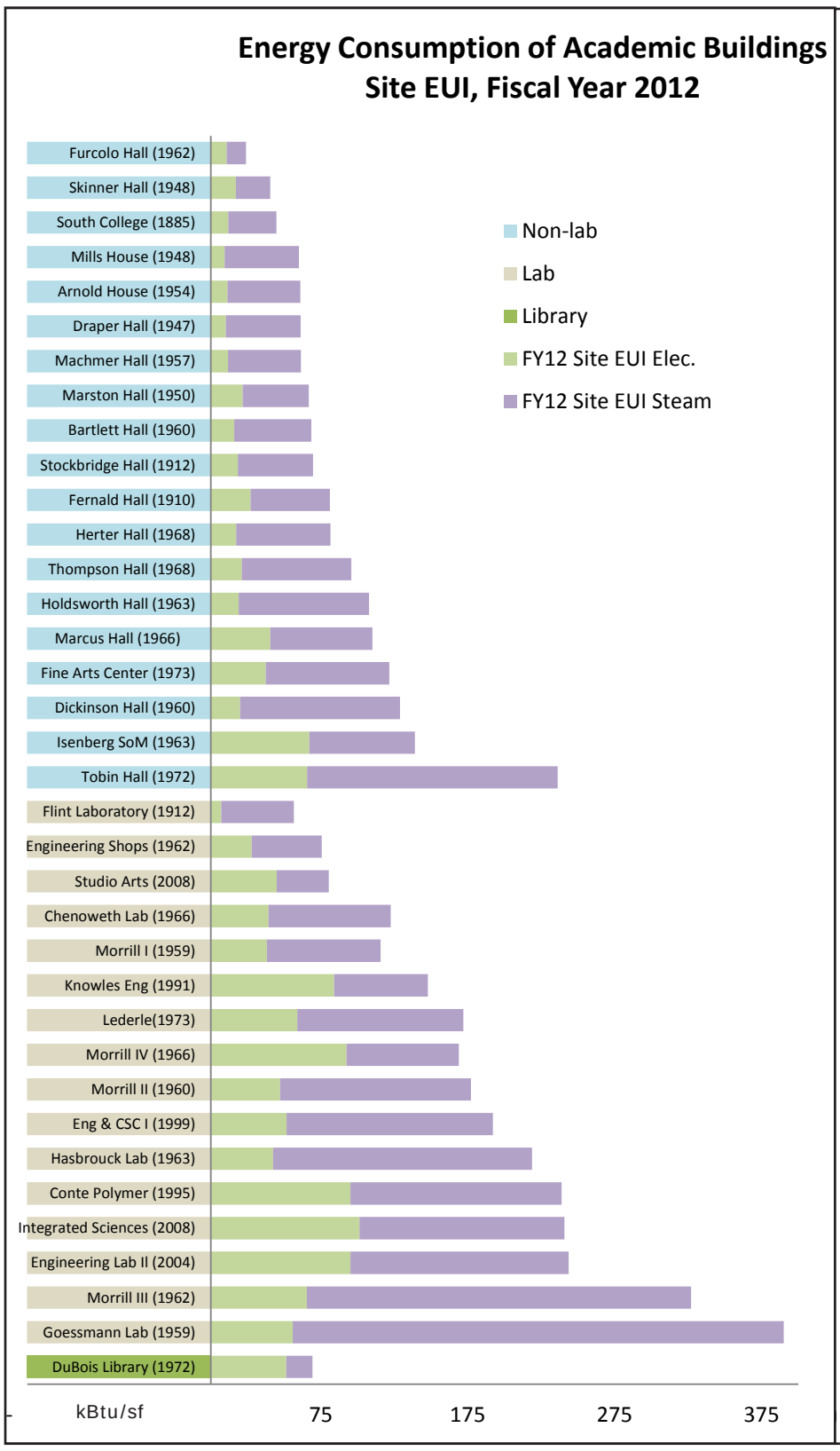


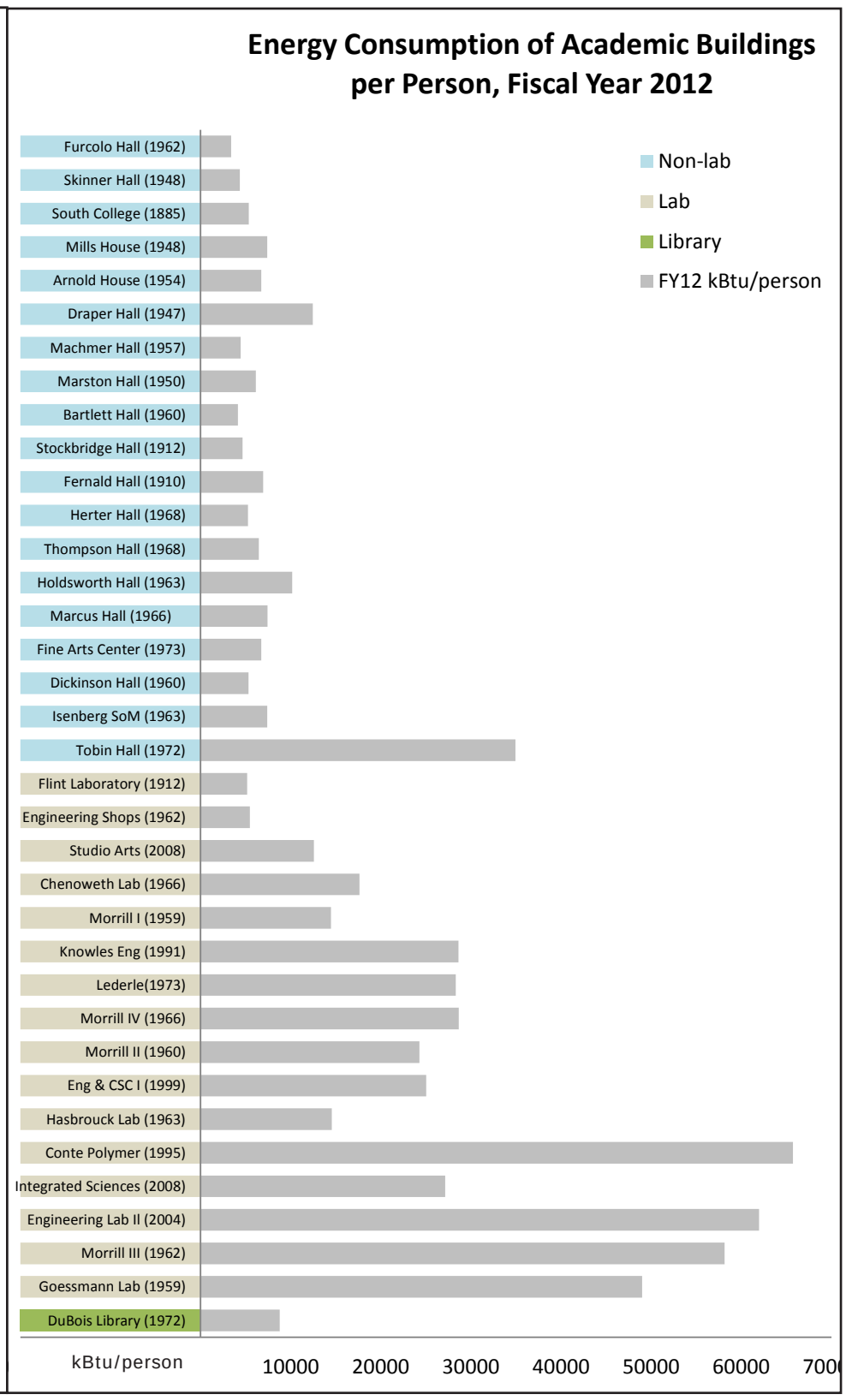


Administrative Buildings

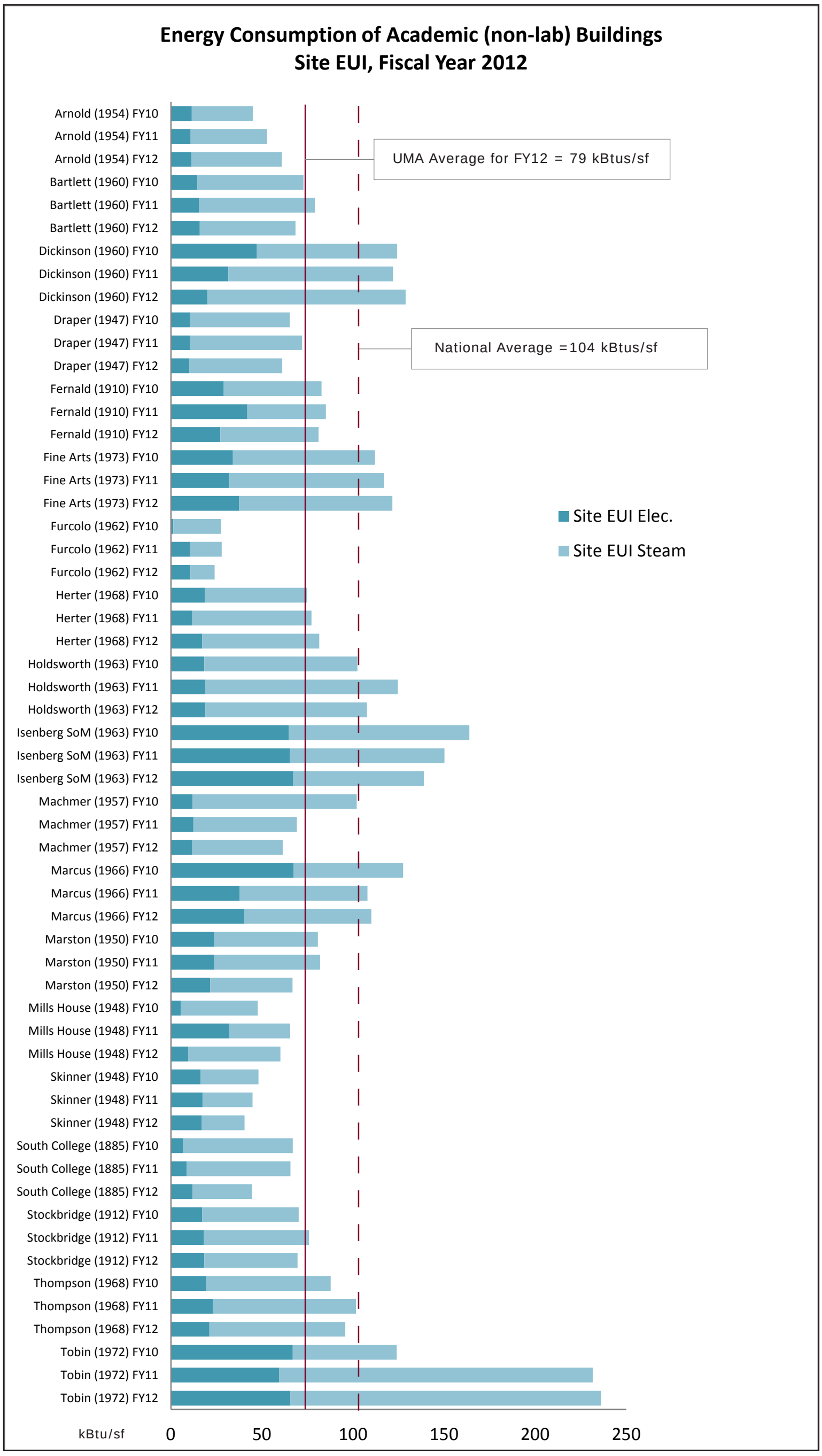


Academic Buildings

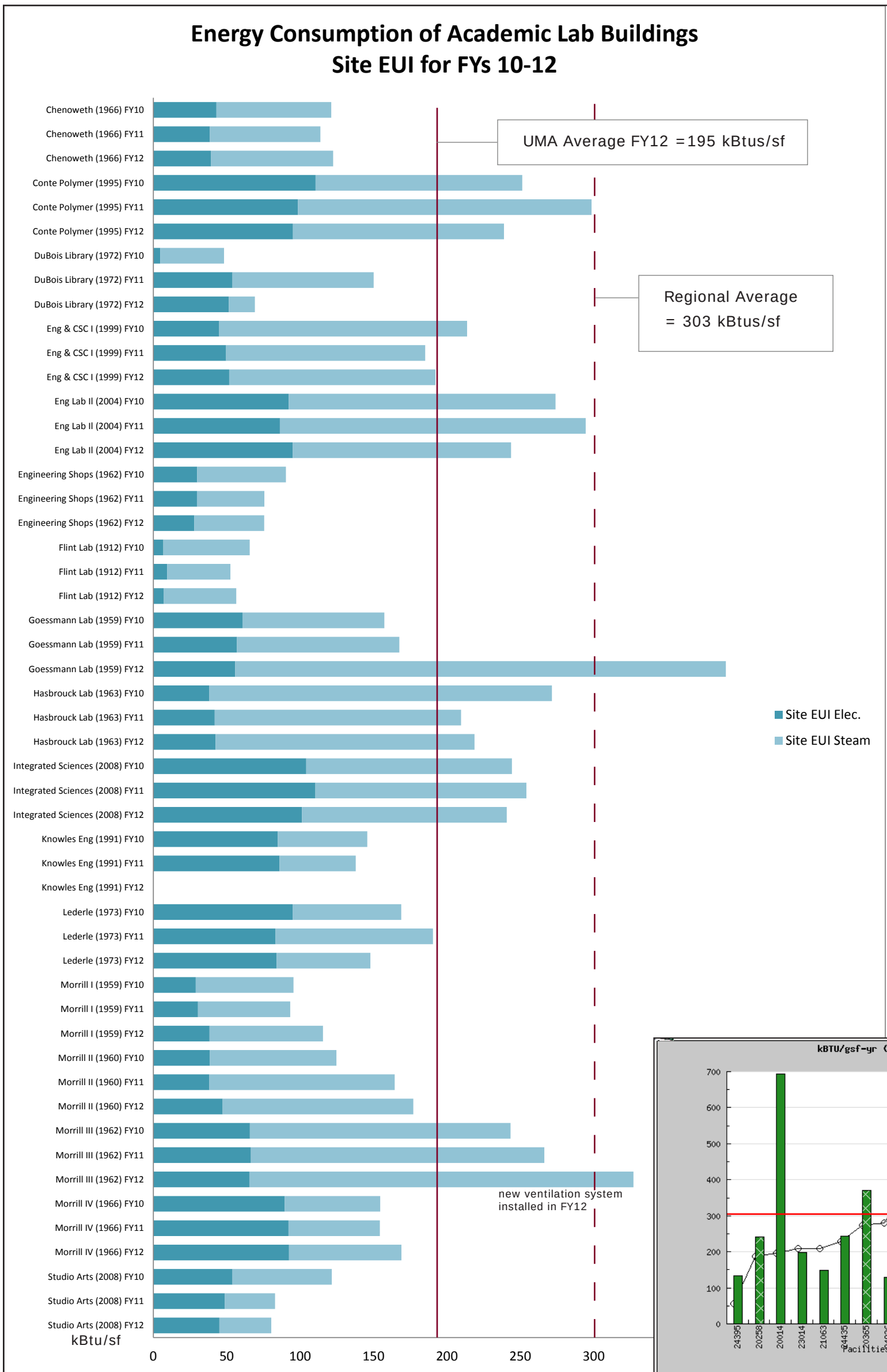


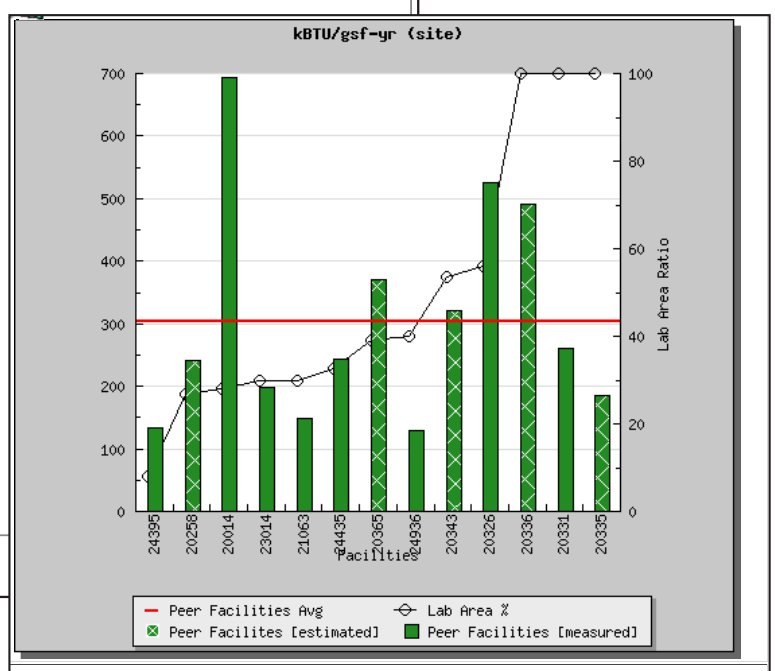


Academic Buildings



Academic Buildings





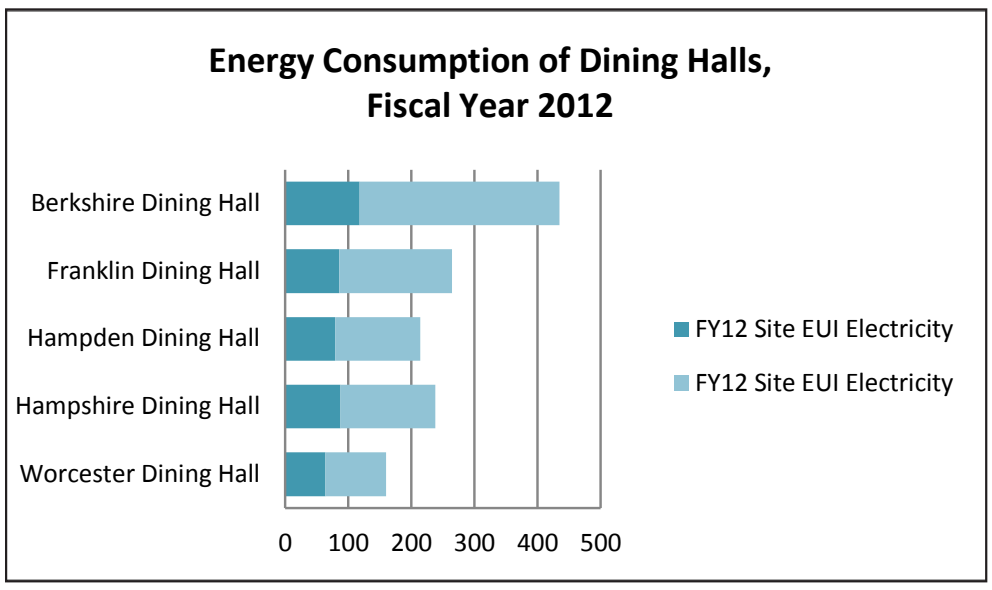
Lab area ratio: 0.00-1.00 | Occupancy hours: Both
Lab type: Chemical, Biological, ChemicalBiological, Physical
Lab uses: Research/Development, Teaching
Climate Zones: 6A
Measured data: Yes Estimated data: Yes

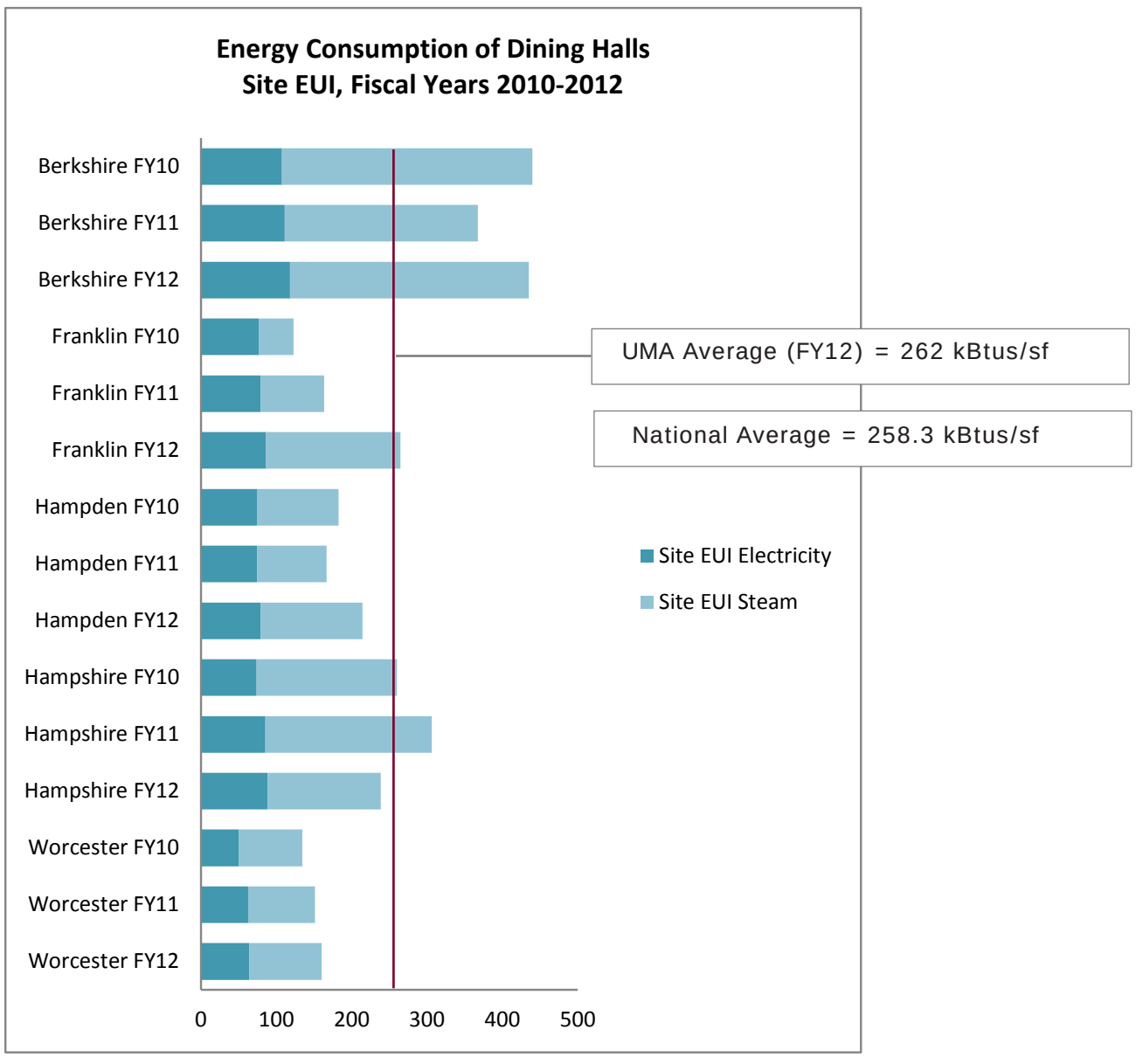
Benchmark Statistics for Peer Facilities

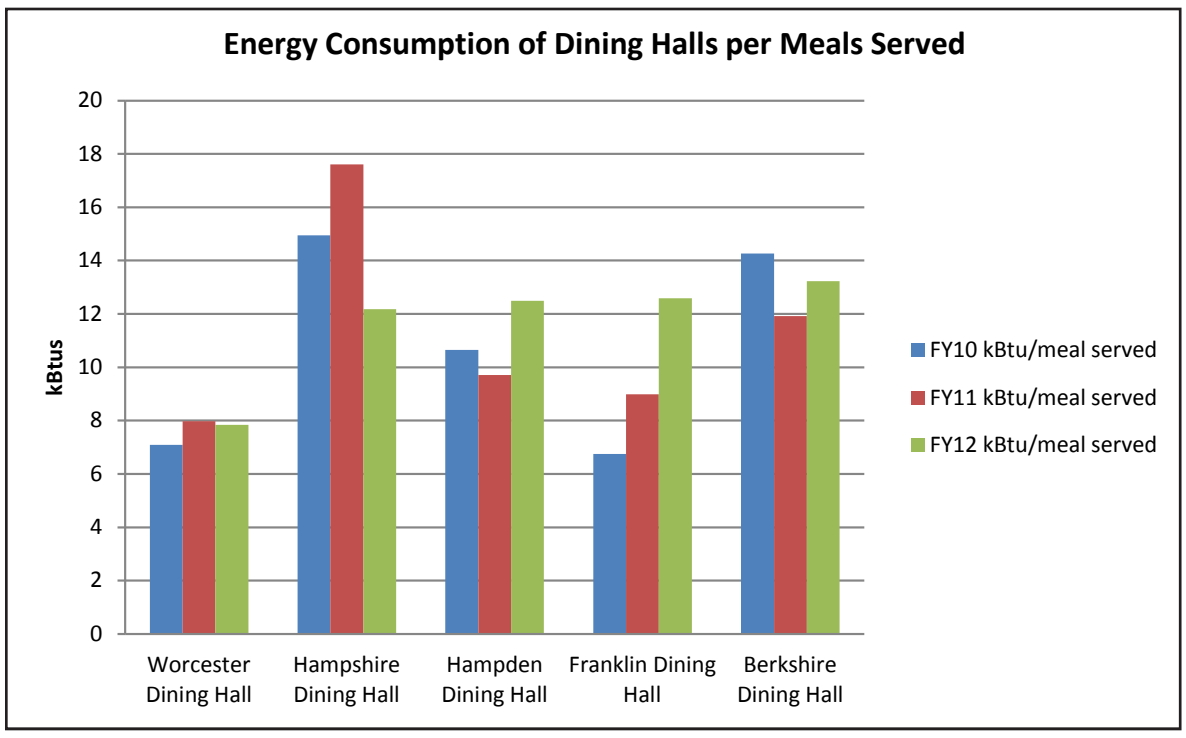
Metric	Min	Avg	Max	Count
Total Building kBTU/gsf-yr (site)	128.37	302.9	692.63	13

Benchmarked Lab Buildings from UMA Climate Zone, Labs21

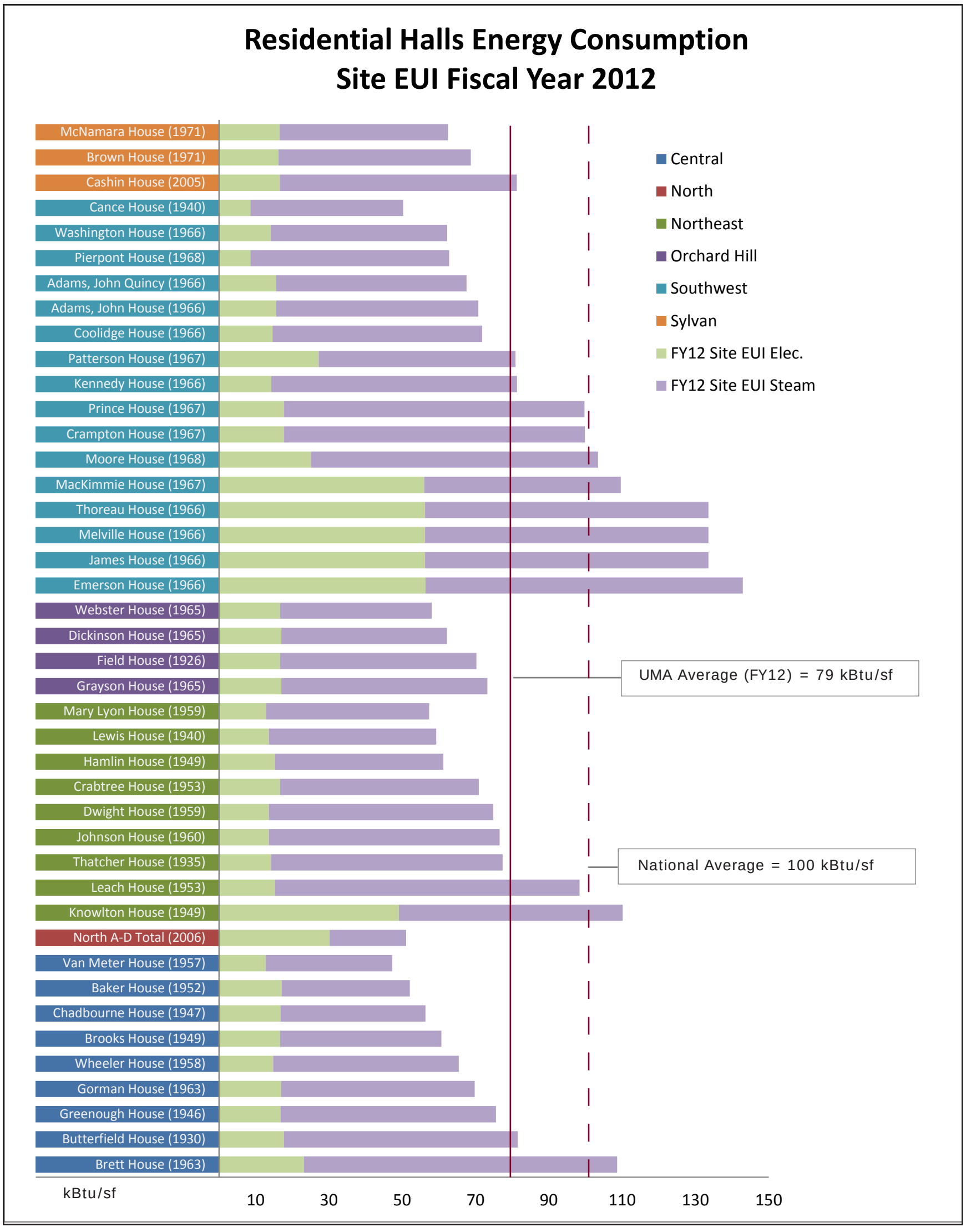
Dining Halls



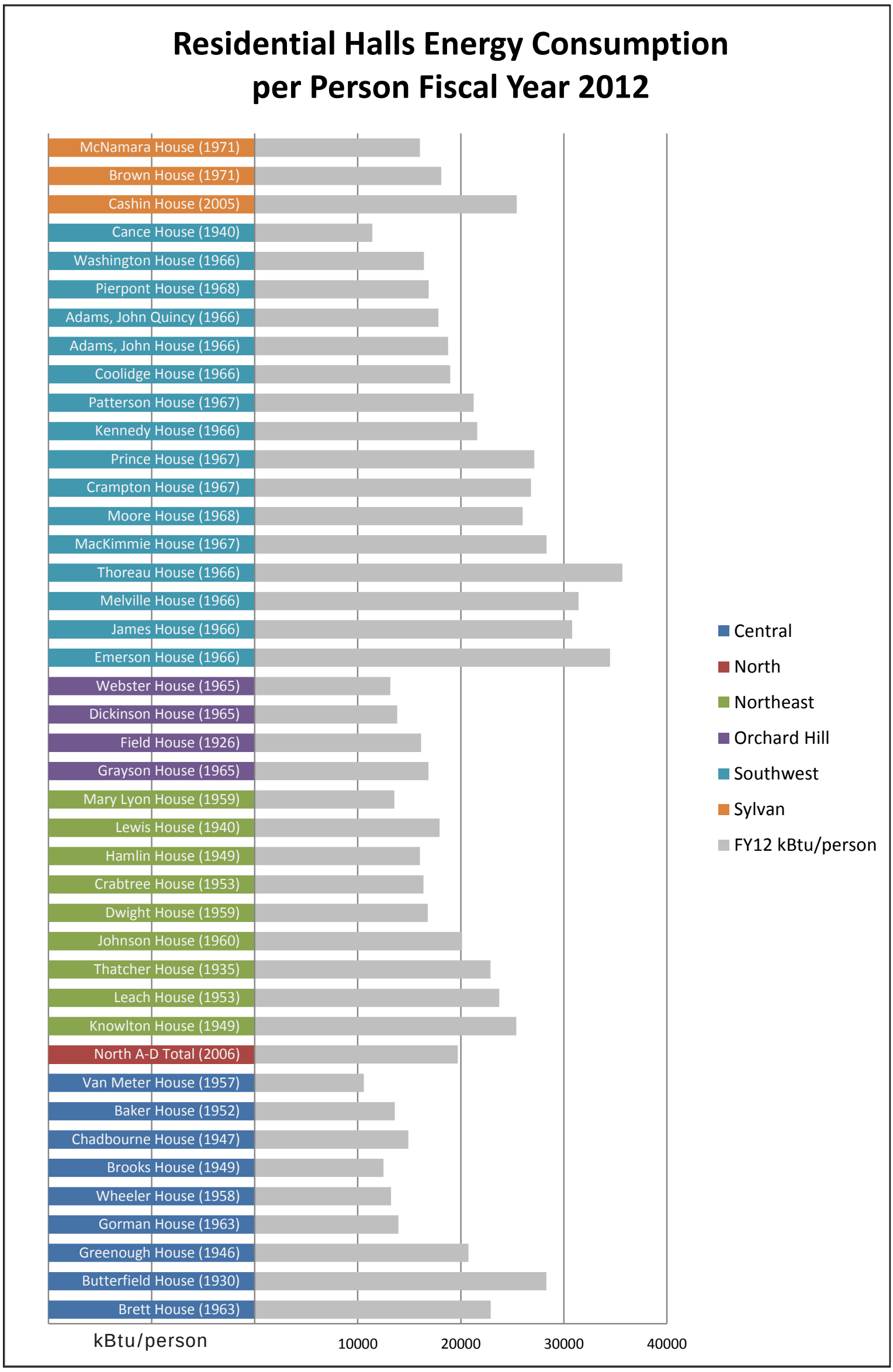




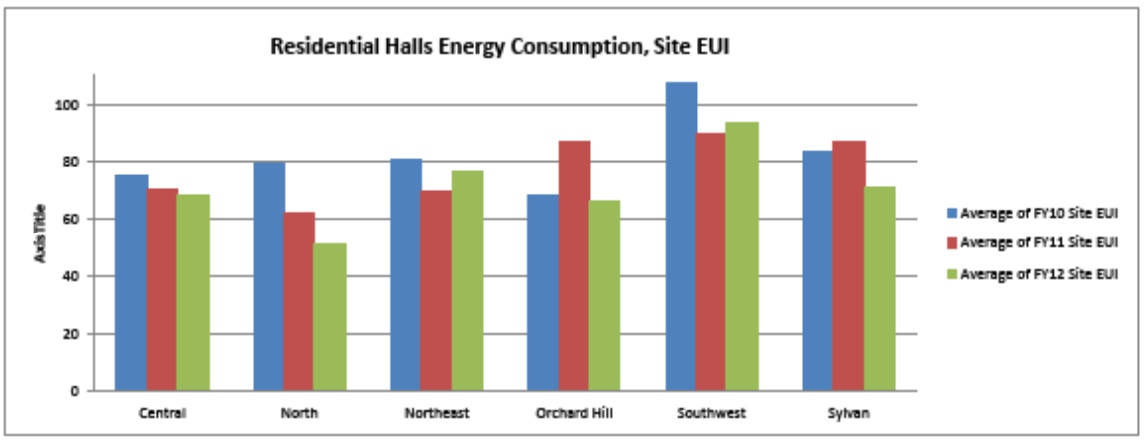
Residential Buildings

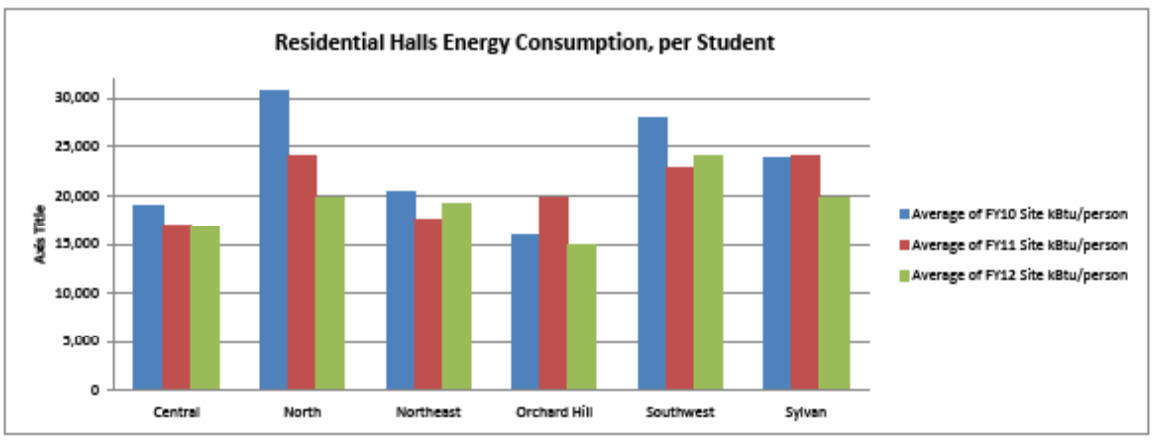


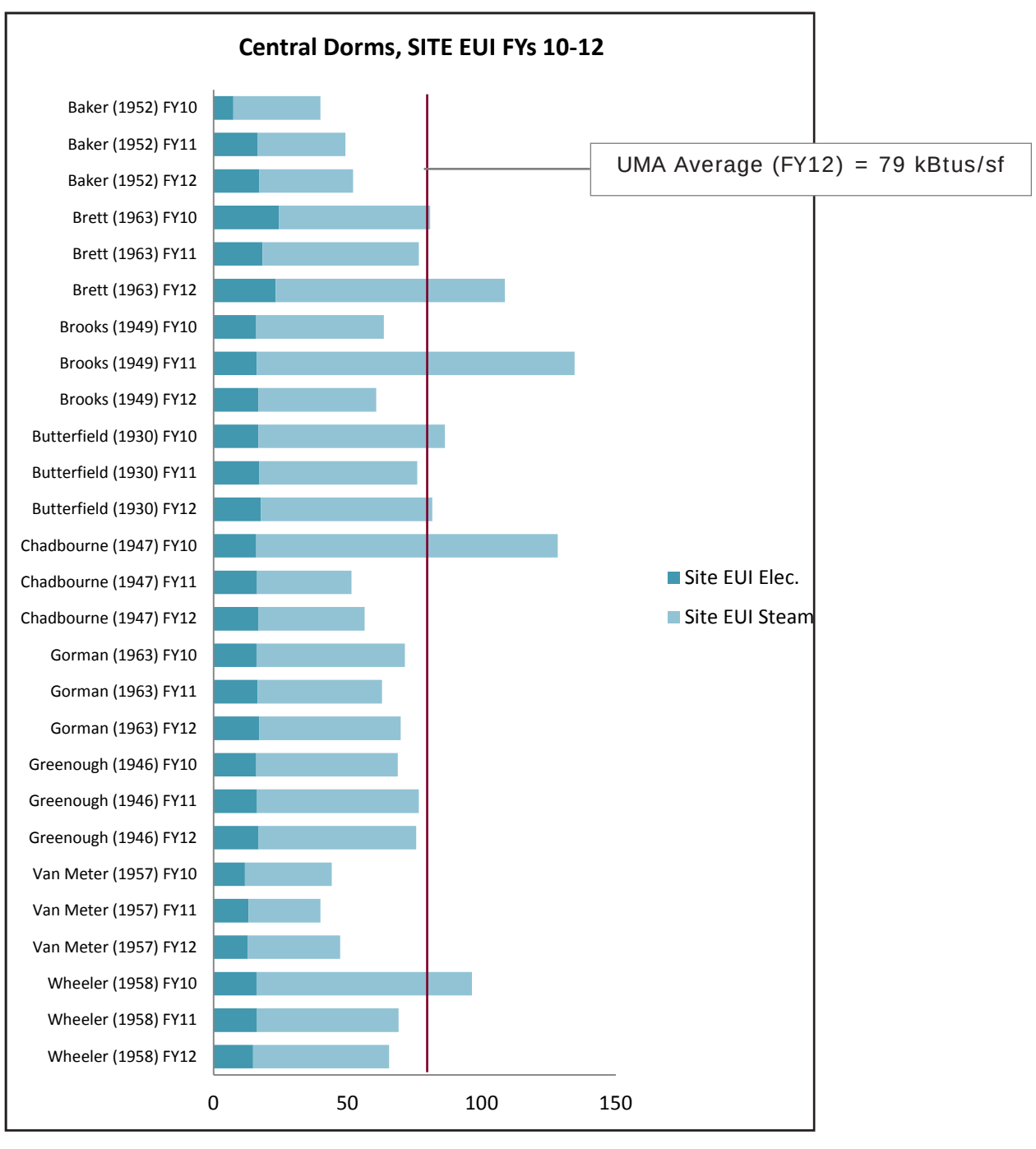
Residential Buildings



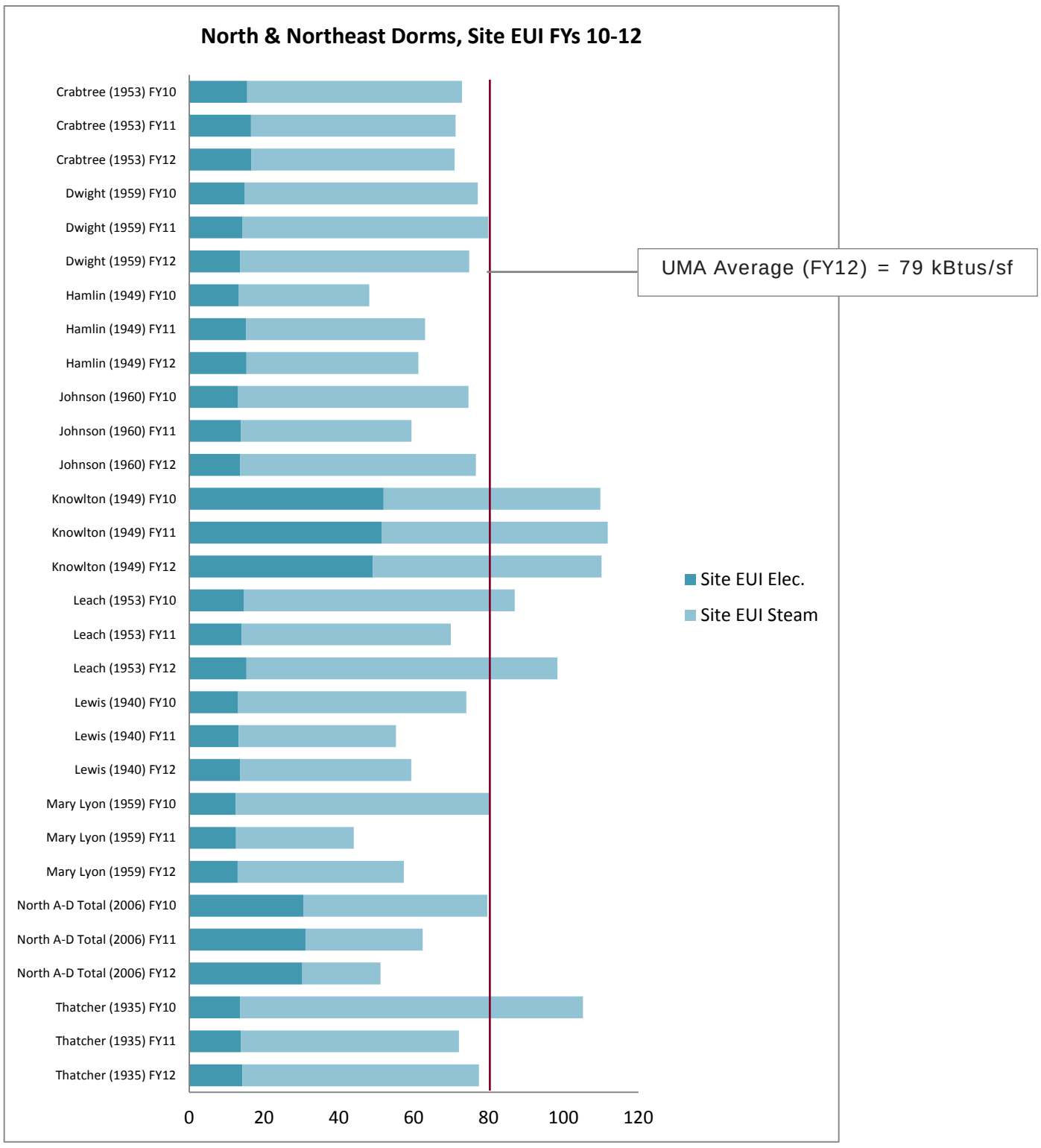
Residential Buildings

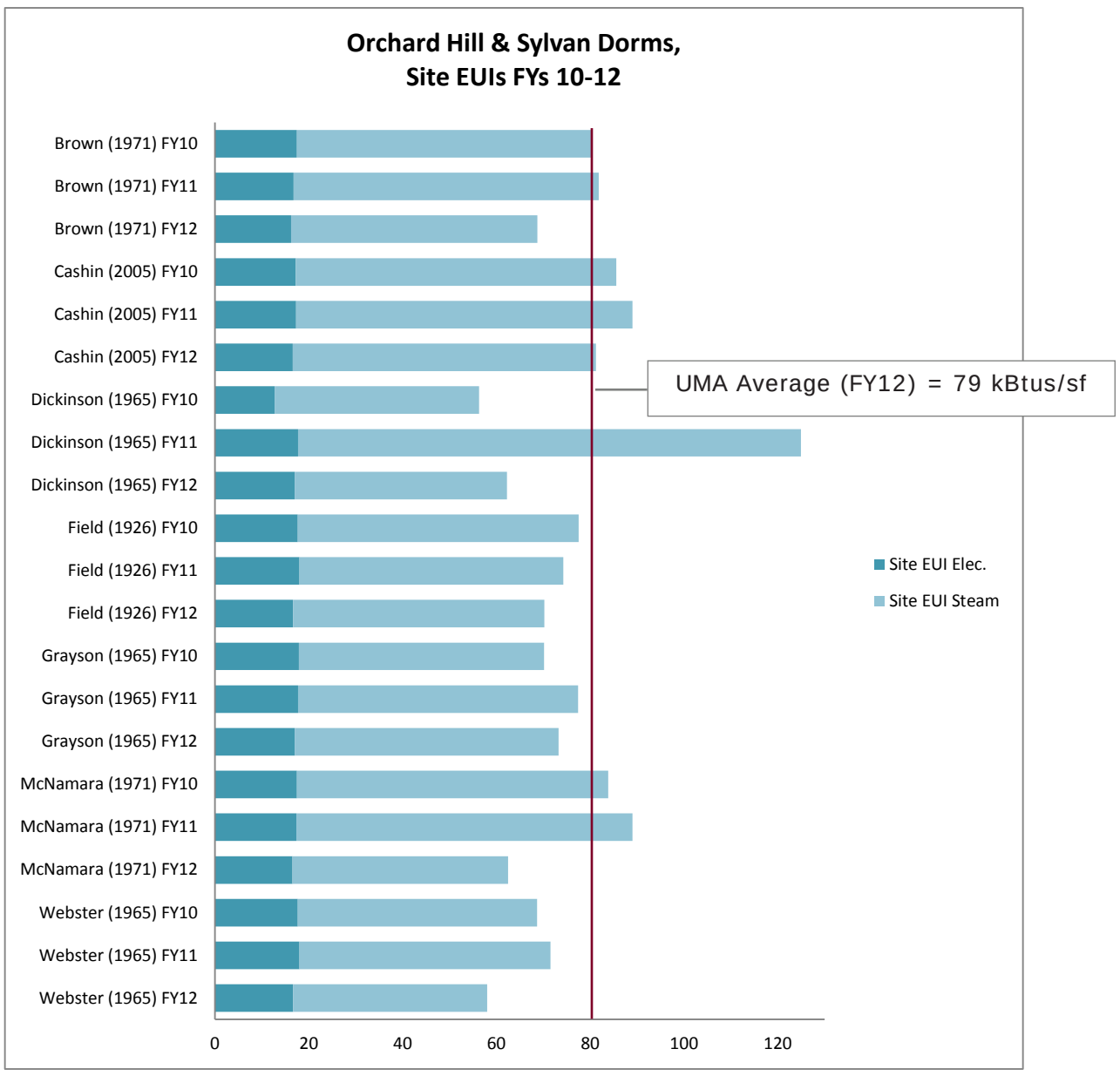




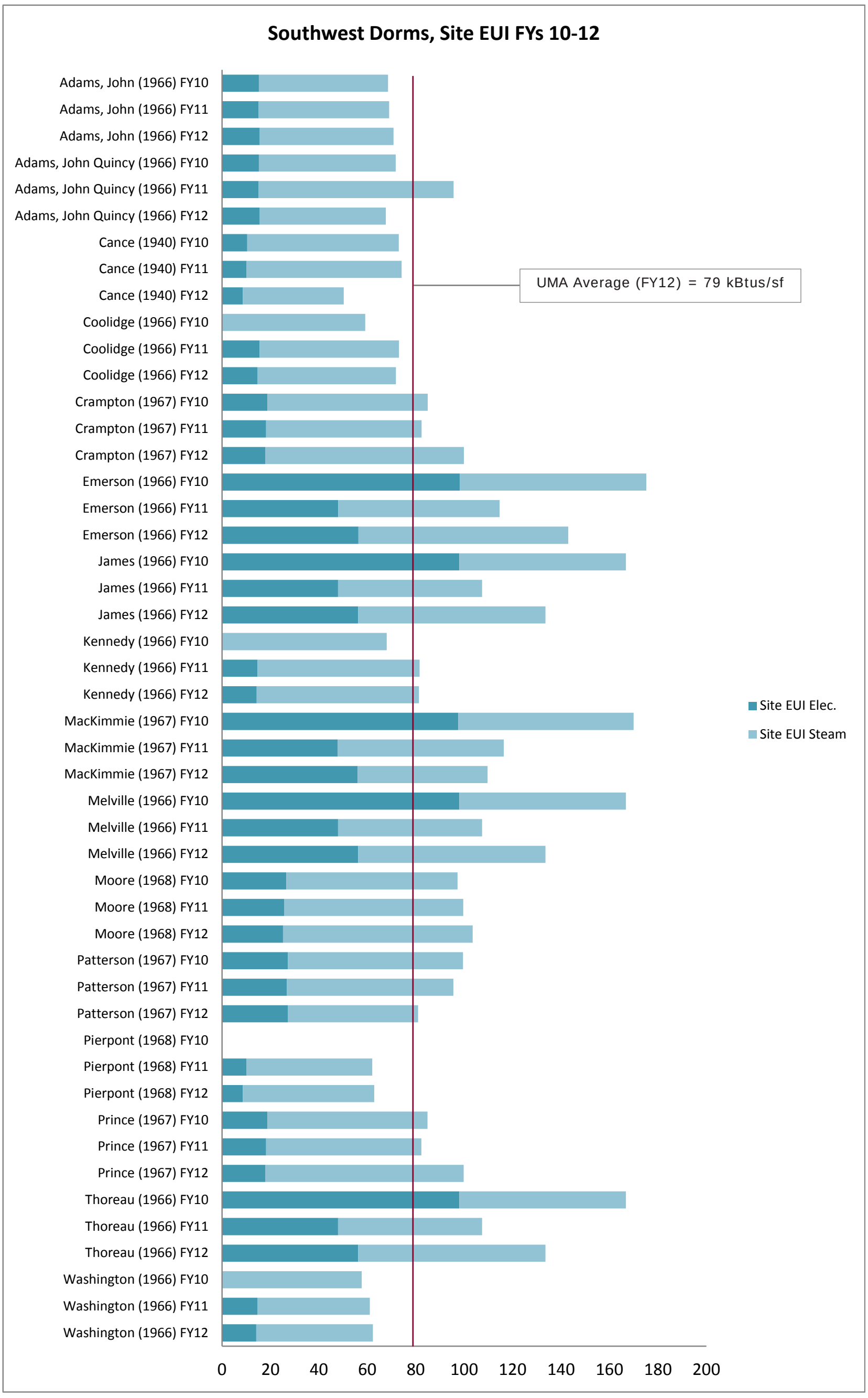


Residential Buildings





Residential Buildings



Integrated Sciences Building

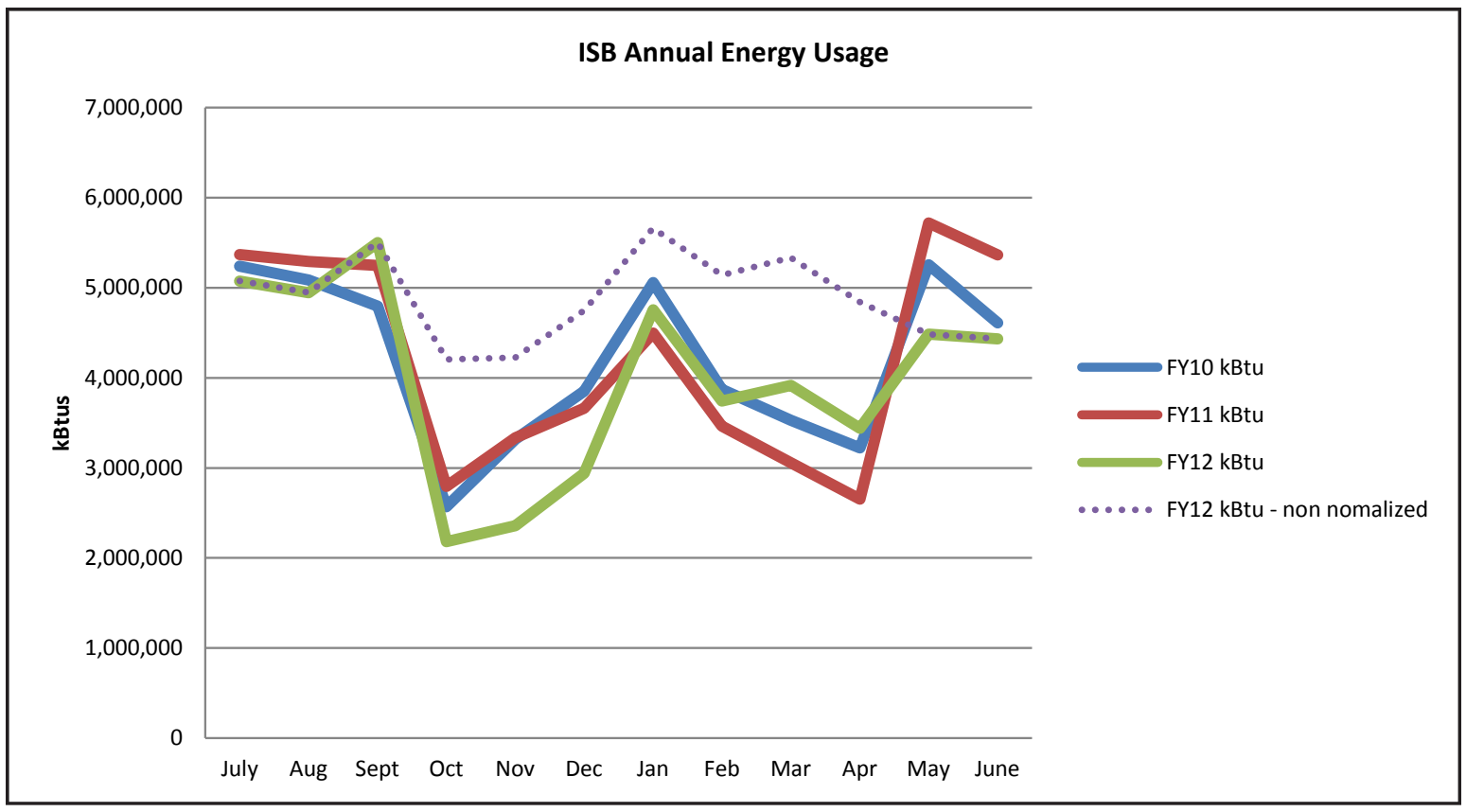
ENERGY PROFILE OF ONE CAMPUS BUILDING

BUILDING PROFILE:

Building Name	Integrated Sciences Building
Building Number	676
Building Type	Academic, Lab
Gross Square Footage	188,332
Capacity	1,761
Year Acquired	2008
Period of Analysis	FY 2010 - 2012

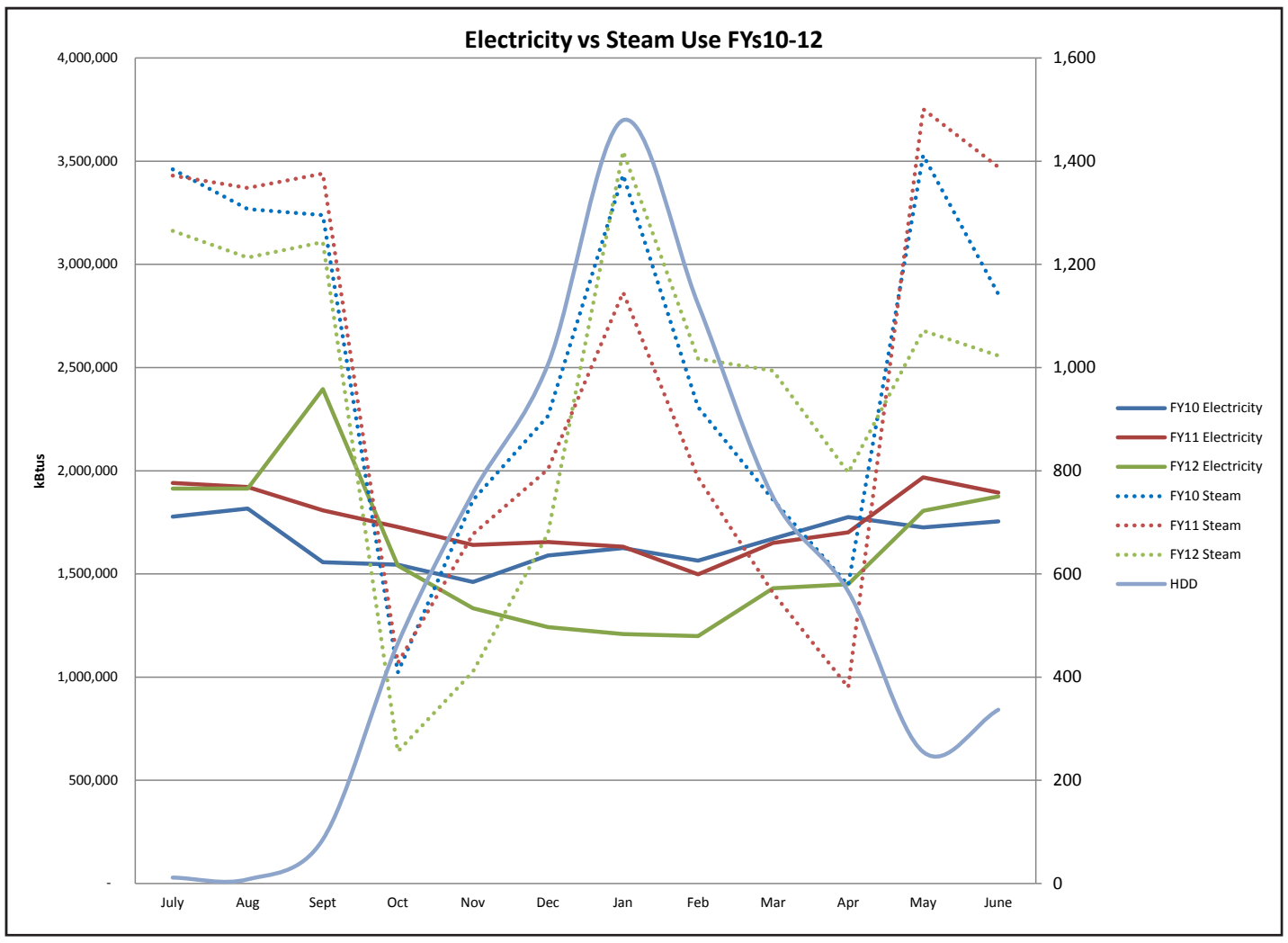
	AVERAGE SITE EUI	AVERAGE SOURCE EUI	TOTAL kBTUS	AVERAGE kBTU/PERSON	TOTAL MT CO2E EMISSIONS	AVERAGE CO2E/ PERSON
FY10	258	381	48,585,654	27,590	9,449	5.37
FY11	268	397	50,462,903	28,656	10,148	5.76
FY12	254	375	47,782,372	27,134	8,939	5.08

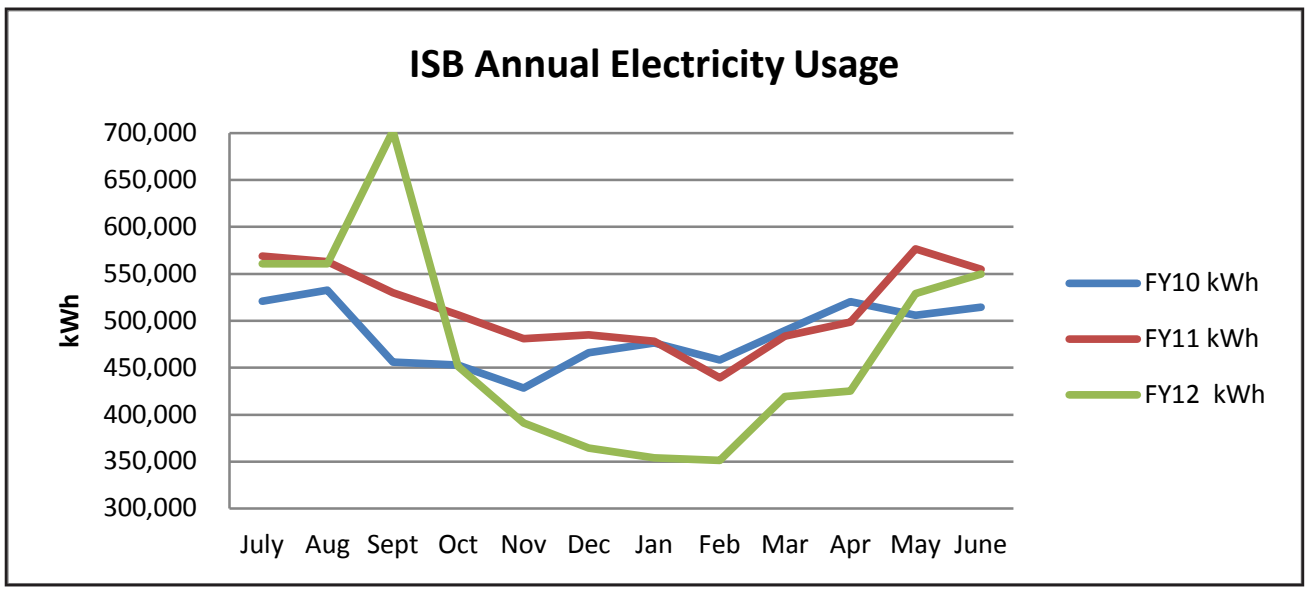
TOTAL ENERGY CONSUMPTION FOR FISCAL YEARS 2010, 2011, 2012

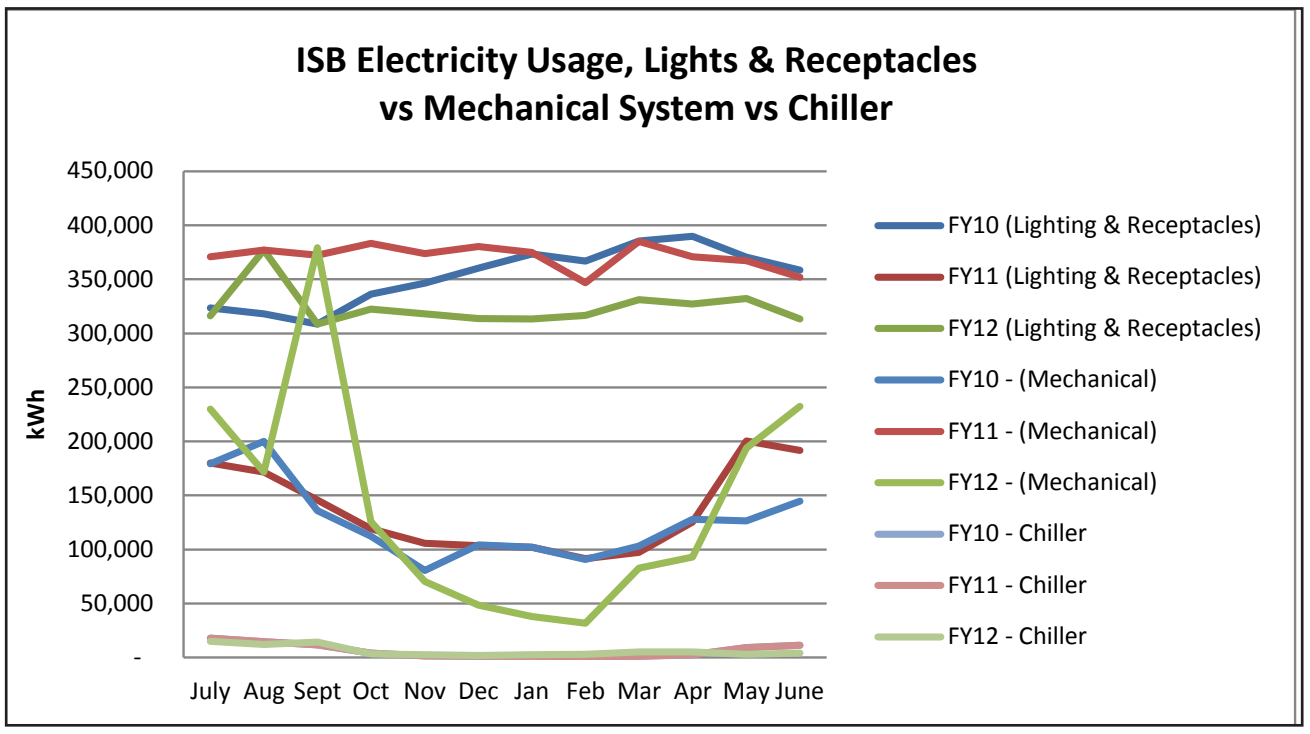


Integrated Sciences Building

ENERGY PROFILE OF ONE CAMPUS BUILDING

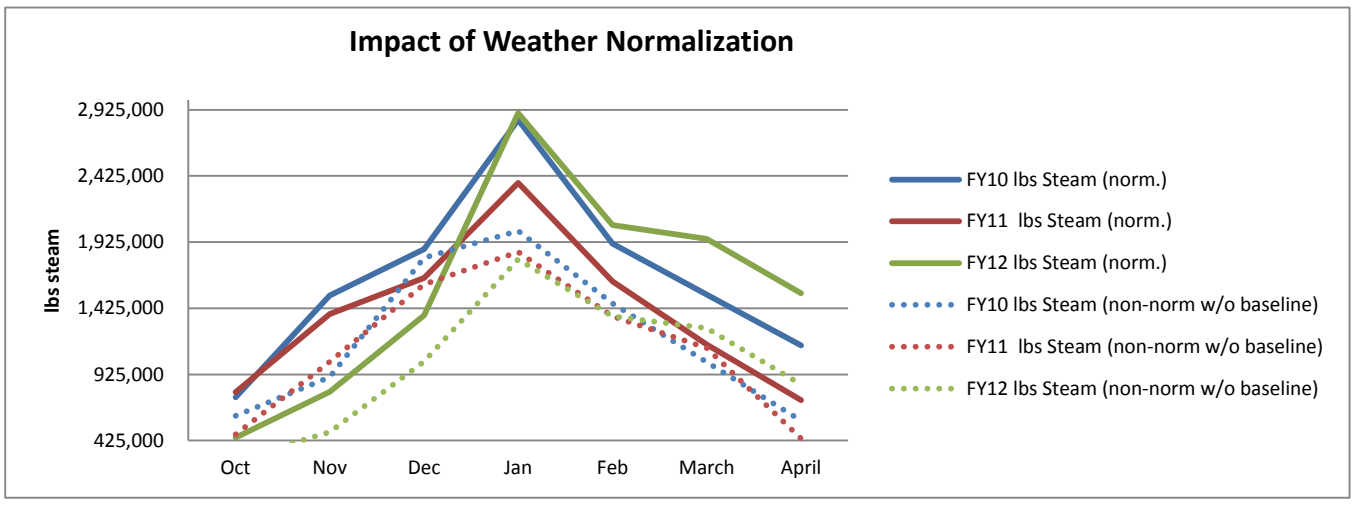




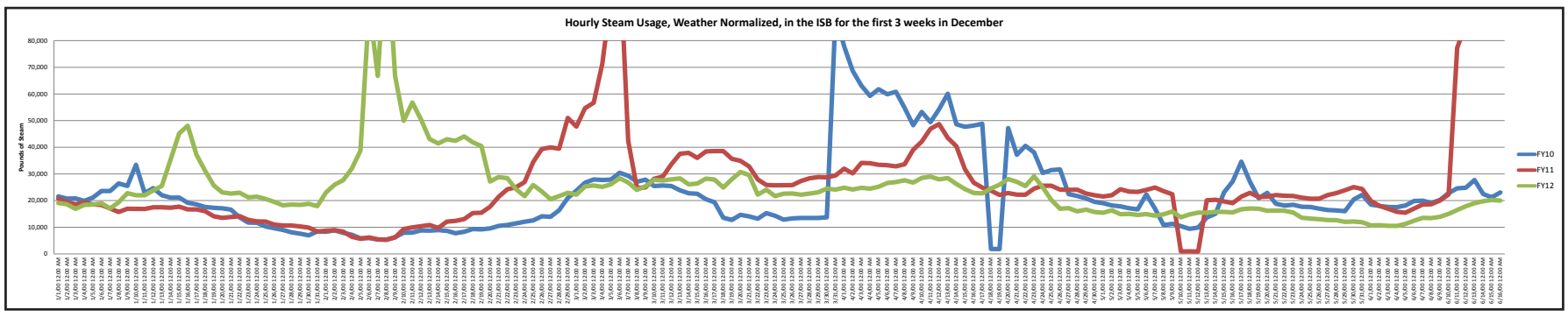


Integrated Sciences Building

ENERGY PROFILE OF ONE CAMPUS BUILDING



Hourly Data Analysis - Experiment



Results of Retrocommissioning Project on the ISB, July - December 2011

ISB Electric Use (6 mo. period)

	kWh	Costs*
FY11	2,258,203	$156,673
FY12	1,884,299	$130,796
Diff.	373,904	$25,877

Yearly projected savings for FY2012= $51,754

*using blended electrical rates from FY2011

ISB Steam Use (6 mo. period)

	lbs	Costs*
FY11	17,810,606	$249,348
FY12	14,823,577	$207,530
Diff	2,987,029	$41,818

Yearly projected savings for FY2012= $83,637

*$14/1000 lbs

ISB Electric Chiller (6 mo. period)

	kWh	Costs*
FY11	399,219	$26,269
FY12	362,050	$23,823
Diff.	37,169	$2,446

Yearly projected savings for FY2012= $4,891

*using consistent kWh rate

ISB Energy Costs & Anticipated Savings:

Costs FY11	Pilot Savings (6mo)	Anticipated Savings FY12	% Savings in $
$869,951	$70,141	$140,282	16.13%

kBtu FY11	Pilot Savings (6mo)	Anticipated Savings FY12	% Savings in kBtu
61,945,362	4,969,505	9,939,010	16.04%

The first round of energy savings at the ISB were obtained by:

- using teaching lab occupancy schedules
- optimizing static pressure setpoints for all building supply and exhaust/return fans
- optimizing air handler discharge air setpoints to dehumidify only when required
- reducing fume hood exhaust levels nights and weekends (still subject to room occupancy sensors)
- reducing static pressures except when labs are occupied
- drastically reducing office wing fan speeds overnight to save fan horsepower, but maintained required building pressure and humidity levels

The bulk of savings were accrued from reduced fan horsepower, particularly during unoccupied periods, with chilled water and steam savings also arising from optimized supply air temperature setpoints.

Significant further savings can be achieved by automating static pressure optimization, demand controlled ventilation in the office wing, making use of lab shutdown mode during extended unoccupied times, and improved programming of heat wheel control as well as improved lighting control.

Although steam savings this year have been large in the winter months, these are predominantly due to much warmer weather this year compared to last. Only the steam savings appearing in the summer and fall, due to reduced reheat requirements, are attributed to this retro-commissioning effort.

Benchmarking Spreadsheet: 3 year comparison

UMA Fiscal Years 2010, 2011, 2012 (July 1 2009 - June 30 2010)

**Note, non-residential occ figures are actually capacity, and do not change.

FY10

Building Name	Bldg. No.	Building Type	G.S.F.	Year Built	FY10 Occ	FY10 Total kBtu	FY10 % Electricity	FY10 % Steam	FY10 Site EUI	FY10 kBtu/person	FY10 Source EUI	FY10 Total CO2E MT	FY10 Total CO2E MT/person	FY10 MT CO2E/sf
Arnold House (1954)	2	Acad	43,292	1954	392	1,944,055	26%	74%	45	4,959	61	240	0.61	0.0055
Bartlett Hall (1960)	107	Acad	113,748	1960	1,882	8,281,572	20%	80%	73	4,400	97	1,118	0.59	0.0098
Dickinson Hall (1960)	132	Acad	29,699	1960	720	3,690,248	38%	62%	124	5,125	180	626	0.87	0.0211
Draper Hall (1947)	87	Acad	39,731	1947	195	2,593,744	16%	84%	65	13,301	86	335	n/a	0.0084
Fernald Hall (1910)	97	Acad	37,774	1910	441	3,122,122	35%	65%	83	7,080	118	446	1.01	0.0118
Fine Arts Center (1973)	420	Acad	220,094	1973	3,978	24,653,265	30%	70%	112	6,197	157	3,275	0.82	0.0149
Furcolo Hall (1962)	289	Acad	101,329	1962	721	2,794,228	5%	95%	28	3,875	34	282	0.39	0.0028
Herter Hall (1968)	406	Acad	113,000	1968	1,756	8,457,758	25%	75%	75	4,816	102	1,122	0.64	0.0099
Holdsworth Hall (1963)	296	Acad	49,496	1963	525	5,067,782	18%	82%	102	9,653	135	562	1.07	0.0114
Isenberg SoM (1963)	317	Acad	75,019	1963	1,412	12,287,806	40%	60%	164	8,702	238	2,023	1.43	0.0270
Machmer Hall (1957)	111	Acad	72,556	1957	1,003	7,404,692	12%	88%	102	7,383	131	744	0.74	0.0102
Marcus Hall (1966)	343	Acad	65,859	1966	976	8,395,410	53%	47%	127	8,602	196	1,728	1.77	0.0262
Marston Hall (1950)	92	Acad	63,469	1950	691	5,123,709	29%	71%	81	7,415	112	668	0.97	0.0105
Mills House (1948)	29	Acad	36,323	1948	295	1,732,986	11%	89%	48	5,875	61	176	0.60	0.0049
Skinner Hall (1948)	128	Acad	60,107	1948	608	3,037,885	32%	63%	51	4,997	72	469	0.77	0.0078
South College (1885)	129	Acad	31,093	1885	259	2,080,318	10%	90%	67	8,032	85	232	0.89	0.0075
Stockbridge Hall (1912)	130	Acad	70,929	1912	1,058	4,977,280	25%	75%	70	4,704	96	726	0.69	0.0102
Thompson Hall (1968)	405	Acad	87,908	1968	1,302	7,711,018	22%	78%	88	5,922	118	1,147	0.88	0.0130
Chenoweth Lab (1966)	101	Acad, lab	56,580	1966	393	6,855,005	36%	64%	121	17,443	173	1,114	2.83	0.0197
Conte Polymer Research (1995)	614	Acad, lab	198,612	1995	738	50,060,643	44%	56%	252	67,833	374	8,870	12.02	0.0447
Eng & CSC I (1999)	651	Acad, lab	78,634	1999	640	17,320,045	20%	77%	220	27,063	296	2,124	3.32	0.0270
Engineering Lab II (2004)	657	Acad, lab	81,304	2004	355	23,827,085	31%	62%	293	67,119	418	3,819	10.76	0.0470
Engineering Shops Building (1962)	293	Acad, lab	45,460	1962	628	4,107,691	33%	67%	90	6,541	128	637	1.01	0.0140
Flint Laboratory (1912)	100	Acad, lab	29,851	1912	326	1,959,244	10%	90%	66	6,010	84	163	0.50	0.0055
Goessmann Lab (1959)	82	Acad, lab	146,805	1959	1,169	23,096,669	39%	61%	157	19,758	228	3,784	3.24	0.0258
Hasbrouck Lab, Add.Only (1963)	318	Acad, lab	72,825	1963	1,095	19,771,658	14%	86%	271	18,056	352	2,013	1.84	0.0276
Integrated Sciences Building (2008)	676	Acad, lab	188,332	2008	1,761	48,585,654	40%	54%	258	27,590	381	9,449	5.37	0.0502
Knowles Eng (1991)	604	Acad, lab	38,325	1991	198	5,584,529	58%	42%	146	28,205	229	1,153	5.82	0.0301
Lederle Grad Research (1973)	502	Acad, lab	506,147	1973	3,074	85,497,278	56%	44%	169	27,813	263	17,151	5.58	0.0339
Morrill I (1959)	126	Acad, lab	60,113	1959	540	6,523,431	27%	61%	109	12,080	153	1,045	1.94	0.0174
Morrill II (1960)	127	Acad, lab	91,239	1960	701	12,165,456	29%	65%	133	17,354	188	1,818	2.59	0.0199
Morrill III (1962)	290	Acad, lab	79,180	1962	460	20,052,270	26%	70%	253	43,592	350	2,770	6.02	0.0350
Morrill IV (1966)	347	Acad, lab	123,247	1966	757	19,824,582	56%	40%	161	26,188	252	4,223	5.58	0.0343
Studio Arts Building (2008)	677	Acad, lab	52,881	2008	375	6,879,522	41%	52%	130	18,345	193	1,212	3.23	0.0229
Tobin Hall (1972)	415	Acad, lab	112,076	1972	758	13,890,240	54%	46%	124	18,325	191	3,186	4.20	0.0284
DuBois Library (1972)	417	Acad, Library	406,480	1972	3,205	19,567,043	10%	90%	48	6,105	61	1,813	0.57	0.0045
Goodell Building (1960)	172	Admin	129,765	1960	661	15,595,107	19%	81%	120	23,593	160	1,552	2.35	0.0120
Lincoln Campus Center (1970)	413	Admin	284,140	1970	2,628	26,200,147	63%	37%	92	9,970	148	5,963	2.27	0.0210
Mullins Memorial Center (1993)	613	Admin	264,654	1993	515	40,549,003	33%	67%	153	78,736	216	6,016	11.68	0.0227
Physical Plant Building (1967)	170	Admin	161,627	1967	551	8,387,066	50%	45%	52	15,222	80	1,840	3.34	0.0114
Research Admin Center (1939)	579	Admin	10,500	1939	67	557,832	100%		53	8,326	97	168	n/a	0.0160
Student Union (1957)	131	Admin	105,939	1957	1,757	10,005,287	19%	81%	94	5,695	125	1,102	0.63	0.0104
Whitmore Hall (1967)	388	Admin	115,281	1967	641	22,504,920	31%	69%	195	35,109	273	3,355	5.23	0.0291
University Health Center (1973)	418	Admin, Health	58,506	1973	321	6,315,269	41%	59%	108	19,674	158	1,060	3.30	0.0181
Berkshire Dining Hall (1968)	399	Dining	48,658	1968	1,044	21,403,042	24%	76%	440	20,501	599	2,921	2.80	0.0600
Franklin Dining Hall (1965)	334	Dining	52,300	1965	981	6,410,034	62%	38%	123	6,534	196	1,370	1.40	0.0262
Hampden Dining Hall (1967)	382	Dining	55,457	1967	617	10,114,139	41%	59%	182	16,392	267	1,598	n/a	0.0288
Hampshire Dining Hall (1966)	357	Dining	46,001	1966	687	11,960,089	28%	72%	260	17,409	360	2,156	3.14	0.0469
Worcester Dining(1961)	86	Dining	68,727	1961	1,246	9,221,130	37%	63%	134	7,401	194	1,929	1.55	0.0281
Boyden Gym (1963)	319	Gym	187,418	1963	1,306	9,424,375	30%	70%	50	7,216	70	1,444	1.11	0.0077
Hicks Phys Ed Building (1987)	576	Gym	67,180	1987	4,452	7,372,868	18%	82%	110	1,656	145	866	0.19	0.0129
Recreation Center (2009)	678	Gym	160,191	2009	n/a					n/a			n/a	0.0000
Totman Phys Ed (1959)	123	Gym	110,505	1959	1,974	10,254,966	17%	83%	93	5,195	122	1,136	0.58	0.0103
Adams, John House (1966)	354	Res	147,178	1966	555	10,088,888	22%	78%	69	18,178	92	1,380	2.49	0.0094
Adams, John Quincy House (1966)	355	Res	147,178	1966	557	10,548,965	21%	79%	72	18,939	96	1,320	2.37	0.0090
Baker House (1952)	3	Res	83,911	1952	319	3,341,224	19%	81%	40	10,474	53	492	1.54	0.0059
Brett House (1963)	295	Res	51,441	1963	230	4,154,841	30%	70%	81	18,065	113	545	2.37	0.0106
Brooks House (1949)	4	Res	30,670	1949	141	1,946,362	25%	75%	63	13,804	87	363	2.58	0.0118
Brown House (1971)	426	Res	102,653	1971	392	8,243,969	22%	78%	80	21,031	108	1,185	3.02	0.0115
Butterfield House (1930)	5	Res	46,190	1930	134	3,983,216	19%	81%	86	29,725	115	419	3.13	0.0091
Cance House (1940)	400	Res	70,005	1940	298	5,110,491	14%	86%	73	17,149	95	595	2.00	0.0085
Cashin House (2005)	427	Res	102,653	2005	302	8,784,540	20%	80%	86	29,088	114	1,329	4.40	0.0129
Chadbourne House (1947)	6	Res	36,505	1947	135	4,684,589	12%	88%	128	34,701	165	403	2.99	0.0111
Coolidge House (1966)	353	Res	147,423	1966	557	8,708,178	0%	100%	59	15,634	71	738	1.33	0.0050
Crabtree House (1953)	12	Res	33,273	1953	143	2,425,115	21%	79%	73	16,959	98	289	2.02	0.0087
Crampton House (1967)	380	Res	52,619	1967	195	4,468,108	22%	78%	85	22,913	114	601	3.08	0.0114
Dickinson House (1965)	331	Res	78,214	1965	331	4,405,261	23%	77%	56	13,309	76	609	1.84	0.0078
Dwight House (1959)	35	Res	39,034	1959	173	3,009,276	19%	81%	77	17,395	102	453	2.62	0.0116
Emerson House (1966)	351	Res	40,777	1966	162	7,142,667	56%	44%	175	44,091	273	1,425	8.80	0.0349
Field House (1926)	332	Res	78,214	1926	339	6,066,108	23%	77%	78	17,894	105	804	2.37	0.0103
Gorman House (1963)	294	Res	66,335	1963	322	4,730,441	22%	78%	71	14,691	96	620	1.92	0.0093
Grayson House (1965)	330	Res	78,214	1965	339	5,486,325	26%	74%	70	16,184	96	857	2.53	0.0110

*residential buildgs are occupancy. All other are capacity.

FY11

Building Name	FY11 Occ	FY11 Total kBtu	FY11 % Electricity	FY11 % Steam	FY11 Site EUI	FY11 kBtu/person	FY11 Source EUI	FY11 Total CO2E MT	FY11 Total CO2E MT/person	FY11 MT CO2E/sf
Arnold House (1954)	392	2,288,991	20%	80%	53	5,839	71	266	0.68	0.01
Bartlett Hall (1960)	1,882	8,990,451	19%	81%	79	4,777	105	1,222	0.65	0.0107
Dickinson Hall (1960)	720	3,620,547	26%	74%	122	5,029	167	582	0.81	0.0196
Draper Hall (1947)	195	2,861,034	14%	86%	72	14,672	94	358	n/a	0.0090
Fernald Hall (1910)	441	3,214,839	49%	51%	85	7,290	129	573	1.30	0.0152
Fine Arts Center (1973)	3,978	25,741,640	27%	73%	117	6,471	161	3,276	0.82	0.0149
Furcolo Hall (1962)	721	2,827,311	38%	62%	28	3,921	40	537	0.74	0.0053
Herter Hall (1968)	1,756	8,719,715	15%	85%	77	4,966	101	863	0.49	0.0076
Holdsworth Hall (1963)	525	6,163,786	15%	85%	125	11,741	162	640	1.22	0.0129
Isenberg SoM (1963)	1,412	11,266,588	43%	57%	150	7,979	222	1,965	1.39	0.0262
Machmer Hall (1957)	1,003	5,016,847	18%	82%	69	5,002	91	734	0.73	0.0101
Marcus Hall (1966)	976	7,108,273	35%	65%	108	7,283	154	1,167	1.20	0.0177
Marston Hall (1950)	691	5,203,231	29%	71%	82	7,530	114	683	0.99	0.0108
Mills House (1948)	295	2,377,645	49%	51%	65	8,060	99	420	1.43	0.0116
Skinner Hall (1948)	608	2,846,160	37%	58%	47	4,681	69	454	0.75	0.0076
South College (1885)	259	2,041,599	13%	87%	66	7,883	85	254	0.98	0.0082
Stockbridge Hall (1912)	1,058	5,376,692	24%	76%	76	5,082	103	760	0.72	0.0107
Thompson Hall (1968)	1,302	8,934,005	23%	77%	102	6,862	137	1,161	0.89	0.0132
Chenoweth Lab (1966)	393	6,435,737	34%	66%	114	16,376	161	924	2.35	0.0163
Conte Polymer Research (1995)	738	59,430,935	33%	67%	299	80,530	423	8,766	11.88	0.0441
Eng & CSC I (1999)	640	15,070,194	26%	71%	192	23,547	265	2,129	3.33	0.0271
Engineering Lab II (2004)	355	25,497,959	27%	66%	314	71,825	439	3,858	10.87	0.0474
Engineering Shops Building (1962)	628	3,439,526	39%	61%	76	5,477	110	620	0.99	0.0136
Flint Laboratory (1912)	326	1,565,275	18%	82%	52	4,801	69	197	0.61	0.0066
Goessmann Lab (1959)	1,169	24,607,892	34%	66%	168	21,050	238	3,746	3.20	0.0255
Hasbrouck Lab, Add.Only (1963)	1,095	15,263,293	20%	80%	210	13,939	280	2,026	1.85	0.0278
Integrated Sciences Building (2008)	1,761	50,462,903	41%	54%	268	28,656	397	10,148	5.76	0.0539
Knowles Eng (1991)	198	5,284,756	62%	38%	138	26,691	220	1,169	5.91	0.0305
Lederle Grad Research (1973)	3,074	96,388,343	44%	56%	190	31,356	282	17,292	5.63	0.0342
Morrill I (1959)	540	6,391,275	29%	59%	106	11,836	152	1,054	1.95	0.0175
Morrill II (1960)	701	15,780,629	22%	73%	173	22,512	236	2,325	3.32	0.0255
Morrill III (1962)	460	21,874,340	24%	72%	276	47,553	379	2,996	6.51	0.0378
Morrill IV (1966)	757	19,795,360	57%	39%	161	26,150	253	4,238	5.60	0.0344
Studio Arts Building (2008)	375	4,835,028	53%	37%	91	12,893	143	1,018	2.71	0.0192
Tobin Hall (1972)	758	25,948,703	26%	74%	232	34,233	317	3,614	4.77	0.0322
DuBois Library (1972)	3,205	60,996,394	36%	64%	150	19,032	215	9,333	2.91	0.0230
Goodell Building (1960)	661	14,594,510	23%	77%	112	22,079	152	1,852	2.80	0.0143
Lincoln Campus Center (1970)	2,628	28,990,146	45%	55%	102	11,031	152	5,384	2.05	0.0189
Mullins Memorial Center (1993)	515	41,905,932	33%	67%	158	81,371	224	6,882	13.36	0.0260
Physical Plant Building (1967)	551	8,221,204	49%	47%	51	14,921	78	1,855	3.37	0.0115
Research Admin Center (1939)	67	514,355	100%		49	7,677	90	152	n/a	0.0144
Student Union (1957)	1,757	8,882,438	22%	78%	84	5,055	113	1,342	0.76	0.0127
Whitmore Hall (1967)	641	21,079,413	31%	69%	183	32,885	256	3,193	4.98	0.0277
University Health Center (1973)	321	4,686,841	58%	42%	80	14,601	126	1,004	3.13	0.0172
Berkshire Dining Hall (1968)	1,044	17,880,021	30%	70%	367	17,126	513	3,053	2.92	0.0627
Franklin Dining Hall (1965)	981	8,538,827	49%	51%	163	8,704	247	1,500	1.53	0.0287
Hampden Dining Hall (1967)	617	9,226,243	45%	55%	166	14,953	248	1,760	2.85	0.0317
Hampshire Dining Hall (1966)	687	14,085,263	28%	72%	306	20,503	423	2,011	2.93	0.0437
Worcester Dining(1961)	1,246	10,372,689	41%	59%	151	8,325	221	2,290	1.84	0.0333
Boyden Gym (1963)	1,306	10,007,805	31%	69%	53	7,663	75	1,618	1.24	0.0086
Hicks Phys Ed Building (1987)	4,452	6,917,324	19%	81%	103	1,554	137	863	0.19	0.0128
Recreation Center (2009)	319	9,875,688	66%	34%	62	30,958	100	2,170	6.80	0.0135
Totman Phys Ed (1959)	1,974	9,476,838	19%	81%	86	4,801	114	1,330	0.67	0.0120
Adams, John House (1966)	555	10,152,101	22%	78%	69	18,292	93	1,415	2.55	0.0096
Adams, John Quincy House (1966)	558	14,072,992	16%	84%	96	25,220	125	1,476	2.65	0.0100
Baker House (1952)	321	4,122,347	34%	66%	49	12,842	70	829	2.58	0.0099
Brett House (1963)	244	3,936,654	24%	76%	77	16,134	104	547	2.24	0.0106
Brooks House (1949)	149	4,127,469	12%	88%	135	27,701	173	434	2.91	0.0141
Brown House (1971)	390	8,401,137	21%	79%	82	21,541	109	1,177	3.02	0.0115
Butterfield House (1930)	133	3,506,622	23%	77%	76	26,366	102	477	3.58	0.0103
Cance House (1940)	308	5,193,033	14%	86%	74	16,860	96	613	1.99	0.0088
Cashin House (2005)	328	9,139,461	19%	81%	89	27,864	118	1,271	3.88	0.0124
Chadbourne House (1947)	138	1,876,532	32%	68%	51	13,598	72	386	2.80	0.0106
Coolidge House (1966)	558	10,764,018	21%	79%	73	19,290	98	1,422	2.55	0.0096
Crabtree House (1953)	144	2,368,733	23%	77%	71	16,450	96	305	2.12	0.0092
Crampton House (1967)	196	4,334,962	22%	78%	82	22,117	111	606	3.09	0.0115
Dickinson House (1965)	352	9,772,408	14%	86%	125	27,763	162	949	2.70	0.0121
Dwight House (1959)	174	3,118,284	18%	82%	80	17,921	105	461	2.65	0.0118
Emerson House (1966)	169	4,674,251	42%	58%	115	27,658	168	807	4.77	0.0198
Field House (1926)	340	5,808,864	24%	76%	74	17,085	101	949	2.79	0.0121
Gorman House (1963)	332	4,166,067	26%	74%	63	12,548	86	655	1.97	0.0099
Grayson House (1965)	340	6,055,189	23%	77%	77	17,809	105	872	2.57	0.0112

***Note FY12 Residential occupancy numbers are a copy of FY1. FY12 data is forthcoming.

FY12

Building Name	FY12 Occ	FY12 Total kBtu	FY12 % Electricity	FY12 % Steam	FY12 Site EUI	FY12 kBtu/person	FY12 Source EUI	FY12 Total CO2E MT	FY12 Total CO2E MT/person	FY12 MT CO2E/sf
Arnold House (1954)	392	2,637,847	18%	82%	61	6,729	81	144	0.37	0.00
Bartlett Hall (1960)	1,882	7,778,605	23%	77%	68	4,133	93	1,194	0.63	0.0105
Dickinson Hall (1960)	720	3,827,600	15%	85%	129	5,316	168	419	0.58	0.0141
Draper Hall (1947)	195	2,427,374	17%	83%	61	12,448	80	311	1.59	0.0078
Fernald Hall (1910)	441	3,063,597	33%	67%	81	6,947	115	443	1.01	0.0117
Fine Arts Center (1973)	3,978	26,760,407	31%	69%	122	6,727	170	3,433	0.86	0.0156
Furcolo Hall (1962)	721	2,431,497	45%	55%	24	3,372	36	512	0.71	0.0051
Herter Hall (1968)	1,756	9,198,649	21%	79%	81	5,238	109	1,090	0.62	0.0096
Holdsworth Hall (1963)	525	5,329,635	18%	82%	108	10,152	142	516	0.98	0.0104
Isenberg SoM (1963)	1,412	10,419,166	48%	52%	139	7,379	210	1,903	1.35	0.0254
Machmer Hall (1957)	1,003	4,449,490	19%	81%	61	4,436	81	630	0.63	0.0087
Marcus Hall (1966)	976	7,244,066	37%	63%	110	7,422	158	1,172	1.20	0.0178
Marston Hall (1950)	691	4,234,121	33%	67%	67	6,128	94	551	0.80	0.0087
Mills House (1948)	295	2,182,013	16%	84%	60	7,397	79	101	0.34	0.0028
Skinner Hall (1948)	608	2,650,930	39%	53%	44	4,360	65	441	0.73	0.0073
South College (1885)	259	1,387,639	27%	73%	45	5,358	61	261	1.01	0.0084
Stockbridge Hall (1912)	1,058	4,930,874	27%	73%	70	4,661	96	633	0.60	0.0089
Thompson Hall (1968)	1,302	8,413,581	22%	78%	96	6,462	129	1,116	0.86	0.0127
Chenoweth Lab (1966)	393	6,926,676	32%	68%	122	17,625	172	1,071	2.73	0.0189
Conte Polymer Research (1995)	738	48,506,927	39%	59%	244	65,728	356	8,202	11.11	0.0413
Eng & CSC I (1999)	640	16,020,336	25%	69%	204	25,032	282	2,282	3.57	0.0290
Engineering Lab II (2004)	355	21,998,046	35%	55%	271	61,966	395	4,052	11.42	0.0498
Engineering Shops Building (1962)	628	3,432,138	37%	63%	75	5,465	109	571	0.91	0.0126
Flint Laboratory (1912)	326	1,685,416	13%	87%	56	5,170	73	160	0.49	0.0054
Goessmann Lab (1959)	1,169	57,259,209	14%	86%	390	48,981	507	5,444	4.66	0.0371
Hasbrouck Lab, Add.Only (1963)	1,095	15,930,680	19%	81%	219	14,549	291	1,940	1.77	0.0266
Integrated Sciences Building (2008)	1,761	47,782,372	40%	55%	254	27,134	374	8,939	5.08	0.0475
Knowles Eng (1991)	198	5,666,352	57%	43%	148	28,618	231	1,131	5.71	0.0295
Lederle Grad Research (1973)	3,074	86,982,935	34%	66%	172	28,296	244	13,491	4.39	0.0267
Morrill I (1959)	540	7,803,192	29%	60%	130	14,450	185	1,214	2.25	0.0202
Morrill II (1960)	701	17,017,696	25%	70%	187	24,276	258	2,495	3.56	0.0273
Morrill III (1962)	460	26,748,625	19%	77%	338	58,149	453	3,420	7.43	0.0432
Morrill IV (1966)	757	21,679,330	53%	44%	176	28,638	272	4,281	5.66	0.0347
Studio Arts Building (2008)	375	4,713,469	50%	40%	89	12,569	138	942	2.51	0.0178
Tobin Hall (1972)	758	26,474,461	28%	72%	236	34,927	326	3,776	4.98	0.0337
DuBois Library (1972)	3,205	28,127,727	74%	26%	69	8,776	116	7,480	2.33	0.0184
Goodell Building (1960)	661	18,259,077	20%	80%	141	27,623	188	2,246	3.40	0.0173
Lincoln Campus Center (1970)	2,628	34,190,697	41%	59%	120	13,010	176	6,160	2.34	0.0217
Mullins Memorial Center (1993)	515	39,077,882	35%	65%	148	75,879	211	6,021	11.69	0.0228
Physical Plant Building (1967)	551	13,439,211	32%	65%	83	24,391	118	1,899	3.45	0.0117
Research Admin Center (1939)	67	544,441	100%		52	8,126	95	161	n/a	0.0153
Student Union (1957)	1,757	9,383,341	20%	80%	89	5,341	118	1,106	0.63	0.0104
Whitmore Hall (1967)	641	18,331,207	28%	72%	159	28,598	220	2,649	4.13	0.0230
University Health Center (1973)	321	4,868,248	56%	44%	83	15,166	130	987	3.08	0.0169
Berkshire Dining Hall (1968)	1,044	21,160,214	27%	73%	435	20,268	599	2,956	2.83	0.0608
Franklin Dining Hall (1965)	981	13,839,746	33%	67%	265	14,108	374	1,992	2.03	0.0381
Hampden Dining Hall (1967)	617	11,869,978	37%	63%	214	19,238	308	1,807	2.93	0.0326
Hampshire Dining Hall (1966)	687	10,964,239	37%	63%	238	15,960	343	1,732	2.52	0.0376
Worcester Dining(1961)	1,246	10,984,236	40%	60%	160	8,816	233	2,239	1.80	0.0326
Boyden Gym (1963)	1,306	9,946,815	30%	70%	53	7,616	74	1,414	1.08	0.0075
Hicks Phys Ed Building (1987)	4,452	8,303,628	15%	85%	124	1,865	161	840	0.19	0.0125
Recreation Center (2009)	319	8,817,809	81%	19%	55	27,642	94	2,236	7.01	0.0140
Totman Phys Ed (1959)	1,974	7,137,556	24%	76%	65	3,616	88	1,010	0.51	0.0091
Adams, John House (1966)	555	10,416,524	22%	78%	71	18,769	95	1,202	2.17	0.0082
Adams, John Quincy House (1966)	558	9,945,222	23%	77%	68	17,823	91	1,293	2.32	0.0088
Baker House (1952)	321	4,367,609	33%	67%	52	13,606	74	815	2.54	0.0097
Brett House (1963)	244	5,588,815	21%	79%	109	22,905	146	615	2.52	0.0120
Brooks House (1949)	149	1,861,153	27%	73%	61	12,491	84	340	2.28	0.0111
Brown House (1971)	390	7,055,185	24%	76%	69	18,090	93	1,027	2.63	0.0100
Butterfield House (1930)	133	3,764,250	22%	78%	81	28,303	110	465	3.49	0.0101
Cance House (1940)	308	3,518,088	17%	83%	50	11,422	66	323	1.05	0.0046
Cashin House (2005)	328	8,340,359	20%	80%	81	25,428	109	994	3.03	0.0097
Chadbourne House (1947)	138	2,057,193	30%	70%	56	14,907	79	351	2.54	0.0096
Coolidge House (1966)	558	10,586,220	20%	80%	72	18,972	96	1,267	2.27	0.0086
Crabtree House (1953)	144	2,359,315	23%	77%	71	16,384	96	301	2.09	0.0090
Crampton House (1967)	196	5,253,949	18%	82%	100	26,806	132	533	2.72	0.0101
Dickinson House (1965)	352	4,867,860	27%	73%	62	13,829	86	721	2.05	0.0092
Dwight House (1959)	174	2,920,506	18%	82%	75	16,785	99	458	2.63	0.0117
Emerson House (1966)	169	5,827,657	39%	61%	143	34,483	208	856	5.06	0.0210
Field House (1926)	340	5,492,788	24%	76%	70	16,155	95	881	2.59	0.0113
Gorman House (1963)	332	4,630,156	24%	76%	70	13,946	95	611	1.84	0.0092
Grayson House (1965)	340	5,730,054	23%	77%	73	16,853	99	806	2.37	0.0103

Benchmarking Spreadsheet: FY12 DATA

University of Massachusetts Amherst Energy Usage

By Building for Fiscal Year 2012 (July 1 2011 - June 30 2012)

1.83

Building Name	Bldg. No.	Group Meter Bldg No.s	Notes	Building Type	G.S.F.	Year Built	Electricity Total kWh	Electricity Total kBtu	Steam Total lbs (weather normalized)	Steam Total kBtu (weather normalized)	Steam Total lbs (non-weather normalized)	Steam Total kBtu (non-weather normalized)	Chilled Water Ton-Hours	Chilled Water Total kBtu	Total kBtu	% Electricity	% Steam	Site EUI - kBtu/sf	Source EUI - kBtu/sf	GHG Emissions from Electricity lbs CO2	GHG Emissions from Steam lbs CO2	GHG Emissions from Chilled Water lbs CO2	Total GHG Emissions lbs CO2	Total GHG Emissions Metric Tons
Adams, John House	354			Res	147,178	1966	672,460	2,295,106	6,801,858	8,121,419	5,704,684	6,811,392	N/A		10,416,524	22%	78%	71	95	1,491,819	1,157,937		2,649,755	1,202
Adams, John Quincy House	355			Res	147,178	1966	672,460	2,295,106	6,407,132	7,650,116	6,693,227	7,991,712			9,945,222	23%	77%	68	91	1,491,819	1,358,591		2,850,410	1,293
Arnold House	2			Acad	43,292	1954	142,392	485,983	1,802,231	2,151,864	11,240	13,420			2,637,847	18%	82%	61	81	315,889	2,281		318,170	144
Baker House	3			Res	83,911	1952	419,515	1,431,805	2,458,797	2,935,804	4,269,130	5,097,342			4,367,609	33%	67%	52	74	930,673	866,548		1,797,221	815
Bartlett Hal	107			Acad	113,748	1960	530,193	1,809,548	4,999,210	5,969,057	7,168,925	8,559,697			7,778,605	23%	77%	68	93	1,176,206	1,455,148		2,631,355	1,194
Berkshire Dining Hal	399			Dining	48,658	1968	1,679,626	5,732,565	12,920,980	15,427,650	13,749,484	16,416,884			21,160,214	27%	73%	435	599	3,726,167	2,790,870		6,517,037	2,956
Boyden Gymnasium	319			Gym	187,418	1963	873,077	2,979,810	5,835,012	6,967,005	5,818,050	6,946,752			9,946,815	30%	70%	53	74	1,936,877	1,180,948		3,117,824	1,414
Brett House	295			Res	51,441	1963	349,175	1,191,736	3,682,646	4,397,080	2,866,089	3,422,110			5,588,815	21%	79%	109	146	774,628	581,759		1,356,387	615
Brooks House	4			Res	30,670	1949	149,827	511,359	1,130,481	1,349,795	2,053,470	2,451,844			1,861,153	27%	73%	61	84	332,383	416,813		749,197	340
Brown House	426			Res	102,653	1971	488,237	1,666,354	4,513,259	5,388,831	5,622,846	6,952,478			7,055,185	24%	76%	69	93	1,083,130	1,181,921		2,265,051	1,027
Butterfield House	5			Res	46,190	1930	239,723	818,174	2,467,400	2,946,076	2,425,003	2,895,453			3,764,250	22%	78%	81	110	531,813	492,227		1,024,040	465
Cance House	400		Electric Meter combined with Pierpont House. kWh is estimated as half total.	Res	70,005	1940	176,099	601,024	2,443,102	2,917,064	1,587,397	1,895,352			3,518,088	17%	83%	50	66	390,666	322,210		712,876	323
Cashin House	427			Res	102,653	2005	498,916	1,702,800	5,559,094	6,637,558	5,343,379	6,379,994			8,340,359	20%	80%	81	109	1,106,820	1,084,599		2,191,419	994
Chadbourne House	6			Res	36,505	1947	179,792	613,631	1,209,014	1,443,562	1,846,723	2,204,987			2,057,193	30%	70%	56	79	398,860	374,848		773,708	351
Chenoweth Laboratory & Chenoweth Laboratory Addition	101	101, 344	both electricity and steam are combined meters	Acad, lab	56,580	1930-1966	651,151	2,222,377	3,939,950	4,704,300	4,519,676	5,396,493			6,926,676	32%	68%	122	172	1,444,545	917,404		2,361,949	1,071
Conte Polymer Research Center	614			Acad, lab	198,612	1995	5,534,407	18,888,933	23,920,406	28,560,965	25,209,817	30,100,522	442,438	1,057,029	48,506,927	39%	59%	244	356	12,277,806	5,117,089	687,069	18,081,964	8,202
Coolidge House	353			Res	147,423	1966	630,514	2,151,944	7,063,882	8,434,275	6,873,652	8,207,140			10,586,220	20%	80%	72	96	1,398,764	1,395,214		2,793,978	1,267
Crabtree House	12			Res	33,273	1953	162,355	554,119	1,511,890	1,805,196	1,491,475	1,780,821			2,359,315	23%	77%	71	96	360,177	302,740		662,917	301
Crampton House	380			Res	52,619	1967	274,567	937,098	3,615,453	4,316,850	2,783,283	3,323,239			5,253,949	18%	82%	100	132	609,114	564,951		1,174,064	533
Dickinson Hall	132			Acad	29,699	1960	173,554	592,339	2,709,599	3,235,261	2,648,699	3,162,547			3,827,600	15%	85%	129	168	385,020	537,633		922,653	419
Dickinson House	331			Res	78,214	1965	390,239	1,331,886	2,961,452	3,535,974	3,565,666	4,257,406			4,867,860	27%	73%	62	86	865,726	723,759		1,589,485	721
Draper Hal	87	87, 88		Acad	39,731	1903, 1947	119,383	407,453	1,691,726	2,019,921	2,069,731	2,471,259			2,427,374	17%	83%	61	80	264,844	420,114		684,958	311
DuBois Library	417			Acad, Library	406,480	1972	6,124,385	20,902,526	6,051,257	7,225,201	14,307,497	17,083,151			28,127,727	74%	26%	69	116	13,586,642	2,904,136		16,490,778	7,480
Dwight House	35			Res	39,034	1959	155,851	531,920	2,000,490	2,388,585	3,275,196	3,910,584			2,920,506	18%	82%	75	99	345,748	664,799		1,010,547	458
Emerson House	351			Res	40,777	1966	673,142	2,297,434	2,956,635	3,530,223	1,934,795	2,310,145			5,827,657	39%	61%	143	208	1,493,332	392,725		1,886,057	856
Engineering & Computer Science Center I	651			Acad, lab	78,634	1999	1,189,021	4,058,128	9,255,607	11,051,194	8,872,133	10,593,326	381,321	911,014	16,020,336	25%	69%	204	282	2,637,783	1,800,865	592,159	5,030,808	2,282
Engineering Laboratory I	657			Acad, lab	81,304	2004	2,263,599	7,725,663	10,118,522	12,081,515	12,257,540	14,635,503	917,026	2,190,868	21,998,046	35%	55%	271	395	5,021,681	2,488,035	1,424,064	8,933,781	4,052
Engineering Shops Building	293			Acad, lab	45,460	1962	370,512	1,264,559	1,815,393	2,167,580	2,149,006	2,565,913			3,432,138	37%	63%	75	109	821,963	436,205		1,258,168	571
Fernald Hall	97			Acad	37,774	1910	300,257	1,024,778	1,707,554	2,038,819	1,535,206	1,833,036			3,063,597	33%	67%	81	115	666,106	311,616		977,722	443
Field House	332			Res	78,214	1926	381,888	1,303,385	3,508,713	4,189,403	5,389,792	6,435,411			5,492,788	24%	76%	70	95	847,200	1,094,020		1,941,220	881
Fine Arts Center	420			Acad	220,094	1973	2,414,662	8,241,241	15,510,189	18,519,166	10,896,815	13,010,797			26,760,407	31%	69%	122	170	5,356,807	2,211,836		7,568,642	3,433
Flint Laboratory	100			Acad, lab	29,851	1912	62,194	212,269	1,233,792	1,473,147	1,056,520	1,261,485			1,685,416	13%	87%	56	73	137,975	214,453		352,427	160
Franklin Dining Hall	334			Dining	52,300	1965	1,319,579	4,503,721	7,819,116	9,336,025	7,218,099	8,618,410			13,839,746	33%	67%	265	374	2,927,419	1,465,130		4,392,549	1,992
Furcolo Hall	289			Acad	101,329	1962	318,790	1,088,032	1,125,180	1,343,465	2,078,372	2,481,576			2,431,497	45%	55%	24	36	707,220	421,868		1,129,088	512
Goessmann Laboratory Lab & Addition	82	81, 82	both electricity and steam are combined meters	Acad, lab	146,805	1922, 1959	2,400,372	8,192,469	41,094,422	49,066,740	32,890,245	39,270,953			57,259,209	14%	86%	390	507	5,325,105	6,676,062		12,001,167	5,444
Goodell Building & Addition	172	171, 172	Electricity meters are combined, steam meters are not.	Admin	129,765	1934, 1960	1,079,118	3,683,031	12,207,743	14,576,045	12,596,493	15,040,212			18,259,077	20%	80%	141	188	2,393,970	2,556,836		4,950,806	2,246
Gorman House	294			Res	66,335	1963	329,619	1,124,990	2,935,650	3,505,167	3,030,412	3,618,312			4,630,156	24%	76%	70	95	731,243	615,113		1,346,356	611
Grayson House	330			Res	78,214	1965	390,239	1,331,886	3,683,558	4,398,168	4,493,648	5,365,416			5,730,054	23%	77%	73	99	865,726	912,121		1,777,847	806
Greenough House	24			Res	36,505	1946	179,792	613,631	1,797,376	2,146,067	1,224,765	1,462,369			2,759,697	22%	78%	76	102	398,860	248,603		647,463	294
Hamlin House	25			Res	34,552	1949	154,914	528,722	1,329,287	1,587,169	975,061	1,164,223			2,115,891	25%	75%	61	84	343,670	197,918		541,588	246
Hampden Dining Hall	382			Dining	55,457	1967	1,285,299	4,386,726	6,267,380	7,483,252	5,578,424	6,660,639			11,869,978	37%	63%	214	308	2,851,372	1,132,309		3,983,680	1,807
Hampshire Dining Hal	357			Dining	46,001	1966	1,185,937	4,047,604	5,792,827	6,916,635	5,846,849	6,981,138			10,964,239	37%	63%	238	343	2,630,943	1,186,793		3,817,736	1,732
Hasbrouck Laboratory Addition	318		steam is a combined meter reading	Acad, lab	72,825	1963	903,513	3,083,689	10,759,624	12,846,991	11,194,864	13,366,668			15,930,680	19%	81%	219	291	2,004,398	2,272,334		4,276,731	1,940
Herter Hall	406			Acad	113,000	1968	571,006	1,948,842	6,071,866	7,249,807	5,595,392	6,680,898	N/A		9,198,649	21%	79%	81	109	1,266,747	1,135,753		2,402,500	1,090
Hicks Physical Education Building, Cage & Addition	576	576, 122, 121	Electricity and Steam meters are combined	Gym	67,180	1931, 1987	368,280	1,256,939	5,901,750	7,046,689	5,099,451	6,088,745			8,303,628	15%	85%	124	161	817,011	1,035,087		1,852,097	840
Hills House	37			Acad	87,634	1960	365,037	1,245,870	2,198,118	2,624,553	2,395,685	2,860,448			3,870,423	32%	68%	44	62	809,816	486,276		1,296,092	588
Holdsworth Hall	296			Acad	49,496	1963	275,451	940,113	3,676,316	4,389,522	2,590,534	3,093,097			5,329,635	18%	82%	108	142	611,074	525,827		1,136,900	516
Integrated Sciences Building	676			Acad, lab	188,332	2008	5,587,131	19,068,879	21,992,975	26,259,612	31,064,722	37,091,278	205,508	2,453,882	47,782,372	40%	55%	254	374	12,394,771	6,305,517	1,006,092	19,706,380	8,939
Isenberg School of Management Building	317			Acad	75,019	1963	1,476,637	5,039,763	4,505,362	5,379,402	4,531,493	5,410,602	N/A		10,419,166	48%	52%	139	210	3,275,846	919,802		4,195,649	1,903
James House	350			Res	45,662	1966	752,335	2,567,721	2,956,635	3,530,223	1,934,795	2,310,145			6,097,943	42%	58%	134	196	1,669,018	392,725		2,061,743	935
Johnson House	36			Res	35,493	1960	141,695	483,604	1,870,795	2,233,729	2,446,857	2,921,548			2,717,333	18%	82%	77	101	314,343	496,663		811,006	368
Kennedy House	352			Res	147,178	1966	615,188	2,099,638	8,262,303	9,865,190	7,451,034	8,896,535			11,964,828	18%	82%	81	107	1,364,765	1,512,411		2,877,176	1,305
Knowles Engineering Building	604			Acad, lab	38,325	1991	943,333	3,219,596	2,049,209	2,446,756	1,978,264	2,362,047			5,666,352	57%	43%	148	231	2,092,737	401,548		2,494,285	1,131
Knowlton House	26			Res	34,552	1949	496,792	1,695,553	1,767,095	2,109,911	1,470,611	1,755,909			3,805,464	45%	55%	110	164	1,102,109	298,505		1,400,614	635
Leach House	27			Res	33,281	1953	149,305	509,578	2,314,808	2,763,880	2,630,465	3,140,775			3,273,458	16%	84%	98	129	331,226	533,932		865,157	392
Lederle Graduate Research Center & Addition	502	502, 412	Combined meters	Acad, lab	506,147	1971, 1973	8,728,932	29,791,846	47,898,735	57,191,089	51,122,607	61,040,393			86,982,935	34%	66%	172	244	19,364,700	10,376,867		29,741,566	13,491
Lewis House	28			Res	36,295	1940	145,032	494,994	1,387,714	1,656,931	916,270	1,094,027			2,151,924	23%	77%	59	80	321,746	185,985		507,731	230
Lincoln Apartments Units 1- 11	23	13-23	Combined meters	Res	63,274	1958	331,352	1,130,904	7,586,400	9,058,162	8,277,056	9,882,805			10,189,066	11%	89%	161	206	735,087	1,680,077		2,415,164	1,096
Lincoln Campus Center	413			Admin	284,140	1970	4,083,781	13,937,943	16,962,105	20,252,754	22,271,115	26,591,711			34,190,697	41%	59%	120	176	9,059,663	4,520,591		13,580,254	6,160
Machmer Hall	111			Acad	72,556	1957	248,418	847,852	3,016,448	3,601,638	4,126,372	4,926,888			4,449,490	19%	81%	61	81	551,104	837,571		1,388,674	630
MacKimmie House	379			Res	62,769	1967	1,029,512	3,513,723	2,820,959	3,368,225	3,129,749	3,736,920			6,881,948	51%	49%	110	167	2,283,920	635,276		2,919,196	1,324
Marcus Hall	343			Acad	65,859	1966	781,103	2,665,903	3,834,307	4,578,163	4,186,964	4,999,235			7,244,066	37%	63%	110	158	1,732,837	849,870		2,582,707	1,172
Marston Hall	92			Acad	63,469	1950	403,257	1,376,316	2,393,472	2,857,805	1,571,870	1,876,813			4,234,121	33%	67%	67	94	894,605	319,058		1,213,664	551
Mary Lyon House	34			Res	38,304	1959	145,032	494,994	1,424,404	1,700,739	1,255,481	1,499,044			2,195,733	23%	77%	57	77	321,746	254,837		576,584	262
McNamara House	428			Res	102,653	1971	496,792	1,695,553	3,951,420	4,717,995	2,564,859	3,062,442			6,413,548	26%	74%	62	86	1,102,109	520,615		1,622,724	736
Melville House	349			Res	45,662	1966	752,335	2,567,721	2,956,635	3,530,223	1,934,795	2,310,145			6,097,943	42%	58%	134	196	1,669,018	392,725		2,061,743	935
Mills House (New Africa House,	29			Acad	36,323	1948	100,830	344,134	1,539,262	1,837,879	66	79			2,182,013	16%	84%	60	79	223,687	13		223,701	101
Moore House	402			Res	58,319	1968	429,451	1,465,718	3,824,509	4,566,464	2,773,710	3,311,809			6,032,181	24%	76%	103	141	952,716	563,008		1,515,724	688
Morrill Science Center Section	126		Chiller data is 16.99% ot tota	Acad, lab	60,113	1959	673,323	2,298,053	3,894,147	4,649,611	4,097,228	4,892,090	71,649	855,528	7,803,192	29%	60%	130	185	1,493,734	831,655	350,767	2,676,156	1,214
Morrill Science Center Section II	127		Chiller data is 25.79% ot tota	Acad, lab	91,239	1960	1,263,273	4,311,552	9,925,139	11,850,616	11,565,384	13,809,069	71,649	855,528	17,017,696	25%	70%	187	258	2,802,509	2,347,542	350,767	5,500,817	2,495
Morrill Science Center Section III	290		Chiller data is 22.38% ot tota	Acad, lab	79,180	1962	1,516,479	5,175,743	17,351,217	20,717,353	18,843,435	22,499,062	71,649	855,528	26,748,625	19%	77%	338	453	3,364,233	3,824,840	350,767	7,539,840	3,420
Morrill Science Center Section IV	347		Chiller data is 34.84% ot tota	Acad, lab	123,247	1966	3,335,389	11,383,683	7,906,298	9,440,119	8,318,614	9,932,425	71,649	855,528	21,679,330	53%	44%	176	272	7,399,394	1,688,512	350,767	9,438,673	4,281
Mullins Memorial Center	613			Admin	264,654	1993	4,028,672	13,749,857	21,212,752	25,328,026	21,366,000	25,511,004	N/A		39,077,882	35%	65%	148	211	8,937,407	4,336,871		13,274,278	6,021
North A	670	670-673	Group meter	Res	81,680	2006	723,578	2,469,572	1,426,455	1,703,188	1,222,538	1,459,711			4,172,759	59%	41%	51	81	1,605,222	248,151		1,853,372	841
North B	671	670-673	Group meter	Res	81,680	2006	723,578	2,469,572	1,426,455	1,703,188	1,222,538	1,459,711			4,172,759	59%	41%	51	81	1,605,222	248,151		1,853,372	841
North C	672	670-673	Group meter	Res	81,680	2006	723,578	2,469,572	1,426,455	1,703,188	1,222,538	1,459,711			4,172,759	59%	41%	51	81	1,605,222	248,151		1,853,372	841
North D	673	670-673	Group meter	Res	81,680	2006	723,578	2,469,572	1,426,455	1,703,188	1,222,538	1,459,711			4,172,759	59%	41%	51	81	1,605,222	248,151		1,853,372	841
North Village Total	500	445-500	Group meter, heat is electrical	Res	166,679	1971	3,336,018	11,385,829	n/a		n/a				11,385,829	100%		68	125	7,400,789	0		7,400,789	3,357
Parking Garage	414			Admin	395,964	1970	316,405	1,079,892	2,367,945	2,827,326	1,635,422	1,952,694			3,907,218	28%	72%	10	14	701,930	331,958		1,033,888	469
Patterson House	378			Res	90,284	1967	720,572	2,459,313	4,059,428	4,846,958	4,503,785	5,377,519			7,306,271	34%	66%	81	115	1,598,553	914,178		2,512,732	1,140
Physical Plant Building & Additior	170	170, 398		Admin	161,627	1960, 1967	1,247,159	4,256,555	7,295,045	8,710,284	6,040,967	7,212,915	39,560	472,372	13,439,211	32%	65%	83	118	2,766,761	1,226,196	193,672	4,186,629	1,899
Pierpont House	401			Res	69,882	1968	176,099	601,024	3,170,829	3,785,970	3,247,382	3,877,374	N/A		4,386,995	14%	86%	63	81	390,666	659,154		1,049,819	476
Prince House	381			Res	82,386	1967	429,451	1,465,718	5,654,939	6,751,997	4,353,339	5,197,887			8,217,714	18%	82%	100	132	952,716	883,641		1,836,357	833
Recreation Center	678			Gym	160,191	2009	2,092,484	7,141,647	1,403,821	1,676,162	1,411,732	1,685,607			8,817,809	81%	19%	55	94	4,642,071	286,553		4,928,624	2,236
Research Administration Center	579		No steam	Admin	10,500	1939	159,520	544,441	n/a		n/a				544,441	100%		52	95	353,887	0		353,887	161
Skinner Hall	128			Acad	60,107	1948	299,717	1,022,935	1,180,804	1,409,880	1,071,757	1,279,678	18,267	218,115	2,650,930	39%	53%	44	65	664,908	217,545	89,427	971,880	441
South College	129			Acad	31,093	1885	107,889	368,226	853,780	1,019,413	1,653,487	1,974,264	N/A		1,387,639	27%	73%	45	61	239,347	335,625		574,972	261
Stockbridge Hall	130			Acad	70,929	1912	382,859	1,306,697	3,035,324	3,624,177	2,688,329	3,209,865			4,930,874	27%	73%	70	96	849,353	545,677		1,395,030	633
Student Union	131			Admin	105,939	1957	548,678	1,872,638	6,290,371	7,510,703	6,016,802	7,184,062			9,383,341	20%	80%	89	118	1,217,215	1,221,291		2,438,505	1,106
Studio Arts Building	677			Acad, lab	52,881	2008	696,489	2,377,117	1,563,886	1,867,280	1,672,835	1,997,366	39,284	469,072	4,713,469	50%	40%	89	138	1,545,126	339,552	192,320	2,076,998	942
Thatcher House	30			Res	34,866	1935	145,032	494,994	1,845,740	2,203,813	2,720,078	3,247,773	N/A		2,698,807	18%	82%	77	102	321,746	552,121		873,868	396
Thompson Hall	405			Acad	87,908	1968	543,652	1,855,485	5,492,542	6,558,095	6,181,456	7,380,658			8,413,581	22%	78%	96	129	1,206,066	1,254,712		2,460,777	1,116

Benchmarking Spreadsheet: FY12 data

UMA Fiscal Years 2010, 2011, 2012 (July 1 2009 - June 30 2010)															
					***Note FY12 Residential occupancy numbers are a copy of FY1. FY12 data is forthcoming.										
					FY12										
Building Name	Bldg. No.	Building Type	G.S.F.	Year Built	FY12 Occ	FY12 Total kBtu	FY12 % Electricity	FY12 % Steam	FY12 Site EUI	FY12 kBtu/person	FY12 Source EUI	FY12 Total CO2E MT	FY12 Total CO2E MT/person	FY12 MT CO2E/sf
Arnold House (1954)	2	Acad	43,292	1954	392	2,637,847	18%	82%	61	6,729	81	144	0.37	0.00
Bartlett Hall (1960)	107	Acad	113,748	1960	1,882	7,778,605	23%	77%	68	4,133	93	1,194	0.63	0.0105
Dickinson Hall (1960)	132	Acad	29,699	1960	720	3,827,600	15%	85%	129	5,316	168	419	0.58	0.0141
Draper Hall (1947)	87	Acad	39,731	1947	195	2,427,374	17%	83%	61	12,448	80	311	1.59	0.0078
Fernald Hall (1910)	97	Acad	37,774	1910	441	3,063,597	33%	67%	81	6,947	115	443	1.01	0.0117
Fine Arts Center (1973)	420	Acad	220,094	1973	3,978	26,760,407	31%	69%	122	6,727	170	3,433	0.86	0.0156
Furcolo Hall (1962)	289	Acad	101,329	1962	721	2,431,497	45%	55%	24	3,372	36	512	0.71	0.0051
Herter Hall (1968)	406	Acad	113,000	1968	1,756	9,198,649	21%	79%	81	5,238	109	1,090	0.62	0.0096
Holdsworth Hall (1963)	296	Acad	49,496	1963	525	5,329,635	18%	82%	108	10,152	142	516	0.98	0.0104
Isenberg SoM (1963)	317	Acad	75,019	1963	1,412	10,419,166	48%	52%	139	7,379	210	1,903	1.35	0.0254
Machmer Hall (1957)	111	Acad	72,556	1957	1,003	4,449,490	19%	81%	61	4,436	81	630	0.63	0.0087
Marcus Hall (1966)	343	Acad	65,859	1966	976	7,244,066	37%	63%	110	7,422	158	1,172	1.20	0.0178
Marston Hall (1950)	92	Acad	63,469	1950	691	4,234,121	33%	67%	67	6,128	94	551	0.80	0.0087
Mills House (1948)	29	Acad	36,323	1948	295	2,182,013	16%	84%	60	7,397	79	101	0.34	0.0028
Skinner Hall (1948)	128	Acad	60,107	1948	608	2,650,930	39%	53%	44	4,360	65	441	0.73	0.0073
South College (1885)	129	Acad	31,093	1885	259	1,387,639	27%	73%	45	5,358	61	261	1.01	0.0084
Stockbridge Hall (1912)	130	Acad	70,929	1912	1,058	4,930,874	27%	73%	70	4,661	96	633	0.60	0.0089
Thompson Hall (1968)	405	Acad	87,908	1968	1,302	8,413,581	22%	78%	96	6,462	129	1,116	0.86	0.0127
Chenoweth Lab (1966)	101	Acad, lab	56,580	1966	393	6,926,676	32%	68%	122	17,625	172	1,071	2.73	0.0189
Conte Polymer Research (1995)	614	Acad, lab	198,612	1995	738	48,506,927	39%	59%	244	65,728	356	8,202	11.11	0.0413
Eng & CSC I (1999)	651	Acad, lab	78,634	1999	640	16,020,336	25%	69%	204	25,032	282	2,282	3.57	0.0290
Engineering Lab II (2004)	657	Acad, lab	81,304	2004	355	21,998,046	35%	55%	271	61,966	395	4,052	11.42	0.0498
Engineering Shops Building (1962)	293	Acad, lab	45,460	1962	628	3,432,138	37%	63%	75	5,465	109	571	0.91	0.0126
Flint Laboratory (1912)	100	Acad, lab	29,851	1912	326	1,685,416	13%	87%	56	5,170	73	160	0.49	0.0054
Goessmann Lab (1959)	82	Acad, lab	146,805	1959	1,169	57,259,209	14%	86%	390	48,981	507	5,444	4.66	0.0371
Hasbrouck Lab, Add.Only (1963)	318	Acad, lab	72,825	1963	1,095	15,930,680	19%	81%	219	14,549	291	1,940	1.77	0.0266
Integrated Sciences Building (2008)	676	Acad, lab	188,332	2008	1,761	47,782,372	40%	55%	254	27,134	374	8,939	5.08	0.0475
Knowles Eng (1991)	604	Acad, lab	38,325	1991	198	5,666,352	57%	43%	148	28,618	231	1,131	5.71	0.0295
Lederle Grad Research (1973)	502	Acad, lab	506,147	1973	3,074	86,982,935	34%	66%	172	28,296	244	13,491	4.39	0.0267
Morrill I (1959)	126	Acad, lab	60,113	1959	540	7,803,192	29%	60%	130	14,450	185	1,214	2.25	0.0202
Morrill II (1960)	127	Acad, lab	91,239	1960	701	17,017,696	25%	70%	187	24,276	258	2,495	3.56	0.0273
Morrill III (1962)	290	Acad, lab	79,180	1962	460	26,748,625	19%	77%	338	58,149	453	3,420	7.43	0.0432
Morrill IV (1966)	347	Acad, lab	123,247	1966	757	21,679,330	53%	44%	176	28,638	272	4,281	5.66	0.0347
Studio Arts Building (2008)	677	Acad, lab	52,881	2008	375	4,713,469	50%	40%	89	12,569	138	942	2.51	0.0178
Tobin Hall (1972)	415	Acad, lab	112,076	1972	758	26,474,461	28%	72%	236	34,927	326	3,776	4.98	0.0337
DuBois Library (1972)	417	Acad, Library	406,480	1972	3,205	28,127,727	74%	26%	69	8,776	116	7,480	2.33	0.0184
Goodell Building (1960)	172	Admin	129,765	1960	661	18,259,077	20%	80%	141	27,623	188	2,246	3.40	0.0173
Lincoln Campus Center (1970)	413	Admin	284,140	1970	2,628	34,190,697	41%	59%	120	13,010	176	6,160	2.34	0.0217
Mullins Memorial Center (1993)	613	Admin	264,654	1993	515	39,077,882	35%	65%	148	75,879	211	6,021	11.69	0.0228
Physical Plant Building (1967)	170	Admin	161,627	1967	551	13,439,211	32%	65%	83	24,391	118	1,899	3.45	0.0117
Research Admin Center (1939)	579	Admin	10,500	1939	67	544,441	100%		52	8,126	95	161	n/a	0.0153
Student Union (1957)	131	Admin	105,939	1957	1,757	9,383,341	20%	80%	89	5,341	118	1,106	0.63	0.0104
Whitmore Hall (1967)	388	Admin	115,281	1967	641	18,331,207	28%	72%	159	28,598	220	2,649	4.13	0.0230
University Health Center (1973)	418	Admin, Health	58,506	1973	321	4,868,248	56%	44%	83	15,166	130	987	3.08	0.0169
Berkshire Dining Hall (1968)	399	Dining	48,658	1968	1,044	21,160,214	27%	73%	435	20,268	599	2,956	2.83	0.0608
Franklin Dining Hall (1965)	334	Dining	52,300	1965	981	13,839,746	33%	67%	265	14,108	374	1,992	2.03	0.0381
Hampden Dining Hall (1967)	382	Dining	55,457	1967	617	11,869,978	37%	63%	214	19,238	308	1,807	2.93	0.0326
Hampshire Dining Hall (1966)	357	Dining	46,001	1966	687	10,964,239	37%	63%	238	15,960	343	1,732	2.52	0.0376
Worcester Dining(1961)	86	Dining	68,727	1961	1,246	10,984,236	40%	60%	160	8,816	233	2,239	1.80	0.0326
Boyden Gym (1963)	319	Gym	187,418	1963	1,306	9,946,815	30%	70%	53	7,616	74	1,414	1.08	0.0075
Hicks Phys Ed Building (1987)	576	Gym	67,180	1987	4,452	8,303,628	15%	85%	124	1,865	161	840	0.19	0.0125
Recreation Center (2009)	678	Gym	160,191	2009	319	8,817,809	81%	19%	55	27,642	94	2,236	7.01	0.0140
Totman Phys Ed (1959)	123	Gym	110,505	1959	1,974	7,137,556	24%	76%	65	3,616	88	1,010	0.51	0.0091
Adams, John House (1966)	354	Res	147,178	1966	555	10,416,524	22%	78%	71	18,769	95	1,202	2.17	0.0082
Adams, John Quincy House (1966)	355	Res	147,178	1966	558	9,945,222	23%	77%	68	17,823	91	1,293	2.32	0.0088
Baker House (1952)	3	Res	83,911	1952	321	4,367,609	33%	67%	52	13,606	74	815	2.54	0.0097
Brett House (1963)	295	Res	51,441	1963	244	5,588,815	21%	79%	109	22,905	146	615	2.52	0.0120
Brooks House (1949)	4	Res	30,670	1949	149	1,861,153	27%	73%	61	12,491	84	340	2.28	0.0111
Brown House (1971)	426	Res	102,653	1971	390	7,055,185	24%	76%	69	18,090	93	1,027	2.63	0.0100
Butterfield House (1930)	5	Res	46,190	1930	133	3,764,250	22%	78%	81	28,303	110	465	3.49	0.0101
Cance House (1940)	400	Res	70,005	1940	308	3,518,088	17%	83%	50	11,422	66	323	1.05	0.0046
Cashin House (2005)	427	Res	102,653	2005	328	8,340,359	20%	80%	81	25,428	109	994	3.03	0.0097
Chadbourne House (1947)	6	Res	36,505	1947	138	2,057,193	30%	70%	56	14,907	79	351	2.54	0.0096
Coolidge House (1966)	353	Res	147,423	1966	558	10,586,220	20%	80%	72	18,972	96	1,267	2.27	0.0086
Crabtree House (1953)	12	Res	33,273	1953	144	2,359,315	23%	77%	71	16,384	96	301	2.09	0.0090
Crampton House (1967)	380	Res	52,619	1967	196	5,253,949	18%	82%	100	26,806	132	533	2.72	0.0101
Dickinson House (1965)	331	Res	78,214	1965	352	4,867,860	27%	73%	62	13,829	86	721	2.05	0.0092
Dwight House (1959)	35	Res	39,034	1959	174	2,920,506	18%	82%	75	16,785	99	458	2.63	0.0117
Emerson House (1966)	351	Res	40,777	1966	169	5,827,657	39%	61%	143	34,483	208	856	5.06	0.0210
Field House (1926)	332	Res	78,214	1926	340	5,492,788	24%	76%	70	16,155	95	881	2.59	0.0113
Gorman House (1963)	294	Res	66,335	1963	332	4,630,156	24%	76%	70	13,946	95	611	1.84	0.0092
Grayson House (1965)	330	Res	78,214	1965	340	5,730,054	23%	77%	73	16,853	99	806	2.37	0.0103
Greenough House (1946)	24	Res	36,505	1946	133	2,759,697	22%	78%	76	20,750	102	294	2.21	0.0080
Hamlin House (1949)	25	Res	34,552	1949	132	2,115,891	25%	75%	61	16,029	84	246	1.86	0.0071
James House (1966)	350	Res	45,662	1966	198	6,097,943	42%	58%	134	30,798	196	935	4.72	0.0205
Johnson House (1960)	36	Res	35,493	1960	135	2,717,333	18%	82%	77	20,128	101	368	2.72	0.0104
Kennedy House (1966)	352	Res	147,178	1966	554	11,964,828	18%	82%	81	21,597	107	1,305	2.36	0.0089
Knowlton House (1949)	26	Res	34,552	1949	150	3,805,464	45%	55%	110	25,370	164	635	4.24	0.0184
Leach House (1953)	27	Res	33,281	1953	138	3,273,458	16%	84%	98	23,721	129	392	2.84	0.0118
Lewis House (1940)	28	Res	36,295	1940	120	2,151,924	23%	77%	59	17,933	80	230	1.92	0.0063
Lincoln Apartments (1958)	23	Res	63,274	1958	n/a	10,189,066	11%	89%	161	n/a	206	1,096	n/a	0.0173
MacKimmie House (1967)	379	Res	62,769	1967	243	6,881,948	51%	49%	110	28,321	167	1,324	5.45	0.0211
Mary Lyon House (1959)	34	Res	38,304	1959	162	2,195,733	23%	77%	57	13,554	77	262	1.61	0.0068
McNamara House (1971)	428	Res	102,653	1971	400	6,413,548	26%	74%	62	16,034	86	736	1.84	0.0072
Melville House (1966)	349	Res	45,662	1966	194	6,097,943	42%	58%	134	31,433	196	935	4.82	0.0205
Moore House (1968)	402	Res	58,319	1968	232	6,032,181	24%	76%	103	26,001	141	688	2.96	0.0118
North A (2006)	670	Res	81,680	2006	221	4,172,759	59%	41%	51	18,881	81	841	3.80	0.0103
North B (2006)	671	Res	81,680	2006	215	4,172,759	59%	41%	51	19,453	81	841	3.92	0.0103
North C (2006)	672	Res	81,680	2006	220	4,172,759	59%	41%	51	18,967	81	841	3.82	0.0103
North D (2006)	673	Res	81,680	2006	192	4,172,759	59%	41%	51	21,790	81	841	4.39	0.0103
North Village Total (1971)	500	Res	166,679	1971	n/a	11,385,829	100%		68	n/a	125	3,357	n/a	0.0201
Patterson House (1967)	378	Res	90,284	1967	344	7,306,271	34%	66%	81	21,239	115	1,140	3.31	0.0126
Pierpont House (1968)	401	Res	69,882	1968	260	4,386,995	14%	86%	63	16,873	81	476	1.83	0.0068
Prince House (1967)	381	Res	82,386	1967	303	8,217,714	18%	82%	100	27,121	132	833	2.75	0.0101
Thatcher House (1935)	30	Res	34,866	1935	118	2,698,807	18%	82%	77	22,871	102	396	3.36	0.0114
Thoreau House (1966)	348	Res	45,662	1966	171	6,097,943	42%	58%	134	35,660	196	935	5.47	0.0205
Van Meter House (1957)	32	Res	85,815	1957	383	4,054,044	27%	73%	47	10,585	65	518	1.35	0.0060
Washington House (1966)	356	Res	147,178	1966	558	9,166,938	23%	77%	62	16,428	84	1,147	2.05	0.0078
Webster House (1965)	333	Res	78,214	1965	345	4,539,035	29%	71%	58	13,157	81	735	2.13	0.0094
Wheeler House (1958)	33	Res	35,195	1958	174	2,303,045	23%	77%	65	13,236	88	357	2.05	0.0101
TOTALS			**8,976,233**		**67,177**	**116,810,000**	**32%**	**69%**	**110**	**18,859**	**155**	**159,774**		