An energy consumption evaluation for existing, commercial buildings

by

Lauren Leigh Brannom Damron

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Julia Keen

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Abstract

The intent of this report is to recommend a process for legislation that can be used to identify commercial buildings that have the greatest potential to reduce energy consumption. A point-based evaluation is completed of current energy processes for existing commercial buildings. The recommended energy evaluation system is applied to an existing building, which allows for a detailed review of how the evaluation is completed for a building. The results are presented to display the value of assessing building energy performance. Additionally, the results reinforce the potential to transform the industry and energy use by buildings.

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Acknowledgements

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Chapter 1 - Background of Study

Primarily, this report's purpose is to determine the best process to assess energy consumption by buildings; its secondary purpose is to supply legislative jurisdictions with a process that can be implemented with the intent to reduce the building sector's energy consumption in the United States. The scope is limited to United States' rating and certification systems (later referred to as energy evaluation systems) for existing commercial buildings that use energy consumption as a major portion of the evaluation.

Chapter 1 discusses the existing commercial building landscape in the United States, the current terminology associated with energy evaluation systems, and the existing legislation pertaining to building energy evaluation. Chapter 2 presents the importance of building energy evaluation systems as a tool to encourage increased energy efficiency. Current energy evaluation systems are examined to select the most appropriate candidate to comparing existing buildings in Chapter 3. The recommended energy evaluation system is then detailed and applied to a case study facility – outlined in Chapter 4. Chapter 5 summarizes the results of the case study, which is used as the basis for recommendation. The final chapter, Chapter 6, applies the over-arching concepts from Chapter 5 to the commercial building landscape and the legislation associated with energy consumption of existing buildings.

The Importance of Existing Buildings in the Energy Landscape

With the enforcement and continued development of energy codes, new buildings will continue to increase in energy efficiency, but the ever-increasing number of buildings will result in an increased total load on the existing energy grid (U.S. Energy Information Administration, 2015). Energy in the form of electricity is particularly important because it is the form that buildings use the most, as indicated in Figure 1.1; this data is from 2012, which is the most recent data available, but based on the past values, it is expected that electricity will continue increasing as a larger percentage of energy consumption. For the last 3 decades, electricity has become a larger portion of energy consumption overtime. As a result, electricity generation and distribution is of the utmost importance in the United States.

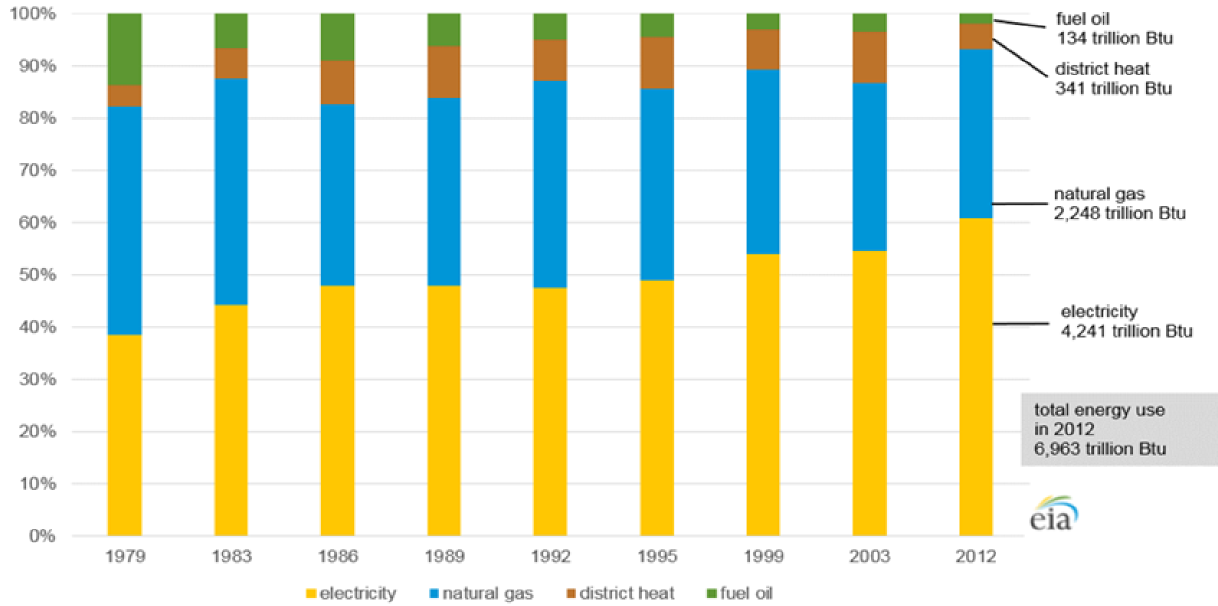


Figure 1.1 United States' Energy Consumption Use Distribution by Type.

The Energy Information Administration. (2017). [Cumulative percent bar chart of energy use in the United States]. Retrieved from https://www.eia.gov/consumption/commercial/

As the demand for electricity increases, buildings will experience power disruptions more frequently due to consumption exceeding electrical generation. If energy consumption is allowed to increase unchecked, power plants will need to increase energy generation rates by building new power plants or expanding the ones currently in use. Electricity is currently produced from many resources such as fossil fuels, water dams, nuclear reactors, wind farms, etc. The U.S. Department of Energy Information Administration (EIA) used energy data from 2012 to predict the necessary electricity generation additions, which is presented in Figure 1.2. The data indicates not only the quantity of electricity needed, it indicates from what energy resources the electricity may be generated. The indication of resource consumption is important with regards to the impact on the environment. Although the environmental impact of energy consumption is not the motivator, a decrease in overall consumption will reduce the conversion rate of fossil fuels to energy. As a result, the goal for the United States should be to reduce energy consumption as opposed to generating more power.

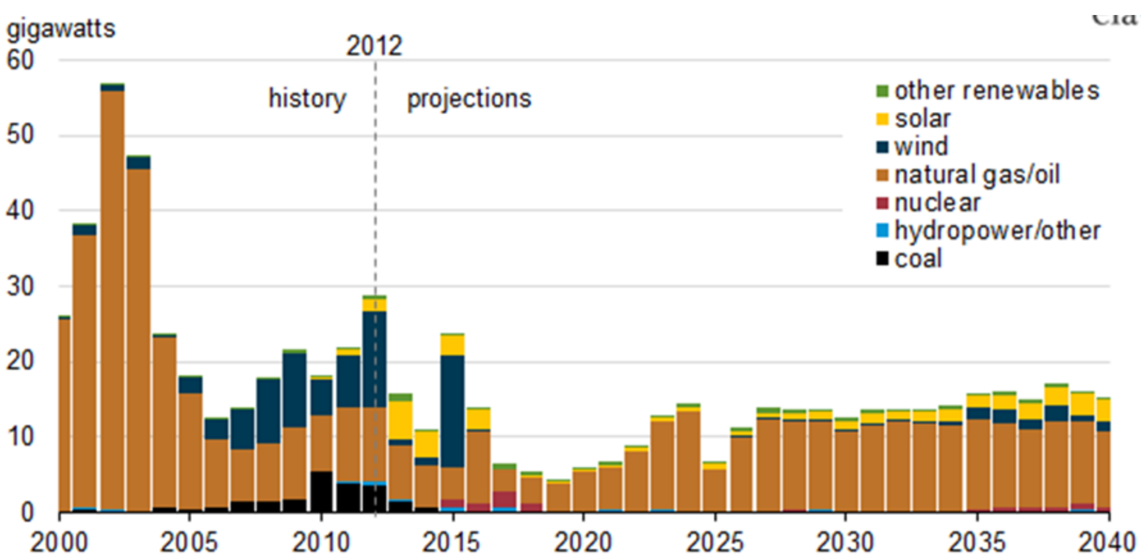


Figure 1.2 Projected Electricity Generation Additions by Generation Source.

The Energy Information Administration. (2017). [Cumulative bar chart]. Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=17131

Existing commercial buildings are the target of this research. The analysis conducted in this paper is based on information provided by the United States' government entity, the U.S. EIA, which monitors energy data of commercial buildings using the Commercial Buildings Energy Consumption Survey (CBECS). CBECS was first administered in 1979. Since then, it has gathered commercial building information such as "structure, ownership, types of energy used, HVAC and other energy related equipment, office equipment and computers, and lighting type" (U.S. Energy Information Administration, 2015). The survey is completed via a questionnaire that is given to building owners and energy providers, and the information gathered is utilized in a modeling program to simulate energy use and cost. The results from the models create the CBECS tables, which contain statistical information pertaining to energy consumption and characteristics of commercial buildings. The data is essential to understanding the landscape of commercial buildings in the United States. Yet, to gather, analyze, and create the CBECS tables requires time (three years) and financial support.

The process begins by EIA employees gathering data from building owners and utility companies during the latter half of the year following the reference year, which is the year the data represents. The most recent report, CBECS 2012, was published in its entirety in 2016. It is based on data gathered from the 2012 reference year by in-person and over-the-phone interviews. The sample contains information for 6,700 buildings in the United States; half of the building owners provided information pertaining to energy consumption and cost, and utility companies provided the other half of energy data through the Energy Supplier Survey (ESS). The EIA administered the ESS during the spring and summer of 2013 (the year following the initial interviews), which concluded the gathering phase of the CBECS 2012. At this time, the EIA is able to begin modeling the raw data, analyzing the results, and creating the tables. For the most recent reference year, the EIA began releasing portions of the CBECS tables during the fall of 2015. Although this process provides meaningful information about commercial buildings, inconsistent funding prevents the creation of CBECS tables for every reference year. As a result, this report uses the most current data, the 2012 reference year (U.S. Energy Information Administration, 2015).

To interpret the data from the CBECS tables, a definition of commercial buildings is necessary: according to the EIA (2015), commercial buildings are “buildings greater than 1,000 square feet that devote more than half of their floor space to activity that is not residential, manufacturing, industrial, or agricultural" (About The Commercial Building Energy Consumption Survey section, para. 1). As a result, most buildings that are not places where people live are considered commercial. The administration has cataloged the quantity of buildings and their total square footage. Based on 2012 CBECS data, there are 5.6 million commercial buildings comprising 87 billion square feet of building area in the United States. Figure 1.3 shows how the amount of commercial buildings has changed over time. By the slopes being different, yet increasing, it indicates that newer commercial buildings are of greater gross floor area. As a result, newer buildings have the potential for greater energy consumption if advances in technology are not implemented and requirements for energy conservation are not enforced.

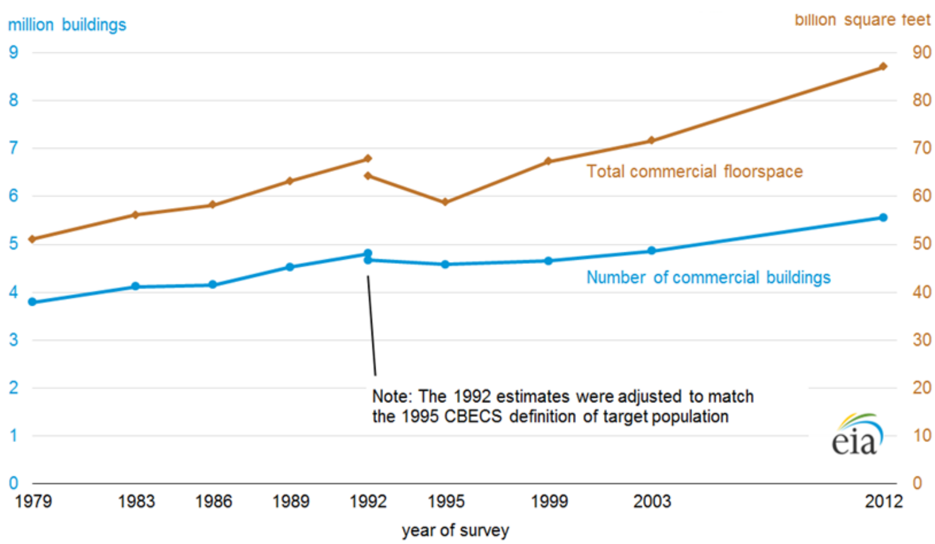


Figure 1.3 Growth of the Built Environment.

The Energy Information Administration. (2017). [Double-axis line chart]. Retrieved from https://www.eia.gov/consumption/commercial/

In 2011, a separate study by the U.S. Energy Information Administration concluded commercial buildings use 19 percent of United States' energy consumption, which is 18 quadrillion BTU (U.S. Energy Information Administration, 2012). Of these structures, half were built prior to the year 1980 and a third were built during the 1980s and 1990s (U.S. Energy Information Administration, 2015). As a result, nearly 4.7 million of today's commercial buildings in the United States were built prior to this millennium; they consumed a combined total of 5,373 trillion BTU in 2012 (U.S. Energy Information Administartion, 2016). This is important because ANSI/ASHRAE/IES Standard 90.1 - 2010 (Standard 90.1) has increased its energy efficiency from its 2004 version to its 2010 version by 23.4 percent (Goel, et al., 2014). Applying the changes in stringency of Standard 90.1 to the pre-millennial commercial buildings, an estimated energy consumption reduction of 1,257 trillion BTUs (approximately 7 percent of current usage) exists. This number is conservative because is assumes all the pre-millennium buildings meet the minimum efficiency values dictated by the Standard 90.1 – 2004, which is likely more efficient than the population, and it assumes a change in efficiency to meet ASHRAE 90.1 – 2010 when more current versions of the Standard 90.1 (2013 and 2016) have greater efficiency requirements. There is great potential for savings in the commercial existing building sector. For this to be done effectively, an evaluation of energy consumption is needed to determine which buildings would benefit the most from increasing energy efficiency.

Evaluating Energy Consumption

There are two ways to assess existing building's energy consumption: rating systems and certification systems. The major difference between the two is how a building is represented among its peers and/or a standard. A rating system produces a numerical result, while a certification system produces a classification or level. An example of a rating system is a standardized test, such as the American College Testing (ACT). Evaluators present the results from the ACT as a score. A score indicates how well an individual performed based on a specific scale. The key to a score is it allows for a comparison between each individual score in a specific and measurable way. Alternatively, a certification system is best represented as a letter grade. A letter grade represents a range of scores that allow for ranking between groups, but does not provide the ability to distinguish between individuals within a group. Both a score (rating) and a grade (certification) have related use. A grade quickly shows the performance level of a student based on the professor’s expectations, which is represented through a grading scale created by the professor. The scale is based on the professor’s expectations of his or her students’ performance; therefore, the scale is subjective. When a scale is created, judgments are made that are subjective by nature. Yet, with a score, a numerical value represents a student’s knowledge of content. This scale has a subjective quality due to how the points are distributed, but the subjective quality does not account for expectations. The element of removing subjectivity makes a score a truer representation of ability than a grade; this is also true of ratings and certifications. A certification represents a group of peoples’ expectations of what is excellent, while a rating measures the level of excellence. For an evolving field such as building energy consumption, a certification will need to be adjusted as ideas of excellence and available technology change over time – an energy efficient building in 1960 is likely to not be considered efficient today. Without change, the scale will become outdated and will not be an accurate representation of performance. For this reason, a rating is more objective because it is a measure of performance at any time regardless of peoples’ opinions and changes in technology.

Specific to building energy consumption, rating systems use numerical values for comparison. The first is energy utilization index (EUI), which is the average annual energy consumption per square foot ($kBTU/yr \cdot ft^2$). There are two types of EUI scores available: site EUI and source EUI. Site EUI represents the energy used by the property within the property boundary line, which is independent of the power source; source EUI represents the energy consumed by the site and includes the energy losses due to energy generation and transmission infrastructure. By multiplying the specific site energy consumed with an efficiency factor (accounts for energy loss during conversion of energy and transporting the energy from the source to a building), the annual source energy consumption can be determined; note that any site-produced energy has a factor of one. Although both EUIs are useful for rating buildings, this report is concerned with building energy consumption as it affects utility infrastructure, which makes the source EUI the preferred rating value.

The other numerical rating value is ECI, which is the acronym for energy cost index. ECI is the average annual energy cost per square foot ($\$/yr \cdot ft^2$). The cost for an ECI comes from the amount of money an owner spends on fuel and/or electricity to power the building at the site level. Although this score is useful for owners, it does not always directly scale with the amount of energy consumed. For example, a building that primarily uses site-generated solar and wind energy will have a low ECI because there is not an external cost of energy. Alternatively, if the same building solely uses energy from the utility grid, the ECI will be higher yet the site EUI will remain the same. Additionally, other methods of power production, building characteristics, and local energy cost can influence an ECI to indirectly trend with site and source EUI. This makes ECI less reliable as a measure for evaluation and building comparison.

Another aspect of energy evaluation systems is terminology. Some rating systems provide certificates; therefore, they call themselves certifications. For the purpose of this report, any system that uses an EUI to generate a level of certification is considered a rating system. Additionally, the report will use the term “certification system” for systems that use point accumulation to provide the level of certification. Lastly, another term in the industry is energy benchmarking, which uses a pre-determined value or goal to assess whether a building is considered energy efficient or not. Although this is a different evaluation logic than a rating, benchmarking systems may use ratings as the qualifier.

Building Energy Consumption Legislation

In this section, legislation pertaining to limiting or benchmarking energy consumption of buildings is discussed. Items covered will include the levels of legislation that have been adopted, locations that have passed such legislation, building type classifications as well as other important criteria used in legislation. The section will conclude with a discussion of trends related to such legislation and the role of legislation and its importance moving forward.

Currently in the United States, legislation exists at the federal, state, county, and city jurisdictional level for building energy performance. Nearly all jurisdictions adopt energy codes for newly constructed commercial buildings. The most common of these are the model codes, International Energy Conservation Code (IECC) and Standard 90.1, or other locally developed energy codes (Chow, 2016). Figure 1.4 is a map depicting the level of energy code stringency adopted and enforced at the state jurisdictional level. The helpful aspect of this figure is it can be used to identify states that are likely to have the greatest potential for reducing energy consumption. It should not be assumed all buildings within that state conform to the minimum requirements for energy efficiency because this is regulation enforced on only new construction. Energy consumption evaluation is necessary for each existing building because there is no reference or indicator to make a generalized evaluation.

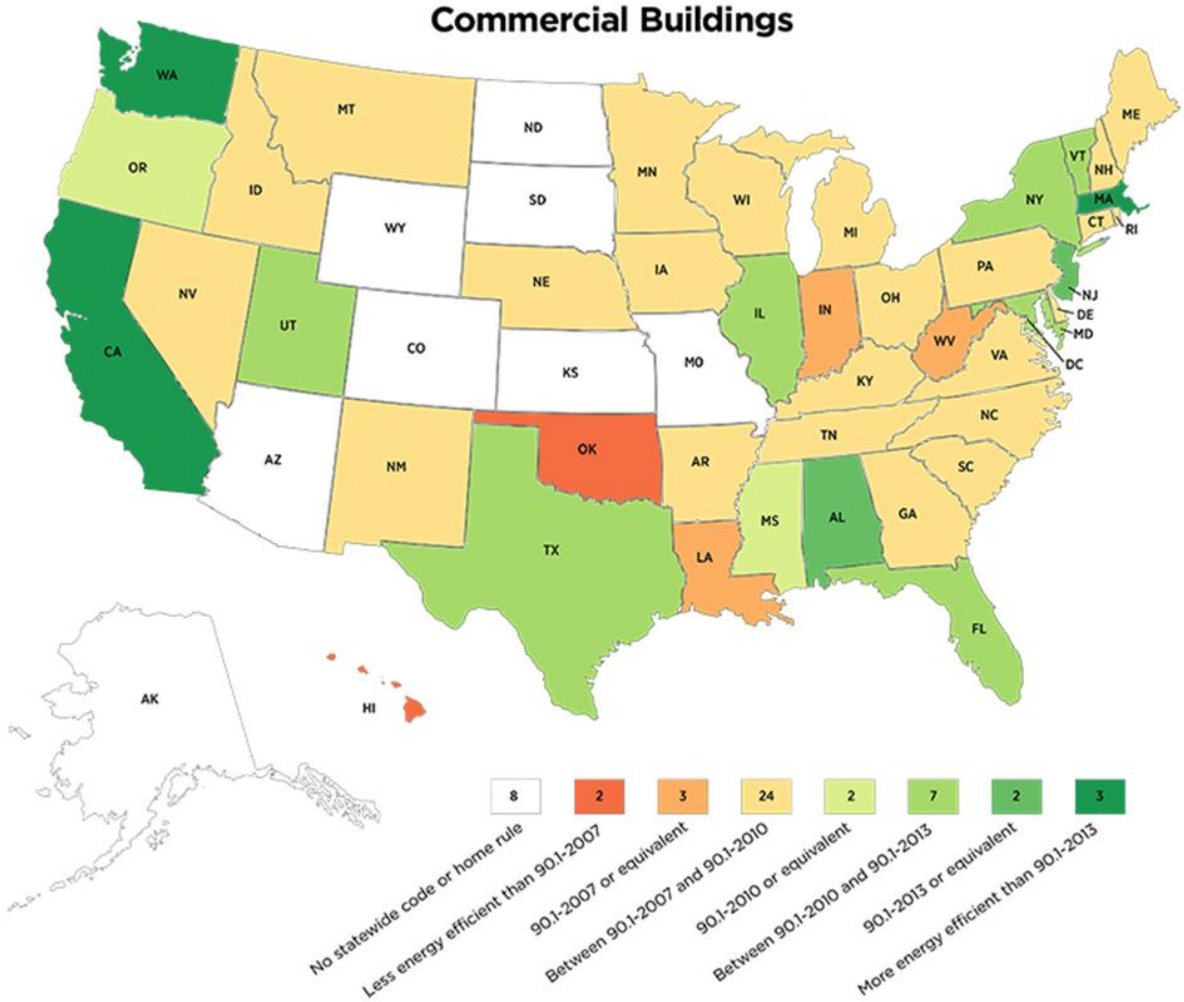


Figure 1.4 State-level Energy Code Adoption.

U.S. Department of Energy's Office of Energy Efficiency & Renewable Energy. (2017). [Color-coded map]. Retrieved from https://www.energycodes.gov/status-state-energy-code-adoption

In response to the need to address the efficiency of existing buildings, new legislation is being developed, which is tabulated in Appendix A. The table, which separates laws by jurisdiction, includes information about when a building energy assessment is required, how frequently a building must be assessed, and what enforcement measures exist. As seen in

Appendix A, there is not a standard template that has been adopted into legislation but rather each jurisdiction is developing their own policies that target specific outcomes. The existing policies vary in three primary areas: the types of buildings that are required to show compliance, the frequency a building needs to be assessed, and whether or not a building's rating is required to be reported. The following paragraphs further discuss these differences.

The major categories of building type classifications used in existing legislation are public/government, non-residential, multi-family residential, and single-family residential (Institute for Market Transformation (IMT), 2017). These categories separate buildings by owner more than by occupancy type. Occupancy type takes into account the occupants' primary function or activity within the space. The current building type classification system is valid if the categories are used exclusively to denote which buildings require ratings; the system is not valid if they are used to establish a source EUI goal. For example, in the non-residential category there are many occupancy types, such as retail stores, medical centers, schools, etc. Each of these building occupancy types have varying characteristics that directly affect their EUI. Differences in operating hours, occupant activity, indoor environmental quality requirements, code minimums, and specialty equipment are examples of such attributes. If legislation requires a specific EUI to be met without considering occupancy type, facilities requiring systems that are especially energy intense such as healthcare would either raise the threshold (allowing for other building classifications to be less efficient) or not meet the defined EUI limits.

Another aspect to consider for policy is the frequency of assessing energy consumption. Currently, an assessment has two different triggers dictated in legislation: a specified date or a specific event (Institute for Market Transformation (IMT), 2017); yet, some jurisdictions do not specify frequency of assessment. The date trigger is used for annual assessments; the annual evaluation functions similarly to vehicle registration. The specific event trigger usually occurs when the property is being sold, rented, or refinanced, and the results are supplied to the prospective owner(s) or tenant(s). Most jurisdictions use date trigger, but Washington State, Seattle, and Austin use event triggers to determine assessment frequency. Additionally, the frequency of assessment is important because each year newly constructed and more efficient buildings reduce the average energy used by the existing building stock.

A final aspect to consider is what entity is responsible for collecting and/or enforcing the energy assessments. The entities available are the authority having jurisdiction (AHJ), a third-party-operated organization, or the parties involved with a transaction. In current legislation, both AHJ and third-party-operated organizations are used for specific date assessments while reporting to parties involved in a transaction for the property are used for specific event assessments. These reporting options can also be combined as is done for properties in the city of Berkley, California.

At this time, implemented legislation compares various building types with inconsistent rating frequencies and different entities to collect the ratings – if reporting is required. As jurisdictions consider adoption of policies to address existing commercial building energy consumption, the current means of categorizing buildings is effective. However, there needs to be more uniform adoption of setting a defined frequency of rating and reporting of energy consumption. Without this, owners can span decades between ratings therefore potentially not being aware of the opportunities for improvement.

Chapter 2 - Statement of the Problem

As demand of utilities increases, it is imperative to reduce the energy use of existing commercial buildings – the second largest sector of the built environment within the United States (the largest sector being residential buildings). In order to determine which buildings have the greatest potential to reduce energy consumption, an effective evaluation of each building's energy performance needs to occur. Without an energy evaluation system for existing buildings, the evaluations are subjective and open to interpretation. Ideally, a rating or certification system will consider the climate, building characteristics, and the energy consumption of the building to create a fair comparison. Without a comparison, each building's benchmark would be based on reducing energy based on past consumption – not average energy consumption of similar buildings. Knowing an average value for energy consumption, a determination can be made as to which buildings have the greatest energy reduction potential based on realistic expectations.

The goal of this study is to evaluate the different energy benchmarking systems to determine which is the most effective for future regulation and to propose a specific rating system that is best suited for incorporation into policy. To do this in an objective manner, each energy benchmarking system needs to be evaluated. This is accomplished using a point-based evaluation system that allocates points in specific categories. The categories incorporated into evaluation are the complexity of the benchmarking system, the degree to which energy is represented, whether a third party ensures the accuracy of the data, how much it costs to complete the benchmarking system, whether indoor environmental quality (IEQ) is verified as being adequate, and the familiarity of the system to the public. The following paragraphs discuss the categories of the benchmarking system evaluation, which is applied in the following chapter to the reviewed benchmarking systems.

The first category is complexity. For this report, complexity is based on the amount of "red tape" involved and the ease an individual, unassociated with the benchmarking system, can understand the benchmarking process. The first aspect of complexity, the "red tape," is a key aspect to consider; it can increase the degree of difficulty to benchmark a building. Some examples of "red tape" are the number of forms (tactile or electronic) necessary to complete the assessment, the number of individuals involved with the assessment (collection, application, and submission) process. The difficulty can be mitigated from an owner's perspective if a third party is involved who completes all necessary correspondence and submissions – this typically results as an additional expense to the owner since a fee is paid to a third party for this service. Although this may appear to simply re-direct the issue, the third party is likely experienced or been instructed in completing the evaluation system, which increases efficiency. Some benchmarking systems require a third party that is certified by the benchmarking system's administrator to make the submission. The second aspect of complexity is the ease of understanding the benchmarking system's evaluation and results. The goal of a benchmarking system is to reduce energy consumption, but, if the results are difficult to interpret, a recommendation for energy efficiency improvements is more difficult to justify. Additionally, a system of high complexity that is unclear as to how a result was determined will require inquiry and justification by a professional affiliated with the benchmarking program. As a result, building owners and consultants can become frustrated and benchmarking associates can be inundated with justification requests. For these reasons pertaining to "red tape" and understanding the system's evaluation process, high complexity is seen as counterproductive.

The second category to consider is the degree to which energy consumption is represented in the benchmarking system. Although all benchmarking systems reviewed in this paper have energy as a portion of the evaluation process, not all systems place the same importance on energy use. Recognizing the ultimate objective of this paper is to identify a benchmarking system to drive reduction in commercial building energy consumption, the system must have energy as a large portion. If not, other categories contributing to the benchmarking system results will skew correlation between the results and the energy consumption. To prevent this, the recommended benchmarking system will require a minimum of 50 percent of the results to be directly related to energy use.

The third category for consideration is third party involvement. Third party involvement is important for two reasons: reduced effort for the owner and assurance of accuracy of the benchmarking input and results. By reducing the required involvement by an owner, the system is less likely to interrupt their current workload. Reducing this interruption, owners as a whole will be more accepting of the benchmarking system than they would be if it caused a high degree of disruption. In addition to reducing owner effort, a knowledgeable and experienced third party can be expected to increase the accuracy of the results of the benchmarking system. Benchmarking result’s accuracy is based on two factors: accurate information and correct completion of the benchmarking system. Any third party is expected to be educated in aspects pertaining to the information required for completion, such as utility data, building systems, and IEQ. Additionally, third parties associated with a specific assessment system are experienced in completing all required documentation as well as understanding the collected and submitted information. Due to the reduced effort for the owner and the ability to increase accuracy of results, a third party is identified as a necessary requirement for the recommended benchmarking system.

The fourth category to evaluate is the cost to benchmark a building. Higher cost inhibits the frequency of benchmarking. Cost can be separated into several components: base cost for benchmarking, third party or professional fees, acceleration fees, auditing fees, etc. The base cost is the absolute minimum cost to benchmark a building by excluding all optional fees and third party or professional expenses. Third party expenses are a result of employing a third party. Acceleration fees—fees for speeding up the process—are not applicable or desirable for all applications for all benchmarking systems, but they are an option for some evaluation systems. The auditing fee is an expense paid to the evaluation's organization for reviewing the results of the benchmarking system in the case an owner believes a mistake was made. There are many variations of cost pertaining to benchmarking systems, so, to allow for a fair comparison, only the base cost is used for evaluation.

The fifth category for evaluation is IEQ. IEQ consists of lighting, thermal comfort, and air quality. Each aspect of IEQ is expected to meet the requirements of health and safety codes mandated within a building's jurisdiction as well as meet recommended levels for good design. Energy is used to achieve appropriate IEQ conditions. Yet, not all systems allow for energy to be reduced without consideration of the effect on the building IEQ which directly relates to occupant comfort and productivity as well as meeting code minimum requirements. An example of an energy saving measure that compromises IEQ is to reduce the amount of outdoor air ventilation below code minimums. This will reduce energy consumption, but when reduced below code minimums the safety of the occupant is at risk. For this reason, IEQ must be assessed to assure that code expectations are maintained at a minimum when reducing energy consumption.

The final category is familiarity. As a rule, people prefer to use things they are familiar with. With familiarity, an expectation and level of trust has already been determined. This notion applies to benchmarking systems as well. If the public is familiar with a benchmarking system or the entity that supplies the benchmarking system, they are more likely to accept the validity of the system. Therefore, if a benchmarking system or its associated entity are commonly known to have a positive reputation, then the system will be considered to be familiar and earn the point in this category.

The intent of a recommended benchmark system is to produce a result that has a very strong correlation with energy efficiency; this results in the energy category being the most fundament for selection. The next category of importance is IEQ, which ensures indoor environmental quality meets, at a minimum, the code requirements to provide occupant health and safety is mandatory of the recommended system. Finally, third parties allow the assessment system to be complex while fully encapsulating the complex field of building energy efficiency. As a secondary advantage, the third party consultant reduces the coordination and involvement of building owners. This likely will minimize the resistance from a building owner which may otherwise hinder the enactment of the policy.

Based on the evaluation of rating and certification systems, each system can earn up to 1 point in each of the six categories previously described. A maximum of 6 points can be achieved; the higher the point total, the more desirable the evaluation system. Additionally, there are categories defined as mandatory concerning this report; these categories are energy, third party involvement, and IEQ. Any system that meets the requirements of these three categories is eligible to be the recommended benchmarking system. Chapter 3 will utilize this evaluation system as the basis for comparing benchmarking systems.

Chapter 3 - Comparison of Existing, Commercial Building Benchmarking Systems

In the United States, there are many different building evaluation systems. However, those considered in this report have been narrowed down to only the systems that apply to existing commercial buildings that have energy consumption as a component of the building's evaluation. This report is targeting existing commercial buildings because it is anticipated they can have the greatest reduction of demand on the energy grid. This chapter compares the available rating and certification systems for this building sector. The chapter begins by introducing each of the systems and then comparing the systems with the ultimate objective to identify the best system for consideration for adoption through legislation.

Benchmarking Systems

This section provides an overview of the different rating and certification systems found in the U.S that meet the characteristics defined in Chapter 2: complexity, energy composition, third party involvement, cost, IEQ, and familiarity. A point will be awarded for each of the following: low complexity, energy comprises at least 50 percent of the rating or certification, a third party is required, zero cost, IEQ is assessed, and the evaluation system or its organization is familiar to the public. The list of the narrowed rating and certification systems considered includes Energy Star's Portfolio Manager, Leadership in Energy and Environmental Design (LEED), Building Energy Quotient (bEQ), Green Globes, and the Energy Asset Score. The format of the subsections progresses by increasing detail. Each subsection begins with an introduction to the system, its origins, and the category type in the first paragraph. The second paragraph includes the aspects evaluated by the assessment and the proportion that each aspect is weighted in the assessment. The final paragraph includes other important information, such as cost and third party involvement, which affect building owners.

ENERGY STAR

Under the Office of Energy Efficiency and Renewable Energy, the Environmental Protection Agency (EPA) developed the Energy Star rating system. Initially, Energy Star was introduced in 1992 to certify low-energy consuming appliances but was expanded to certify low-energy consuming buildings. As a result, the public trusts Energy Star as a leader in energy conservation. Figure 3.1 shows the certification statistics from 2001 through 2015, which indicates Energy Star becoming more familiar to the public. The Portfolio Manager is Energy Star's online tool used to manage rating information and to produce ratings for existing buildings. The Portfolio Manager contains many ratings for buildings in terms of a normalized EUI that produces a statistically reliable average EUI for most building types. It is common for other rating systems to use the building type average EUIs determined by the Portfolio Manager (ENERGY STAR, n.d.).

An Energy Star rating is a percentile that is determined by a weather-normalized source EUI that is compared to the average source EUI for the building type. By separating buildings by type, the EUI accounts for variations in building operational hours and the typical loads of different building types. The percentile systems that Energy Star utilizes only compares EUIs within each calendar year. As a result, the average normalized source EUI decreases each year due to newer technology used in buildings and more energy efficient buildings coming online which reduces a buildings' energy consumption. The comparison data set and average decrease annually, which makes it more challenging to achieve the same score each year without increasing efficiency. To obtain a normalized EUI, the Portfolio Manager requires information pertaining to building characteristics and energy consumption. Other optional information, such as operational hours, a count of the number of computers, etc. can be recorded but is not required to attain a score. The energy data includes energy consumption and its associated cost, water consumption and its associated cost, and waste. After this information is input, a determination is made whether the score is high enough to certify the building through Energy Star: the rating must be in the 75th percentile or greater, which equates to a score of 75 or above (the average building is assigned a score of 50) (ENERGY STAR, n.d.).

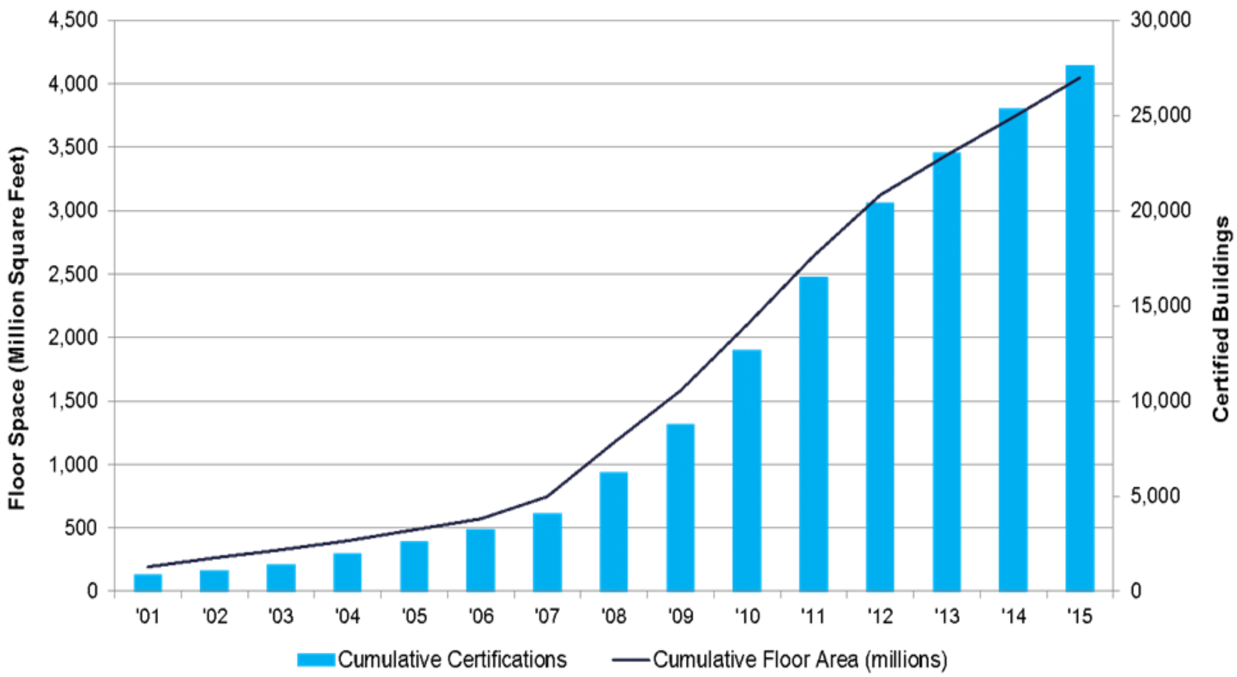


Figure 3.1 Cumulative Energy Star Certifications.

Energy Star. (2017). [Cumulative line and bar chart]. Retrieved from https://www.energystar.gov/buildings/about-us/find-energy-star-certified-buildings-and-plants

The only cost of using this system is associated with a third party's fee, and it is only in the event that the building receives a rating of 75 or higher and a certificate is desired by the owner. To be certified, a third party, being either a professional engineer (PE) or registered architect (RA), is required to complete a walkthrough and verify all submitted information. If a certificate is not desired, there is no cost to input a building in Energy Star because anyone can enter the information to attain the score. Because the certification is based on a rating that is a result of a building's percentile for a specific calendar year, the certification is only valid for the year that it is rated as indicated on the certificate. To maintain a current Energy Star certification, a building must be evaluated annually (ENERGY STAR, n.d.).

Based on the above discussion, points are awarded as follows… The online portal is a simple system to use with detailed instruction. An owner or building representative simply inputs utility company recorded energy consumption each month; all other information is supplement and is not necessary to receive a score. As a result a point is awarded. The score is based entirely on energy, which allows for an additional point earned. A third party is not required to achieve a score, and a third party is the only associated cost with this system. Although IEQ is assessed prior to certification, it is not a prerequisite to receive a score. Lastly, Energy Star is a commonly known indicator of energy efficiency and has been present in the market for more than two decades. The results are depicted in Table 3.1 with five total points accumulated.

Table 3.1 Evaluation of Energy Star

Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
•	•	•	•		•	5

LEED

The LEED certification system was developed by the U.S. Green Building Council (USGBC) in the year 1998. It has had several updates with the current version being v4. USGBC offers certifications for 5 different applications: Building Design and Construction (BD+C), Operations and Maintenance (O+M), Interior Design and Construction (ID+C), Neighborhood

Development (ND), and Homes (HOMES). This report is reviewing LEED O+M for existing buildings (U.S. Green Building Council, 2017).

LEED uses a scorecard to accumulate points as a means to determine the awarded certification level; although this is a certification system, the category of the scorecard pertaining to energy does require a rating as a prerequisite. LEED certifications have four levels: Certified (40 to 49 points), Silver (50 to 59 points), Gold (60 to 79 points), and Platinum (80 or more points). Buildings must meet the perquisites prior to accumulating points in a category of the scorecard. There are a total of 110 points available. The LEED O+M existing building scorecard has 8 categories: Location and Transportation (up to 15 points), Sustainable Sites (up to 10 points), Water Efficiency (up to 12 points), Energy and Atmosphere (up to 38 points), Materials and Resources (up to 8 points), Indoor Environmental Air Quality (up to 17 points), Innovation (up to 6 points), and Regional Priority (up to 4 points). The Energy and Atmosphere category qualifies this certification system to be included in this report. One of this category's prerequisites is the building must receive a rating of 75 or higher through Energy Star's Portfolio Manager, or, if unable to receive a rating, it must perform 25 percent better than at least three buildings within its building type. Since this is a prerequisite, if not met, then the building is unable to be certified (U.S. Green Building Council, 2017).

To complete a LEED O+M existing building certification, there are several things to consider in addition to the above certification qualifications. A third party must be used who has the designation of a LEED Accredited Professional (LEED AP) – the clarified certification type will follow this acronym. This person is necessary to complete all the documentation and submission forms required. For a LEED O+M existing building project, the LEED AP O+M will complete nearly 50 forms for a single project. The number of forms vary by certification and sub certification category (e.g. O+M and Existing Building). In addition to the third party professional, another aspect to consider is the cost of certification. As a LEED member (the highest discount available), the minimum cost in 2017 is $3,100; this value is based on the registration fee ($1,200) and the minimum certification review fee ($1,900) listed in Figure 3.2. The final consideration of the LEED certification is the frequency of certification. The certification was awarded for a specific year, so to maintain a current certification the building must be re-evaluated each year (U.S. Green Building Council, 2017).

OPERATIONS AND MAINTENANCE FEES PER BUILDING	SILVER, GOLD AND PLATINUM LEVEL MEMBERS		ORGANIZATIONAL OR NON-MEMBERS	
REGISTRATION	$1,200		$1,500	
PRECERTIFICATION (PERFORMANCE PATH PROJECTS ONLY—AVAILABLE IN ARC)				
Flat fee (per building)	$4,000		$5,000	
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$5,000			
CERTIFICATION REVIEW	RATE	MINIMUM	RATE	MINIMUM
Project gross floor area (excluding parking): less than 250,000 sq ft	$0.038 /sf	$1,900	$0.046 /sf	$2,250
Project gross floor area (excluding parking): 250,000 - 499,999 sq ft	$0.035 /sf	$9,500	$0.042/sf	$11,400
Project gross floor area (excluding parking): 500,000 - 749,999 sq ft	$0.030 /sf	$17,500	$0.036 /sf	$21,000
Project gross floor area (excluding parking): more than 750,000 sq ft	Contact GBCI		Contact GBCI	
Expedited review (reduce from 20-25 business days to 10-12, available based on GBCI review capacity)	$10,000			

Figure 3.2 LEED O+M Fee Breakdown.

U.S. Green Building Council. (2017). [Table]. Retrieved from http://www.usgbc.org/cert-guide/fees#om

In summation, a LEED certification requires a lot of documentation, which makes it a complex evaluation system, but this is minimized for the owner by the fact that a third party is required to complete all the documentation. A minimum level of energy efficiency is required to earn points in the Energy & Atmosphere category; even if all points were earned for the category, energy could only comprise 35 percent of the certification. Another prerequisite is to establish that IEQ is met, which is done by the LEED AP during the on site assessment. A LEED expense, therefore it does not receive a point in the associated evaluation category. Finally, LEED is a popular evaluating system and has been in existence for nearly 20 years which qualifies it as a familiar system. Three points were accumulated by the LEED O+M system as displayed in Table 3.2.

Table 3.2 Evaluation of LEED O+M: Existing Building.

Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
		●		●	●	3

Building Energy Quotient

ASHRAE, a non-profit professional organization, developed a rating system known as the Building Energy Quotient, which is referred to as bEQ. It was introduced to the industry in 2012. This system offers a certificate based on the rating for two different categories: “bEQ – As Designed” and “bEQ – In Operation.” This study looks only at the In Operation rating because it applies to existing buildings. ASHRAE is currently adapting how it accepts information for the rating process. Prior to Fall 2017, third parties submitted rating documentation via an Excel Workbook to ASHRAE for approval. This submission process has changed to a web-based portal to make data entry easier and more efficient.

ASHRAE represents the bEQ level as a letter grade with an accompanying description. A lower score results in a greater level of certification because lower values reflects lower energy consumption. The levels available are Zero Net Energy (A+; 0 or less rating), High Performance (A; 0 to 25), Very Good (A-; 25 to 55), Efficient (B; 55 to 85), Average (C; 85 to 115), Inefficient (D; 115 to 145), and Unsatisfactory (F; 145 or greater). The 6 categories contained in the workbooks used for evaluation includes Building Characteristics, Water Use, Energy Calculations, Indoor Environmental Quality (IEQ), Energy Savings, and Energy End Use. The Energy Calculations combined with the Building Characteristics provide a normalized source EUI score, which is compared to a climate zone specific median source EUI for the multi-use occupancy types, if applicable. The climate zone median is derived from CBECS data for each climate zone and occupancy use – just as Energy Star does. ASHRAE adjusts the CBECS data using methods from AHSRAE Standard 100, which has its process prepared by Oak Ridge National Laboratory in document ORNL/TM-2014/215. In addition to a score, the system provides a list of energy efficiency measures that if incorporated into the building would likely result in its ability obtain the next highest certification level. The recommendations include information about the payback time and the initial cost (Building Energy Quotient, n.d.). This list of energy efficiency measures emphasizes the desire to see improvement in existing building performance rather than to just benchmark current performance.

To complete a bEQ certification, a third party is required. The third party is either an ASHRAE Certified Building Energy Assessment Professional (BEAP) or a PE licensed in the state that the building is located. A third party is necessary because information in the workbook requires technical expertise. Yet, other than fees associated with a BEAP, there will be no cost for submitting for a certification on the online format, which is available starting in mid-November (Pratt, 2017). Like the other systems reviewed so far, the certificate identifies the year of certification. ASHRAE recommends recertifying the building every three years due to changes to building and to account for the changing normalized average source EUI from Energy

Star; this prevents excessive assessment that will overload ASHRAE and be more expensive for an owner (Building Energy Quotient, n.d.).

Table 3.3 indicates the point allocation for bEQ. The system requires significant data collection and input as well as requires coordination with a third party to complete an on-site assessment. This qualifies it as a complex and costly system. The on-site assessment is when the third party verifies the building is conforming to IEQ standards. Additionally, the score and certification resulting from the evaluation is solely dependent on energy consumption. Lastly, although the general public may not know ASHRAE well, the engineering community uses ASHRAE's technical documents as the basis of the model energy code.

Table 3.3 Evaluation of bEQ In Operation.

Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
	•	•	•	•	•	4

Green Globes

Green Globes is a certification system that was created by the non-profit organization Green Building Initiative (GBI). GBI is a Canadian company that originally based their energy rating systems on the popular energy rating system used in Europe, Building Research Establishment Environmental Assessment Method (BREEAM); GBI converted Green Globes for the American market in 2004. Since then, they consider themselves LEED's direct competition. Green Globes offers 3 different certifications (New Construction, Existing Buildings, and Interiors). This report only considers the existing building certification (Green Building Initiative, 2014).

Green Globes offers 4 levels of certification for existing buildings based on a system comprised of 1,000 points that are converted into a percentage: One Globe (35 to 54 percent), Two Globes (55 to 69 percent), Three Globes (70 to 84 percent), and Four Globes (85 to 100 percent). These points come from 6 different categories: energy, water, resources, emissions, IEQ, and environmental manager; the energy component itself comprises 35 percent of the overall point score (Green Building Initiative, 2014).

To complete the certification, Green Globes requires a pre-evaluation to verify the building is qualified for a certification. Like the previously covered programs, a third party is also required for this certification. However, it differs in that this person is a designated professional assigned by and contracted through Green Globes. This individual will provide a quote for the cost of the assessment during the pre-evaluation phase. After qualifying for evaluation and purchasing the assessment, the Green Globes' assessment representative is assigned to the building. The purpose of the representative is to manage documentation for the rating process as well as perform an on-site assessment. As with the other systems, the certification denotes a specific year (Green Building Initiative, 2014).

Table 3.4 represents the points earned by evaluating the Green Globes certification system. The system is complex due to the initial documentation submitted to GBI, which determines if the building meets qualifications to be certified as well as to determine the quoted price for certification. Upon payment, a third party is assigned whose fee is incorporated into the original quote. Although the certification does not have energy consumption as the focus of a majority of its points, it does verify that IEQ is satisfactory. Lastly, although the system has been used for a couple decades, it has not achieved as much notoriety as other systems.

Table 3.4. Evaluation of Green Globes: Existing Building.

Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
		•		•		2

Energy Asset Score

Under the EPA, another energy rating system, Energy Asset Score (EAS), began in 2016. Although this rating system includes greater input detail pertaining to building characteristics than Energy Star requires, it uses the Portfolio Manager to assess energy performance. An analogy for the two rating systems is a microscope: Energy Star (microscope) captures some building characteristic details, but by using EAS (an additional magnifying lens) more detail is available, which provides greater understanding of energy consumption. In addition to the detail, EAS determines consumption by running simulations as opposed to calculations done by Energy Star. This system is only for rating energy consumption of commercial buildings, which subsequently separates it from Energy Star; there is no certification available (Office of Energy Efficiency & Renewable Energy, 2016).

EAS indicates results on a 10-point scale with half-point increments, as seen in Figure 3.3. In addition to being visually simplified, the scale allows for comparison of what a potential score could be and where a building is compared to defined energy standards. It uses building energy simulation software to predict current energy consumption, which is then used in conjunction with the Portfolio Manager to produce a numerical score. EAS also uses the simulation software to predict potential scores with the implementation of energy efficiency measures that are later recommended as part of the final report provided to the owner. The simulations are generated using input information that includes general building information, envelope components, fenestration, lighting fixtures, mechanical components, service water heating equipment, and operation information (Office of Energy Efficiency & Renewable Energy, 2016).

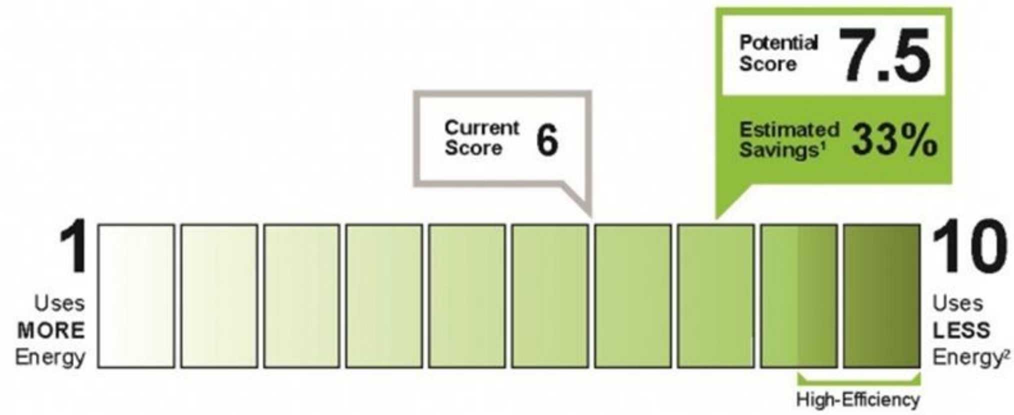


Figure 3.3 Point Scale for Energy Asset Score.
The Office of Energy Efficiency & Renewable Energy. (2017). [Image]. Retrieved from https://energy.gov/eere/buildings/building-energy-asset-score

There is not a requirement of an on-site assessment or a third party to receive a score, which allows an owner or employee to complete the rating entirely on his or her own at little cost (because EAS is funded as a federal government program). Therefore, there is no external cost to the owner. All required information is submitted online. Important distinguishing features of this system is that it does not provide a certification, and its rating is only valid as long as the building is unaltered from its evaluated state (Office of Energy Efficiency & Renewable Energy, 2016).

This system is meant to supply owners with more information about efficiency upgrades, but, in doing so, the complexity of the information needed to be input is not common knowledge for most building owners. The third party may still be needed depending on the owner and their staff's knowledge and skill-set for the data collection. Not requiring a third party potentially brings questions to the validity of the results. The rating is completely dependent on energy consumption, but it is based on computer-based energy models – not solely on the buildings performance. Although the rating system is new, it is produced by the same organization who manages the Energy Star program. The point allotted are displayed as noted in Table 3.5.

Table 3.5 Evaluation of Energy Asset Score.

Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
	•		•		•	3

Comparison of Benchmarking Systems

The purpose of this paper is to establish the most appropriate system to recommend to jurisdictions as they consider implementing legislation to address existing building performance. After introducing the 5 established evaluation systems applicable to existing buildings, aspects of each need to be compared to conclude which system is best for evaluating existing commercial building consumption. By comparing the benchmarking systems with respect to the mandatory categories and the total number of points, the recommended system is evident. In Table 3.6, each evaluation system is listed in order of discussion with the point distribution and total. Additionally, the mandatory columns—energy, third party, and IEQ—have been highlighted green. As mentioned in the previous chapter, a system that is available for recommendation must have a point in each mandatory category.

As a result, Building Energy Quotient is the only eligible system for recommendation as a benchmarking tool. Yet, Energy Star does perform an IEQ assessment if a certification is completed; if legislation prescribes an Energy Star certification as the benchmarking goal, then it would be a viable candidate as well. Therefore, both Energy Star and bEQ will be assessed further to better understand both systems as applied to a case study building in Chapter 4. The chapter will discuss both system’s process of rating and the results of rating in detail.

Table 3.6 Comparison of Evaluated Systems.

	Complexity	Energy	3rd Party	Completion Cost	IEQ	Familiarity	Total
Energy Star	●	●	●	●		●	5
LEED			●		●	●	3
bEQ		●	●	●	●	●	~~4~~5
Green Globes			●		●		2
Energy Asset Score		●		●		●	3

Chapter 4 - Application of Building Benchmarking Process

Chapter 4 demonstrates the case study certification process for Energy Star and bEQ. To best and most accurately represent this process, a specific building is used as an example. Items that are covered in this process description include how to attain or access the necessary data; preparation for and the actual building walk-through; required coordination with the owner, building engineer, or facility manager; and the submittal process for certification. Procedural instructions regarding rating completion are annotated within this chapter.

Case Study Building

The building used as the case study is the Leadership Studies Building located on Kansas State University's main campus located in Manhattan, Kansas. This building operates independently from campus central utility services (chilled water and steam). This is important because it allows for more accurate and simplified measurement of energy and fuel consumption. Pertaining to its characteristics, the Leadership Studies Building is an independent structure that is comprised of two above-grade levels for a total gross area of 36,842 square feet. The on-grade level consists primarily of classroom space but also includes a small café that serves espresso drinks, smoothies, breakfast and lunch foods, etc. The upper level contains employee offices and conference rooms. Based on these three occupancies, the Leadership Studies Building is a mixed-use occupancy containing office space (18,089 square feet), education space (17,103 square feet), and restaurant space (1,650 square feet).

The Leadership Studies Building's construction was completed in 2010. It was certified as LEED BD+C: New Construction (v2.2) with a Gold level designation the same year. LEED BC+D: New Construction (v2.2) had a minimum consumption standard set as a prerequisite requiring new construction to consume 10 percent less energy than code-defined minimums in

IECC 2006. This compliance was modeled using energy simulation software (U.S. Green Building Council, 2017). Since the Leadership Studies Building completion, the facilities department has not implemented any changes to the original construction. The point allocation for the LEED certification is documented in the appendix, Table B.1.

The building's utilities are from commercial providers for electricity, natural gas, and district water. Utility data for the years 2012 through 2016 was gathered for all three sources by the Kansas State University facilities department. In 2015, the facilities department noted that the electricity meter was faulty which lead to inaccurate readings from August 2014 through June 2015. In addition to this missing data, there was a concern with the electricity data for May through July of 2016 because it was not consistent with past performance; during these summer months, the electricity consumption was less than the lowest energy consumption otherwise recorded. This is shown graphically in Figure 4.1. These atypical summer months cannot be contributed to weather entirely because ventilation would still be required – preventing the energy consumption from being significantly less than evident in the spring or autumn. These minimums are during the months of February and November. As a result, the electrical consumption for June 2016 is too low for the conditions present during that month – mild air conditioning, ventilation, and building electrical load. The facilities department did not indicate any changes in operation; therefore, it is assumed that another faulty meter may be to blame.

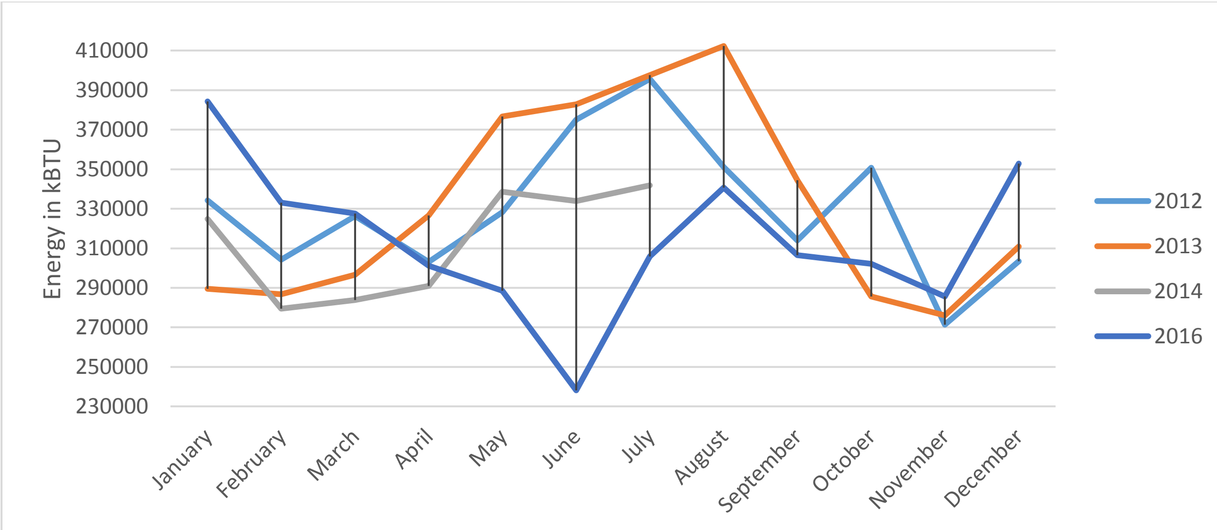
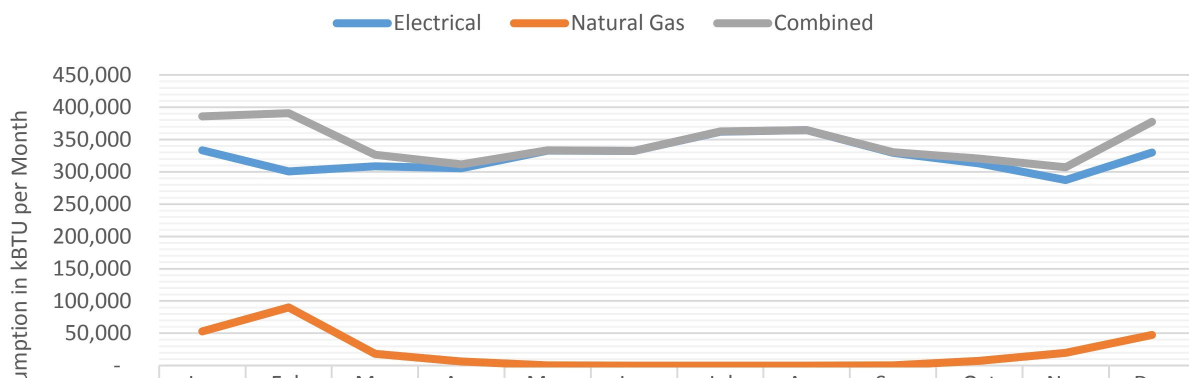


Figure 4.1 Leadership Studies Building's Electricity Consumption from 2012 to 2017. Data source: Kansas State University's Facilities Department.

The inaccuracy of the electrical data collected from the Leadership Studies Building created implications when applying the two evaluation systems. The Energy Star and bEQ ratings use the most current utility data for electricity, natural gas, and water. This would have been from July 2016 through June 2017. With the discovery of the faulty meter, the data set for this time period would not provide an accurate rating. In an effort to create a representative data set to enable a rating to be conducted, the monthly utility data is averaged excluding the electrical data from August 2014 through June 2015 to determine an approximate annual usage; these values account for discrepancies in annual weather cycles. The results are located in Figure 4.2.

In addition to the utility data, information about the building characteristics was attained from the as-built plans supplied by the facilities department, the Leadership Studies Building's webpage through the Kansas State University website, and the Leadership Studies' director's office. The information used for the two rating systems is from the above sources.



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Electrical	333,21	300,91	308,62	305,44	333,01	332,50	362,35	364,39	329,63	312,98	287,37	330,00
Natural Gas	52,958	89,972	17,965	6,157	358	-	78	60	585	7,347	19,902	47,457
Combined	386,17	390,88	326,59	311,60	333,37	332,50	362,42	364,45	330,21	320,33	307,27	377,45

Figure 4.2 Leadership Studies Building's Average Energy Consumption.

ENERGY STAR's Portfolio Manager

The Portfolio Manager tool as well as a step-by-step process to complete a rating is found on Energy Star's webpage - energystar.gov; additionally, screenshots of the webpages applied to the Leadership Studies Building are provided in Appendix B. Before creating an account for the Portfolio Manager, a few fact-gathering steps need to occur, which begins on the Portfolio Manager homepage depicted in Figure C.1. The first of these tasks is to identify the building type. On the left of the webpage, a link list is provided; it contains "Identify your property type." By clicking this link, it will direct you to the page to identify a building type. Primary building types are listed in the first bulleted list. Below the primary building types, there are lists of secondary building types. The secondary building types are more refined classifications. The Leadership Studies Building falls under the primary building type category of Mixed Use. This indicates there is more than one occupancy type present in the building that are to be defined individually: a primary building type of Education with a secondary building type of College/University, a primary building type of Office with a secondary building type of Office, and a primary building type of Food Service and Sales with a secondary building type of Restaurant (ENERGY STAR, n.d.).

After identifying the building type, the next item is to determine what building characteristics are necessary based on the building type. To find this information, use "The benchmarking starter kit" link on the left side of the webpage. Once the page loads, hyperlinked text is on the page written in blue. Of the links available, click the "data collection worksheet" link, which will load a webpage that provides a tool to identify the necessary building information; Figure C.2 is an image of this webpage. Use the drop-down menus to fill in the necessary information – the country where the property is built and the property type. For the Leadership Studies Building, the country location is the United States, and the secondary property type is College/University, Office, and Restaurant. Once this information is entered, click the "Lookup Required Data" button, which initiates a list of information that needs to be collected, including items specific to the secondary building type. The option to create a PDF or Word document is provided which is useful in efficiently collecting the necessary information. The resulting worksheet pages are provided in Figures C.3 to C.7 (ENERGY STAR, n.d.).

Once the listed information is collected, the next stage is to create a Portfolio Manager account. The creation of a Portfolio Manager account requires the entry of personal identification information: name, address, generation of a username, and password. Once an account is created, the webpage will open to "MyPortfolio" displaying all created properties as shown in Figure C.8; a first time user does not have any properties listed. To create a property, select the link on the right of the webpage "Add a Property." In the case an entire portfolio of projects need to be input, an Excel file can be used to create multiple properties at once. When creating the property, the gathered information from the list is added to the online system; this is done in a page resembling Figure C.9. After creating the property, a user may select it to view, edit, or add information later (ENERGY STAR, n.d.).

Upon opening the webpage for a created building, there are seven tabs under the property information: Summary, Details, Energy, Water, Waste & Materials, Goals, and Design. The Summary tab, seen in Figure C.10, displays all results of the input data in a central location as well as provides common trends. The Details tab is used to add information to the property, such as optional building characteristics; for the Leadership Studies Building, the optional building characteristics that were added are the number of full-time equivalent employees and the number of computers – presented in Figure C.11. The three tabs labeled Energy (shown in Figure C.12), Water, and Waste & Material are used to input utility information. For the Leadership Studies Building, there are two meters under the Energy tab—one for electricity and one for natural gas; this is shown in Appendix Figure C.13. Once the information is recorded in the Portfolio Manager, a graph is generated and available on the Energy tab that displays consumption. A similar process is followed for Water and Waste & Materials meters, but this information was not input for the Leadership Studies Buildings because the information does not contribute to generating a score. The tabs for Goals and Design are used to set targets for results and predicting scores reflecting potential changes to a property, and the details for these tools is shown in Figures C.14 and C.15.

The available results include an Energy Star score, source EUI, site EUI, energy cost, total greenhouse gas emissions, water usage, and total waste. The Energy Star score is the rating and is based on a weather-normalized source EUI compared to all other properties of the same secondary property type; the details for the average property type is available under the Design tab. An Energy Star score is not available for the Leadership Studies Building because it is a multiuse building type, and a single building type does not comprise at least 50 percent of the total gross floor area. Even without a score, the Energy Star results do provide a weather-normalized source EUI and expresses the building performance in relation to other similar properties. In Chapter 5, the results of the rating are discussed (ENERGY STAR, n.d.).

Building Energy Quotient

The process for obtaining a rating using bEQ is simple from an owner's perspective; a hired third party gathers the building characteristic information, conducts the building walk-through, and submits the information with ASHRAE's bEQ web portal. As mentioned in Chapter 3, the third party must be either a BEAP or a PE. To find a qualified professional, an owner can visit the Building Energy Quotient website - buildingenergyquotient.org. Under the In Operation section, there is a link, "Find a bEQ Qualified Practitioner," which prompts several fields: name, organization, certification type, and location. Once completed, a table lists BEAPs near the building's location. If there is not a BEAP in the area, any Professional Engineer licensed within the building's state is acceptable. Upon hiring a third party, the owner's involvement is reduced to supplying the professional with building information and answering any questions that the professional may have (Building Energy Quotient, n.d.).

Once hired, the third party gathers information about the building through as-built drawings, metered data, etc. in preparation for an on-site evaluation. They add the information to the Excel workbook, which is free to download from bEQ's website under the In-Operation section. The workbook contains pre-formulated cells, input cells, and additional instructions to assist the third party with completing the workbook. Beginning November 2017, ASHRAE will require the information collected to be input using an online portal in lieu of the Excel workbook (Pratt, 2017). The online portal will contain all the same fields for data entry; it simply will bypass the need to create a workbook.

The In-Operation Excel workbook contains several sheets: bEQ Terms & Conditions; General Instructions; Building Types; Form 1 Building Characteristics; Photographs; Form 2 Energy Calcs, Multiple Use Worksheet, Metered Data; Form 3 IEQ Screening; Form 4 Energy Savings; Form 5 Energy End Use; Form 6 Water Use, Additional Notes, HVAC Inventory; and ATTACHMENTS. The first sheet necessary is the Building Type sheet. It lists the building types used by ASHRAE that classify buildings by primary building activities and sub-categories via CBECS. CBECS classifies the Leadership Studies Building as a Multiuse building comprised of College/University, Administrative/Professional Office, and Restaurant/Cafeteria spaces.

The paragraph will begin to describe the sheets found in the bEQ Excel workbook, and in Appendix C there are images of the completed pages for the Leadership Studies Building. The building characteristics (Form 1) combined with utility data (Metered Data sheet) partially complete Form 2. The Metered Data sheet only allows for utility data of electricity and natural gas; any other energy sources are added in Form 2. After completing these 3 sheets, a weather-normalized site EUI and a weather-normalized source EUI is generated, and the weather-normalized source EUI is compared to the weather-normalized source mean EUI for the building type (from Energy Star's Portfolio Manager). The comparison, dividing the bEQ source EUI by the Portfolio Manager source median EUI, is multiplied by 100 percent, and this value is the bEQ rating. The rating is assigned to the correct certification level, which was discussed in Chapter 3. The next form, Form 3 – IEQ Screening, evaluates the building's IEQ to ensure indoor air quality and lighting requirements are met. The final sheet that contains data is Form 6, which is used for water usage consumption and savings. Upon completion, the remaining sheets are for analysis and recommendation.

The first of the recommendation sheets, Form 4, is used to recommend energy efficiency measures – including the cost range and payback period – in an effort to aid in increasing the buildings performance. In addition to recommendations, Form 4 also indicates by what percentage the building's energy must be reduced to obtain the next highest certification level. Another analysis sheet used for recommendations is Form 5, the energy end use sheet. This form is optional, but it does provide more insight as to which building systems are consuming the most energy; this aids the third party in his or her recommendations of energy efficiency measures. The remaining sheets are for additional information, two to six allowable photos, general instructions, and terms and conditions.

Upon completion of an on-site evaluation, the workbook can be completed and prepared for submission to ASHRAE for review; the third party will submit the registration fee at this time. Upon receipt, ASHRAE verifies the information, and, once approved, the rating results and materials are sent to the third party to share with the owner. The materials include a certificate, a dashboard, and a plaque, which have been attached in Appendix D as samples. The certificate will include the bEQ rating, the Energy Star rating, EUI, etc. The dashboard provides a visual representation of the rating and the accompanying rating information. Lastly, a plaque will be provided indicating the level of performance, the rating system used, and the year it was completed. These three items will be presented to the owner upon completion of the rating (Building Energy Quotient, n.d.).

For the Leadership Studies Building, the Kansas State University facilities department in the form of PDF files, AutoCAD files, and Operations & Maintenance files supplied much of the information necessary to receive a score from ASHRAE. From these documents, information pertaining to mechanical equipment, lighting, power distribution, and code information is used to fill in the Excel sheets. Yet, Form 3 (information pertaining to IEQ) required an on-site assessment to take measurements to determine if the building was meeting the code to which it was designed. Some measurements that are required are outdoor air volumetric flow rate, the temperature and relative humidity in the space, and light levels; in addition to these, sound levels, carbon dioxide levels, and pressure measurements were recorded. Although, the require IEQ measurements are required for certification of a building, they are not needed to receive a score; only information for forms one, two, the multi-use worksheet, and metered data worksheets are required. Because of this aspect, the Leadership Studies Building does have an approximated score even though it is unable to be certified due to the electricity data.

Chapter 5 - Results and Analysis of the Rating Methods

The intent of this chapter is to review the results for the Energy Star Portfolio Manager and bEQ – In Operation ratings to determine which to use as the recommended benchmarking system. With respect to source EUI, it is expected both rating systems to have similar results since the building's source EUI is a common formula with the same information; additionally, both systems should have similar mean source EUI's because they both use CBECS data as the basis for calculation. However this is not the case, and the following paragraphs provide additional information.

The Energy Star Portfolio Manager provided multiple pieces of information in the results including three EUIs, the annual cost of energy, and the greenhouse gas emissions. For this paper, the data of greatest importance are the EUIs as the other items are irrelevant to the paper's scope. The three EUIs presented in Table 5.1 represent the building's site EUI, source EUI, and normalized source EUI. It is important to note the normalized source EUI is lower than the source EUI. This is due to the weather component of the normalized rating. A lower normalized EUI value indicates the weather in Manhattan, Kansas is more extreme than its peers' locations, therefore requiring more energy to heat and cool the facility. The most influential of the information provided by Energy Star is the comparison of the normalized EUI to the average normalized EUI of the peer buildings. It identifies the degree of efficiency or inefficiency of the Leadership Studies Building is 175 percent worse than the median rating, which is 123.1 kBTU/ft^2·yr. Additionally, the median is determined by accounting for the average fuel mix used to generate electricity for the state of Kansas and the building's operational hours. (ENERGY STAR, n.d.)

Table 5.1 Portfolio Manager's Resulting EUIs.

Data source: Energy Star

Site EUI (kBTUh/ft^2·yr)	Source EUI (kBTUh/ft^2·yr)	Normalized EUI (kBTUh/ft^2·yr)
112.5	339.5	339.1

Although Energy Star could generate EUIs and compare the Leadership Studies Building to peer buildings, it did not provide a rating for the building because there was not a secondary building type that comprised at least 50 percent of the total gross floor area. The largest secondary building type for the Leadership Studies Building is the office space, which comprises 49.1 percent of the building. Although a score was not given, Energy Star did indicate the building is less efficient than the median building – resulting in a score of less than 50. Consequently, the Leadership Studies Building would be ineligible for certification in the event is was scored.

Using Energy Star, there is the Design tab that assists the user in increasing energy efficiency. The user builds a design by inputting building type information, energy distribution, and a goal. The building type information indicates square footage, operating hours, and other detailed information specific to the building type; for the Leadership Studies Building, the same information used to rate the building was added in this tab. The energy distribution can be manually inserted by the user based site specific energy sources, or the system uses average values based on the state the property resides – the latter option was used for the Leadership Studies Building. Lastly, a goal can be set by a specific Energy Star score (only if eligible for a score) or by selecting a percent to exceed the median; for the Leadership Studies Building, the design is set to 50 percent better than the median since this was the LEED requirement for Energy & Atmosphere that the building was certified for in 2010. This results in a source EUI design of 61.6 kBTU/ft^2·yr, which is 50 percent of the average annual use for 2012 through 2016.

As a result, if the building was expected to achieve the same goals of LEED Gold, the building must reduce its consumption by 50 percent.

Based on the bEQ workbook, the Leadership Studies Building yields a source EUI of 339 $kBTU/ft^2 \cdot yr$ rounded to the nearest whole number; this value is within three-tenths of a percent of the Energy Star produced source EUI. ASHRAE determined a source median EUI of 243 $kBTU/ft^2 \cdot yr$ for the building; it differs from Energy Star because it determined the median by different methods than Energy Star. Although both Energy Star and bEQ use the same CBECS climate zone and occupancy use data, they differ in that bEQ corrects the median with regard to the heating degree days (HDD) and cooling degree days (CDD). This accounts for variations in weather temperatures from CBECS 2012 reference year to a different year. By accounting for changes in climate annually, the Leadership Studies Building receives a score of 139 and a certification level of D (Inefficient) from bEQ. This is comparable to the hypothetical Energy Star score of less than 50.

Chapter 6 - Recommendation and Conclusion

Based on the results of the Energy Star and Building Equivalent Quotient ratings, bEQ In Operation is the recommend benchmarking system. It is eligible because it meets the three categories determined in the final paragraph of Chapter 2: energy, third party involvement, and IEQ minimums verification. Although Energy Star could meet these same conditions as bEQ when an owner applies for a certification, bEQ offered a score for the Leadership Studies Building – a multi-use building without a single building type having 50 percent majority. bEQ provides EUIs, ratings, and certifications for all commercial buildings, which makes it a more inclusive rating system. In addition to the certification aspect, bEQ incorporates greater detail in median EUI calculations. As a result, bEQ provides a more normalized rating. The results are a fairer comparison for buildings since weather is specific to each location as well as building characteristics.

In addition to rating inclusivity and better normalized ratings, bEQ certification supplies owners with the information about energy efficiency measures (EEMs) that are best suited to increasing the buildings energy efficiency. The added advantage of this is it alters the system from being purely informational to instructive. If the same result is desired of Energy Star, a third party needs to be hired to supply this information, which results in an additional investigation and fee; because this is not incorporated into the system, it would be up to the owners discretion. As a result, bEQ gives the advantage of assisting owners to decrease their energy consumption as well as operational cost.

As a benchmarking system for jurisdictional legislation, ASHRAE's Building Energy Quotient is the preferred system because it allows for quick identification of commercial buildings with the greatest potential to reduce energy consumption; this is because the benchmark correlates directly with energy use. Each median source EUI is adjusted for climate zones and annual weather trends to better compare buildings. Additionally, a bEQ certification provides owners with the information to increase the efficiency of their buildings. This added information enables owners to begin implementing energy efficiency measures upon receiving the bEQ certification documentation, which results in expedited consumption changes. This allows both legislative and owner desires to agree – making the benchmarking system beneficial for both stakeholders.

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Appendix A - Energy Benchmarking in Legislation

Table A.1 Energy Rating Legislature at the Jurisdictional Level.

Data Source: Institute for Market Transformation at http://buildingrating.org/

Jurisdiction	Compliance Details	Disclosure	Reporting
Alabama	Enforcement: No	Required: No	Required: Yes Frequency: none
California	Enforcement: No	Required: Yes Method: Public Website Recipients: Government, Public Website Frequency: Annually	Required: No
Delaware	Enforcement: No	Required: No	Required: Yes Frequency: none
Hawaii	Enforcement: No	Required: No	Required: No
Michigan	Enforcement: No	Required: No	Required: Yes Frequency: none
Minnesota	Enforcement: No	Required: No	Required: No
New York	Enforcement: No	Required: No	Required: Yes Frequency: none
Ohio	Enforcement: No	Required: No	Required: Yes Frequency: none
Oklahoma	Enforcement: No	Required: No	Required: Yes Frequency: none
Oregon	Enforcement: No	Required: No	Required: No
Utah	Enforcement: No	Required: No	Required: Yes Frequency: none
Washington	Enforcement: No	Required: Yes Method: none Recipients: Buyers, Lessees, Lenders Trigger Events: Purchase/sell (required), Rent (required)	Required: No
Cook County	Enforcement: No	Required: Yes Method: Public Website Recipients: none Trigger: Date Certain Frequency: Annually	Required: No
Montgomery County	Enforcement: Yes Penalties for Non-Compliance: No	Required: Yes Method: Public Website Recipients: Public Website Trigger: Date Certain Frequency: Annually	Required: Yes Frequency: Annually
Atlanta, GA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Written notice of first	Required: Yes Method: Public Website Recipients: Public Website	Required: Yes Frequency: Annually

	violation; Fine of $1,000 if 30 days late, an additional $1,000 every year thereafter	Trigger: Date Certain Frequency: Annually	
Austin, TX	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Proof of culpable mental state is not required for a fine of up to $500. If a person acts with criminal negligence, a fine of up to $2,000 may be assessed.	Required: Yes Method: none Recipients: Buyers or Lessees Trigger: Point of Transaction	Required: Yes Frequency: Annually
Berkeley, CA	Enforcement: No	Required: Yes Method: Report to Recipient Recipients: Tenants, Buyers, Lessees Trigger: Point of Transaction Recipients: Government Frequency: Annually	Required: Yes Frequency: Annually Trigger: Time of Transaction
Boston, MA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: $75 to $200 per day for owners. Maximum annual fine is $3,000. Non-residential tenants may be fined up to $35 at a time for failing to supply building owners with their energy data. Residential tenants will not be fined.	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
Boulder, CO	Enforcement: Yes Penalties for Non-Compliance: Yes	Required: Yes Method: none Recipients: Public Website Frequency: Annually	Required: Yes Trigger: none
Cambridge, MA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: First violation results in a warning. Subsequent violations result in a fine of $300 per day.	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
Chicago, IL	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Owner subject up to $100 fine for 1st violation and additional fines up to $25/day	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
Denver, CO	Enforcement: Yes Description: The Manager is empowered to enforce the provisions of this article and any rules and regulations adopted by the Board pursuant to this article.	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: No
Denver, CO	Enforcement: No	Required: No	Required: No
District of Columbia	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Up to $100 per day.	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually

Evanston	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Any person who violates any provision of this Chapter will be fined one hundred dollars ($100) for each such offense. Every month a violation continues will be deemed a separate offense.	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: Yes Frequency: Annually
Kansas City, MO	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Written warning for first failure to comply; fine of up to $500 if compliance not met within 60 days of warning; additional to other remedies, city may file suit	Required: Yes Method: Report to Recipient Recipients: Government, Public Website Frequency: Annually	Required: Yes Frequency: Annually
Los Angeles, CA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Failure to comply with this division shall subject the owner to noncompliance fees as specified in Section 98.0411 of the Los Angeles Municipal Code, except that the amount of the noncompliance fee shall be $202.	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: No
Minneapolis, MN	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Warning notice mailed to the building owner, indicating 45 days to comply else face a penalty. Failure to comply with penalties may result in a suspension of commercial building registration.	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
New York City, NY	Enforcement: Yes Penalties for Non-Compliance: Yes Description: $500 fine for missing May 1st benchmarking deadline, additional $500 fines for each subsequent quarter failing to benchmark (maximum: $2,000)	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
Orlando, FL	Enforcement: No	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: Yes Frequency: Annually
Philadelphia, PA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: $300 fine for the 1st 30 days, and then $100/day	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: Yes Frequency: Annually
Pittsburgh, PA	Enforcement: No	Required: Yes Method: Public Website Recipients: none Frequency: none	Required: No
Portland, OR	Enforcement: Yes Penalties for Non-Compliance: Yes Description: $500 for every 90 day period during which violations continue.	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: Yes Frequency: Annually

Portland, ME	Enforcement: Yes Penalties for Non-Compliance: Yes Description: For the first violation, a written warning may be issued. Any subsequent or ongoing violation will be subject to a fine of up to $20.00 per day.	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: Yes Frequency: Annually
Rockville	Enforcement: No	Required: Yes Method: Public Website Recipients: Public Website Frequency: Annually	Required: No
Salt Lake City, UT	Enforcement: No	Required: Yes Method: Public Website Recipients: none Frequency: Annually	Required: No
San Francisco, CA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Warning, then public notice, then fine Compliance Rate (Based on Building Area): 82% (2013)	Required: Yes Method: Public Website Recipients: Tenants Frequency: Annually	Required: Yes Frequency: Annually
Seattle, WA	Enforcement: Yes Penalties for Non-Compliance: Yes Description: Penalties accrue quarterly, starting 90 days after reporting deadlines. Buildings 50,000 SF or greater: $1,000/quarter. Buildings greater than or equal to 20,000 SF and less than 50,000 SF: $500/quarter	Required: Yes Method: Public Website, Report to Recipient Recipients: Public Website, Tenants, Buyers, Lenders Trigger: Point of Transaction	Required: Yes Frequency: Annually
West Chester, PA	Enforcement: No	Required: Yes Method: none Recipients: none Frequency: Annually	Required: No

Appendix B - Leadership Studies Building LEED Scorecard

0010345971, Manhattan, KS

KSU School of Leadership Studies

LEED BD+C: New Construction (v2.2) — GOLD, AWARDED DEC 2010

SUSTAINABLE SITES		AWARDED: 8 / 14
SSc1	Site selection	1 / 1
SSc2	Development density and community connectivity	1 / 1
SSc3	Brownfield redevelopment	0 / 1
SSc4.1	Alternative transportation - public transportation access	0 / 1
SSc4.2	Alternative transportation - bicycle storage and changing rooms	1 / 1
SSc4.3	Alternative transportation - low emitting and fuel efficient vehicles	1 / 1
SSc4.4	Alternative transportation - parking capacity	1 / 1
SSc5.1	Site development - protect or restore habitat	0 / 1
SSc5.2	Site development - maximize open space	1 / 1
SSc6.1	Stormwater design - quantity control	1 / 1
SSc6.2	Stormwater design - quality control	0 / 1
SSc7.1	Heat island effect - non-roof	1 / 1
SSc7.2	Heat island effect - roof	0 / 1
SSc8	Light pollution reduction	0 / 1

WATER EFFICIENCY		AWARDED: 4 / 5
WEc1.1	Water efficient landscaping - reduce by 50%	1 / 1
WEc1.2	Water efficient landscaping - no potable water use or no irrigation	1 / 1
WEc2	Innovative wastewater technologies	0 / 1
WEc3.1	Water use reduction - 20% reduction	1 / 1
WEc3.2	Water use reduction - 30% reduction	1 / 1

ENERGY & ATMOSPHERE		AWARDED: 9 / 17
EAc1	Optimize energy performance	6 / 10
EAc2	On-site renewable energy	0 / 3
EAc3	Enhanced commissioning	1 / 1
EAc4	Enhanced refrigerant Mgmt	1 / 1
EAc5	Measurement and verification	1 / 1
EAc6	Green power	0 / 1

MATERIAL & RESOURCES		AWARDED: 6 / 13
MRc1.1	Building reuse - maintain 75% of existing walls, floors & roof	0 / 1
MRc1.2	Building reuse - maintain 95% of existing walls, floors & roof	0 / 1
MRc1.3	Building reuse - maintain 50% of interior non-structural elements	0 / 1
MRc2.1	Construction waste Mgmt - divert 50% from disposal	1 / 1
MRc2.2	Construction waste Mgmt - divert 75% from disposal	1 / 1
MRc3.1	Materials reuse - 5%	0 / 1

MATERIAL & RESOURCES		CONTINUED
MRc3.2	Materials reuse - 10%	0 / 1
MRc4.1	Recycled content - 10% (post-consumer + 1/2 pre-consumer)	2 / 1
MRc4.2	Recycled content - 20% (post-consumer + 1/2 pre-consumer)	0 / 1
MRc5.1	Regional materials - 10% extracted, processed and manufactured regionally	1 / 1
MRc5.2	Regional materials - 20% extracted, processed and manufactured regionally	1 / 1
MRc6	Rapidly renewable materials	0 / 1
MRc7	Certified wood	0 / 1

INDOOR ENVIRONMENTAL QUALITY		AWARDED: 10 / 15
EQc1	Outdoor air delivery monitoring	1 / 1
EQc2	Increased ventilation	0 / 1
EQc3.1	Construction IAQ Mgmt plan - during construction	1 / 1
EQc3.2	Construction IAQ Mgmt plan - before occupancy	0 / 1
EQc4.1	Low-emitting materials - adhesives and sealants	1 / 1
EQc4.2	Low-emitting materials - paints and coatings	1 / 1
EQc4.3	Low-emitting materials - carpet systems	1 / 1
EQc4.4	Low-emitting materials - composite wood and agrifiber products	1 / 1
EQc5	Indoor chemical and pollutant source control	1 / 1
EQc6.1	Controllability of systems - lighting	1 / 1
EQc6.2	Controllability of systems - thermal comfort	0 / 1
EQc7.1	Thermal comfort - design	1 / 1
EQc7.2	Thermal comfort - verification	1 / 1
EQc8.1	Daylight and views - daylight 75% of spaces	0 / 1
EQc8.2	Daylight and views - views for 90% of spaces	0 / 1

INNOVATION		AWARDED: 5 / 5
IDc1	Innovation in design	4 / 4
IDc2	LEED Accredited Professional	1 / 1

TOTAL		42 / 69

Figure B.1 Leadership Studies LEED Scorecard.

U.S. Green Building Council. (2010). [Image]. Retrieved from https://www.usgbc.org/projects/ksu-school-leadership-studies

Appendix C - Portfolio Manager Navigational Images

Figure C.1 Portfolio Manager Homepage.

Energy Star. (2017). [Image]. Retrieved from https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager

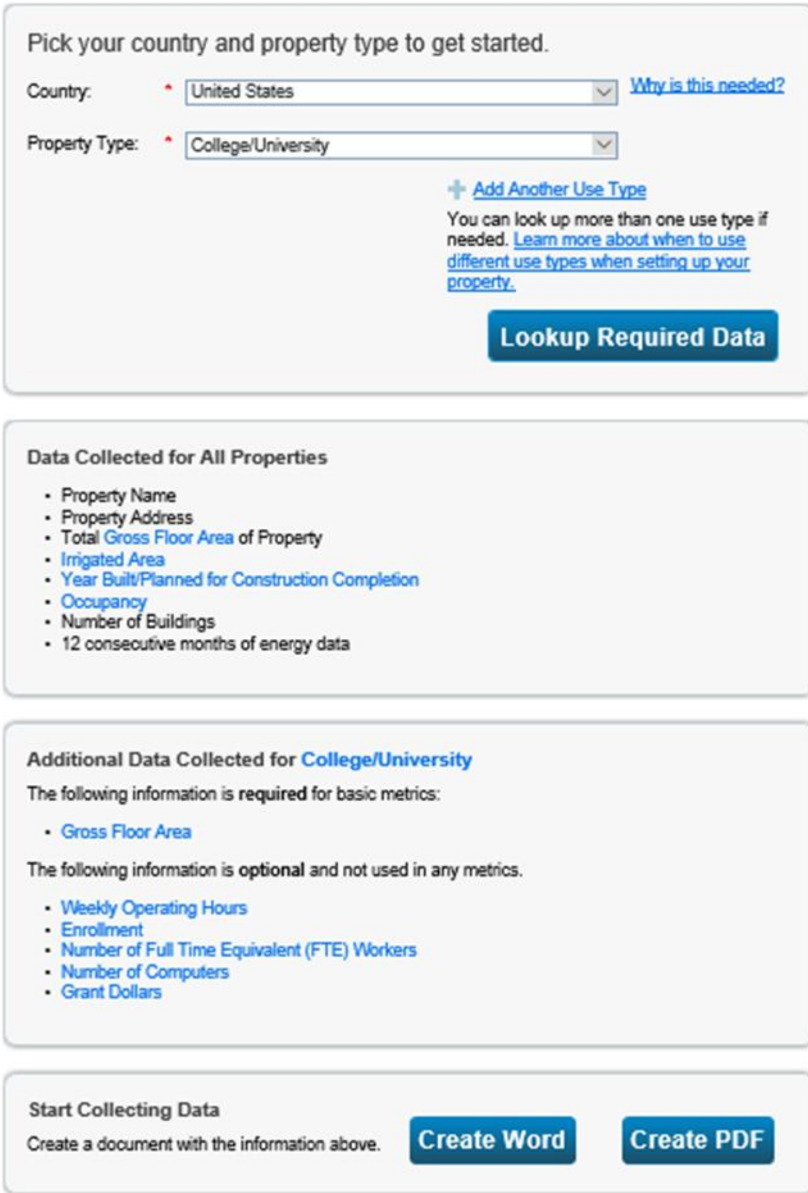


Figure C.2 Required Data for College/University Building Type.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

Portfolio Manager - What data is required?

In order for Portfolio Manager to calculate metrics about your property, you must provide several key pieces of information about your property's operation, in addition to your energy, water or waste data. The information required varies by the type of property and whether or not your property is eligible for an ENERGY STAR Score.

Data Required for All Properties

Property Name ______________________________

Property Address ______________________________

Total Gross Floor Area of Property ______________________________ Sq. Ft./Sq. M.

Irrigated Area ______________________________ Sq. Ft./Sq. M./Acres

Year Built/Planned for Construction Completion ______________________________

Occupancy ______________________________ %

Number of Buildings ______________________________

Helpful Hints for All Properties

- Definitions for Property Use Details are available in the Portfolio Manager Glossary (in the Help section, or https://portfoliomanager.energystar.gov/pm/glossary).
- Some properties may contain multiple Property Uses within a single building (e.g. office, data center, and parking; OR K-12 School and Swimming Pool). In most cases, EPA recommends you enter as few Property Uses as possible. More information about when to enter a separate Property Use is in this FAQ.
- For properties with multiple tenants within the same property use (e.g. Office), these tenants should be entered separately only when the number of Weekly Operating Hours differs by more than 10 hours. For example, say an Office Building has a Gross Floor Area of 100,000 square foot (SF) where 75,000 SF operates 60 hours a week and 25,000 SF operates 80 hours a week. Enter these as two separate Property Uses (one 75,000 SF property and one 25,000 SF property).

Figure C.3 Data Collection Worksheet, Page 1.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

College/University Uses

Data Collected for College/University Uses

The following information is required for basic metrics:

Gross Floor Area ________________________________

The following information is optional and not included in any metrics:

Weekly Operating Hours ________________________________

Enrollment ________________________________

Number of Full Time Equivalent (FTE) Workers ________________________________

Number of Computers ________________________________

Grant Dollars ________________________________

Definition for College/University

College/University refers to buildings used for the purpose of higher education. This includes public and private colleges and universities.

Gross Floor Area should include all space within the building(s), including classrooms, laboratories, offices, cafeterias, maintenance facilities, arts facilities, athletic facilities, residential areas, storage rooms, restrooms, elevator shafts, and stairways.

Office Uses

Data Collected for Office Uses

The following information is required to get an ENERGY STAR Score (if eligible):

Gross Floor Area ________________________________

Figure C.4 Data Collection Worksheet, Page 2.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

Weekly Operating Hours ______________________________

Number of Workers on Main Shift ______________________________

Number of Computers ______________________________

Percent That Can Be Heated ______________________________

Percent That Can Be Cooled ______________________________

Definition for Office

Office refers to buildings used for the conduct of commercial or governmental business activities. This includes administrative and professional offices.

Gross Floor Area (GFA) should include all space within the building(s) including offices, conference rooms and auditoriums, break rooms, kitchens, lobbies, fitness areas, basements, storage areas, stairways, and elevator shafts.

If you have restaurants, retail, or services (dry cleaners) within the Office, you should most likely include this square footage and energy in the Office Property Use. There are 4 exceptions to this rule when you should create a separate Property Use: If it is a Property Use Type that can get an ENERGY STAR Score (note: Retail can only get a score if it is greater than 5,000 square feet) If it accounts for more than 25% of the property's GFA If it is a vacant/unoccupied Office If the Hours of Operation differ by more than 10 hours from the main Property Use More on this rule.

Helpful Hints for Office

- If more than 10 percent of the office's gross floor area on average was vacant through the last 12 months, enter the vacant space as a separate Property Use with zero for Weekly Operating Hours, Number of Workers on Main Shift and Number of Computers.
- The Weekly Operating Hours value is the number of hours per week that the office is occupied by the majority of its occupants. It should not include hours when the building is occupied solely by maintenance/security personnel or HVAC run times when the building is not occupied by the majority of occupants.
- The Number of Workers on Main Shift should be entered as the number of workers present on a site at the same time, not the total number of workers added up across all shifts during a day.
- When determining the Number of Computers, do not count extra monitors or tablets. For example, a desktop computer with 3 monitors would count as 1. Similarly, a laptop computer with an external monitor would count as 1.

Figure C.5 Data Collection Worksheet, Page 3.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

Other - Restaurant/Bar Uses

Data Collected for Other - Restaurant/Bar Uses

The following information is required for basic metrics:

Gross Floor Area ________________________________

The following information is optional and not included in any metrics:

Weekly Operating Hours ________________________________

Number of Workers on Main Shift ________________________________

Number of Computers ________________________________

Definition for Other - Restaurant/Bar

Other – Restaurant/Bar refers to buildings used for preparation and sale of ready-to-eat food and beverages, but which does not fit into the fast food restaurant, restaurant, or bar/nightclub property types.

Gross Floor Area should include all space within the building(s), including kitchens, sales areas, dining areas, staff break rooms, and storage areas. Gross Floor Area should *not include* any outdoor/exterior seating areas, but the energy use of these outdoor areas should be reported on your energy meters.

Figure C.6 Data Collection Worksheet, Page 4.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

Meter Information

What's required to see metrics:

- 12 consecutive, complete months of bills if your energy or water is metered continuously.
- At least one delivery if your energy is delivered in bulk quantities (e.g. filling a propane tank.)

Please copy this sheet as needed to account for all meters at your property.

Basic Meter Information	
Meter Name or ID	______________________________
Meter Type (e.g. Electricity)	______________________________
Units (e.g. kWh)	______________________________
Date Meter Became Active	______________________________
Date Meter Became Inactive	______________________________

You can use the form below to get ready to enter your data so you can see metrics, however you can create your property and set up your meters without entering your meter data. You can add bills later.

Meter Bills

Start Date/Delivery Date	End Date (leave blank for deliveries)	Usage/Quantity	Cost (optional)

Figure C.7 Data Collection Worksheet, Page 5.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/dataCollectionWorksheet

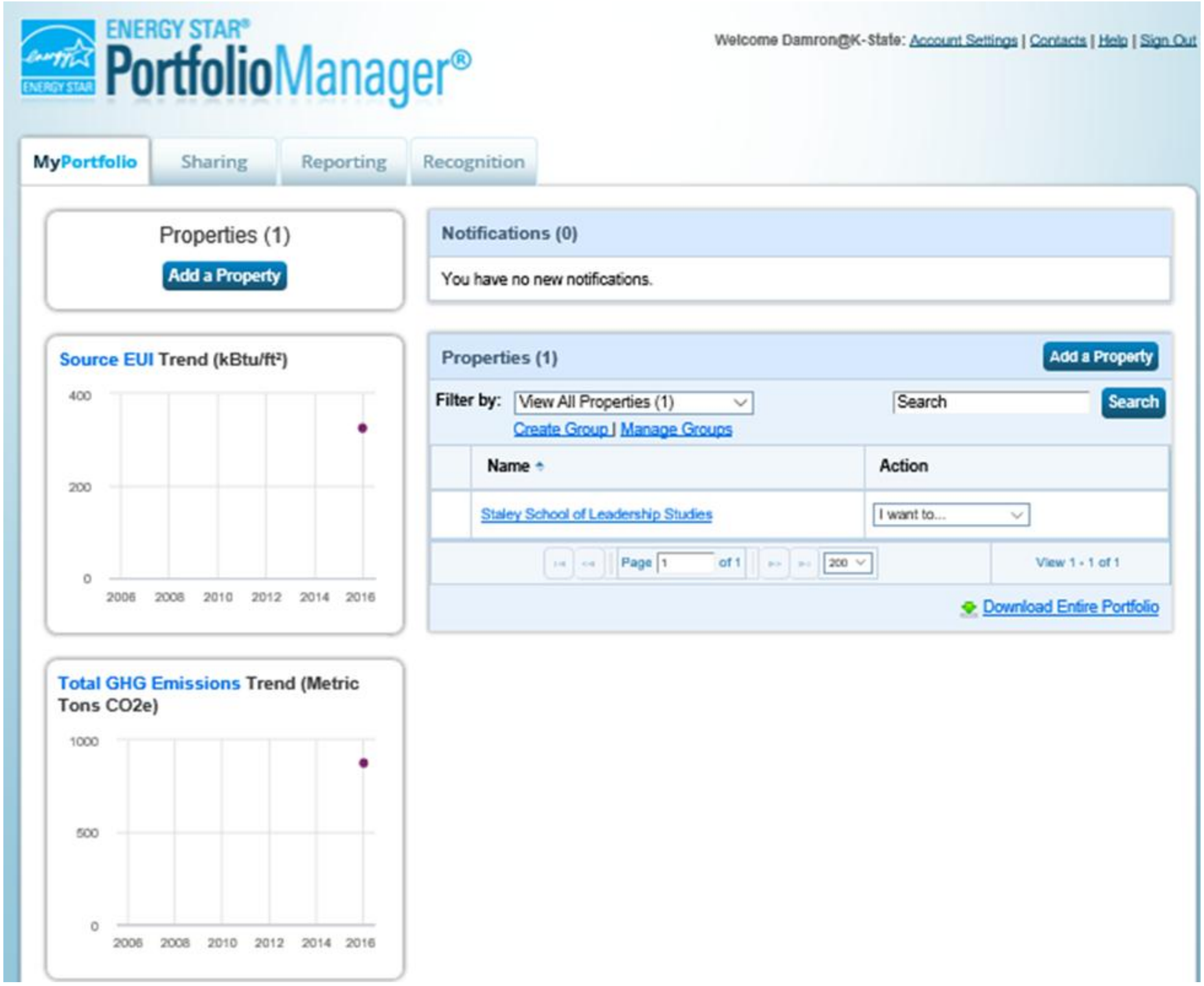


Figure C.8 Portfolio Manager's Properties Webpage.

Energy Star. (2017). [Image]. Retrieved from

https://portfoliomanager.energystar.gov/pm/home.html

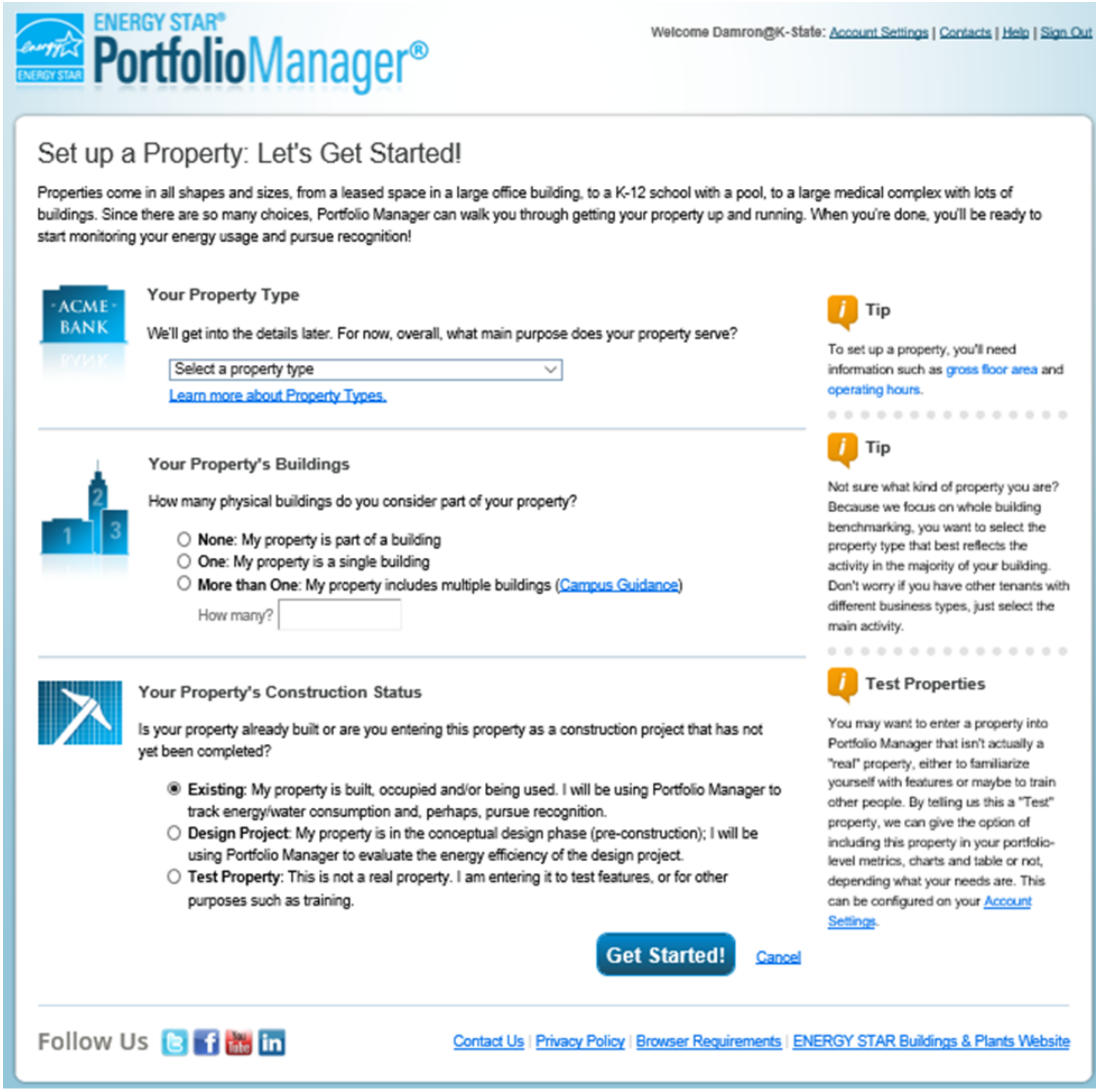


Figure C.9 Property Addition Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/propertySetup?execution=e1s1

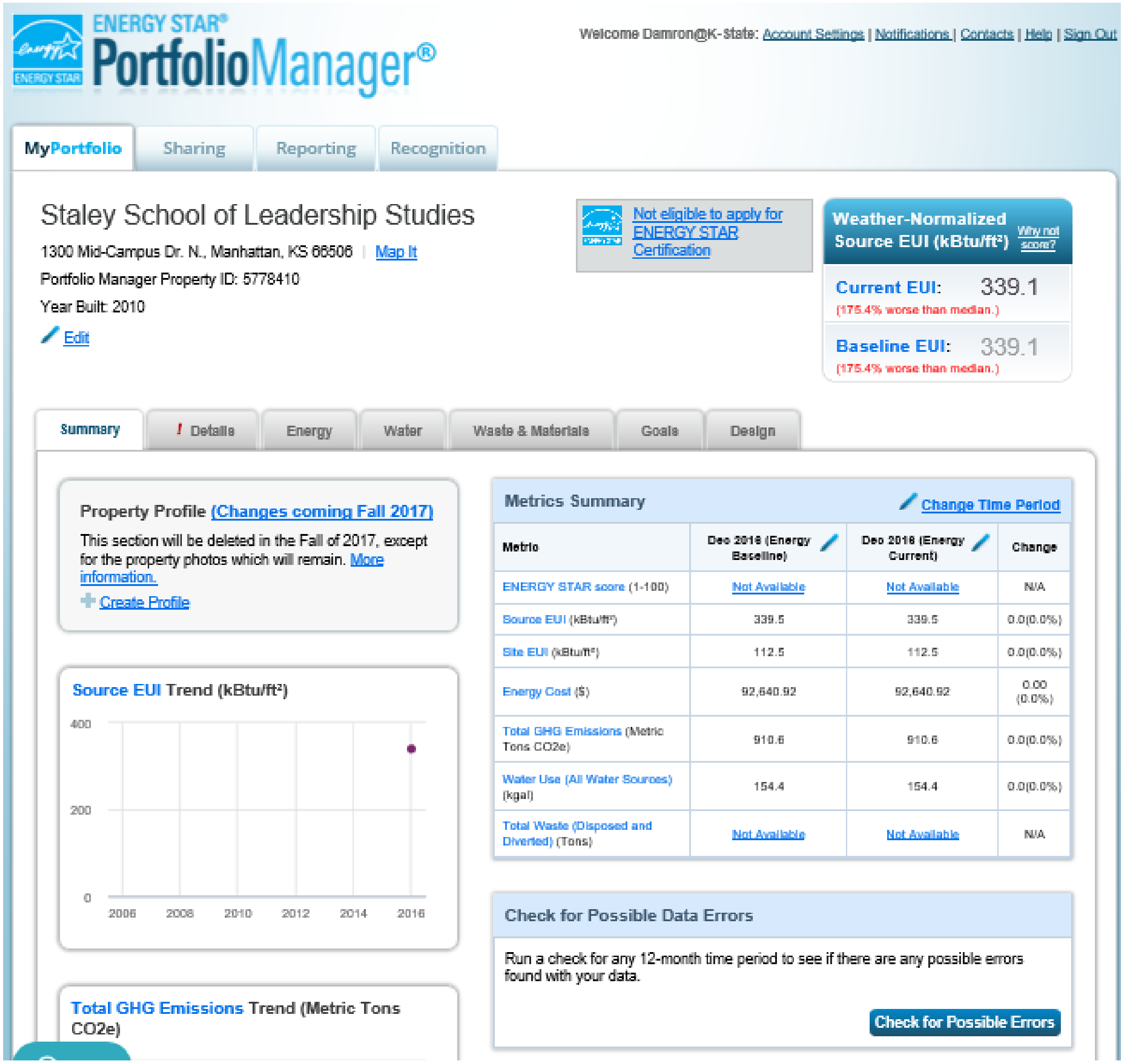


Figure C.10 Property Summary Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/property/5778410#summary

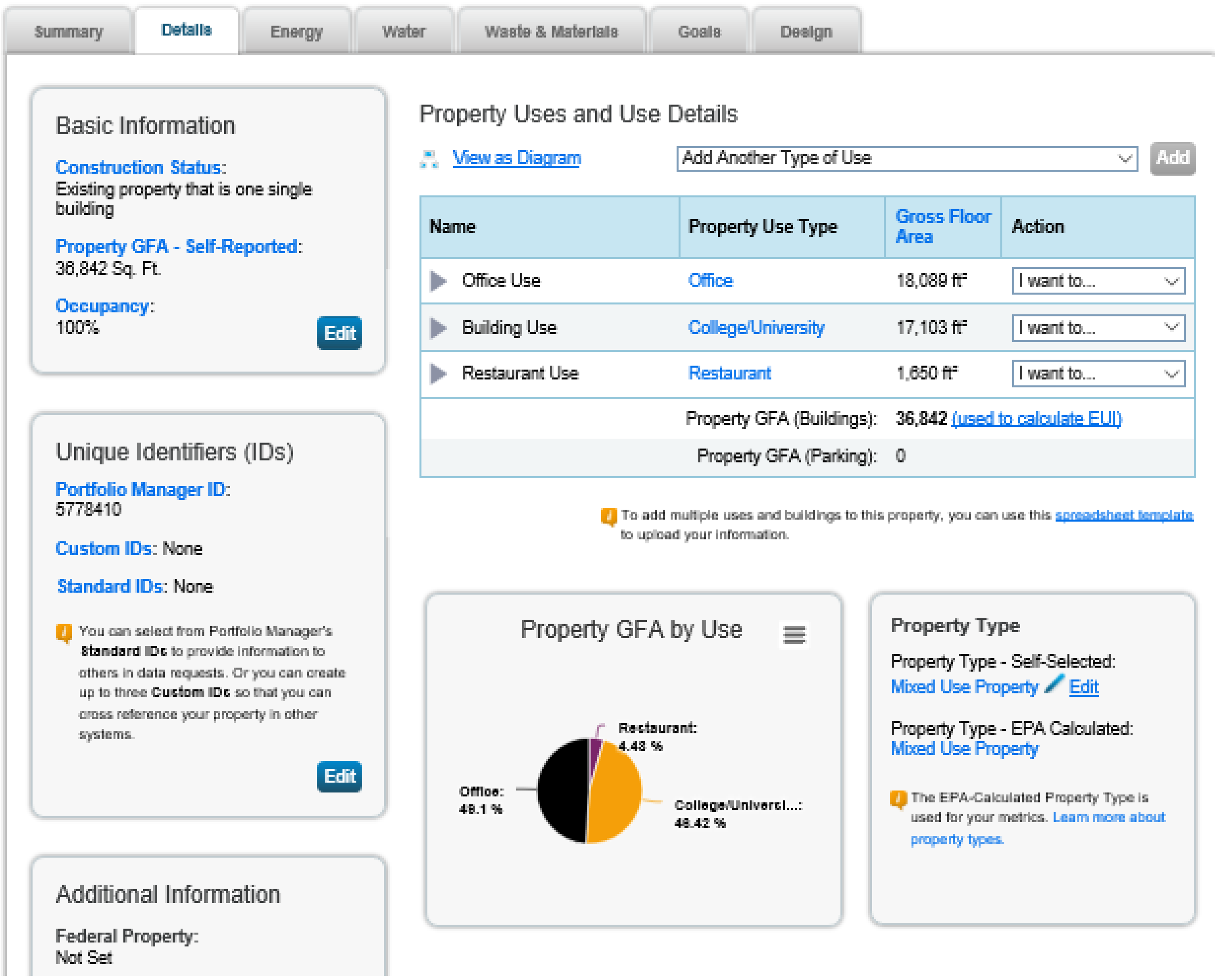


Figure C.11 Property Details Webpage.

Energy Star. (2017). [Image]. Retrieved from

https://portfoliomanager.energystar.gov/pm/property/5778410#details

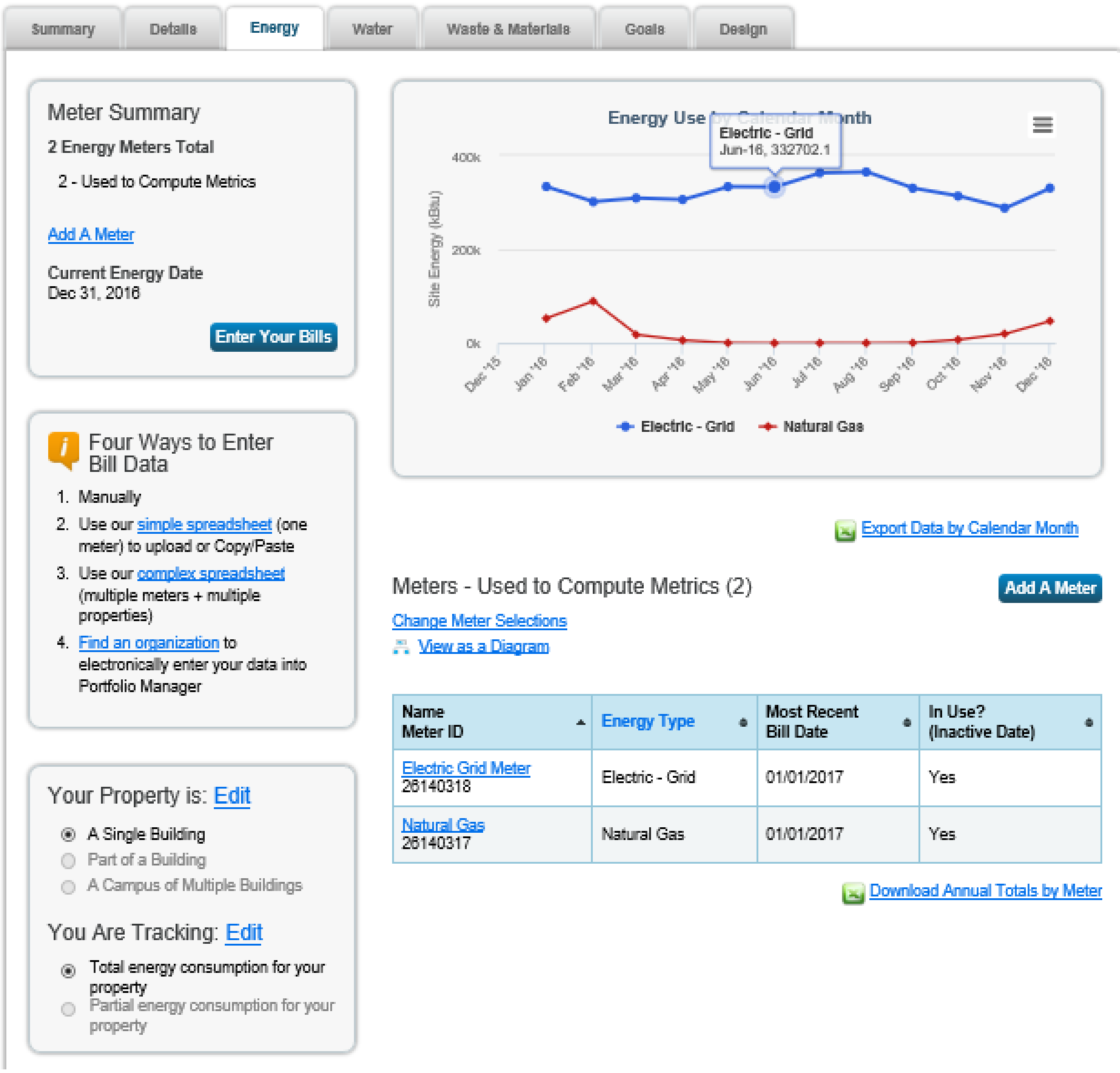
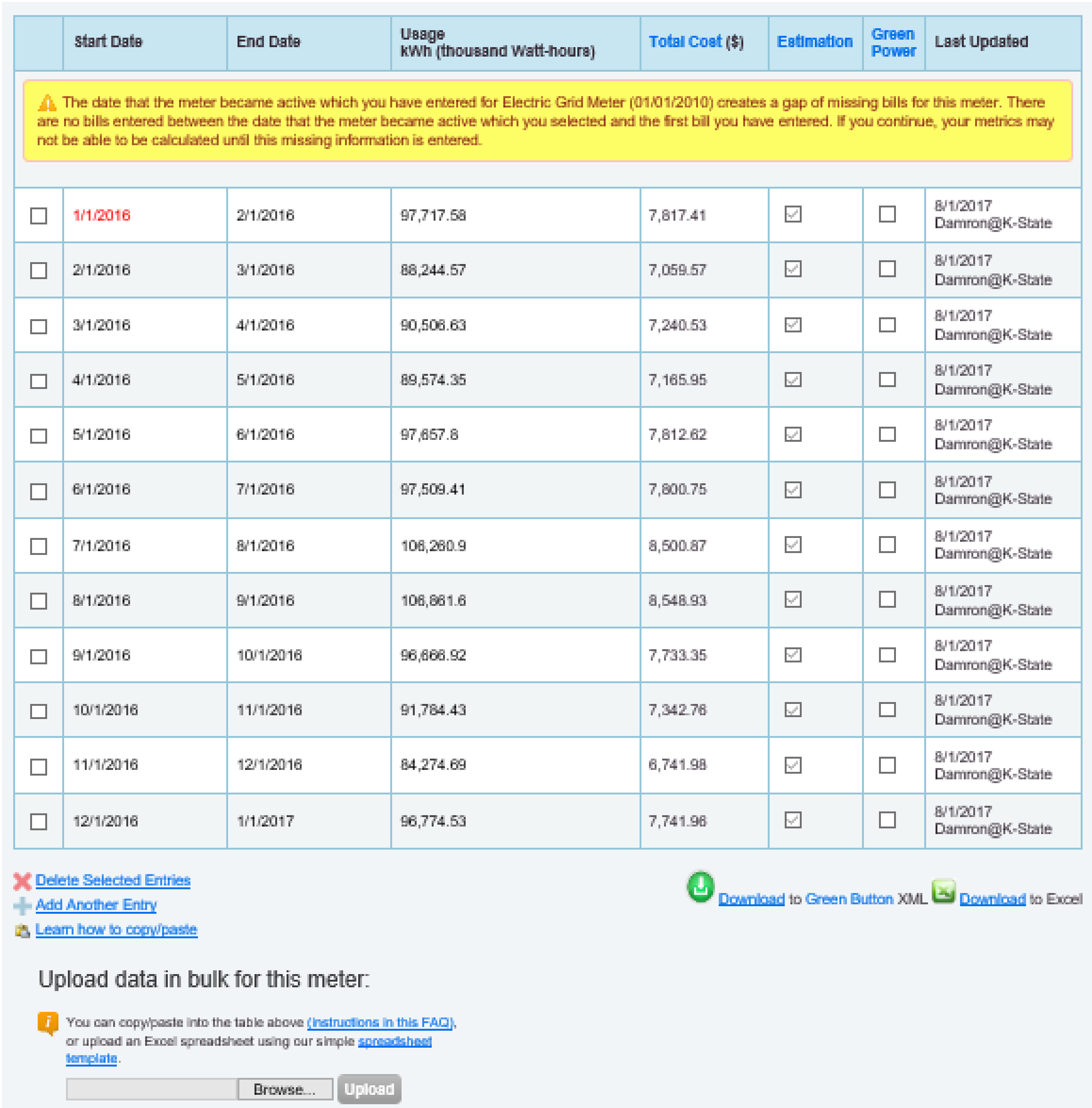


Figure C.12 Property Energy Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/property/5778410#energy



	Start Date	End Date	Usage kWh (thousand Watt-hours)	Total Cost ($)	Estimation	Green Power	Last Updated
☐	1/1/2016	2/1/2016	97,717.58	7,817.41	☑	☐	8/1/2017 Damron@K-State
☐	2/1/2016	3/1/2016	88,244.57	7,059.57	☑	☐	8/1/2017 Damron@K-State
☐	3/1/2016	4/1/2016	90,506.63	7,240.53	☑	☐	8/1/2017 Damron@K-State
☐	4/1/2016	5/1/2016	89,574.35	7,165.95	☑	☐	8/1/2017 Damron@K-State
☐	5/1/2016	6/1/2016	97,657.8	7,812.62	☑	☐	8/1/2017 Damron@K-State
☐	6/1/2016	7/1/2016	97,509.41	7,800.75	☑	☐	8/1/2017 Damron@K-State
☐	7/1/2016	8/1/2016	106,260.9	8,500.87	☑	☐	8/1/2017 Damron@K-State
☐	8/1/2016	9/1/2016	106,861.6	8,548.93	☑	☐	8/1/2017 Damron@K-State
☐	9/1/2016	10/1/2016	96,666.92	7,733.35	☑	☐	8/1/2017 Damron@K-State
☐	10/1/2016	11/1/2016	91,784.43	7,342.76	☑	☐	8/1/2017 Damron@K-State
☐	11/1/2016	12/1/2016	84,274.69	6,741.98	☑	☐	8/1/2017 Damron@K-State
☐	12/1/2016	1/1/2017	96,774.53	7,741.96	☑	☐	8/1/2017 Damron@K-State

Figure C.13 Property's Metered Data Entry Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/meter/usage/5778410#26140318?editConsumption&energy

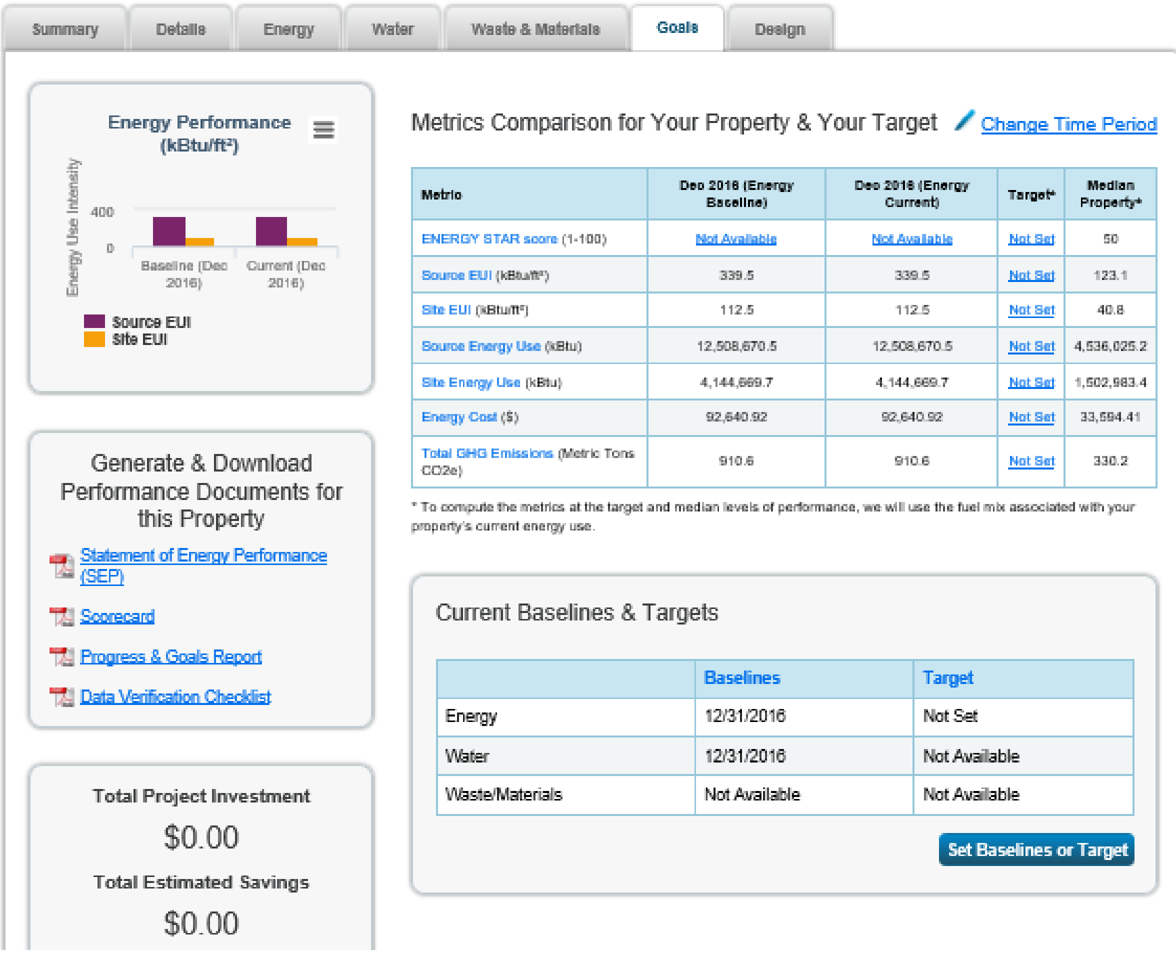


Figure C.14 Property Goals Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/property/5778410#goals

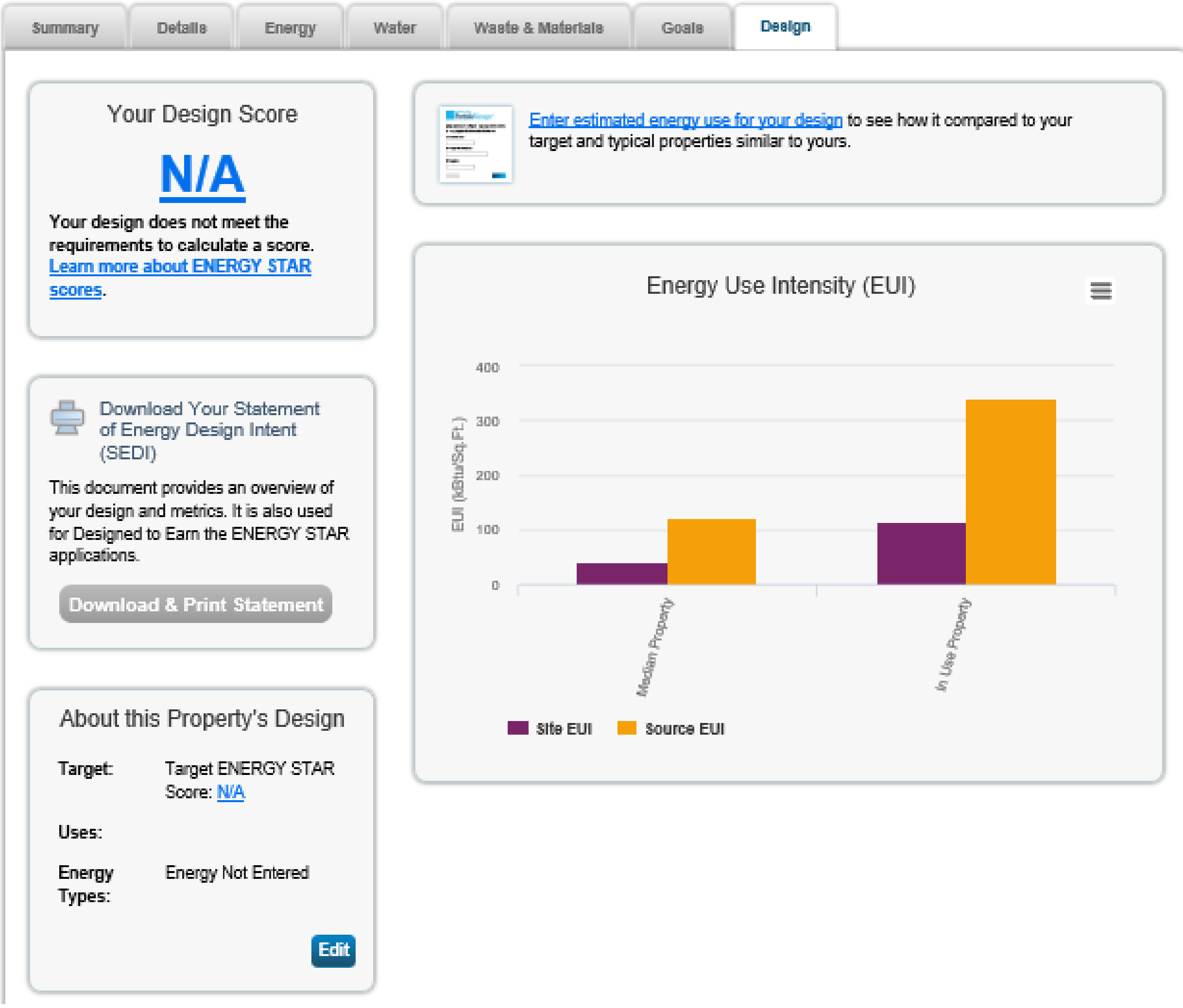


Figure C.15 Property Design Webpage.

Energy Star. (2017). [Image]. Retrieved from https://portfoliomanager.energystar.gov/pm/property/5778410#design

Appendix D - Leadership Studies Building Workbook

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

FORM 1 - BUILDING CHARACTERISTICS FOR IN OPERATION RATING

Building Name:	Staley School of Leadership Studies			**Assessment Date:**	12-May-17
Address:	1300 Mid-Campus Dr.				
City:	Manhattan	State/Prov:	Kansas	Zip/Post:	66506
Building Owner:	**Kansas State University**	**Building Type:**	Multiple Use Building or Campus		
Building Contact/Title:	**Edward Heptig / Director of Facilities Maintenance**			Phone:	(785) 532-1700
Address:	202 Dykstra Hall, 1628 Claflin Road			E-mail:	baml@k-state.edu
City:	Manhattan	State/Prov:	Kansas	Zip/Post:	66506
Assessor Name/Company:	Julia Keen / Kansas State University			Phone:	(785) 532-3575
Address:	240 Seaton Hall, 920 N. 17th St.			E-mail:	jkeen@k-state.edu
City:	Manhattan	State/Prov:	Kansas	Zip/Post:	66506

Climate Data

DOE Climate Zone:	4A	HDD65:	4851	CDD50:	4427	Period of Data:	Mean Annual (2012-2016)
Source of Climate Data:	www.weatherdatadepot.com						

Building Characteristics

Gross Floor Area (ft^2):	36,842	Gross Conditioned Floor Area (ft^2):	36,842		
Separately Metered EXCLUDED Area (ft^2):	0	**Net RATED Floor Area (ft^2):**	36,842		
Number of Conditioned Floors:	2	Floors Above Grade:	2	Floors Below Grade:	0
Original Year of Construction:	2009	Hours of Operation:	Average		

Brief Building Description (construction and use):

The building is a IIB construction type with fire seperation assemblies and smoke barriers of a 1-hour rating. This university building contains classrooms, offices,and a small coffee café.

Description of On-Site Renewable Energy Systems (include rated thermal or electrical capacity):

There are not any on-site renewable energy systems.

Description of Major Renovations including years completed (List top 3, use Additional Notes Sheet for others):		
1	Year:	
2	Year:	
3	Year:	
Building Systems Commissioned including years completed (List top 3, use Additional Notes Sheet for others):		
1 Initial Systems Commissioning	Year:	2010
2	Year:	
3	Year:	
Energy Efficiency Improvements since Construction including years completed (List top 3, use Additional Notes Sheet for others):		
1	Year:	
2	Year:	
3	Year:	
Other Operational Features (List top 3, use Additional Notes Sheet for others):		
1	Year:	
2	Year:	
3	Year:	
Brief List of Building Photos Included with submission (Insert Photos into separate worksheet tab marked Photographs):		

Building Performance Credentials

☐ ENERGY STAR Score:		Years:	☐ GreenGlobes Rating:		Years:
☑ LEED Rating/Version:	LEED BD+C: New Construction - Gold/v2.2		LEED EA Points:	42	
☐ Other Rating (select):			Version/Score (enter):		
☐ Other Rating (select):			Version/Score (enter):		
☐ Designed to meet ASHRAE Advance Energy Design Guide			Specify:		
☑ Designed to meet state/provincial/international energy code:			Specify:	2006 (IBC, IPC, IMC, IECC, IFC), Kansas Fire Prevention Code, &	

Figure D.1 bEQ Workbook Form 1.

Building eQ®

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

MULTIPLE USE BUILDING / CAMPUS WORKSHEET

SPACE TYPE ALLOCATION					
Type of Multi-Use Application (Select from Menu):		Building with Multiple Space Usage			
	Building Space Type	**Area (ft^2)**	**Space %**	**Hours of Operation**	**Median EUI**
Space Type #1	College/university	17,103	46%	Average	299.64
Space Type #2	Administrative/professional office	18,089	49%	Average	158.10
Space Type #3	Restaurant/cafeteria	1,650	4%	Average	597.37
Space Type #4			0%		0.00
Space Type #5			0%		0.00
Space Type #6			0%		0.00
Space Type #7			0%		0.00
Space Type #8			0%		0.00
Total area of listed space types		36842	100%		
Net RATED Floor Area (from FORM 1)		36,842	Weighted Average Median EUI:		**243**

SEPARATELY METERED EXCLUDED SPACE TYPES			
	Building Space Type	**Area (ft^2)**	**Space %**
Space Type #1			0%
Space Type #2			0%
Space Type #2			0%
Separately Metered EXCLUDED Floor Area		0	0%
Separately Metered EXCLUDED Floor Area (from Form 1)			0%
Total Gross Floor Area (with excluded spaces)		36,842	100%

Figure D.2 bEQ Workbook Multiple Use Sheet.

Building eQ

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

FORM 2 - ENERGY CALCULATIONS FOR IN OPERATION RATING

Utility Information and Rating Calculation

Enter Electricity and Natural Gas metered data into Metered Data Worksheet. Use 12 consecutive months of billing data starting at least 6 months after the building is fully occupied and operational and terminating no more than 6 months prior to the date of submission.

Annual Energy Use by Fuel Type	Value	Units	Conversion Factor	Site Energy - kBtu	Source-Site Ratio	Source Energy (kBtu)	Billed Energy Cost - $$
Electricity	3,900,473	kBTU	1.00	3,900,473	3.14	12,247,485	$114,383
Natural Gas	242,839	kBTU	1	242,839	1.05	254,981	$1,179
LPG	0	kBTU	1	0	1.01	0	$0
Steam	0	kBTU	1	0	1.21	0	$0
Hot Water	0	kBTU	1	0	1.28	0	$0
Chilled Water	0	Ton-Hour	1	0	1.05	0	$0
Wood / Biomass	0	Ton	0	0	1.0	0	$0
Fuel Oil (1,2,4,5,6,Diesel, Ker, etc)	0	kBTU	0	0	1.01	0	$0
Other Fuel (Enter Fuel Type)	0	kBTU	0	0	1.01	0	$0
Other Fuel (Enter Fuel Type)	0	kBTU	0	0	1.01	0	$0
TOTAL BUILDING ENERGY USE				4,143,312		12,502,466	
Qualified Renewable Energy	0			0	3.14	0	
Percent Qualified Upstream Renewable Energy:				0%			

NET ENERGY USE			4,143,312		12,502,466	$115,562
Gross Floor Area (ft2):			36,842			
Separately Metered EXCLUDED Area (ft2):			0			
Net RATED Floor Area (ft2):			36,842			
Metered Building EUIs (kBtu/ft^2-yr)		Site EUI:	112	Source EUI:	339	
Building Type	Multiple Use Building or Campus			Source Median EUI:	243	
BuildingEQ Rating		**D**	**Inefficient**	**(Source/Median)*100:**	**139**	

Figure D.3 bEQ Workbook Form 2.

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Building eQ

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

METERED DATA WORKSHEET FOR IN OPERATION RATING

ELECTRICITY METERED DATA

Use 12 consecutive months of billing data starting at least 6 months after the building is fully occupied and operational and terminating no more than 6 months prior to the date of submission

Start Date	End Date	Days	kBTU	$	kWH/day
12 MONTHS OF DATA FOR bEQ RATING CALCULATION					
1/1/2016	2/1/2016	31	333,217	$9,772	10,749
2/1/2016	3/1/2016	29	300,914	$8,824	10,376
3/1/2016	4/1/2016	31	308,628	$9,051	9,956
4/1/2016	5/1/2016	30	305,449	$8,957	10,182
5/1/2016	6/1/2016	31	333,013	$9,766	10,742
6/1/2016	7/1/2016	30	332,507	$9,751	11,084
7/1/2016	8/1/2016	31	362,350	$10,626	11,689
8/1/2016	9/1/2016	31	364,398	$10,686	11,755
9/1/2016	10/1/2016	30	329,634	$9,667	10,988
10/1/2016	11/1/2016	31	312,985	$9,178	10,096
11/1/2016	12/1/2016	30	287,377	$8,427	9,579
12/1/2016	1/1/2017	31	330,001	$9,677	10,645
1/1/2016	1/1/2017	366	3,900,473	$114,383	
ADDTIONAL DATA					
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
1/0/1900	1/0/1900	0	0	$0	

Figure D.4 bEQ Workbook Electricity Metered Data Sheet.

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

METERED DATA WORKSHEET FOR IN OPERATION RATING

NATURAL GAS METERED DATA

Use 12 consecutive months of billing data starting at least 6 months after the building is fully occupied and operational and terminating no more than 6 months prior to the date of submission

Start Date	End Date	Days	kBTU	$	MCF/Day
12 MONTHS OF DATA FOR bEQ RATING CALCULATION					
1/1/2016	2/1/2016	31	52,958	$257	1,708
2/1/2016	3/1/2016	29	89,972	$437	3,102
3/1/2016	4/1/2016	31	17,965	$87	580
4/1/2016	5/1/2016	30	6,157	$30	205
5/1/2016	6/1/2016	31	358	$2	12
6/1/2016	7/1/2016	30	0	$0	0
7/1/2016	8/1/2016	31	78	$0	3
8/1/2016	9/1/2016	31	60	$0	2
9/1/2016	10/1/2016	30	585	$3	20
10/1/2016	11/1/2016	31	7,347	$36	237
11/1/2016	12/1/2016	30	19,902	$97	663
12/1/2016	1/1/2017	31	47,457	$230	1,531
1/1/2016	1/1/2017	366	242,839	$1,179	
ADDTIONAL DATA					
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
		0			NA
1/0/1900	1/0/1900	0	0	$0	

Figure D.5 bEQ Workbook Natural Gas Metered Data Sheet.

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

FORM 3 - BUILDING INDOOR ENVIRONMENTAL QUALITY (IEQ) SCREENING INFORMATION

Review of IEQ Conditions

- ☐ **IEQ Observations are consistent with the intent of the bEQ label**
- ☐ **Attach summary of results of Occupant Survey (Optional)**
- ☐ **Reviewed Occupant Issue/Resolution Logs with Facility Manger or Building Engineer**

Issues/Resolution Log (Characterize predominant nature of recurring and unresolved issues for further investigation)

Review of Thermal Comfort Conditions

Describe HVAC system types (brief description - use Additional Notes sheet for more detail):

Each floor has roof-top unit (DX cooling / gas heat) with integral energy recovery wheel to provide cooling air and ventilation. The units are designed with an air economizer cylce controlled with enthalpy sensors and utilize integral barometric dampers for relief. Additionally, electric humidifiers are provided for each floor and they are located in the duct. A combination of VAV terminal units with electric heating coils and VAV fan powered terminals with electric heating coils are used to control space temperature at the zone level. Vestibules have supplemental heat with electric unit heaters.

Observed Thermal Comfort Issues Indicators (e.g. blocked or altered supply diffusers; personal fans or space heaters):

There were not any visible indicators of thermal comfort issues aside from occupants keeping light jackets in their offices.

Space by Space Measurement and Building Spaces (representative spot measurements required)

Required space measurements				Optional space measurements					
Location	**Space Type**	**AIR T**	**RH**	**T FLR**	**VERT dT**	**dBA**	**FPM Air**	**CO_2**	**ABS psi**
Info Café	Restaurant/Cafeteria	75.2	38.3	-	-	72.2/32.4	-	855	981
Hallway (CR101/CR102)	College/University	75.3	37.8	-	-	52.8/45.3	-	735	981
Conference (Room 114)	College/University	74.2	40.1	-	-	-	-	832	980.9
Classroom (Room 127)	College/University	75.5	37.9	-	-	47.3/34.4	-	502	981.1
Conference (Room 201)	Administrative/Profession:	72.5	40.9	-	-	51.0/40.4	-	556	980.5
Conference (Room 247)	Administrative/Profession:	71	43.2	-	-	55.7/41.6	-	579	980.5
Open Meeting (CR201A)	Administrative/Profession:	69	45	-	-	53.3/46.9	-	523	980.5
Work Room (Room 228)	Administrative/Profession:	72.8	41.1	-	-	56.9/47.5	-	582	980.3
Temperature units used:		°F		°F	°F				
Instrument(s) last calibration date:		Jan. 2017 or more recent		**Outdoor CO_2:**		434 ppm (at grade) & 468 ppm (on roof)			

Figure D.6 bEQ Workbook Form 3, Page 1.

Building eQ

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

FORM 3 - BUILDING INDOOR ENVIRONMENTAL QUALITY (IEQ) SCREENING INFORMATION

Review of Lighting Quality

Provide Description of General Lighting Systems including lamps, luminaries, controls:

The light fixtures in the Leadership Studies building are primarily recessed and florescent luminaries using type T8 and TT series lamps. Other lamping is used in special applications. All individual spaces / rooms are conrolled using occupancy sensors in addition to the manual switching (in many spaces dual level lighting is provided). A lighting control panel is used to manage the general space lighting.

Operator Reported Lighting Quality Issues:	Occupant Reported Lighting Quality Issues:

Lighting Systems Measurements and Description of Building Spaces (representative spot measurements required)

Location	Space Type	Description of lighting conditions or issues	FC
Info Café+B58:C79	Assembly	Located in the SW corner of first floor with window walls along S & W faces	25
Hallway (CR101/CR102)	Business	Located in the SE corner of first floor with glass vestibule to the S	18
Conference (Room 114)	Assembly	Located centrally on the first floor with solid walls only	24
Classroom (Room 127)	Business	Loacted in N corner of first with large windows on NE and NW faces	62
Hallway (CR101)	Business	Located centrally on the first floor with solid walls only	17
Conference (Room 102)	Business	Located on S side of first floor with glass door opening to exterior hall with S-facing window v	22
Classroom (Room 111)	Business	Located on NE exterior of first floor with large windows on NE face	31
Hallway (CR102)	Business	Located centrally on the first floor with solid walls only	32
Hallway (CR103)	Business	Located centrally on the first floor with NE facing glass vestibule at end	19
Open Meeting	Business	Located on W exterior of first floor with a full building height window wall	13
Vestibule (VB102)	Business	Located centrally on the first floow with solid walls only	39
Conference (Room 201)	Business	Located on W exterior of second floor with large windows on S, W & N faces	31
Conference (Room 247)	Business	Located centrally on the second floor with one glass wall to corridor 206	19
Open Meeting (CR201A)	Business	Located in SW corner of second floor above the info café with S & W window walls	22
Work Room (Room 228)	Business	Located centrally on the second floor with solid walls only	39
Open Meeting (CR203B)	Business	Located in the SE corner of the second floor with large windows on S & E faces	39
Office (Room 209)	Business	Located on S exterior of second floor with large window on S face	35
Open Office (CR203A)	Business	Located on NE exterior of second foor with large window on NE face	39
Hallway (CR206)	Business	Located centrally on the second floor with natural light at either end (W & NE faces)	36
Office (Room 257)	Business	Located on NW exterior of second floor with large window on NW face	40
Open Office (CR202B)	Business	Located centrally on second floor with minimal natural light	19
Open Meeting (CR202A)	Business	Located centrally on second floor with minimal natural light	25

Figure D.7 bEQ Workbook Form 3, Page 2.

Building Energy Quotient

ASHRAE's Building Energy Labeling Program

Worksheet Updated 3/1/2015

FORM 3 - BUILDING INDOOR ENVIRONMENTAL QUALITY (IEQ) SCREENING INFORMATION			
Review of Ventilation for Indoor Air Quality			
Does the original design intent, if available, appear to meet ASHRAE Standard 62.1?	Yes	If Yes, Version of 62.1:	2007
Does the system as operating appear to follow the original design intent?	Yes		
If the original design documents are not available, is a functional ventilation system installed to deliver approximately the flow rates in ASHRAE Standard 62.1?	NA	If Yes, Version of 62.1:	
Method used to calculate 62.1 minimum flow rates:			
Used ASHRAE 62 MZCalc spreadsheet?	NA	If no, other methology used:	

Flow rate (cfm) at representative sample of OA intakes (representative spot measurements required):			
OA Intake Location	**Flow Rate**	**OA Intake Location**	**Flow Rate**
Roof Top Unit 1	15,025 CFM	Roof Top Unit 2	0 CFM

Method(s) used to determine flow rate (cfm):

At four location on air intake (36" x 84") for RTU-1, both air velocity and air flow rate were measured, and then the air velocity measures were converted flow rates. These points were then averaged individually and rounded to the nearest five CFM. RTU-2 was not drawing air.

Does the building have a CO monitoring system in place?	Yes	Does the building have other toxic gas monitoring?	No
CO Level (ppm) in the vicinity of combustion equipment: [OPTIONAL]			

Operator Survey/Interview of Air Distribution Systems (required for each typical Air Distribution System)

System #1 Identifier and Type:	**RTU-1**		
Scheduled Operation:	Continuous	Distribution System:	VAV & VAV-R
Control of Outside Air:		OA Damper Operation:	
Condition of Mech Rm:	N/A	Drain Pan Drainage:	
Coil Cleanliness:		Duct Liner:	
Return Air Plenum:		MERV filter Level:	8

System #2 Identifier and Type:	**RTU-2**		
Scheduled Operation:	Continuous	Distribution System:	VAV & VAV-R
Control of Outside Air:	Economizer	OA Damper Operation:	Fully Modulating Actuator - Enthalpy Limit
Condition of Mech Rm:	N/A	Drain Pan Drainage:	
Coil Cleanliness:		Duct Liner:	
Return Air Plenum:		MERV filter Level:	8

Figure D.8 bEQ Workbook Form 3, Page 3.

Appendix E - bEQ Certification Results

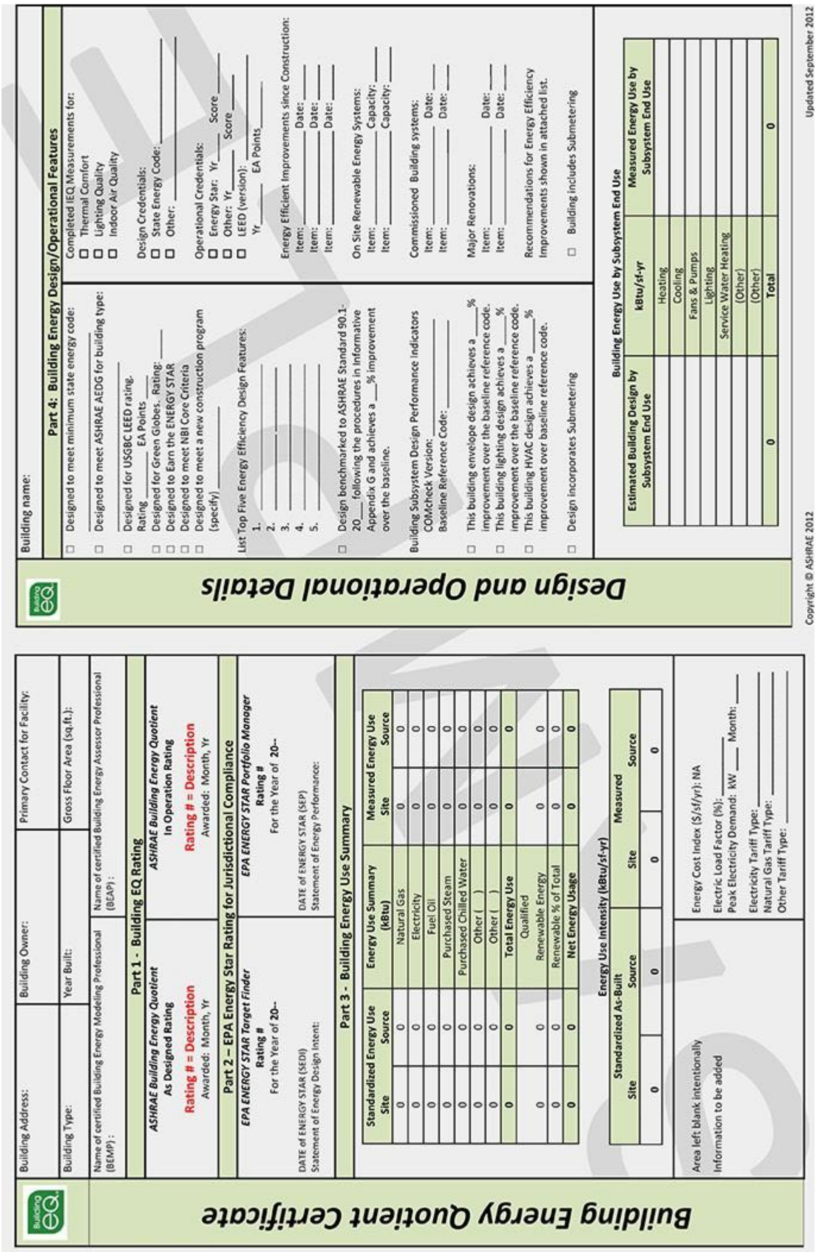

Figure E.1 bEQ Sample Certificate.

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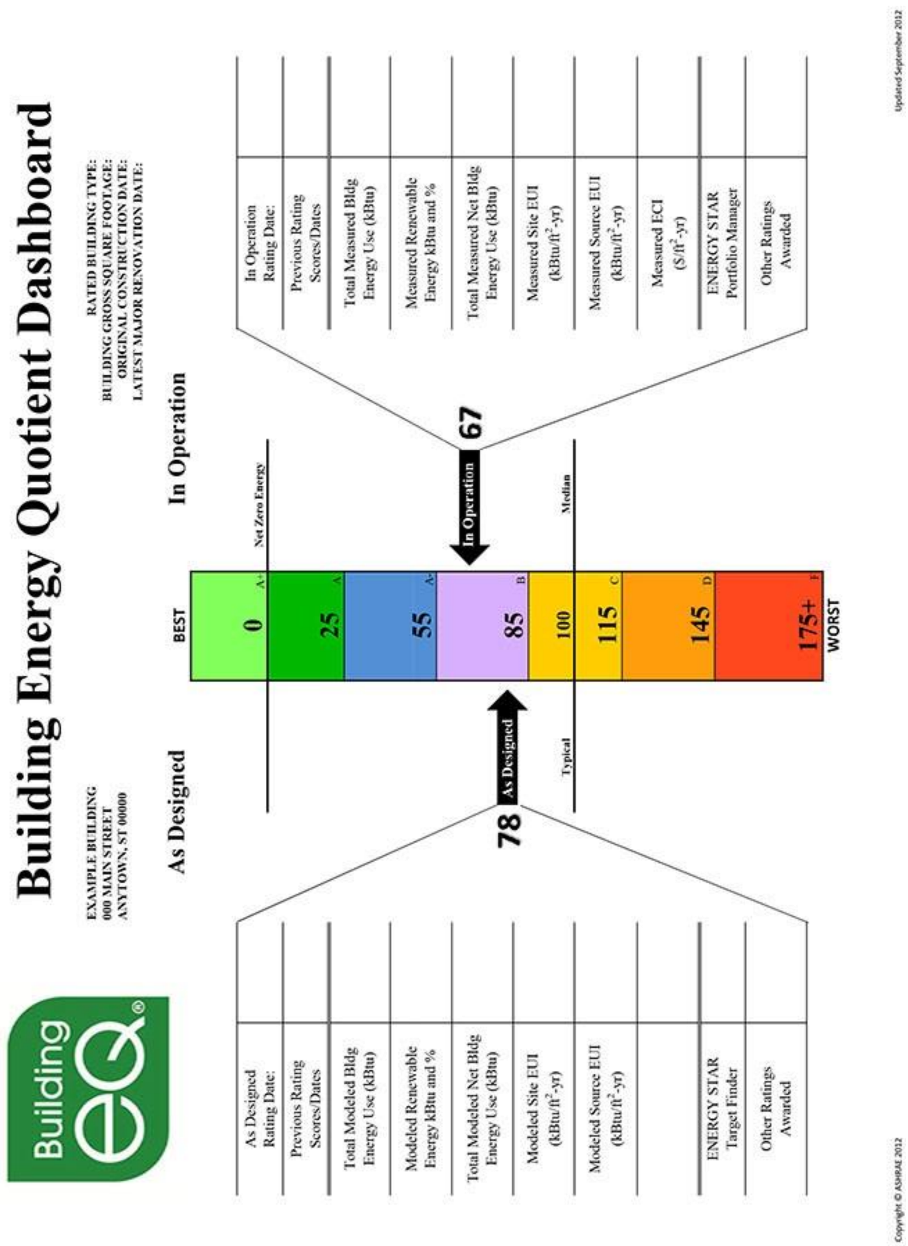

Figure E.2 bEQ Sample Dashboard.

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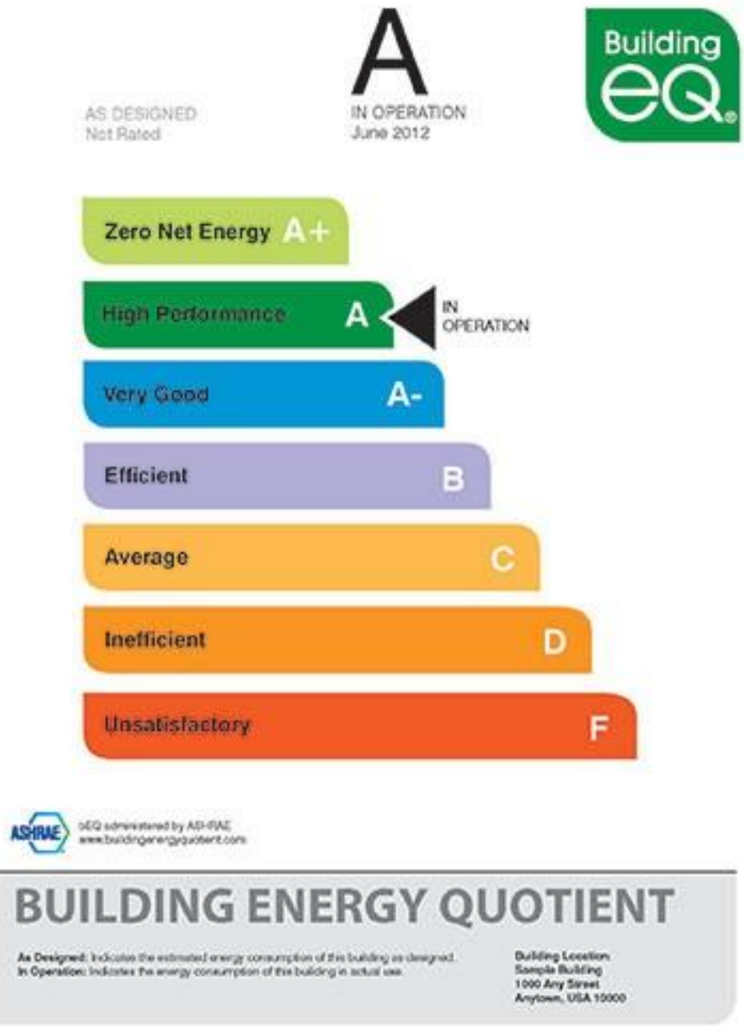

Figure E.3 bEQ Sample Plaque.

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Appendix F - Copyright Approval

Harr, Julie <JHarr@ashrae.org>

Thu 8/10/2017 9:20 AM

To: Lauren Damron <llbdamron@ksu.edu>;

Cc: Gokce, Kristin <KGokce@ashrae.org>; Publication Permissions <permissions@ashrae.org>; Julia Keen <jkeen@ksu.edu>; Pratt, Lilas <LPratt@ashrae.org>;

5 attachments (2 MB)

bEQ Sample Certificate.jpg; bEQ Sample Dashboard.jpg; bEQ Sample Plaque.jpg; Leadership Studies' Workbook 2.0 - Multi-use.xlsx; Permission Release Forms.docx;

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-

Best Regards,
Julie Harr

Julie Harr
Administrative Assistant
ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329
Tel: 678-539-1217

Figure F.1 ASHRAE Copyright Permission

Marketing at USGBC <marketing@usgbc.org>

Tue 8/15/2017 9:08 AM

To: Lauren Damron <llbdamron@ksu.edu>;

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Ashley Katz

Vice President, Marketing & Communications
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