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Commercial Building Energy Asset Score

Program Overview and Technical Protocol (Version 1.1)

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August 2013



Pacific Northwest
NATIONAL LABORATORY

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Pacific Northwest National Laboratory
Richland, Washington 99352

Summary

The U.S. Department of Energy (DOE) is developing a voluntary national scoring system for commercial buildings to help building owners and managers assess a building's energy-related systems independent of operations. The goal of the score is to facilitate cost-effective investment in energy efficiency improvements of commercial buildings. The system, known as the Commercial Building Energy Asset Score, will allow building owners and managers to compare their building infrastructure against peers and track building upgrades over time. The system will also help other building stakeholders (e.g., building investors, tenants, financiers, and appraisers) understand the relative efficiency of different buildings in a way that is independent from operations and occupancy.

DOE's long-term goal is to ensure that there is a linked set of compatible metrics and scoring approaches that building stakeholders can seamlessly use to effectively evaluate a building's as-built and in-operation efficiencies. DOE envisions these linked scores describing various aspects of building energy performance, such as the performance of building assets, performance of building operations, and how a building compares to its peers. Given this larger vision, the Asset Score is being designed to work in concert with tools such as ENERGY STAR Portfolio Manager. Where possible, the Asset Score incorporates methods that are consistent with ENERGY STAR Portfolio Manager.

Prior to developing the Asset Score, DOE performed a market study to ensure that the effort would help address market needs and fill identified gaps. In 2012, DOE began initial pilot testing of the Asset Score. As a result of that effort, improvements to the tool, training materials, and other aspects of the program have been made. In 2013, DOE is continuing to assess the Asset Score through additional pilot testing as well as a variety of technical evaluations and performance analyses. Results from these efforts will be published in a separate document. In addition, this report will be updated periodically to reflect changes to the scoring methodology, the Asset Scoring Tool, and other aspects of the program.

This report outlines the technical protocol used to generate the Asset Score, explains the scoring methodology, and provides additional details regarding the Asset Scoring Tool. The alternative methods that were considered prior to developing the current approach are described in the Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013).

Asset Score

The Asset Score enables building owners and managers to evaluate the as-built physical characteristics of buildings contributing to their overall energy efficiency, independent of occupancy and operational choices. The physical characteristics evaluated include the building envelope, the mechanical and electrical systems, and other major energy-using equipment, such as commercial refrigeration. The Asset Score is generated by simulating building performance under a standard set of typical operating and occupancy conditions. By focusing only on buildings' physical characteristics and removing occupancy and operational variations, the system allows "apples-to-apples" comparisons between differently operated buildings (see Table S.1).

Table S.1. Scope of Asset Score.

Included in Asset Score	Does NOT Affect Asset Score
General	
Building geometry and orientation	Building surroundings (such as shading from trees or other buildings)
Window orientation, window-to-wall ratio	
External shading devices (overhangs, vertical fins)	Internal shading devices such as curtains, blinds
Thermal performance of building envelope (walls, windows, roof, and floor)	
Main heating, ventilating, and air-conditioning (HVAC) systems (types and efficiencies)	Back-up systems, efficiency degradation related to age and maintenance, system oversize
Service hot water system (type and efficiency)	
Lighting systems (types and numbers)	
Percentage of lighting controlled by sensors (occupancy sensors and daylighting controllers)	Settings of sensors and controls
Specific (example only)	
Refrigeration in grocery stores (types, number efficiencies)	Refrigerators in office buildings
Commercial kitchen appliances and ventilation systems in restaurants (types, number, efficiencies)	Kitchen appliances in office buildings
Computer servers in data centers (IT equipment power)	Small server closet in office buildings
Operating Assumptions	
Typical operating hours for each building type	Actual operating hours
Standard indoor air thermostat settings	Actual indoor air thermostat settings
Typical occupancy density for each building type	Actual number of occupants
Typical plug loads for each building type	Actual plug loads

The Asset Score uses modeled source energy use intensity (EUI) as the primary metric to generate the Asset Score, for the following reasons:

- A source energy metric reduces the likelihood that one energy fuel type will be unintentionally penalized or favored over another.
- Source energy more accurately gauges the global impact of energy consumption, taking into account the impact of the energy supply chain rather than only looking at what occurs at the building level.
- Source energy is more closely correlated with energy cost, and so is more likely to drive investment decisions.
- A source energy metric is aligned with the ENERGY STAR Portfolio Manager.

As complementary information, site energy is also calculated and shown as part of the Asset Score Report.

The modeled source EUI is used to generate a building’s Asset Score. Each building type has an associated 100-point technical scale (not a statistical scale). The calculated EUI is placed on a fixed scale for each building type and no baseline building is needed for the score calculation. The energy asset scoring scale is intended to reflect the current variability within the commercial building stock and allow for improved energy efficiency of both inefficient and high-performance buildings. The scale development and scoring methodology are discussed in detail in this protocol report.

Asset Scoring Tool

The Asset Scoring Tool is a web-based evaluation tool. The tool is built on a centralized modeling engine to reduce the implementation cost for the users and increase standardization compared with an approach that requires users to build their own energy models. A centralized modeling approach lessens the user's ability to tailor a model to a unique design feature because the levels of the input details are limited to accommodate the common building types and characteristics. With this tool, users can enter building information online to obtain a standard Asset Score Report and feedback on areas and options for energy efficiency improvements.

The Asset Scoring Tool integrates a simplified data collection method with full-scale energy modeling through an input generator, which estimates building parameters not entered by users. Given this approach, the tool reduces the time and expertise required to model a building accurately while supporting variable and complex commercial buildings. The approach is designed to provide preliminary analysis, directing further effort and investment to where it can be most effectively applied. The protocol documented in this report describes the energy modeling and tool development methodologies.

The Asset Scoring Tool provides two levels of use: simple and advanced. The data requirements for each level are outlined in this protocol. The simple score is based on a highly reduced set of key building characteristics. For the additional details beyond the input set, the model relies on inferred values generated by the Asset Scoring Tool to minimize the data collection requirements of the user. The advanced score is based on the minimum set of key building characteristics plus any additional pertinent building characteristics known to the users. Both levels yield building Asset Scores, provide feedback on building improvements, and estimate the potential for improving the Asset Score.

The Asset Scoring Tool is not intended to replace a more comprehensive energy audit or engineering analysis needed to properly identify and design building system upgrades, but instead to provide building owners and operators with a quick, low-cost, standardized way to rate building energy assets through a consistent, national program. DOE expects that all scores—whether simple or advanced—would be considered preliminary until validated by a qualified professional. Real estate transactions would likely require the validated advanced score. Requirements for validation have not yet been developed.

Asset Score Report

The Asset Scoring Tool produces a standard Asset Score Report that includes four sections:

- **Asset Score.** The report provides a building's current score and potential score after all recommended upgrades are made.
- **Building system evaluations.** The system evaluations separately characterize the building's envelope (e.g., windows, walls, roof); lighting system; heating and cooling systems; and service hot water system. This information can help users identify the part of the building most in need of attention. For two buildings with the same Asset Score, the system evaluation helps identify the unique problems and potentials of the two buildings.
- **A list of improvement areas and options.** The report provides feedback on areas and options for energy efficiency improvement based on the analysis outlined in section 5.4 of this report. A related

guide on what to consider when implementing the building upgrade is also provided to tool users (http://www1.eere.energy.gov/buildings/commercial/assetscore_tool.html).

- Building assets. The report provides a detailed list of building characteristics that contribute to a building's Asset Score.

A sample report is included in this protocol (see Appendix F). The contents of each section can also be found in this protocol.

Implementation Phases

The Asset Score is being rolled out in multiple phases, based on building category:

- The first phase included buildings in the office, education, retail, and unrefrigerated warehouse categories. These building types were implemented in the initial pilot of the Asset Score and tool in 2012.
- The second phase included libraries, lodging, multi-family housing, and courthouses, as well as mixed-use buildings that incorporate the abovementioned use types, which are currently under pilot testing.
- Buildings with more complex systems or those for which there is currently a limited body of information, such as food sales, food service, data centers, laboratories, refrigerated warehouses, and health-care facilities will be included in the future development.

This protocol document focuses on the building types rolled out in the first two phases, with limited discussion of other building types. Some discussions about the scoring and modeling methodologies may not apply to the building types to be developed.

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Acronyms and Abbreviations

ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
CBECS	Commercial Buildings Energy Consumption Survey
COMNET	Commercial Energy Services Network
COP	coefficient of performance
DOE	U.S. Department of Energy
DX	direct expansion
EEM	energy efficiency measure
EER	energy efficiency ratio
EPA	U.S. Environmental Protection Agency
EUI	energy use intensity
FEDS	Facility Energy Decision System
HVAC	heating, ventilating, and air conditioning
IESNA	Illuminating Engineering Society of North America
kBtu	thousand British thermal units
LCC	life-cycle cost
LEED	Leadership in Energy and Environmental Design
PNNL	Pacific Northwest National Laboratory
TDV	time-dependent valuation
TOU	time-of-use

Glossary

Asset Score – An assessment of building energy performance based solely on a building’s physical characteristics, excluding the effects of building operation characteristics.

Asset Score Report – A short form document showing only key outcomes for a building that has undergone the energy asset scoring process.

baseline energy performance – The amount of energy consumed annually before implementation of energy efficiency measures, based on historical metered data, engineering calculations, submetering of buildings or energy-consuming systems, building load simulation models, statistical regression analysis, or a combination of these methods.

benchmark – The building profile used as a reference point for comparing energy use and other performance characteristics.

building type – Building classification identifying the principal function of the building.

energy cost – Monetary cost associated with energy consumption at a building site.

energy modeling or simulation – The practice of using computer-based programs to model the energy performance of an entire building or the systems within a building.

ENERGY STAR Portfolio Manager – A web-based, portfolio-wide energy and water tracking system that tracks many metrics of energy use, including total site energy, source energy, weather normalized energy use index, greenhouse gas emissions, indoor and outdoor water usage, and (for some building types) the ENERGY STAR score.

ENERGY STAR energy performance scale – A percentile score (1–100) that indicates how a building performs relative to similar buildings nationwide. The scores are adjusted using standardized methods to account for differences in building attributes, operating characteristics, and weather variables. Buildings performing better than 75% of similar buildings can be certified to ENERGY STAR.

energy efficiency measure (EEM) – Any capital investment that reduces energy costs in an amount sufficient to recover the total cost of purchasing and installing such measure over an appropriate period of time and maintains or reduces non-renewable energy consumption.¹

energy use intensity (EUI) – A unit of measurement that describes a building’s energy use relative to its size. EUI is calculated by dividing the total energy consumed in 1 year (measured in kBtu) by the total floor area of the building (measured in square feet).

interval scale – A scale for which each location along its span relates directly to some metric or measurement.

¹ Source: 10 CFR 420.2 [Title 10 – Energy; Chapter II – Department of Energy; Subchapter D – Energy Conservation; Part 420 – State Energy Program; Subpart A – General Provisions for State Energy Program Financial Assistance]

input generator – A component of the Asset Scoring Tool that is used to estimate building parameters (such as system efficiency) based on the information provided by users (such as system type and age) and provide the inferred values and other assumptions specific to the needs of the asset scoring tool simulation.

metric – A measure of a building’s performance.

net onsite energy use – The sum of all energies that are consumed in a building minus any energy that is generated on site.

operational rating – An assessment of building performance that is developed to reflect the energy performance of a building, accounting for its physical assets and its specific operational characteristics.

percentile rank scale – A percentile scale that is defined solely in relation to a sample population; the scale itself contains no information in absence of information regarding the specific sample population. The primary purpose of a percentile rank scale is comparison between peer buildings.

preliminary score – An Asset Score shown on the preliminary Asset Score Report, which is automatically generated by the Asset Scoring Tool for a simple level user who is not generating a score for official purposes.

site energy use – The amount of energy consumed at a building location or other end-use site, as reflected in the utility bills. Site energy use includes total building energy consumption minus electricity generated by onsite renewable energy systems as well as cogeneration systems.

stakeholder – A building owner, operator, manager, or agency who can supply data on the building physical details and energy consumption or has some authority or influence on, or interest in, decisions made about the building.

source energy use – The total energy used at a site, including upstream losses in distribution, storage, and dispensing of primary fuels, or power generation, transmission, and distribution of electricity.

weather adjustment – The practice of removing the impact of weather variables from building energy simulation results or utility bills to facilitate comparison between different regions or time periods.

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1.0 Introduction

The U.S. Department of Energy (DOE) is developing a national Commercial Building Energy Asset Score and an Asset Scoring Tool to evaluate the physical characteristics and as-built energy efficiency of commercial buildings and to identify potential energy efficiency improvements. The goal of the Asset Score and Asset Scoring Tool is to facilitate cost-effective investment in energy efficiency and reduce energy use in the commercial building sector. The Asset Score allows building owners to compare their buildings with those of their peers and track building energy efficiency improvement over time. The Asset Score also enables other building stakeholders (e.g., building operators, tenants, financiers, and appraisers) to understand the relative efficiency of different buildings in a way that is independent from their operations and occupancy.

The Asset Score is intended to complement the U.S. Environmental Protection Agency (EPA) ENERGY STAR Portfolio Manager and other existing building rating and benchmarking tools in the market. The score also supports other DOE initiatives, such as the DOE Better Building Challenge (in which partners commit to an energy savings pledge, assess improvement opportunities across their portfolio, undertake a showcase building retrofit, and share their progress) and DOE's partnership with the Appraisal Foundation (aimed at enabling investors, building owners and operators, and others to accurately assess the value of energy efficiency as part of the overall building appraisal).

In support of DOE's effort to design a voluntary energy Asset Score that effectively addresses the needs of the commercial building market, Pacific Northwest National Laboratory (PNNL) building scientists undertook a series of tasks. A market research study was conducted from April 2011 through January 2012 to better understand the market demand for energy asset scoring and to find the best way to communicate energy and cost savings to owners, investors, financiers, and others to overcome market barriers and motivate capital investment in building energy efficiency (McCabe and Wang 2012). Webinars, focus groups, a request for information (DOE EERE 2011a), and a stakeholder workshop, among other forums, were used to gain input from outside organizations and other interested parties. Existing building energy rating systems, such as the ENERGY STAR Portfolio Manager, the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Building Energy Quotient, and the European Energy Performance of Building Directive, were systemically examined to identify the strengths and gaps in the existing tools.

This report documents the protocol followed to develop the Asset Score and the Asset Scoring Tool. It also outlines the rationale for the current system. Topics addressed include the following:

- target audiences and buildings for an Asset Scoring Tool
- key metrics to evaluate building as-built efficiencies
- data input requirements to obtain an Asset Score
- Asset scoring methodology
- Asset Scoring Tool methodology
- quality assurance techniques
- sample Asset Score Report.

This protocol document is organized as follows:

- Section 2 describes the DOE Asset Score in the context of current rating systems and identifies how the system intends to close gaps among those systems.
- Section 3 details the scoring methods (metrics and scales) selected for the Asset Score.
- Section 4 describes the Asset Scoring Tool—the centralized modeling tool developed to facilitate application of the Asset Score.
- Section 5 explains the components of the Asset Score Report.
- Appendices A through H provide additional details on building type classifications (Appendix A), weather adjustments (Appendix B), weather coefficients (Appendix C), the Asset Score tables for building types that have been incorporated in the Asset Scoring Tool (Appendix D), a list of building data input of the energy asset scoring tool (Appendix E), a sample energy asset score report (Appendix F), energy costs used in the Asset Scoring Tool (Appendix G), and a list of Asset Score upgrade recommendations (Appendix H).

2.0 Asset Score

To date in the U.S., the dominant way to rate building energy performance has been based on an evaluation and comparison of utility bills. Recently, benchmarking tools like ENERGY STAR Portfolio Manager have started helping building owners and operators see how their energy usage compares to similar buildings. An Asset Score is a different type of information that building owners, operators, lessees, and buyers can use to further understand the energy performance of a building.

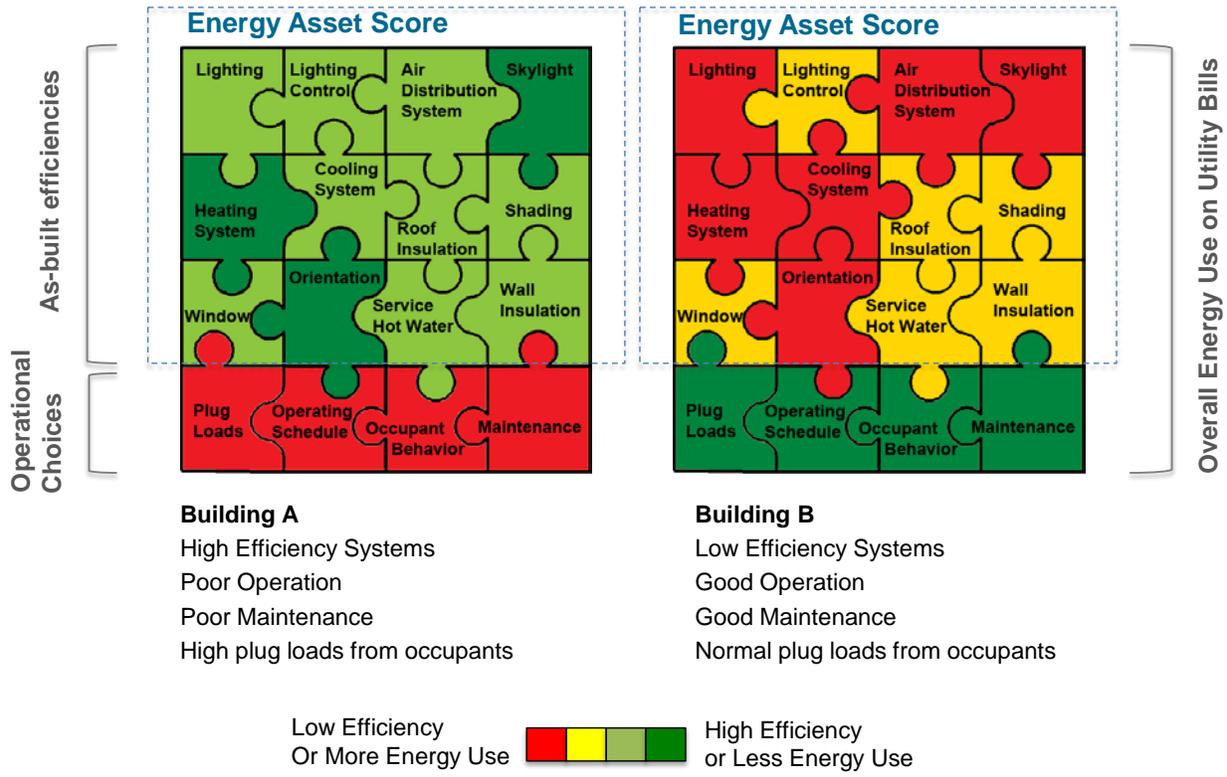
An Asset Score can help commercial building stakeholders decipher the extent to which their usage is being driven by operational choices or by the actual energy systems of a building. By applying consistent operational assumptions, an Asset Score allows evaluation of the physical “as-built” energy systems of a building. As shown in Figure 2.1, two buildings may have the same measured energy consumption but different potential energy consumption based on building design and installed equipment. Asset Scores of these two buildings can reveal differences in the state of the physical assets (e.g., whether functioning as efficient as designed or in need of improvement) that are masked when simply comparing measured energy consumption.

Information provided by the Asset Score can assist building owners and investors in making decisions about efficiency improvements. A primary goal of the score is to encourage improvement of energy-related building characteristics, which include the building envelope; heating, ventilation, and air conditioning (HVAC) systems; lighting systems; and other major building service-related equipment, such as commercial refrigeration. An Asset Score can also inform prospective buyers and tenants who may want to compare among existing, new, and renovated buildings.

Recent regional energy asset rating initiatives, such as California Assembly Bill No. 758¹ and the Massachusetts Commercial Asset Labeling Program (Mass DOER 2010),² indicate growing interest in energy asset scoring. More discussion about market drivers and opportunities can be found in the market research report (McCabe and Wang 2012).

¹ “This bill requires the Energy Commission, By March 1, 2010, to establish a regulatory proceeding to develop and implement a comprehensive program to achieve greater energy savings in California’s existing residential and nonresidential building stock.” “The comprehensive program may include, but need not be limited to, a broad range of energy assessments, building benchmarking, energy rating, cost-effective energy efficiency improvements, public and private sector energy efficiency financing options, public outreach and education efforts, and green workforce training” (California Assembly Bill No. 758, Chapter 470).

² In 2008, the Commonwealth of Massachusetts convened a Zero Net Energy Building Task Force to evaluate how best to achieve net-zero energy construction in both the commercial and residential sectors. Subsequently, Massachusetts was chosen by the National Governors Association Center for Best Practices to participate in its Policy Academy for Building Energy Retrofits. Through these processes, the commonwealth began identifying and addressing the barriers to a commercial building asset labeling program. In December 2010, the Massachusetts Department of Energy Resources (Mass DOER) released *An MPG Rating for Commercial Buildings: Establishing a Building Asset Rating Program in Massachusetts*, outlining a framework and proposed pilot to implement a commercial building asset labeling program as the first step toward a mandatory requirement (Mass DOER 2010).



	Building A	Building B
Lighting	T8 fluorescents	T12 fluorescents
Lighting Control	Occupancy sensors	Timers
Air Distribution System	80% efficient fan	60% efficient fan
Skylight	North-facing sawtooth skylight	No skylight
Heating System	Heat pump system	55% efficient boiler
Cooling System	Rooftop unit energy efficiency ratio (EER) = 9	Rooftop unit EER = 7
Roof Insulation	R20	R15
Shading	Horizontal shading devices for south-facing windows	No shading devices
Window	Double-pane low-e windows	Double-pane windows
Orientation	Facing south/north	Facing east/west
Service Hot Water	80% efficient hot water heater	75% efficient hot water heater
Wall Insulation	R20	R10
Plug Loads	5 W/ft ²	2 W/ft ²
Operating Schedule	70 hours per week	30 hours per week
Occupant Behavior	Occupants override lighting controls.	Occupants turn lights off when not in the room.
Maintenance	No regular maintenance and commissioning	Regular equipment maintenance and commissioning performed

Figure 2.1. Example scenarios highlighting the interaction between as-built efficiency and operational choices.

2.1 Scope of the Asset Score

The Asset Score is based on an evaluation of a building’s as-built physical characteristics and its overall energy efficiency, independent of occupancy and operational choices. The physical characteristics include the building envelope, the mechanical and electrical systems, and other major energy-using equipment (e.g., commercial refrigeration). Miscellaneous loads (e.g., office equipment) vary with building occupancy and are therefore standardized by building type in the Asset Score.

The Asset Score also includes installed controls, such as daylighting controls, occupancy sensors, and centralized building energy management systems. However, the specific control schemes/schedules based on building operational choices are not modeled. To calculate the associated energy savings from these control systems, assumptions are made based on the average savings. For example, ASHRAE 90.1-2007 Appendix G (Table G3.2) allows by default a 10% reduction in lighting power density for areas that incorporate occupancy sensor control of lighting. Table 2.1 lists the building characteristics that are included in the scope of the Asset Score.

Table 2.1. Scope of Asset Score.

Included in Asset Score	Does NOT Affect Asset Score
General	
Building geometry and orientation	Building surroundings (such as shading from trees or other buildings)
Window orientation, window-to-wall ratio	
External shading devices (overhangs, vertical fins)	Internal shading devices such as curtains, blinds
Thermal performance of building envelope (walls, windows, roof, and floor)	
Main heating, ventilating, and air-conditioning (HVAC) systems (types and efficiencies)	Back-up systems, efficiency degradation related to age and maintenance, system oversize
Service hot water system (type and efficiency)	
Lighting systems (types and numbers)	
Percentage of lighting controlled by sensors (occupancy sensors and daylighting controllers)	Settings of sensors and controls
Specific (example only)	
Refrigeration in grocery stores (types, number efficiencies)	Refrigerators in office buildings
Commercial kitchen appliances and ventilation systems in restaurants (types, number, efficiencies)	Kitchen appliances in office buildings
Computer servers in data centers (IT equipment power)	Small server closet in office buildings
Operating Assumptions	
Typical operating hours for each building type	Actual operating hours
Standard indoor air thermostat settings	Actual indoor air thermostat settings
Typical occupancy density for each building type	Actual number of occupants
Typical plug loads for each building type	Actual plug loads

All buildings are scored using the same method (the scoring method and scale development are discussed in section 3). Scoring scales will vary among building types, and differences in weather across climate zones are accounted for. Two Asset Scores are calculated: a current score based on the current building characteristics and an estimated potential score reflecting recommended building system upgrades. The Asset Score not only provides an overall building efficiency evaluation, but also gives building stakeholders insight into the performance of separate building systems (envelope, electrical and

mechanical systems, etc.). Two buildings may have the same utility consumption and Asset Score, but different combinations of system efficiency and therefore different potentials.

As shown in Figure 2.2, Building C has a good HVAC system but a poor lighting system, making it a great candidate for low-cost lighting upgrades. Building D has low-efficiency cooling equipment and poor wall insulation. Because insulation usually costs more to upgrade, Building D’s estimated cost-effective potential score may be lower than Building C’s. Therefore, building system evaluations provide important information for building owners, manager, tenants, and investors when they buy, lease, or retrofit a building.

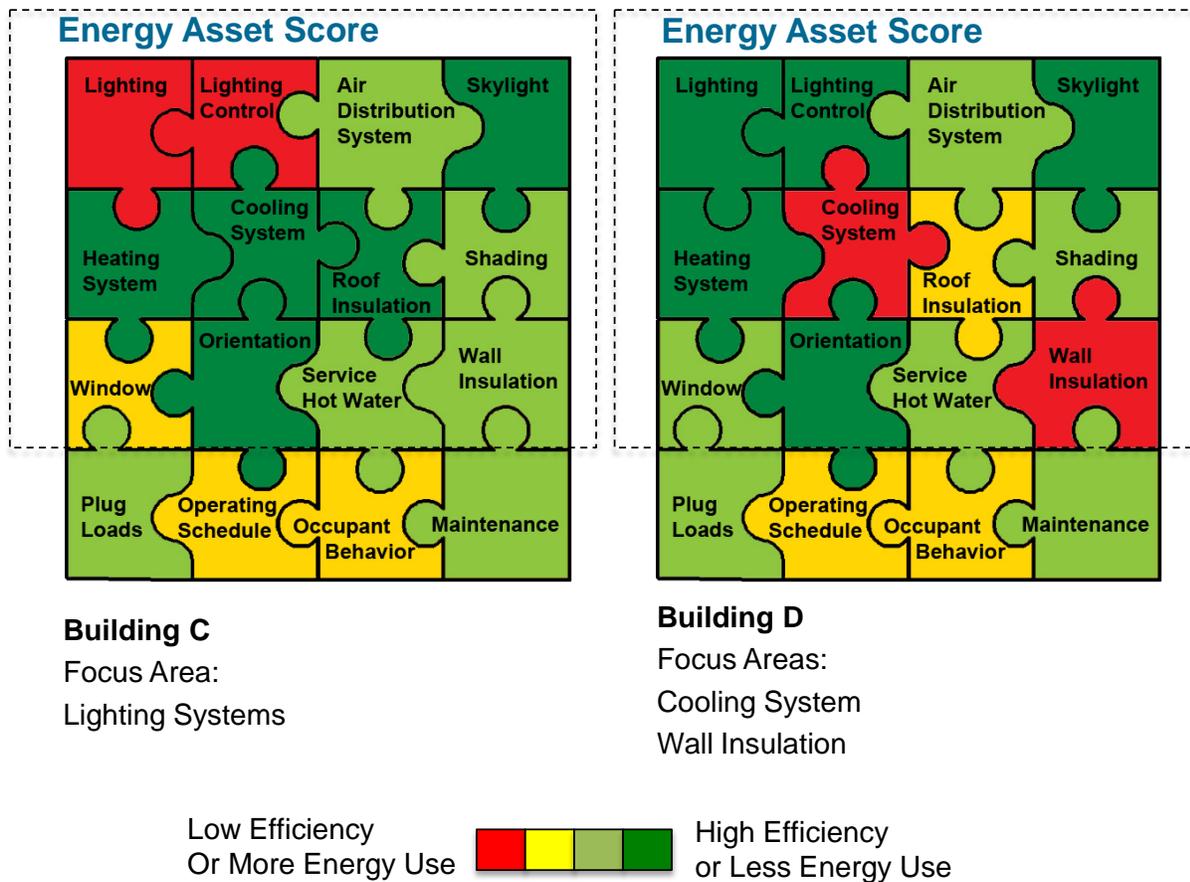


Figure 2.2. Example building scenarios highlighting the importance of system evaluations.

DOE has designed the building Asset Score such that it can be applied broadly to both new and existing commercial buildings and provide affordable and reliable information on building energy efficiency to building stakeholders. DOE intends for the Asset Score to work with and complement the ENERGY STAR Portfolio Manager, once the Asset Score is sufficiently demonstrated. Portfolio Manager compares an existing building to its peers by analyzing the building’s energy bills and operational characteristics.

In any given building, several factors influence energy use and the outcomes measured by the energy bill; the Asset Score will help segregate factors related to the building’s physical infrastructure. This can enable building stakeholders to better determine whether higher-than-expected energy use is due to

inefficient physical infrastructure and specific building systems or to the occupancy, operations, or other factors.

Integrating the Asset Score (which separates out savings related to building infrastructure) with Portfolio Manager (which combines operations and infrastructure energy performance) provides a feedback loop for building owners and operators. This integration would help building owners ensure that buildings are performing as intended and meeting their potential. An integrated building rating system would also help building operators track the results of energy efficiency measures (EEMs) and identify potential operation and maintenance problems.

In the example in Figure 2.1, Building A has highly efficient energy assets, yet its overall energy use performance may only be fairly good, potentially making it a great candidate for low-cost operational improvements. Building B has poor energy assets, although its overall energy use performance may be comparable to Building A, driven by its improved operational characteristics, which mask the opportunities for improving the building systems. Further, Building B's obsolete equipment may be more likely to fail, requiring substantial near-term capital investment to replace. Insight like this, which could be provided by a building energy Asset Score, would provide the information needed to enable building owners to make more informed management and upgrade decisions in order to allocate limited resources more efficiently and, in doing so, improve overall building stock efficacy over time.

Both the DOE Asset Score and the ENERGY STAR Portfolio Manager are expected to evolve, providing opportunities for more integration. The two systems together would comprise a national building score that effectively combines the as-built building efficiency with a gauge of operational success. DOE currently is focused on designing the Asset Score to rate as-built efficiency.

One barrier to energy efficiency investments is the difficulty of obtaining reliable information on building system efficiencies and the related challenge of finding cost-effective ways to improve energy efficiency. Through the Asset Score, DOE is addressing this barrier by developing a common approach for assessing the as-built energy efficiency of commercial buildings and developing an easy-to-use tool to help building owners and stakeholders identify improvement opportunities. Accordingly, the Asset Score has three components:

- The Asset Score, which quantifies a building's as-built energy efficiency based on a standard set of typical operating conditions. This gives building owners and operators insight into the relative performance capability of their building envelope and mechanical and electrical systems.
- The Asset Scoring Tool, which includes a web-based application to maintain building data entered by building owners, managers, or operators and to analyze building energy use, accounting for envelope, mechanical and electrical systems, and other major energy-using equipment. This tool simulates the energy performance of a building and enables building owners, managers, and operators to benchmark their building's efficiency and identify candidate energy efficiency improvement opportunities.
- The Asset Score Report, which is generated by the Asset Scoring Tool and presents the evaluation results along with potential energy efficiency considerations for improving the score.

DOE intends to support continuous improvement of energy efficiency by allowing buildings to be re-rated following implementation of EEMs.

In the current rollout, the Asset Scoring Tool is not able to account for renewable generation. After the calculation of the onsite generation is added to the scoring tool, DOE will develop a means to give credits to buildings using onsite renewable energy.

The Asset Score is designed to emphasize energy efficiency prior to renewable energy; therefore, only onsite renewable generation will be considered. Various supply-side renewable energy technologies (e.g., waste streams, biomass, utility-based wind) are also available for achieving the zero-energy building goal; however, these are not considered to be part of the energy asset of the building. Furthermore, buildings are more likely to reduce their loads if investing in onsite renewable generation than if simply purchasing offsite renewable energy. Proper calculation of onsite generation and potential consideration of offsite supply options will be further evaluated and added to the tool later as appropriate.

2.2 Target Audience and Guiding Principles

The Asset Score is intended to enable building stakeholders—including owners, managers, operators, investors (who buy a stake in exchange for a return on investment), and financiers (banks or lenders for loans) to directly compare expected as-built energy performance among similar buildings and to analyze the potential for capital improvements to cost-effectively improve energy efficiency. The system is intended to give building stakeholders insight into a property’s long-term energy cost. It is intended to illustrate for stakeholders the impact of potential capital improvements. Research (McCabe and Wang 2012; McKinsey 2009) shows a need to communicate energy and cost savings to owners, investors, financiers, and others to overcome market barriers and motivate capital investment in building energy efficiency.

In addition, the Asset Score is aimed at tenants, appraisers, and designers. It may also inform local governments, utilities, and green-building rating systems. The Asset Scoring Tool provides technical information and highlights potential improvement opportunities that building energy professionals can evaluate further to identify and implement appropriate EEMs.

Finally, the Asset Score can raise public awareness of building efficiency among those who have limited knowledge of building energy use. The rating system conveys complex building energy system efficiency information in an easy-to-understand score.

DOE’s intention is to provide an affordable system that gives a useful score with minimal data collection. The program’s primary goal is to encourage commercial building energy improvements in new construction and/or retrofits. Therefore, the score’s guiding principles (listed below) are based on market needs:

- Information must be credible, reliable, and replicable.
- Information must be transparent and easy to understand.
- Costs of collecting information and generating a score must be affordable.
- Opportunities identified must be relevant and practical.
- The Asset Score must include effective quality assurance.
- The Asset Score must recognize building energy performance across the full range of building efficiency.

2.3 Building Types

Buildings have been categorized in different ways. Examples include the classifications applied in the Commercial Buildings Energy Consumption Survey (CBECS), ENERGY STAR benchmarking, and Commercial Energy Services Network (COMNET) energy modeling (Appendix A). The CBECS is a national survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures. The CBECS data provide only measured energy use, which is the outcome of a building’s as-built efficiency and its actual operational choices. To ensure a fair score and comparison, buildings need to be categorized by use type, primarily because the assumed standard operating conditions differ among building types. For example, operating schedules and miscellaneous plug loads in schools differ substantially from those in retail establishments. In the Asset Score, the building type classifications determine the standard operating conditions, including occupant density, receptacle power, and operating schedule.

The Asset Score is being rolled out in multiple phases, each focusing on different groups of building types (Table 2.2):

- The first phase, which is being included in the initial rollout, includes buildings in the office, education, retail, and non-refrigerated warehouse categories. These building types are included in this phase because there is adequate literature on them to provide reliable references. There is also sufficient building performance data (e.g., CBECS), which is another primary consideration for selecting building types by phase because the existing building stock is an important reference to establish scoring scales that truly reflect the energy use of each building type.
- The second phase includes library, lodging, multi-family housing, and courthouse buildings, as well as mixed-use buildings that incorporate use types from the first two phases. These buildings are included in the second phase because less information is available on them compared with the building types included in the first phase, and therefore additional energy modeling and analysis is required to fill the information gap. Development of the building types included in the first phase will help provide references and experience for the building types included in the second phase.
- Buildings with more complex systems or those for which there is currently a limited body of information, such as food sales, food service, data centers, laboratories, refrigerated warehouses, and health-care facilities will be included in the future development.

The Asset Score building types are based on CBECS building classifications. Some building types in the first two phases, such as public assembly and service buildings, have diverse subtypes and will need further investigation before being classified for Asset Score.

Table 2.2. Building types.

Phase	Energy Asset Score Building Type	Building Use Type Examples	Availability of Reference Resources			
			CBECS	Portfolio Manager	DOE Reference Building and 90.1 Prototype Building	COMNET
First Phase	Office	Administrative/professional Bank/other financial Government	x	x	x	x

Phase	Energy Asset Score Building Type	Building Use Type Examples	Availability of Reference Resources				
			CBECS	Portfolio Manager	DOE Reference Building and 90.1 Prototype Building	COMNET	
		Medical non-diagnostic					
	Education	College/university ^(a) Elementary/middle school High school Preschool/daycare	x	x	x	x	
	Retail	Strip shopping mall Enclosed mall Retail other than mall (vehicle dealership/showroom, retail store)	x	x	x	x	
	Warehouse (Non-refrigerated)	Distribution and shipping center Self-storage Non-refrigerated warehouse	x	x	x	x	
	Second Phase	Public Assembly (Library)	Library (including college/university library)	x			x
	Lodging	Dormitory/fraternity/sorority Hotel Motel or inn	x	x	x	x	
	Multi-family Housing	Apartment/multi-family housing			x	x	
	Public Order and Safety (Courthouse)	Courthouse	x	x		x	
	Religious Worship		x	x		x	
Future Development	Food Sales	Convenience store Convenience store with gas station Grocery store/food market	x	x	x		
	Food Service	Fast food Restaurant/cafeteria Bakery	x	x	x	x	
	Inpatient Health Care	Hospital/inpatient health	x	x	x	x	
	Nursing	Nursing home/assisted living					
	Outpatient Health Care	Medical office (diagnostic) Clinic Veterinarian	x	x	x	x	
	Data Center			x			
	Laboratory		x				
	Warehouse (Refrigerated)	Refrigerated warehouse	x	x	x	x	

Phase	Energy Asset Score Building Type	Building Use Type Examples	Availability of Reference Resources		
			CBECS	Portfolio Manager	DOE Reference Building and 90.1 Prototype Building COMNET
	Public Assembly	Entertainment/culture Recreation Social/meeting Funeral home Exercise center/pool			
	Service	Post office/postal center Repair shop Vehicle service/repair shop Vehicle storage/maintenance Industrial shop Dry-cleaning/laundry			
	Public Order and Safety	Fire station/policy station Jailhouse Penitentiary			
	Truck Terminal				
	Parking Garage				

(a) Depending on the actual functions, not all college/university buildings are in the Education category. For example, university libraries should be considered in the Library category; buildings for administration only should be considered in the Office category; buildings with laboratories may be considered as Laboratory or Mixed-use type.

While the main intent of the Asset Score is to evaluate the performance of existing buildings, the process can also be applied to buildings in the planning stages. The Asset Score can be used for preconstruction building evaluation; the design team could enter the design parameters into the Asset Scoring Tool and examine how different options can affect the simulated energy use and the resulting score. However, to obtain an official Asset Score for a new building, the building data need to reflect the actual installed systems.

In addition to overall building energy use evaluation, the Asset Score Report can be used to obtain system evaluation and measures to improve performance. The Asset Score is designed to provide building owners with information on the energy efficiency of their existing buildings along with general guidelines for improving their performance. The determination of cost effectiveness would be slightly different for a new building; however, the general recommendations would still apply.

2.4 User Levels

The Asset Score is designed to be applied under two user levels: simple and advanced.

- The *simple* application requires minimal data from the users. The simple application yields a preliminary score based on building efficiency, identifies candidate improvement opportunities, and estimates the energy impact of those improvements. The simple score is based on a more limited set of user-specified building characteristics. It can give users quick feedback on building efficiency and improvement potential.

- The *advanced* application allows for expanded user input beyond what is available under the simple level. Users may specify additional pertinent building characteristics as applicable and known. Real estate transactions would likely require this level of score, with validation of data accuracy performed by a qualified professional.

The Asset Scoring Tool is not intended to replace engineering analyses needed for detailed selection and specification of optimal building retrofits, but instead to provide building owners and operators with a quick, low-cost, standardized way to rate building energy assets through a national program. DOE expects that all scores—whether simple or advanced—would be considered preliminary until validated by a qualified professional. Requirements for validation have not yet been developed.

3.0 Energy Asset Scoring Methods

This section discusses scoring metrics as well as methods for creating a scoring scale. The Asset Score is intended to work as part of a broader set of commercial building energy performance tools, including ENERGY STAR Portfolio Manager. Therefore, as described below, where possible, the Asset Score incorporates methods that are consistent with ENERGY STAR Portfolio Manager.

Section 3.1 details the scoring metric, source energy use intensity (EUI), selected for the Asset Score, for reasons discussed below. Other scoring metrics considered, including site EUI, energy cost, and greenhouse gas emissions were discussed in the Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013).

The selection of scoring scales is discussed in section 3.2. After examining numeric scales reflecting physical units (e.g., kBtu/ft²), categorical scales (e.g., A–E ratings), interval scales (e.g., 10-point scale), and continuous scales (e.g., 100-point scale), DOE selected a non-statistical 100-point scale. The pros and cons of other considered scales can be reviewed in the Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013). The score calculation method for single-use and mixed-use building types is also discussed in this section.

Weather coefficients for heating and cooling energy use were developed to adjust modeled energy use to account for weather impact and to enable a fair comparison between similar buildings across the United States. The methodology is discussed in section 3.2.4.

A series of rating scales was developed for each building type. The methodology is discussed in section 3.2.5. The intended durability of the developed scales is discussed in the following section.

3.1 Energy Asset Scoring Metrics

There are several ways to describe a building's expected energy performance, including energy use, energy cost, and greenhouse gas emissions associated with building energy use. Various factors may be relevant to evaluating the effect of a building's source energy use, such as fuels used in the building, varying fuel mix for electric generation, onsite renewable generation, and combined heat and power.

While no single metric can tell the whole story about building energy use, DOE selected source EUI as the primary metric for generating the Asset Score. Other metrics, including site energy use, cost savings, simple payback, and relative system-level indicators, are provided as reference metrics. These additional metrics may help building owners, managers, and operators more fully understand and communicate the meaning of their results. The following sections discuss the pros and cons of using the source energy metric and the additional energy metrics.

3.1.1 Primary Metric: Source Energy Use Intensity

An energy metric is the most transparent and portable way to represent building energy performance. DOE selected source EUI as the primary metric for the Asset Score, for the reasons discussed below.

Source energy incorporates all transmission, delivery, and production losses on top of site energy consumption by the building systems, thereby enabling a more complete assessment of the energy

required to operate a building. Source EUI is calculated by using a conversion factor for each fuel type to convert site EUI to a source equivalent. The conversion of site energy to source energy is discussed in section 3.1.2. Although site energy is most closely related to the energy use that customers see on their energy bills for each fuel type, source energy more closely reflects the net energy requirement and the long-term cost implications of different energy choices.

Using source energy also aligns the Asset Score with ENERGY STAR Portfolio Manager, which uses source energy as its basic metric. Source energy use is familiar to building owners and operators who have been using Portfolio Manager or other building scoring methods that rely on Portfolio Manager. Source energy use (or primary energy use, extended site energy use) has been used by DOE for assessing the impact of energy use on the economy, security, and environmental quality (National Research Council 2009).

3.1.2 National Average Site-Source Conversion Factors

To convert each unit of energy (in kBtu) used on site into the equivalent source energy consumed, a conversion factor (or source-site ratio) for each fuel type is needed. Depending on how the secondary energy is generated, the conversion factors can vary for the same fuel type.

DOE considered three types of site-to-source conversion factors for the Asset Score: state average, regional average, and national average. After evaluating these options, DOE chose a national average conversion factor. The reasons for DOE's decision to not use state or regional average are discussed in the Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013).

National average site-to-source conversion factors allow national-level comparisons and ensure that a building does not receive a high or low rating for the relative efficiency of its regional power grid and generation source mix. The Asset Score employs the national conversion factors used by Portfolio Manager.

Source-site ratios shown in Table 3.1 are used by Portfolio Manager to convert each kBtu of energy used on site into the total kBtu of equivalent source energy consumed. The current grid-purchased electricity and natural gas conversion factors are based on the averages over 5 years, from 2001 through 2005. The most current revision of all source-site ratios occurred in 2007; these ratios are expected to change as the national infrastructure and fuel mix evolve. EPA reviews the ratios every 3 to 5 years and updates accordingly (EPA 2011). DOE will review the updated ratios in the future and evaluate their effect on the Asset Score. Buildings that have received an Asset Score will receive notice and an updated score if any changes are made to the source-site ratios.

Table 3.1. Source-site ratios (EPA 2011).

Source	Ratio
Electricity (grid purchase)	3.34
Electricity (onsite solar or wind installation)	1.0
Natural gas	1.047
Fuel oil (1, 2, 4, 5, 6, diesel, kerosene)	1.01
Propane and liquid propane	1.01
Steam ^(a)	1.21
Hot water	1.28
Chilled water ^(b)	1.05
Wood	1.0
Coal/coke	1.0
Other (e.g., waste biomass)	1.0

- (a) The weighted average of two source-site factors: 1.35 for conventional steam factor and 1.01 for CHP (combined heat and power) steam factor (EPA 2011).
- (b) The weighted average of two source-site factors: 1.14 for electric chiller and 1.04 is for natural gas-fired chiller (EPA 2011).

When renewable energy is produced at a building through solar photovoltaic panels or wind turbines, DOE is currently undecided whether the electrical calculation will be based on an annual net basis or an instantaneous basis. An annual net-basis approach calculates the net site electricity use (total annual electricity use minus total onsite generation) and converts it to source energy. An instantaneous-basis approach calculates the net energy use per time unit (for example, hourly electricity use minus hourly onsite generation), converts it to source energy, and then calculates the annual energy use. The latter approach more accurately reflects the actual amount of electricity purchased from the grid or generated on site; however, it requires more complicated energy simulation.

Table 3.2 shows an example of how the two calculation methods can affect the source energy use of a building. An instantaneous-basis calculation yields higher source energy use because the source-site ratio for onsite generation is lower than that for grid purchase. Further analysis will be conducted to evaluate the effects of these two methods on the Asset Score. More discussion on renewable energy calculation can be found in section 3.2.5.

Table 3.2. Comparison of annual-basis and instantaneous-basis calculations.

Time Unit	Electricity Use (kBtu)	Electricity Generation (kBtu)	Net Site Electricity Use (kBtu)	Source-Site Ratio	Source Energy Use (kBtu)
1	1,000	2,000	-1,000	1	-1,000
2	2,000	2,000	0	1	0
3	3,000	2,000	1,000	3.34	3,340
4	4,000	3,000	1,000	3.34	3,340
5	8,000	3,000	5,000	3.34	16,700
6	5,000	3,000	2,000	3.34	6,680
7	3,000	3,000	0	1	0
8	2,000	3,000	-1,000	1	-1,000
9	1,000	2,000	-1,000	1	-1,000
10	500	2,000	-1,500	1	-1,500
Total (instantaneous-basis)					25,560
Total (annual-basis)	29,500	25,000	4,500	3.34	15,030

3.1.3 Additional Metrics

The Asset Score provides additional metrics as references to give building owners, managers, and operators a more complete picture of building energy use and efficiency. These metrics include:

- site energy use by fuel type and system type
- energy cost savings potential
- system-level performance indicators.

DOE is also considering the best way to include other metrics (such as greenhouse gas emissions) that may be of interest to building owners and their stakeholders.

3.1.3.1 Site Energy Use

The Asset Scoring Tool generates a report that gives the modeled site energy use under common operating conditions, separated out by fuel type and building system. Building owners, managers, and operators can use this information to estimate the cost savings based on their own financial models. Site energy use breakout by fuel type and system type can inform building operators about building energy use distribution and help identify the areas where the most savings might be realized. Local governments, utilities, and other interested parties can also develop a local source energy use indicator based on the regional site-to-source factors.

3.1.3.2 Energy Cost Savings

Consumers are generally more familiar with cost metrics. However, energy costs for commercial buildings can vary considerably across different parts of the country and change over time, including over the course of the day. Without much more specific information about a building’s operations and its time-dependent per-unit energy prices, energy cost is not a durable, comparable metric on which to base a

score. Another downside of using energy cost is that the cost includes a demand component, which relates to the utility infrastructure and greatly varies by region. Therefore, a cost metric alone cannot be used directly to judge building energy performance. For these reasons, DOE did not choose cost information as the primary metric for the Asset Score.

The Asset Score uses cost information as a metric to assess opportunities for improving building energy efficiency and describe the likely impacts associated with those improvements. The Asset Scoring Tool performs life-cycle cost analysis to suggest a package of EEM considerations and associated energy cost savings. This information is not intended to be used by building owners and managers to purchase equipment or materials, but to help them learn their buildings' potential and identify areas and options for energy efficiency improvement. It is expected that building owners and managers will seek professional assistance in the identified opportunity areas when ready to make more detailed and actionable building retrofit decisions.

Time-dependent valuation (TDV) has been used in the cost-effectiveness calculation for the Title 24 Energy Standards since 2005. Compared to energy cost savings based on annual average price of electricity or natural gas, TDV accounts for variations in cost related to time of day, seasons, geography, and fuel type by summing the hourly savings over the analysis year. This method requires developing an hourly TDV factor for each climate location (for example, 16 sets of TDV factors for 16 climate zones in California). Under a similar concept, COMNET also developed time-of-use rate schedules for electricity, gas, steam, and chiller water. The Asset Score uses the COMNET energy cost data, which considers the cost savings related to high cost times of the day and year.

3.1.3.3 System-Level Performance Indicators

The Asset Scoring Tool generates a report that evaluates building systems. Although the whole building EUI indicates the overall building efficiency as an integrated system, it is inadequate in fully explaining the influence of individual component characteristics. A building with a well-insulated envelope and low-efficiency HVAC equipment could, theoretically, use the same amount of energy as a building with a poorly insulated envelope and high-efficiency HVAC equipment. System evaluations are provided for the building envelope (roof, walls, windows), lighting, HVAC, and service hot water systems. This information can help identify the specific components of the building most in need of attention. For two buildings with the same Asset Score, the system-level evaluations can give users insight into existing problems and point to potential areas of improvements for the two buildings.

3.2 Energy Asset Scoring Method

3.2.1 1- to 100-Point Interval Scale

There are several ways to deliver building energy performance information to consumers. Various types of scales have been used in the existing building rating systems, such as scales reflecting physical units (e.g. kBtu/ft²) or converting physical units into ratios, categories, or numerical scores. After considering the alternatives (see Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013)), DOE selected a 1- to 100-point scale for the Asset Score. The Asset Score uses a scoring system that does not rely on any baseline buildings and instead simply converts modeled source EUI into a score. For some building use types, each additional point on the scale corresponds to an

equivalent amount of reduction in source EUI. For some other building use types, the scales are divided into multiple sections. Less efficient buildings need to achieve higher energy reduction to obtain an additional point. The scale development method is discussed in section 3.2.1.

Both the Asset Score and ENERGY STAR Portfolio Manager use a 100-point scale; however, the Asset Score evaluates as-built systems, not operation of the building. Therefore, the Asset Score cannot be compared directly to the ENERGY STAR score. In some cases, a building's Asset Score and ENERGY STAR Portfolio Manager score may align, but in many cases they will not. DOE and EPA plan to develop a systematic approach to help communicate the meaning of each score to users. As market research shows (McCabe and Wang 2012), the comparison of Asset Score and ENERGY STAR results can provide valuable information and insights to building owners and operators.

3.2.2 Score Calculation

To develop a simple and standardized score, DOE is using a predefined scale for each building type. A source energy use value corresponds to a fixed point on the 100-point scale. In other words, a score is calculated directly based on the modeled energy use without the need to create a reference building. The overall methodology for determining a building's Asset Score includes three steps, as illustrated in Figure 3.1:

Step 1: Source EUI is obtained by performing the whole-building energy simulation using the Asset Scoring Tool. The tool chooses the weather station having the most similar climate to the user-entered zip code¹.

The whole-building energy simulation is performed via the Asset Scoring Tool—a web-based application. The tool consists of a simple user interface, the EnergyPlus simulation engine to calculate the building energy use, and an EEM evaluation module to consider potential building upgrades. An input generator is also built into the tool to allow all key variables for a full-scale EnergyPlus model to be inferred from a reduced set of variables. Users submit the required data and receive an Asset Score Report through the online tool. The development of such a tool reduces modeling time and expertise requirements while supporting the variability and complexity of commercial buildings. The tool development methodology is discussed in section 4.

Step 2: The modeled EUI is adjusted to account for local climate.

A series of corresponding coefficients is applied to the modeled site HVAC EUI values to account for climate variability. A total site EUI is then calculated and converted to source EUI. The development of weather coefficients is discussed in section 3.2.4.2.

$$\begin{aligned} \text{Adjusted EUI}_{\text{Weather Site A}} &= \text{Heating Coefficient}_{\text{Weather Site A}} \times \text{Heating EUI} \\ &+ \text{Cooling Coefficient}_{\text{Weather Site A}} \times \text{Cooling EUI} \\ &+ \text{Fan Coefficient}_{\text{Weather Site A}} \times \text{Fan EUI} \\ &+ \text{Other EUI (not weather dependent)} \end{aligned}$$

¹ If no climate-similar station is found, the tool will select the nearest weather station.

Step 3: An Asset Score is calculated using the adjusted source EUI and the predefined scale for each use type.

The scale development is explained in section 3.2.5.

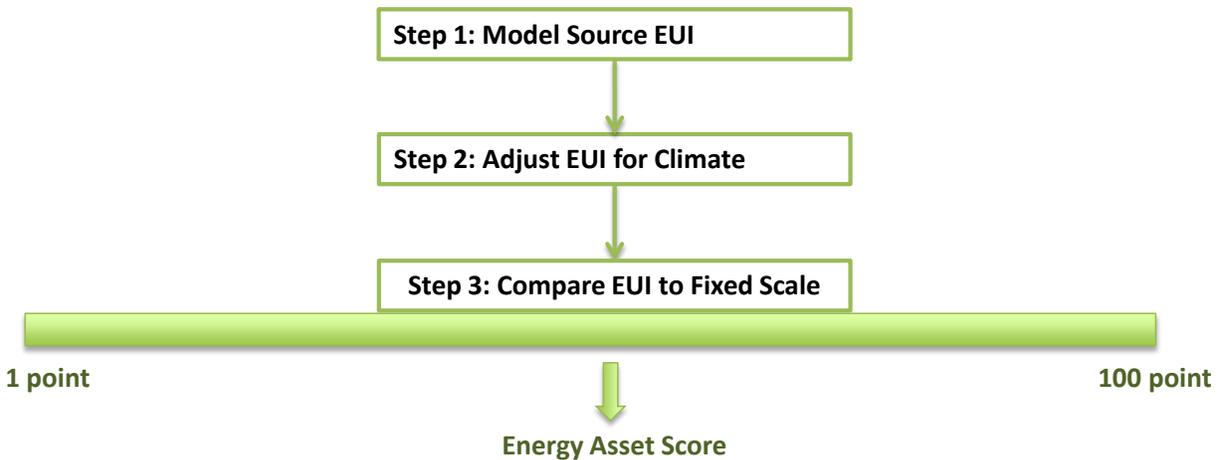


Figure 3.1. Asset Score calculation steps.

3.2.3 Scoring for Mixed-Use Buildings

Mixed-use buildings that incorporate use types included in the first two phases of the Asset Score are included in the 2013 pilot test. Buildings with more complex systems or those for which there is currently limited information (such as food sales, food service, data centers, laboratories, refrigerated warehouses, and health-care facilities) will be included in the third phase.

A weighted rating is used to evaluate mixed-use types: each use is rated separately and then the weighted rating is computed based on the square footage of each use type in the overall building. Table 3.3 provides an example of two office/retail mixed-use buildings. Both buildings have the same floor area (70% of office and 30% retail) and total energy use. Building A has a more efficient office portion, while Building B has a more efficient retail portion. The office and retail portions are assessed separately using their corresponding scales. Then, the weighted ratings for the mixed-used commercial properties are calculated based on the individual rating and floor area of each use type (and shown on the orange part of the table).

Another weighting approach could be in proportion to the total energy use instead of the total floor area. However, a weighted overall rating by energy use cannot consistently represent the energy efficiency of a mixed-use building and its use-type portions. In the example of Building A in Table 3.3, the overall scores based on percentage of energy use (as shown in the blue section at the bottom of the table) tend to favor retail—a use type with high energy intensity. The original score is close to the score of the retail portion, although it accounts for only 30% of the total floor area. A 20% energy reduction in the office portion does not affect the overall score. A 20% energy reduction in the retail portion will affect the overall score more. This would lead building owners to ignore the energy efficiency of the office portion. In the example of Building B in Table 3.3, after a 20% energy reduction in the retail portion, the overall score unexpectedly decreases.

Using floor area as a weighting factor does not favor or penalize a building for its use types. It can also fairly reflect the energy reduction of each portion of the building. As shown from the example scenarios illustrated in Table 3.3, the overall score improvement is proportional to the overall energy savings. Therefore, it is expected that a mixed-use building's score will be prorated based on the percentage of floor area of each use type.

Table 3.3. An example of prorated scores for mixed-use buildings.

	Building A		Building B		Building A with 20% energy reduction in office portion		Building B with 20% energy reduction in office portion		Building A with 20% energy reduction in retail portion		Building B with 20% energy reduction in retail portion	
Total Floor Area (ft ²)	100,000		100,000		100,000		100,000		100,000		100,000	
Use Type	Office	Retail	Office	Retail	Office	Retail	Office	Retail	Office	Retail	Office	Retail
Floor Area (ft ²)	70,000	30,000	70,000	30,000	70,000	30,000	70,000	30,000	70,000	30,000	70,000	30,000
Source Energy Use (MBtu) ^(a)	7000	9000	13000	3000	5600	9000	10400	3000	7000	7200	13000	2400
Total Energy Saving (MBtu)	N/A		N/A		1400		2600		1800		600	
Source EUI (kBtu/ft ²)	100	300	186	100	80	300	149	100	100	240	186	80
Asset Score by Use Type	82	55	54	89	87	55	67	89	82	67	54	91
% of Floor Area	70%	30%	70%	30%	70%	30%	70%	30%	70%	30%	70%	30%
Overall Score by Floor Area	74		65		77		74		78		65	
Additional Points After Savings	N/A		N/A		4		9		4		0	
% of Energy Use	44%	56%	81%	19%	38%	62%	78%	22%	49%	51%	84%	16%
Overall Score by Energy Use	67		61		67		72		74		60	
Additional Points After Savings	N/A		N/A		0		11		8		-1	

(a) MBtu is million British thermal units.

3.2.4 Weather Adjustment

To account for climate variability and enable a fair comparison between energy uses of buildings at different locations, energy loads that are sensitive to weather should be adjusted before a building is scored. A series of corresponding coefficients have been developed and applied to the modeled site HVAC EUI values. The method is discussed in this section.

3.2.4.1 ASHRAE Standard 90.1-2004 Prototype Buildings as Baselines

The DOE commercial prototype building models developed by PNNL were used to investigate how weather variability affects modeled energy use across all EnergyPlus weather locations for the United States. These prototype buildings represent typical building characteristics and provide a consistent baseline for evaluating building energy efficiency across climate zones (Figure 3.2). Therefore, they were chosen to develop coefficients for weather adjustment. A prototype building was simulated using all available weather station data files (TMY3 data sets), which represent numerous weather locations within each climate zone in the United States. Using identical building models in all locations (with envelope characteristics adapted to ANSI/ASHRAE/IESNA Standard 90.1 for each climate zone for construction year 2004) allowed the effect of weather to be isolated. The hypothesis was that although buildings with different properties (e.g., thermal properties, design features, and mechanical systems) respond to weather differently, the relative difference between EUI modeled at a specific location and the mean EUI of all locations remains similar, if not exactly the same.

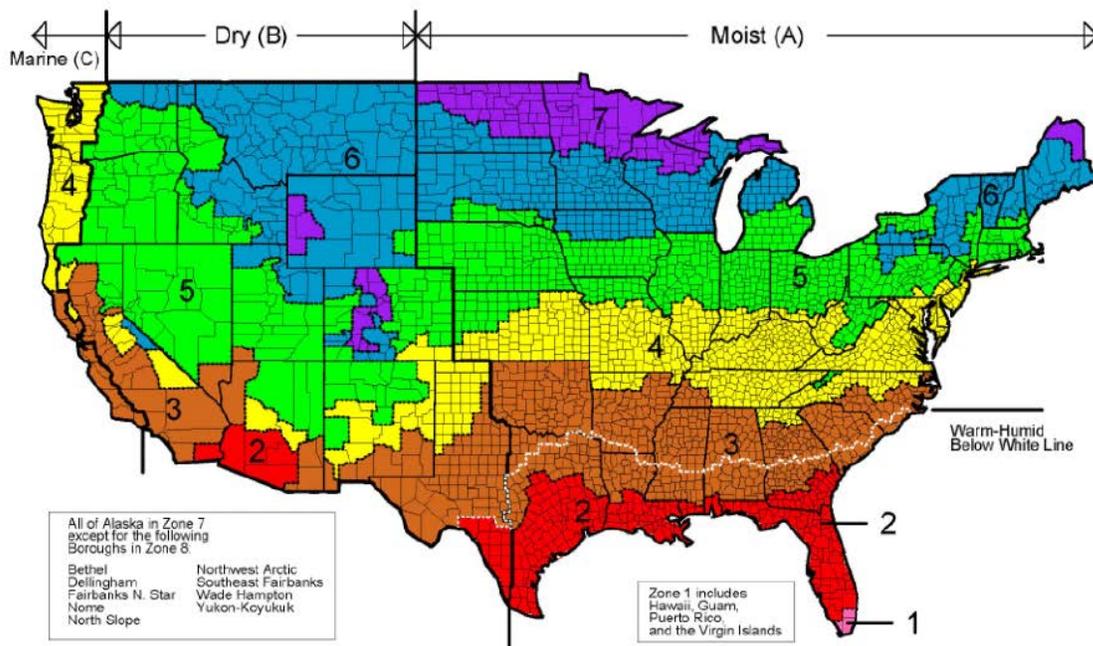


Figure 3.2. U.S. climate zone classification (NREL 2011, p. 7).

This difference can be measured by the ratio of location-specific to average EUI. Verification and validation of this hypothesis allows the Asset Score to use this difference to develop a “coefficient” (inverse of the EUI ratio) to adjust for the effect of weather in that specific weather location so that adjusted EUIs can be compared for buildings independent of location:

$$EUI\ Ratio_{Weather\ Site\ X} = \frac{EUI_{Modeled\ at\ Weather\ Site\ X}}{Average\ EUI_{Modeled\ at\ All\ Weather\ Sites}}$$

$$Coefficient_{Weather\ Site\ X} = \frac{1}{EUI\ Ratio_{Weather\ Site\ X}}$$

$$Adjusted\ EUI_{Weather\ Site\ X} = Coefficient_{Weather\ Site\ X} \times Modeled\ EUI_{Weather\ Site\ X}$$

The purpose of weather adjustment is to enable a fair comparison between buildings in different locations. Given the fact that thermal properties of buildings affect their unique ways of responding to their immediate exterior environment—temperature, humidity, solar radiation, and wind—it is impossible to equally diminish the effect of weather on all buildings using one set of predefined coefficients. Therefore, a unique weather adjustment coefficient was derived for each available weather station location based on prototype buildings compliant with ASHRAE Standard 90.1-2004. Buildings with less efficient thermal properties will be less adjusted because they are more affected by their exterior environment. This effect will be even more pronounced for buildings in extremely hot or cold climates where the relative difference between a location-specific EUI and the mean EUI is larger. This is acceptable from an energy-efficiency perspective because the Asset Score is intended to encourage and give credits to good envelope thermal performance, which is particularly more important for buildings in hot or cold climates.

To develop weather adjustment coefficients, several building types representing typical commercial buildings were selected. In this selection, the variation of building characteristics (e.g., size, design, system types, internal loads, and schedules) was a critical criterion in order to observe behavior of buildings with different properties in response to weather across and within different climate zones. The chosen prototype buildings included small office, large office, primary school, secondary school, small hotel, strip mall, stand-alone retail, midrise apartment, and warehouse (non-refrigerated). These buildings represent a sample of typical building types exhibiting large variations in their designs and installed systems according to location and climate (see Appendix B, Table B.1). This variation was crucial in developing robust weather coefficients that can be applied to a broad range of buildings. The original models of all chosen prototype buildings were used except for the large office type. The data center in the original large office model was removed because its extremely high internal loads would significantly affect the heating and cooling requirements. The data center will be examined as a separate use type in the future phase.

3.2.4.2 Development of Weather Coefficients

Weather coefficients were developed in three steps. The following analysis made no distinction between size and use type of the prototype buildings. Rather, it treated each chosen prototype building as a unique observation at a given weather station location.

Step 1: Extract weather-dependent energy use from simulations of all chosen prototype buildings at all weather locations.

Simulations using EnergyPlus were carried out at each weather station location, and site EUIs were calculated for all end uses of the above nine prototype buildings. The end uses calculated include heating (electricity), heating (gas), heating (district), cooling (electricity), interior lighting, exterior lighting, interior equipment, exterior equipment, fans, pumps, heat rejection, hot water systems (electricity), and hot water systems (gas). Not all end uses are weather sensitive; therefore, there is no need to adjust all energy consumption for weather. As a result, only weather-sensitive end uses were examined. These end uses include space and water heating, space cooling, fans, and pumps. Note that exterior lighting and equipment are in the prototype buildings but currently are not included in the Asset Score. They do not affect the development of weather coefficients because they are not weather-dependent loads and their energy use accounts for only a small portion of the total energy use of the prototype buildings.

Step 2: Calculate EUI ratios by end use and develop weather coefficients for each prototype building.

To assess the effect of the local weather conditions on building EUI, an EUI ratio for each weather-sensitive end use was computed at each weather site for each prototype building. Each EUI ratio was calculated by dividing each location-specific end-use EUI (e.g., cooling EUI) at each weather site by the average end-use EUI (e.g., average cooling EUI) calculated from modeling the prototype building across all TMY3 weather station sites (1008 in total). This EUI ratio represents the relative distance between the modeled EUI at one weather location and the mean EUI obtained over all weather locations. This distance reflects how much the EUI needs to be adjusted in order for buildings at that specific location to obtain a “fair” Asset Score (one that can be compared to other buildings of that type regardless of their respective locations). Site EUI instead of source EUI is used to calculate this ratio because the purpose of this step is to investigate the relationship between a building’s energy use and its weather site regardless of its fuel choice. The calculation below was repeated on all end-use EUIs that are directly affected by weather. A set of EUI ratios for space and water heating, space cooling, fans, and pumps was calculated for each weather location.

$$\begin{aligned} &EUI\ Ratio_{Prototype\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1} \\ &= \frac{EUI_{Prototype\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1}}{Average\ EUI_{Prototype\ Building\ 1,\ All\ Weather\ Sites,\ End\ Use\ 1}} \end{aligned}$$

A weather coefficient for a specific end use (e.g., space cooling) is simply the inverse of the EUI ratio calculated at a specific weather site. A total of 1008 sets of weather coefficients were calculated for each prototype building. A total of 1012 TMY3 weather files are available in EnergyPlus; however, a handful of weather files (.IDD files) did not successfully run because they were either incomplete or corrupted.

$$\begin{aligned} &Coefficient_{Prototype\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1} \\ &= \frac{1}{EUI\ Ratio_{Prototype\ Building\ 1,\ All\ Weather\ Sites,\ End\ Use\ 1}} \end{aligned}$$

Step 3: Calculate average weather coefficients using all chosen prototype buildings.

Results of EUI ratios calculated from all chosen prototype buildings¹ indicated that except for the warehouse building, buildings with different characteristics respond similarly to variations in external heating and cooling loads (Figure 3.3 and Figure 3.4). This observation partially validated the original hypothesis that although buildings respond to weather conditions differently, the relative difference is similar. Therefore, a predefined set of location-based coefficients can be used to adjust weather for the Asset Score, for most building types. Note that while most of the individual EUI ratios cluster nicely, there is significant variability found in some limited weather station locations (for example, within climate zones 8A for heating). These individual models with extremely high heating energy use will need to be further investigated.

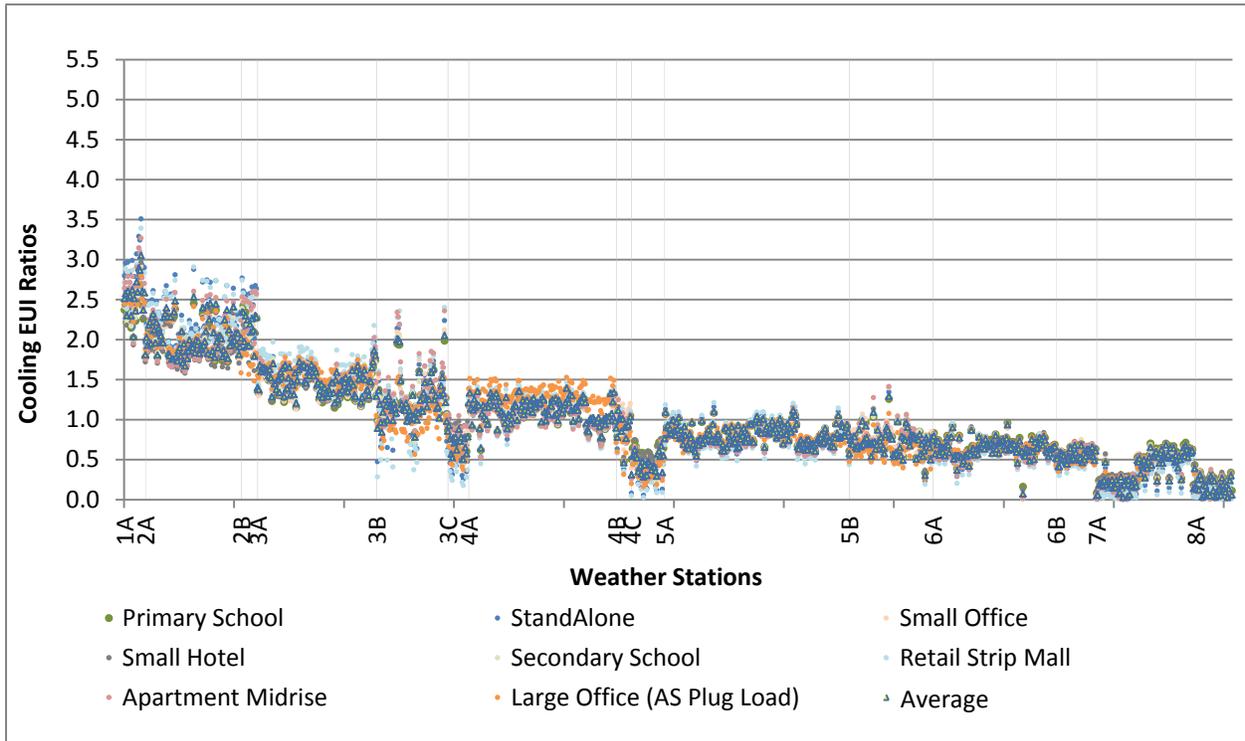


Figure 3.3. Cooling EUI ratios of eight prototype buildings and their average.

¹ For this analysis, the data center in the large office model was removed. The standard plug load assumption for Asset Score was used to modify the original prototype large office model. Other prototype buildings were used without modification.

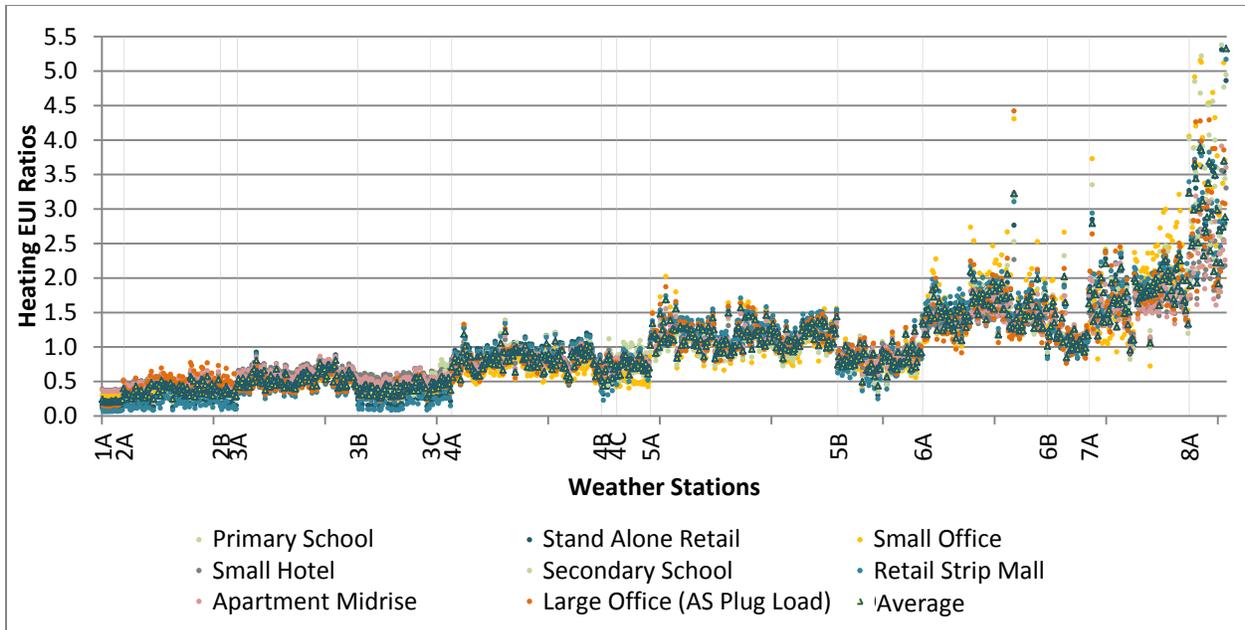


Figure 3.4. Heating EUI ratios of eight prototype buildings and their average.

Compared to heating and cooling EUI ratios, the variance of fan EUI ratios across the modeled buildings and weather locations is small (Figure 3.5). Pump EUI ratios are unpredictable because the energy use for pumps varies by HVAC system type (Figure 3.6). For example, cooling systems that use direct expansion (DX) coils may not use any energy for pumps. Only three prototype buildings have pump energy use for space heating. On average, the pump energy use of the three prototype buildings accounts for less than 3% of the total HVAC energy use; therefore, pump energy use is excluded from the weather adjustment.

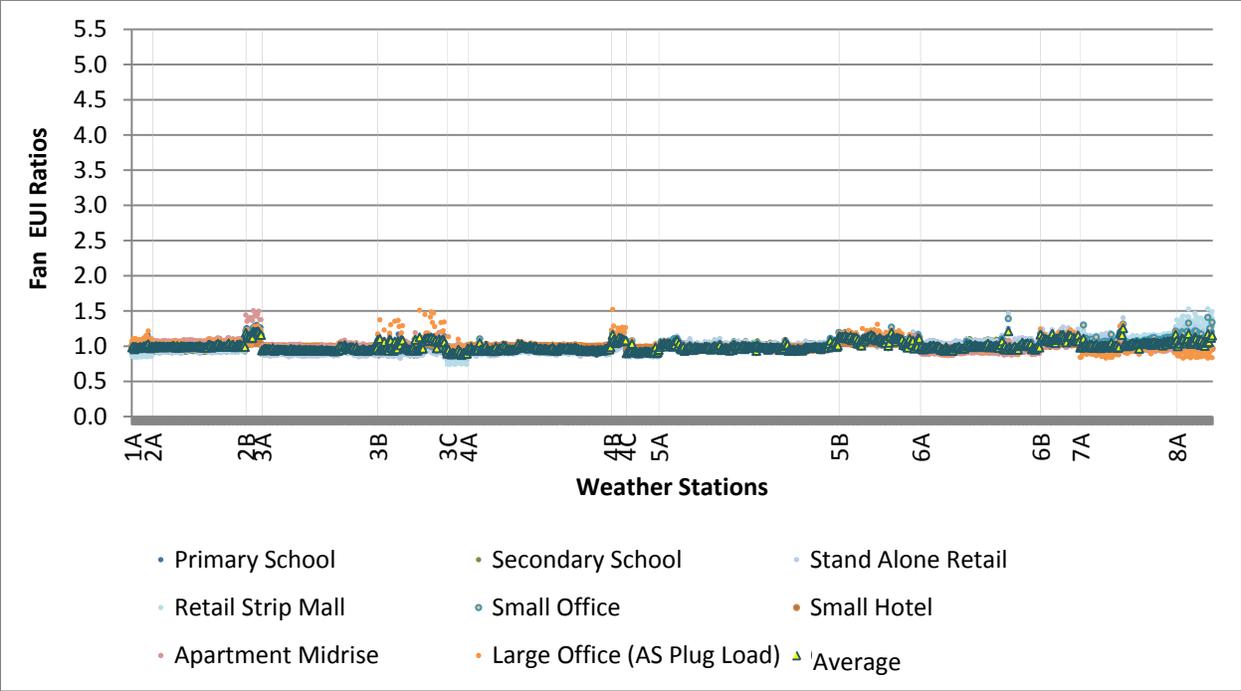


Figure 3.5. Fan EUI ratios of eight prototype buildings and their average.

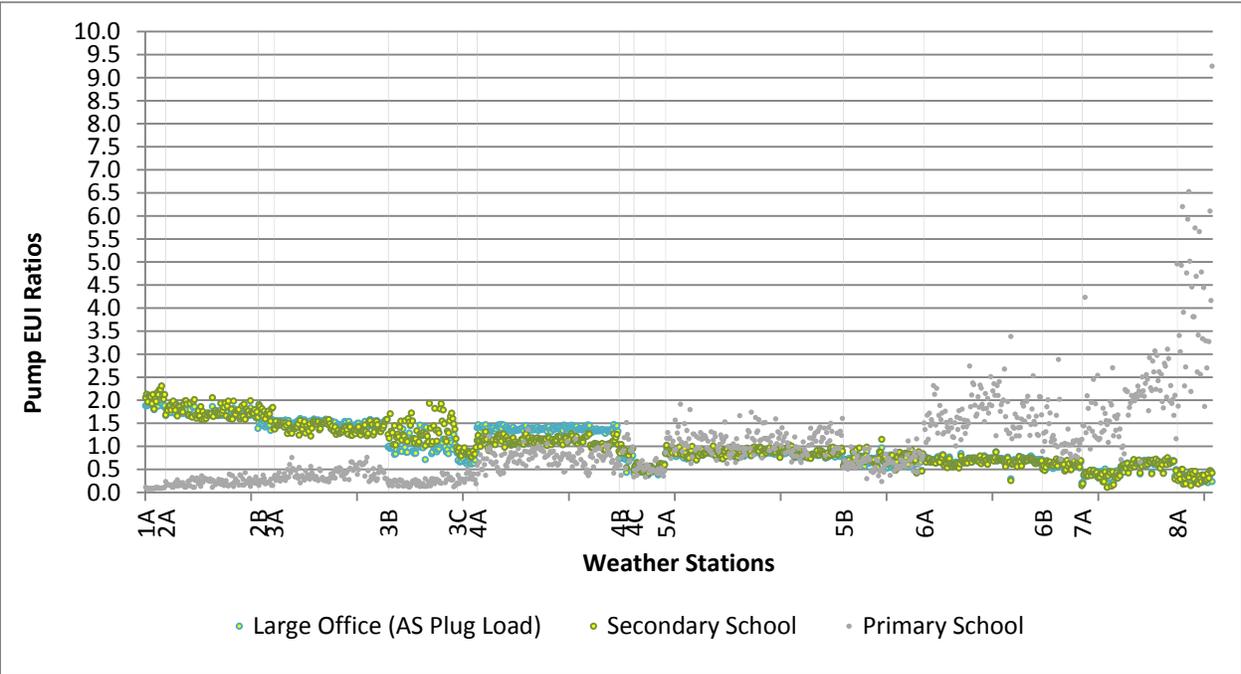


Figure 3.6. Pump EUI ratios of three building types.

Based on results observed, for simplification of implementation of weather adjustment, EUI Ratios derived from multiple prototype buildings were combined into a single EUI Ratio, the inverse of which was used as a single coefficient for each weather-sensitive end use (heating, cooling, and fans) and weather station location. The average coefficient for the eight prototype buildings (excluding for

warehouse) was calculated and the final weather coefficients for these use types that are included in the first two phases of the Asset Score were collapsed into three sets of coefficients (heating, cooling, and fans) for each of the 1008 available weather locations.

Figure 3.7 through Figure 3.9 show the heating, cooling, and fan EUI ratios of warehouse. The much greater discrepancy observed in behavior of the warehouse building type in response to weather was caused by its low requirements for ventilation and space conditioning due to its nearly zero occupancy. Also, lower levels of required envelope insulation for the set of buildings grouped into this category also lead to more variation based on weather. Therefore, the Asset Scoring Tool uses a separate set of coefficients for warehouses, derived from the warehouse prototype building. The final coefficient tables for all use types can be found in Appendix C.

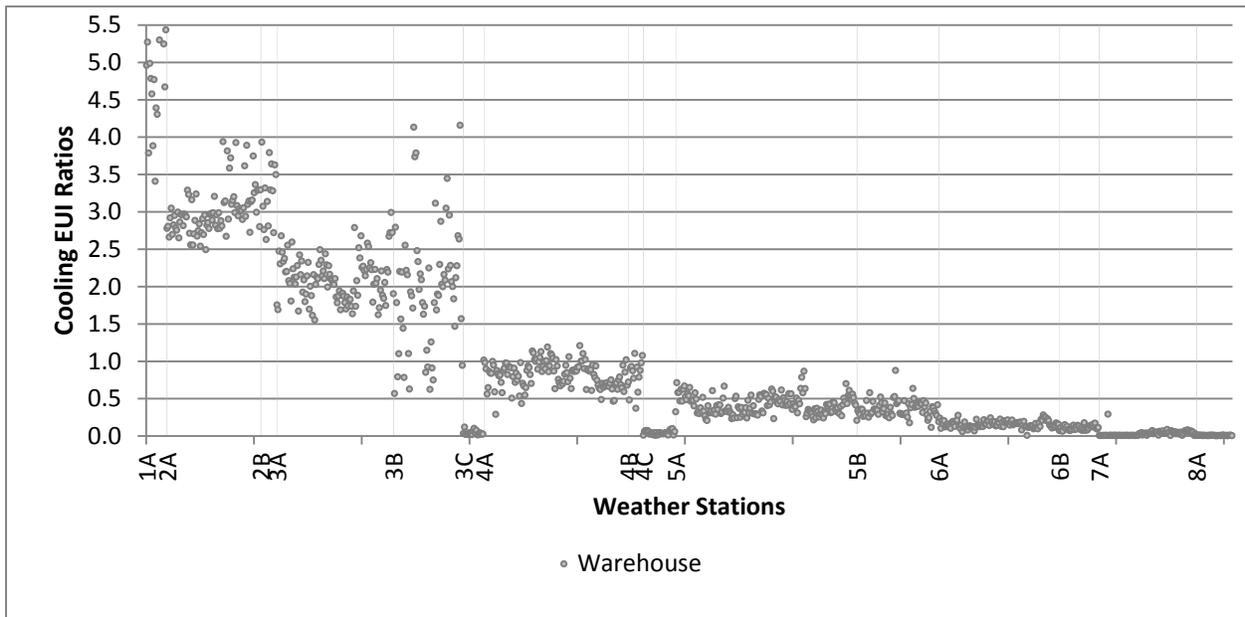


Figure 3.7. Cooling EUI ratios of warehouse (separated because of observed difference in response to weather when compared to other building types).

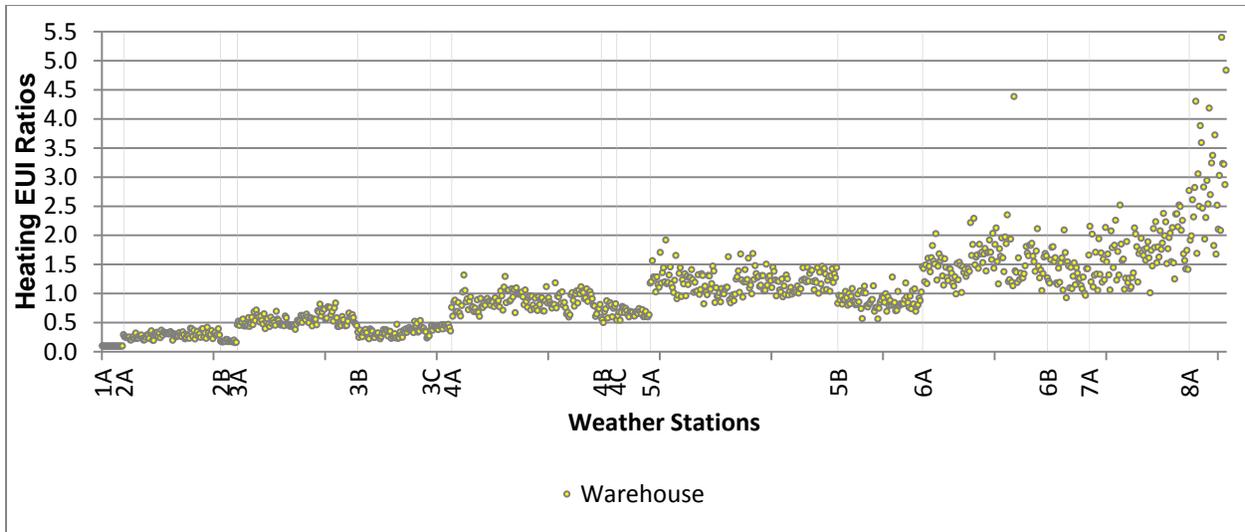


Figure 3.8. Heating EUI ratios of warehouse (separated because of observed difference in response to weather when compared to other building types).

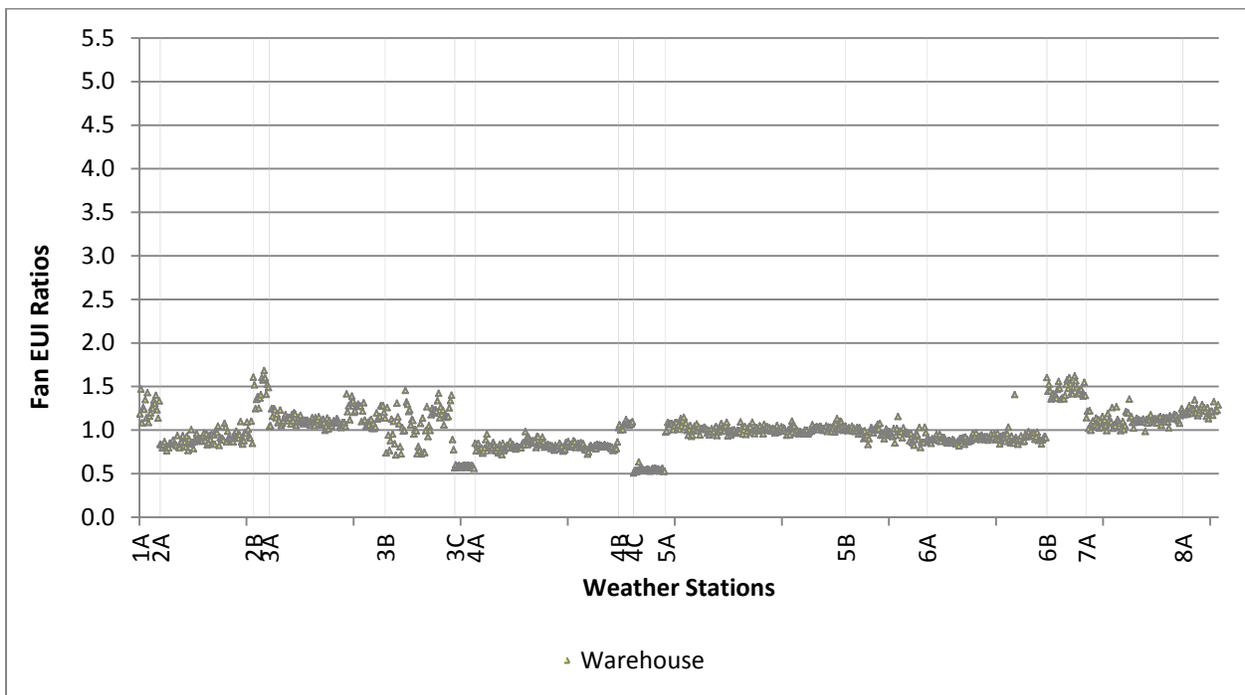


Figure 3.9. Fan EUI ratios of warehouse (separated because of discrepancy in response of fan load to weather when compared to other building types).

3.2.4.3 Implementation of Weather Coefficients

The weather coefficients were implemented into the database of the Asset Scoring Tool. After the simulation engine generates the breakdown of energy use for each end-use of a building, heating EUI, cooling EUI, and fan EUI are calculated as the first step of the data post-processing. Corresponding coefficients are then applied to the modeled heating, cooling, and fan EUIs to adjust them for differences

in weather. For example, given the modeled end-use EUIs of a candidate building “A” located near weather station site 1, the adjusted site EUI is calculated as shown in Table 3.4.

Table 3.4. Example of calculating weather-adjusted site EUI

Site EUI (electricity)	Coefficients			Adjusted Site EUI (electricity)	Site EUI (gas)	Coefficients			Adjusted Site EUI (gas)
$EUI_{\text{heating_elec}}$	X	$\text{Coeff}_{\text{heating}}$	=	$EUI_{\text{heating_elec_adj}}$	$EUI_{\text{heating_gas}}$	X	$\text{Coeff}_{\text{heating}}$	=	$EUI_{\text{heating_gas_adj}}$
EUI_{cooling}	X	$\text{Coeff}_{\text{cooling}}$	=	$EUI_{\text{cooling_adj}}$					
EUI_{fans}	X	$\text{Coeff}_{\text{fans}}$	=	$EUI_{\text{fans_adj}}$					
EUI_{pumps}				EUI_{pumps}					
EUI_{lighting}				EUI_{lighting}					
$EUI_{\text{plug loads}}$				$EUI_{\text{plug loads}}$					
Adjusted Site EUI Total (Electricity)					Adjusted Site EUI Total (Gas)				

After weather adjustment, the adjusted site EUIs are converted into source EUIs (based on the fuel specific coefficients discussed in section 3.1.2), the total of which is then used for scoring. The adjusted EUI is not intended to represent the building energy use. Rather, it is used only to calculate a building’s Asset Score as a comparison to the performance of similar buildings in other locations. Therefore, to avoid confusion, the adjusted EUI is not shown on the Asset Score Report. The building energy use data presented on the Asset Score Report (e.g., energy use by system or by fuel type) is the modeled EUI before weather adjustment.

3.2.4.4 Test of Weather Coefficients

Testing the applicability and expandability of the weather coefficients is challenging because the various combinations of commercial building type, design, thermal properties, and mechanical systems cannot be simply summarized. Simulating buildings using all weather files in EnergyPlus requires a significant amount of time and effort. Therefore, a series of testing procedures was designed to maximize testing results through a reduced number of simulations.

Testing was carried out in four parts (four test scenarios). In the first test scenario, energy consumptions of several DOE commercial reference buildings were adjusted across all weather stations to investigate how well the coefficients can adjust for impact of weather. In the second test scenario, the coefficients were tested on real buildings from the 2012 pilot. Three buildings from the 2012 pilot were selected with different sizes, designs, thermal properties, and mechanical systems. Their EUIs were adjusted across all weather stations. In the third test scenario, all buildings from the 2012 pilot were adjusted for their own weather location (NOT all 1008 weather locations). This test was to demonstrate the impact of weather adjustment on the scoring of a set of random buildings across the country. In the fourth test scenario, weather coefficients were tested on a large number of randomly sampled buildings (generated by computer) modeled at the representative cities of each climate zone. These randomly sampled buildings were also used to develop the Asset Score scale, which is discussed in section 3.2.5.

The test results show that the weather coefficients effectively reduce EUI variation due to the weather impact and enable a fair comparison of buildings at different locations. As discussed previously, it is impossible to totally eliminate the weather impact using a predefined set of coefficients developed from the 2004 prototype buildings. The goal is to minimize the weather impact to the fullest extent possible and acceptable. The application of these weather adjustment coefficients is expected to result in controlling the score impact of location to within 3 points. These four tests and results are further explained in Appendix B.

3.2.5 Scale Development

3.2.5.1 Definitions of the Two End Points

Developing the energy asset scoring scale begins with defining the EUI for the two end points, 1 and 100, with the high end of the scale representing the most highly-efficient buildings.

During the 2012 pilot project, a score of 100 was equated to zero net energy use. A benefit of setting 100 at net zero energy is that the high end of the scale would never need to change. However, the net zero setting has drawbacks as well. First, the current scoring tool does not capture renewables, making it impossible for any building at this time to score 100 (if this end point was pegged at net-zero energy use). Second, even after renewables are incorporated into the tool, very few net-zero energy buildings exist today. As observed in the 2012 pilot, the net-zero end point also made it difficult for highly efficient buildings to obtain high scores (e.g., above 90). Given these realities, DOE reconsidered how to set the EUI for the 100-point rating on the scales for different building types. For the purpose of 2013 pilot, DOE equated a score of 100 to the lowest EUI that can be achieved with current technologies. While that EUI still represents a “stretch” goal, it is now one that is attainable by a larger segment of the existing market, and more feasible as a goal for new construction.

The low end of the scale represents the most inefficient buildings. However, DOE has chosen not to use the least efficient building in today’s commercial building stock to define the score of 1 because this would skew the scale toward the low-efficiency end. To that end, the 90th percentile of the CBECS data was used to set the EUI for “1” on the scale for some use types. Furthermore, it should be noted that a score of 50 does not necessarily correspond to the mean or median of any database because the energy asset scoring scale is not a statistical scale but an interval scale tied to source EUI.

3.2.5.2 Progressive Binning with 2004 Prototype Buildings as Control Points

To be effective, the energy asset scoring scale needs to reflect the variability within the building stock and recognize the energy efficiency improvements of both low- and high-efficiency buildings. A uniform scale is simple to implement. On a uniform scale, the decremental EUI, that is, the amount of energy reduction required to earn an additional point, is constant across the entire scale. However, given the fact that it is usually more expensive to further reduce energy use in a highly efficient building where all of the low-cost measures have been implemented, a uniform scale may make the low-score end too easy and high-score end more difficult. Therefore, progressive bins are used to define the scale—at the low-score end, the decremental EUI is higher. Prototype buildings compliant with ASRAHE Standard 90.1-2004 are used as control points to make the scales more comparable across different building types.

3.2.5.3 Example of Scale Development

In this section, office building type is used as an example to describe the procedure of scale development. The scoring scales for other building types are included in Appendix D.

NREL performed a sensitivity analysis on the Asset Score input variables (NREL 2013). Through this analysis, building types included in the first two phases of the Asset Score were simulated and examined with various combinations of building characteristics (Asset Score inputs) based on 2004 prototype buildings. These building models representing the least and most efficient buildings and hundreds of thousands of variations in between were also used for developing the most appropriate range of EUIs for the 1- to 100-point scale. Note that these models used the same building operating assumptions as defined for Asset Score. Therefore, they are more relevant in setting the scale than CBECS data in which building operation plays a significant role in the total energy use of each building.

More than 120,000 simulation runs were carried out for the office use type, including small, medium, and large office buildings. The output is a large set of building energy use in 17 climate zones. Figure 3.10 shows distribution of simulated source EUIs found for the medium and large office buildings.

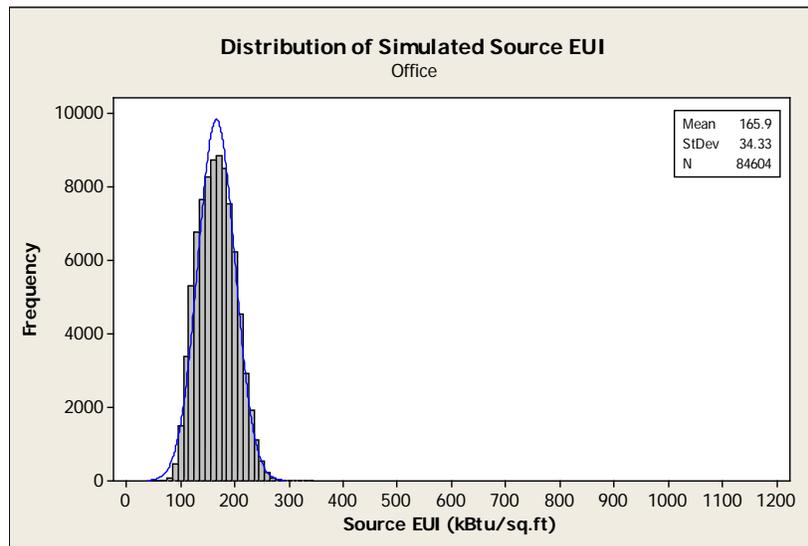


Figure 3.10. Distribution of office source EUI from simulations.

Data from the 2003 CBECS (EIA 2006) were used as another resource to understand the building stock and to establish the energy asset scoring scale. The CBECS is a national survey that collects information on the stock of U.S. commercial buildings, their energy-related building characteristics, and their energy consumption and expenditures. The CBECS data provide only measured energy use, which is the outcome of a building's as-built efficiency and its actual operational choices. Under standard operational choices (to calculate Asset Score), the energy use of a building in the CBECS database could be higher or lower than its measured value. Although being less applicable than the simulation mentioned above, CBECS provides a good reference to evaluate the energy asset scoring scale.

Energy use data by fuel types for office buildings (total 976 buildings), where the principal building activity is "Office," were extracted from CBECS. Source energy use of each office building was calculated using the national site-to-source conversion factors (Table 3.1). Figure 3.11 shows office building source EUI distribution from the CBECS database. CBECS office buildings have a wider range

of EUIs compared to simulation results because they include a larger variation of building operation and occupancy than the Asset Score database. Additionally, simulated EUI results are limited to the sizes, designs, and mechanical systems defined in the prototype models. Despite these discrepancies, the CBECS database provides a good external validation of the modeled data.

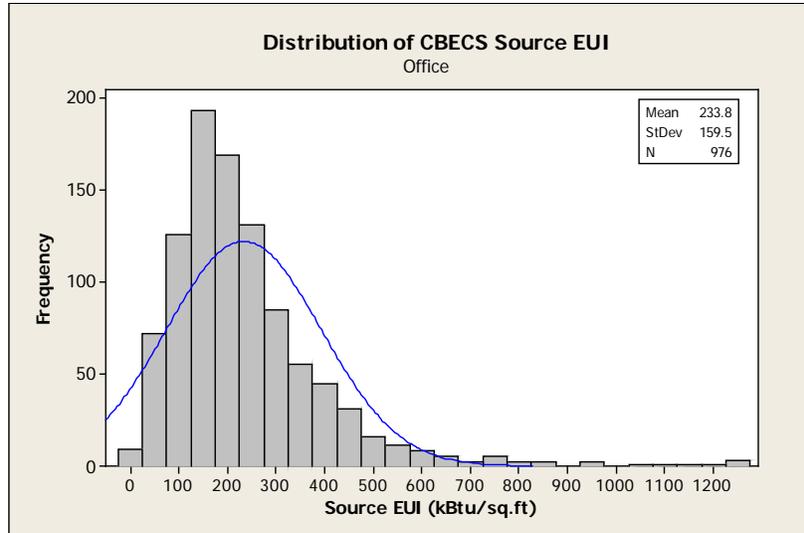


Figure 3.11. Distribution of office source EUIs from the CBECS database.

A progressive binning method was employed to establish an appropriate scale for the Asset Score. To establish a standard method for developing the progression of bins across building use types, three EUIs were first defined as control points. Selection of these EUIs was based on results from the simulations explained above, the CBECS data set, and 2004 prototype buildings:

- minimum EUI – Achievement of this EUI or lower entitles a building to receive a score of 100. Minimum EUI was set to be equal to the minimum EUI achieved in the simulation environment or the upper 10th percentile in CBECS data set when the simulated EUIs were significantly lower than the CBECS data.
- code-compliance EUI – Achievement of this EUI entitles a building to receive a score in the 60-70 range. Average EUI was selected as that of a prototype building complying with minimum requirements of ASHRAE Standard 90.1-2004.
- maximum EUI – A building with an EUI of this level or greater will receive a score of 1. Maximum EUI was selected to be equal to the lower 95th percentile of simulated EUI or the 90th percentile of the CBECS data.

A score table was developed based on this methodology (see Appendix D). The simulation data were then used to test the developed score table. Figure 3.12 shows the distributions of Asset Scores.

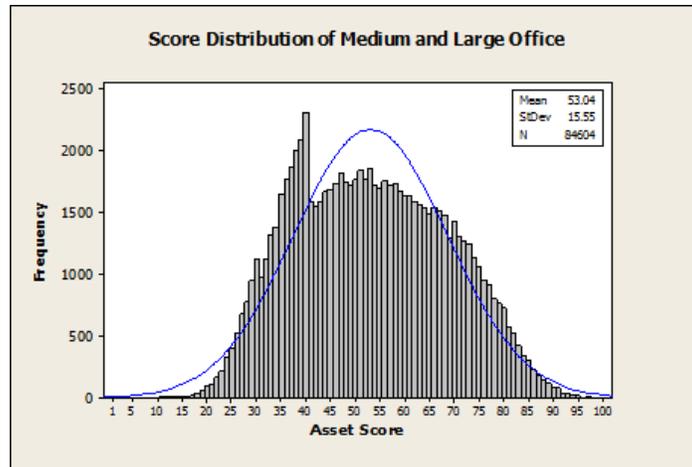


Figure 3.12. Score distributions of simulation data and CEBCS data.

The energy asset scoring scale was further evaluated using DOE prototype buildings. Three different models represent small, medium, and large office buildings. Two versions of each prototype building models complying with the minimum requirements of ASHRAE Standards 90.1-2004 and 90.1-2010 were tested. Table 3.5 shows the Asset Scores for six office models based on the average source EUI value of different climate zones. On average, the buildings compliant with Standard 90.1-2010 are expected to achieve a score above 80. This varies slightly depending on building type.

Table 3.5. Asset Scores for prototype buildings.

	90.1- 2004		90.1- 2010	
	Average Source EUI (kBtu/ft ²)	Asset Score	Average Source EUI (kBtu/ft ²)	Asset Score
Large Office	128	71	98	86
Med Office	158	56	110	80
Small Office	131	70	105	83
Average	139	66	104	83

3.2.6 Durability of Asset Scoring Scales

The durability of energy asset scoring scales (i.e., the period for which a scoring scale is valid) depends on three factors:

- changes in building stock due to advancement in energy efficiency technologies and their deployment
- equipment degradation with age and usage
- updates to underlying simulation software.

Given DOE's consideration of these factors as discussed below, DOE expects that a building's score will remain current for at least 10 years, as long as the building does not undergo significant infrastructure changes including replacement of asset-related energy systems. After establishing 100-point scales for all relevant building types, DOE expects that the scales can remain static for at least 10 years.

3.2.6.1 Changes in Building Stock

Table 3.6 shows that average commercial primary energy consumption intensities of existing buildings are projected to vary within 8 kBtu/ft² over the next two decades. On the current energy asset scoring scale (Appendix D), buildings need to reduce energy use by 2 to 8 kBtu/ft² (depending on the building types) to earn an additional point. An 8-kBtu/ft² variation in 20 years equates to a score change of 1 to 4 points on average. The scale can still effectively reflect the building stock in 20 years if the projected energy consumption is realized.

Table 3.6. Commercial energy consumption intensities prediction (DOE EERE 2011b).

3.1.3 Commercial Delivered and Primary Energy Consumption Intensities, by Year						
	Floorspace (million SF)	Percent Post-2000 Floorspace (1)	Delivered Energy Consumption		Primary Energy Consumption	
			Total (10 ¹⁵ Btu)	Consumption per SF (thousand Btu/SF)	Total (10 ¹⁵ Btu)	Consumption per SF (thousand Btu/SF)
1980	50.9	N.A.	6.02	118.3	10.62	208.7
1990	64.3	N.A.	6.76	105.2	13.39	208.3
2000	(2) 68.5	N.A.	8.22	120.0	17.22	251.4
2008	(2) 78.8	18%	8.62	109.5	18.47	234.4
2010	(2) 81.2	26%	8.54	105.1	18.35	226.0
2015	(2) 85.5	35%	9.02	105.5	18.94	221.7
2020	(2) 91.5	45%	9.51	104.0	20.22	221.0
2025	(2) 97.4	54%	9.96	102.3	21.43	220.1
2030	(2) 103.5	62%	10.51	101.5	22.75	219.7
2035	(2) 109.8	70%	11.07	100.8	24.02	218.8

Note(s): 1) Percent built after Dec. 31, 2000. 2) Excludes parking garages and commercial buildings on multi-building manufacturing facilities.
Source(s): EIA, State Energy Data 2008: Consumption, June 2010, Tables 8-12, p. 24-28 for 1980-2000; DOE for 1980 floorspace; EIA, Annual Energy Outlook 1994, Jan. 1994, Table A5, p. 62 for 1990 floorspace; EIA, AEO 2003, Jan. 2003, Table A5, p. 127 for 2000 floorspace; and EIA, Annual Energy Outlook 2011 Early Release, Dec. 2010, Summary Reference Case Tables, Table A2, p. 3-5, Table A5, p. 11-12, and Table A17, p. 34-35 for 2008-2035.

The DOE energy reduction goals are to develop strategies to construct new buildings that achieve improvements of 50% by 2016 (relative to ASHRAE Standard 90.1-2004) and for net-zero energy buildings to be a cost-effective alternative to traditional construction by 2025 (DOE EERE 2010). The rate of change in commercial building stock is expected to begin to accelerate rapidly if these goals are achieved. Taking office buildings as an example, if an across-the-board energy savings of 10% to 50% is achieved,¹ more than 40% of sample buildings would have Asset Scores between 80 and 100 (Figure 3.13). At that time, the low end of the scoring scale (a score of 1) would need to be adjusted to ensure the full range of the scale was related to the building stock. However, given the fact that a large fraction of existing building stock is unlikely to keep pace with the level of improvement for new construction, DOE will periodically review latest energy consumption data to determine whether updates to the scale are needed.

¹ 10–50% energy savings are applied randomly across the board. This is based on the assumptions that not all buildings achieve 50% energy reduction goals and DOE goals are targeting mainly new constructions.

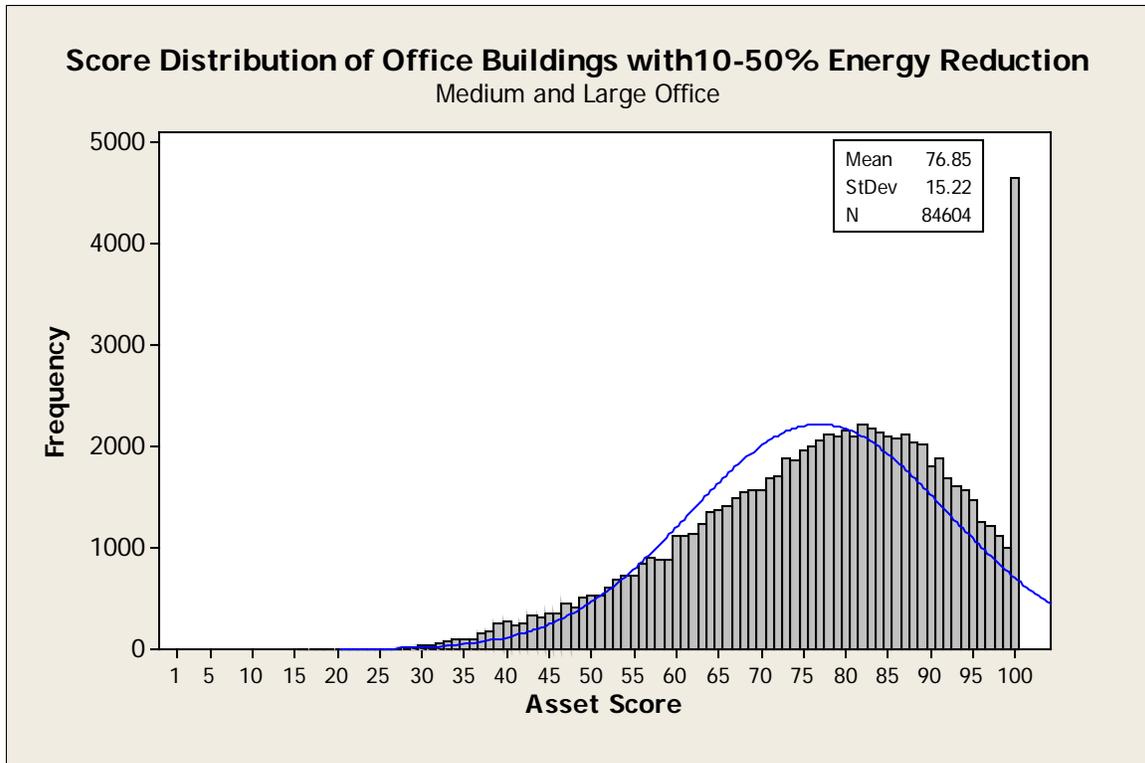


Figure 3.13. Improvement of energy performance with random 10–50% energy reduction over the simulated office buildings.

3.2.6.2 Degradation of HVAC Equipment

Degradation of HVAC equipment is another consideration when determining energy asset scoring scale durability. It is difficult to measure equipment degradation relative to initial conditions because many factors affect HVAC system performance and it can be impossible to separate equipment degradation from maintenance problems. For example, common problems such as leaves blown against the HVAC condenser coil and blocking airflow, a ductwork leak causing additional fan energy use, or an economizer being disabled may not be captured in an equipment test procedure, which evaluates system efficiency, but could be addressed in an operations and maintenance program. Some equipment degradation issues, such as refrigerant charge, compressor wear, expansion valve wear or failure, bending of condensers fins, filter clogging, or dirty condenser coils, can also be addressed with proper maintenance.

Drawing the line between equipment degradation with age and system maintenance/commissioning is complicated, and testing actual equipment efficiency is expensive. In addition, the literature review did not reveal any significant research on how aging influences HVAC system performance. A test on water heaters showed no clear correlation between age and the magnitude of performance degradation (Goetzler et al. 2011). Therefore, equipment degradation should not significantly affect the durability of the energy asset scoring scale. In other words, if a building does not undergo significant infrastructure changes, its Asset Score will remain the same until the scoring scale is updated.

3.2.6.3 Major Updates to Underlying System Software

The Asset Scoring Tool is built on EnergyPlus and the Facility Energy Decision System (FEDS). The tool development methodology is discussed in section 4. EnergyPlus generates the EUI, which is used to calculate a building's Asset Score. FEDS provides default or inferred values when a certain variable is not entered by users. FEDS also runs life-cycle cost (LCC) analysis to provide feedback on areas and options for energy efficiency improvement. An update to EnergyPlus has been released about every 6 months since 2001¹; the FEDS model has typically had at least a minor update every year or two and its EEM and cost database is updated every few years. Most often, the new features of the updated software extend modeling capability and increase simulation speed. New versions of software and their effect on Asset Scores will be examined annually.

The scoring tool will be updated periodically to incorporate new versions of the underlying energy models. Many of these updates are unlikely to affect the modeled results. However, if updates do change modeled results, tool users who have received an Asset Score will be notified and receive an updated score.

The EEM evaluation module will be updated regularly to reflect new technologies and cost information. These updates will not affect a building's score but may affect the identified options for energy efficiency improvement. For example, the lower cost of LED lights in the future may make this EEM applicable for more buildings. The building owners who have received an Asset Score will be notified about the updates. The building owners can choose to resubmit their buildings without modifying the building information. Neither of the above changes will require tool users to modify the data entered for their buildings. A building would need to be re-rated only if an energy efficiency upgrade were implemented.

As noted above, DOE expects that a building's score is unlikely to change for at least 10 years if no significant changes are made to building equipment. To the greatest extent possible, the scales and scoring tool are being designed to create enduring scores.

¹ EnergyPlus Release Schedule can be found at http://apps1.eere.energy.gov/buildings/energyplus/energyplus_schedule.cfm.

4.0 Asset Scoring Tool

This section describes the Asset Scoring Tool—the centralized modeling tool developed to facilitate application of the energy asset scoring system.

The basic criteria for establishing a national building energy score include the consistency, repeatability, and accuracy of the modeled results. Another consideration is the time and resources required to obtain a score. With energy expenditures in U.S. commercial buildings averaging \$2.44/ft² (\$26.26/m²) (DOE EERE 2011c), a 20% improvement in efficiency could yield savings of \$0.49/ft² (\$5.25/m²). However, a comprehensive energy audit and modeling analysis can cost up to \$0.50/ft² (\$5.38/m²) (CEC 2000; Carver 2011). The cost of audits depends on the location, level of detail, size, and complexity of the facility. For example, one consulting firm charges base fees of \$200 plus \$0.25/ft² for a Level 1 audit (walkthrough analysis) and \$200 plus 0.35/ft² for a Level 2 audit (energy survey and analysis) (Bluegill 2012). An environmental consulting and design firm that has assisted on Leadership in Energy and Environmental Design (LEED) projects estimated energy modeling costs of \$15,000 to \$30,000 per project (Northbridge Environmental Management Consultants 2003). Therefore, detailed audits and modeling can often be cost-prohibitive for all but the largest buildings and commercial building owners. While the Asset Score is not designed nor intended as a substitute for detailed audits and assessments, it is also recognized that even a more moderate cost burden related to data collection and modeling can impose a significant barrier to the implementation of the Asset Score.

The usability of the Asset Score is another critical criterion. Unlike large institutional investors who more actively benchmark their portfolios to improve the market value of their properties, many smaller-building owners/investors and owner-occupied building owners may lack motivation to obtain an Asset Score, given the relatively unimportant role that energy efficiency plays in real estate transactions in these markets. For this group of building owners, easy, ready access to suggestions for energy efficiency improvement is likely to be more valuable than a score.

Based on these considerations, DOE developed the Asset Scoring Tool as part of the Asset Score to facilitate application, reduce cost, and increase standardization, allowing for consistent and reliable comparisons. In addition to generating a building Asset Score, the tool provides users with information on the energy efficiency of their existing building systems and guidelines for improving their performance.

The Asset Scoring Tool is not intended to replace a full energy audit of a building, but rather to produce a preliminary assessment that can then direct more detailed energy analysis and investment. The tool has three objectives:

1. give property owners a way to gauge the efficiency of their properties compared both to a potential efficiency and to similar properties
2. provide guidance on key actions to motivate owners to make reasoned and value-conscious investments
3. enable the targeting of limited capital resources toward those areas that will produce the greatest return.

4.1 Modeling Approach: Dynamic Energy Simulation

All buildings are different, and conventional building energy modeling is in many ways as much art as science that requires each modeler to apply a substantial amount of judgment. This judgment leaves room for different interpretations of standards and different approaches to modeling a specific situation. While this flexibility can be a boon to modelers, it can create challenges when trying to compare models created by different individuals.

To avoid potential modeler bias and reduce the implementation cost, the Asset Scoring Tool is designed to reduce reliance on specialized energy modeling expertise. The tool sets out generalized procedures by using a uniform method of estimating building performance while following the applicable modeling requirements specified in Appendix G of ASHRAE Standard 90.1-2007 and COMNET.

After evaluating several options, including the pre-simulation method, time series data analysis, and normative calculation method (see Wang and Gorrissen 2013), DOE selected dynamic energy simulation as the modeling approach for the Asset Scoring Tool. DOE considered two different real-time dynamic building energy modeling options as a means to calculate building energy use:

- energy modeling based on an existing analysis tool, such as FEDS¹ (PNNL 2008) – This type of analysis tool usually offers a number of simplifying features to provide a tool that is easier to use and more accessible to a broader user group. Data input is typically less demanding and time-consuming than detailed building design models and analyses can be performed in a fraction of the time. While many of these features would benefit the needs of the Asset Score, a plan to follow this approach exclusively was abandoned due to a desire to have the greater modeling flexibility afforded by some of the more advanced sub-hourly simulation engines available on the market.
- a highly detailed, sub-hourly whole-building energy model – This approach can provide the level of detail required to model the most complex buildings being built today and produce results in which the end users would presumably have greater confidence (assuming that an established tool were used). The drawback of the detailed modeling approach is that if users need to provide all inputs required to build a detailed model, the tool will be limited to the most experienced user group and the modeling process would be highly time consuming and costly.

To overcome the inherent issues in each of the approaches examined, while taking advantage of their relative strengths, the Asset Scoring Tool is built on a combination of an analytic tool and a sub-hourly energy-modeling tool. The Asset Scoring Tool includes a simplified user interface, an analytic engine, and a detailed energy modeling engine. The user interface enables the creation of a simplified building geometry and the collection of a reduced set of model inputs. EnergyPlus,² a widely accepted building energy modeling tool, is used to generate a whole-building energy model. One reason to use a detailed energy model is to enable users to store their building information in a standardized model that can be user-downloaded and used for other purposes. Although a sub-hourly simulation may provide more detail than needed for an Asset Score at this stage, the approach provides opportunities for future expansion. This method is in essence similar to the wizard levels (schematic and design development) of eQUEST.³ In the wizards, all inputs have defaults based on the California Title 24 building energy code, requiring

¹ <http://www.pnnl.gov/feds/>

² <http://apps1.eere.energy.gov/buildings/energyplus/>.

³ <http://doe2.com/>.

less building modeling experience to operate. To use eQUEST’s detailed interface, users must have extensive knowledge of building technologies and experience with energy simulation tools.

To link a simplified user interface with a detailed energy model input for the Asset Scoring Tool, it was necessary to use an analytic engine to infer additional building variables not entered by users. This was accomplished by building on the aforementioned existing analytic tool—FEDS (PNNL 2008). FEDS maps out one-to-many relationships between the different building characteristics, which are derived from a number of sources listed in section 4.4.2.

These relationships, integrated into the FEDS model (PNNL 2008), when combined with additional assumptions and settings specific to the Asset Score approach, allow the Asset Scoring Tool to produce the required detailed inputs from a small subset of user inputs. The smallest allowable set of user inputs is described as the simple-level input set. This input level is required by all tool users, and therefore was developed to be relatively simple to collect accurately. This set of simplified inputs is then used to predict the remaining building characteristics to make the tool useful to a wide set of user groups, including building owners. Generated input values are arrived at by a number of means. All are based in some way on user inputs, such as building location and age (Table 4.1). These inputs are used in conjunction with data derived from a wide range of sources, listed above. As users include more detailed inputs on the way to the advanced-level set, the energy model results reflect the added detail by becoming more tailored to the user’s specific building.

Table 4.1. Model input generation methodology.

Minimum User Inputs	Inferred Values for Energy Model	Values Based on
Roof type	Roof assembly U-value, insulation thickness/R-value	Roof type, building location, year of construction, wall type, use type
Wall type	Wall assembly U-value, Insulation thickness/R-value	Wall type, building location, year of construction, use type
Window framing type and glass type	Window U-value, Solar heat gain coefficient	Window framing type and glass type
Lighting type and % of floor served	No. of fixtures	Standard illuminance levels for the building space type
Cooling equipment type	Cooling coefficient of performance (COP)	Equipment type and year of manufacture (assuming typical replacement rates based on the type of equipment)
Heating equipment type and fuel	Heating efficiency	Equipment type and year of manufacture (assuming typical replacement rates based on the type of equipment)
	Thermal zone layout and perimeter zone depth	Building footprint dimension
Service hot water type and fuel	Hot water system efficiency	Equipment type and year of manufacture (assumed to be year of construction if not entered by users)

The combination of the simplified user interface, an analytic engine, and a modeling engine makes the final tool user-friendly to encourage broad adoption and provides the accuracy, detail, and extensibility needed for applicability across the wide range of variation that exists within the built

environment. Two key elements of this approach are data collection design and parameter categorization into different levels of input sets. The Asset Score data inputs are outlined in the following sections.

4.2 Asset Score Data Input Requirements

Building performance is determined by multiple factors, including building function and design, local climate conditions, system operation, occupancy and occupant behavior, and system maintenance and equipment and building component degradation. To account for this, the energy modeling methodology for the Asset Score defines a consistent set of inputs for energy asset characteristics and standard assumptions for characteristics of non-energy assets. When the set of required user-collected inputs is defined, the focus is on factors that drive the most significant changes in energy efficiency. Interviews and feedback received during the development of the Asset Scoring Tool reflected responses from a mix of stakeholders; although there is a concern over additional burden of time and expense, some stakeholders also desired the ability to provide more detailed energy modeling inputs to build greater confidence in simulation results. The following sections describe the inputs required for the Asset Scoring Tool, with consideration given to such stakeholder feedback.

To determine the required inputs that Asset Scoring Tool users would be expected to provide, the input variables had to be classified. A comprehensive list of building characteristics that influence building energy consumption was collected and analyzed. Variables related to operational choices were removed from the list, then the potential energy asset rating variables were assessed based on ease of collection by target user, impact on energy consumption, and expected variability between buildings. The data selection process was described in Program Overview and Technical Protocol Version 1.0 (Wang and Gorrissen 2013).

4.2.1 Input Set Levels

The Asset Score variables correspond to the input thresholds for two use-cases, each having a unique purpose and target users and thus having different levels of requirements for data reliability (Figure 4.1).

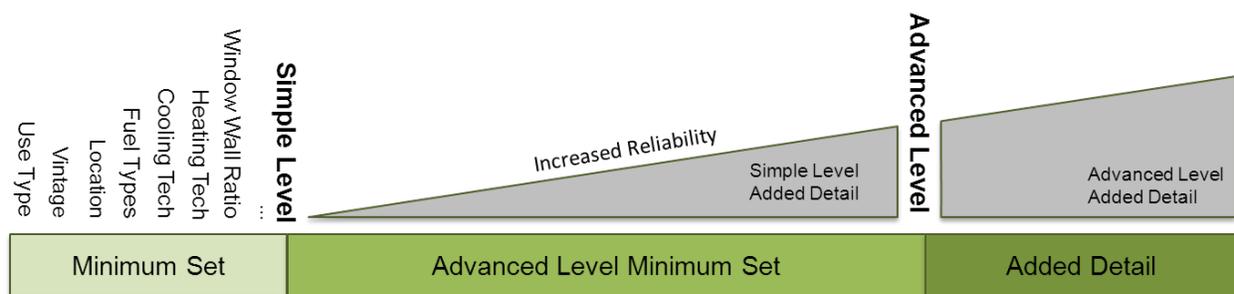


Figure 4.1. Different levels of data collection.

Simple-level use requires a reduced set of key building characteristics from the user. Its use is not recommended for official purposes, such as real estate transaction, appraisal, or public display. The application for this set of inputs represents a preliminary analysis of building performance and guidance in finding potential areas for building performance improvement. These variables are generally quick to collect and do not require a high level of building energy domain expertise to accurately ascertain. If a

variable deemed slightly more time consuming to collect is placed into this category, it is because it is considered to be highly important in accurately assessing a building's total energy consumption.

Advanced-level use requires more data from the user. If a stakeholder wants to use a score for official purposes, it is likely that the advanced level would be required as well as some type of validation of the score and data inputs. These inputs have been selected to produce more robust predictions of building energy use and likely areas for cost-effective asset upgrades. Added details beyond the advanced level can provide more insight into the performance of the building being examined. Examples of these additional inputs include air infiltration rates and fan blade efficiencies. However, these variables are usually more difficult to capture. Currently, assumptions are made based on the building construction and vintage and equipment type. These data will be further examined in the future sensitivity analysis.

4.2.2 User Requirements

Commercial property owners, managers, and operators are expected to be the primary users of the Asset Scoring Tool. Secondary users of the Asset Score may include lenders and investors, appraisers, and designers/engineers. Owners of larger properties or portfolio owners may use the tool as a first pass, essentially a preliminary energy report to assess their buildings and prioritize which buildings should be investigated further using a more detailed energy audit. Smaller property owners can use the tool as a low- or no-cost way to evaluate energy efficiency and identify opportunities for improving building performance. At a minimum, the individual collecting the building information needs some familiarity with building systems and the process of extracting building characteristics from drawings and equipment cut sheets, or have ready access to people with such experience. There is no qualification requirement for users interested in generating a score for informal purposes. However, user requirements to ensure quality of the data will likely be needed for score validation.

4.2.3 Data Collection Time

In addition to the input variable classification described in the previous sections, the process of data collection was classified based on likely information source and the time estimated to collect it. Some information will likely be immediately known to the facility manager (e.g., number of floors, HVAC system type), whereas collecting other inputs may require referring to the architectural or mechanical construction drawings or equipment cut sheets (e.g., window-to-wall ratios, fan airflows), or performing onsite measurement (e.g., air infiltration). These inputs were further classified as immediate, short, and long, based on the time required to collect the information as described in Table 4.2. The estimated average time for collecting data of the immediate, short, and long variable types is less than 2 minutes, 5 to 10 minutes, and 10 to 30 minutes, respectively, given appropriate level of expertise and access to building systems or data. Note that some onsite measurement such as a blower door test can be more time consuming; therefore, informed estimates can often suffice. The total required time is estimated to be less than 6 hours for the simple level and less than 20 hours for the advanced level, based on the interviews with the experienced energy auditors at PNNL. The 2012 pilot project showed that the average data collection time is 6 to 8 hours. This is based on surveys among a mixed group of simple- and advanced-level users. The 2012 pilot participants also indicated that the simple level data are easy to collect.

Table 4.2. Estimation of data collection time.

Data Collection Time	Data Description
Immediate (easy)	Information immediately known to a person experienced with the building; e.g., number of floors, HVAC system type.
Short (moderate)	Information that may be obtained immediately after referring to the building drawings; e.g., wall construction, thermal zoning.
Long (difficult)	Information that may be obtained after studying the building drawings or equipment specifications and performing further analysis, or through an onsite measurement; e.g., air infiltration, cooling tower fan power.

4.2.4 Automated Error-Checking for Quality Assurance

The accuracy of user inputs is essential for the accuracy of the modeled results. The Asset Scoring Tool gives users a warning message when automated checks suggest that data entered may be incorrect or incomplete. Users cannot submit their building information if any required data are missing. Users may leave non-required fields in the application set at their respective defaults, allowing the system to infer values based on reported characteristics of the building. If users enter an invalid value, they will be informed of the proper range of the input. Additional data quality assurance will rely on qualified assessors to verify the submitted data. This mechanism is still under development.

4.3 Building Use-Dependent Operational Settings

The Asset Score disaggregates building energy use information by simulating building performance under standard operating and occupancy conditions. Focusing only on buildings' physical characteristics and removing occupancy and operational variations allows "apples-to-apples" comparisons between differently operated buildings. To evaluate building energy use under typical operations, maintenance, and occupancy conditions, inputs related to building operation and maintenance are standardized. Operating assumptions include thermostat settings, number of occupants, and receptacle, process, and hot water loads. Schedules of operation for HVAC, lighting, and other systems also are included. Assuming all buildings of a similar type have identical hours of operation and occupancy patterns allows the Asset Scoring Tool to focus on the as-built efficiency of a building.

Appendix G shows the standard operating inputs currently used in the Asset Scoring Tool. The data are derived from ASHRAE Standard 90.1-2013. The model assumptions that are not specified in ASHRAE Standard 90.1 follow the inputs as specified in the DOE commercial prototype buildings models or use EnergyPlus defaults (NREL 2011).

4.4 Software Development

The Asset Scoring Tool has three components (Figure 4.2):

- user interface
- analytic engine (infers model parameters not entered by users; identifies areas and options for energy efficiency improvement; assigns a whole building score as well as qualitative assessments of individual building systems)
- modeling engine.

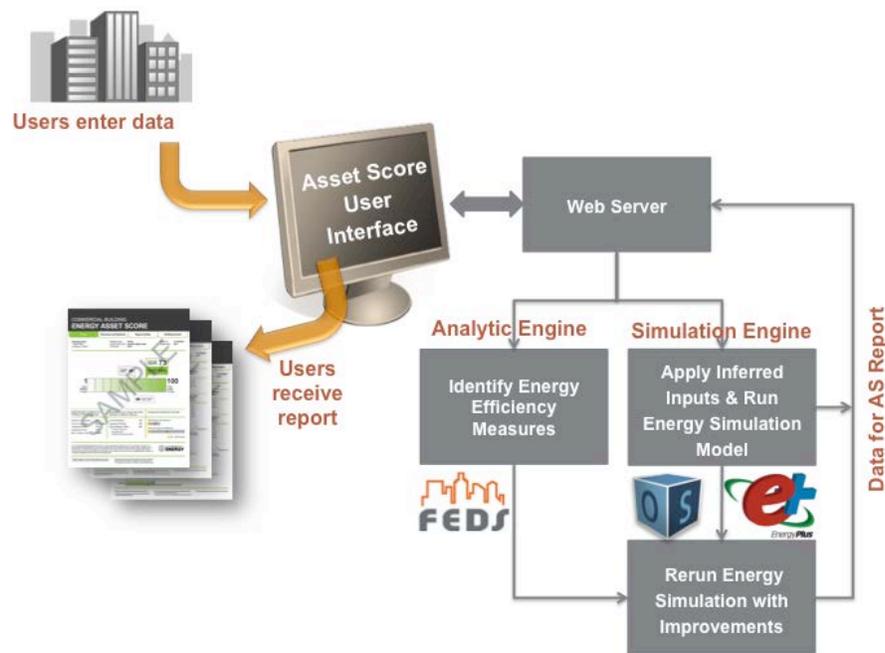


Figure 4.2. Asset Scoring Tool components.

4.4.1 User Interface

The user interface allows the user to create any number of buildings, each of which can contain multiple blocks (Figure 4.3). Each block will be one of six different shapes (rectangle, courtyard, L, H, U, or T), and the user can specify values for the following seven categories:

- building information, including location, year of construction, use type, number of floors, floor-to-ceiling height, and orientation
- block geometry dimensions
- opaque envelope characteristics, including wall, roof, and floor construction types, insulation thickness, and R-value
- glazing specifications, including window and skylight layout and size, framing types, solar heat gain coefficient, and U-value

- lighting characteristics, including luminaire type, number, and lighting control systems
- HVAC system characteristics, including zone layout, HVAC types, efficiencies, and capacities
- water heater type, capacity, and efficiency.

As the users work, they see a live 3D representation of the building, which can be manipulated to accurately represent the shape of the building being modeled.

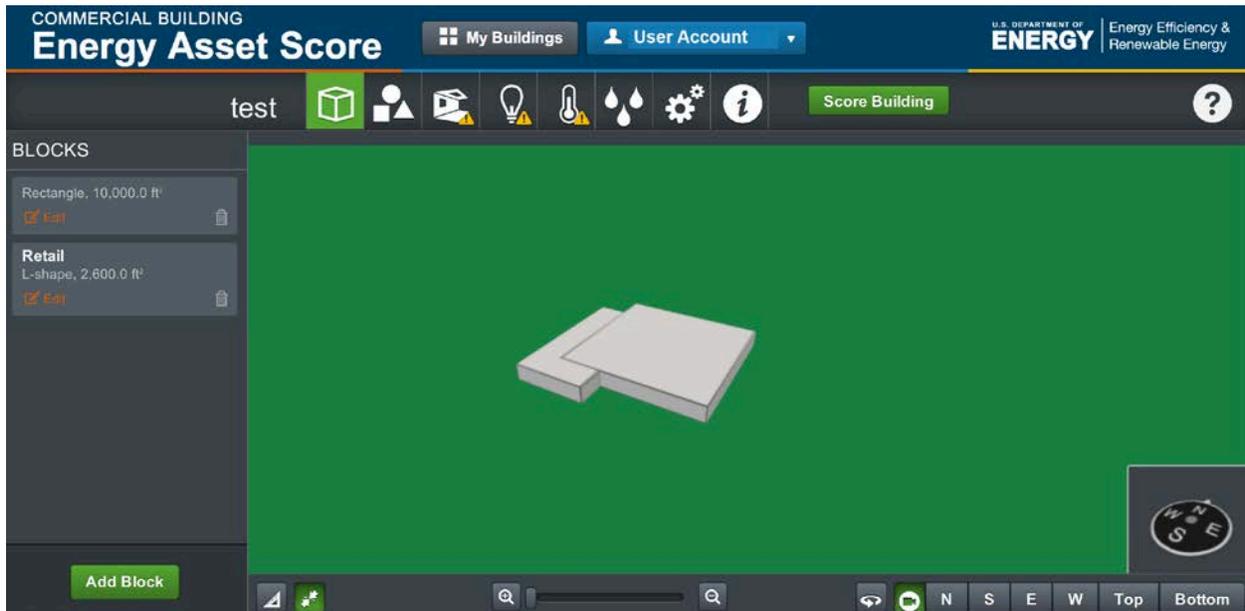


Figure 4.3. Asset Scoring Tool user interface.

4.4.2 Analytic Engine

To minimize effort for the user, a mechanism was needed to predict a building’s difficult-to-find characteristics. Most existing modeling tools either use the chosen energy codes to provide defaults or rely on a regional database that applies only to a certain climate condition. FEDS—developed by PNNL to facilitate performing large numbers of building energy audits over a short period of time (PNNL 2008)—has been identified to meet the requirements of Asset Scoring Tool development. The similarity between the existing FEDS tool and the Asset Scoring Tool, as well as the established nature of the FEDS system and the in-house access to the FEDS developers, led DOE to adopt both the FEDS inference approach and the FEDS retrofit optimization techniques for use in the Asset Scoring Tool. The constraints of that task closely mirror those of a low-cost Asset Scoring Tool.

The FEDS tool inferences are derived from multiple sources and techniques, including the following:

- dummy variable ordinary least squares regression of CBECS data based on age, use type, size, and climate
- equipment efficiency standards
- building energy codes and adoption rates
- ASHRAE handbooks (*Fundamentals* and *HVAC Systems and Applications*)

- energy model internal system sizing algorithms
- previous research, including the Bonneville Power Administration End-Use Load and Consumer Assessment Program (ELCAP; Pratt et al. 1991).

4.4.3 Energy Models

In addition to data-driven inferences, FEDS uses an internal energy modeling system to predict the necessary system capacities for a specific building. This approach is based on the cooling load temperature difference/cooling load factor method outlined in the 1989 *ASHRAE Handbook—Fundamentals* (ASHRAE 1989). This widely-used load prediction method allows for the rapid determination of a building’s heating and cooling load. This load is then used in conjunction with the system parameters specified by the user to estimate the required equipment capacity for a building. These system capacities, along with system age and type, are then used to infer expected system efficiencies. The internal energy simulation model is also used to select a package of LCC-optimized EEMs as described in section 5.4.

When the necessary building characteristics have been inferred, such that a complete building data description is available, it is then necessary to predict the energy consumption of the building based on those characteristics. EnergyPlus was selected as the tool to perform this estimation. Built on OpenStudio¹ (a cross-platform collection of software tools to support whole-building energy modeling using EnergyPlus), a web service translates the user inputs and inferred variables into the complete set required for an EnergyPlus simulation.

4.4.4 Data Processing and Report Generation

Figure 4.4 illustrates how the Asset Scoring Tool processes data and generates an Asset Score Report. The steps are as follows:

1. The user interface collects all pertinent data available from the user.
2. The web service passes data through to the FEDS engine.
3. FEDS fills in default building information and missing user data to produce a complete building data file. This data file is also used within FEDS to evaluate potential EEM opportunities—the method is explained in section 5.4.
4. The original building configuration data and the EEM-implemented building configuration data are sent back to the web service.
5. The web service builds two energy model files—current building and upgrade building—and passes them to EnergyPlus to perform the detailed energy simulation. OpenStudio runs the energy simulation. This will allow the Asset Scoring Tool to expand its functionality when more features are added to OpenStudio.
6. The results of the EnergyPlus simulation are combined with the identified EEMs and passed back to a report processor in the web service.
7. An Asset Score Report is sent to the user.

¹ <http://openstudio.nrel.gov/>.

All user-entered data and the final Asset Score and report are also written to a database in parallel with the above steps.

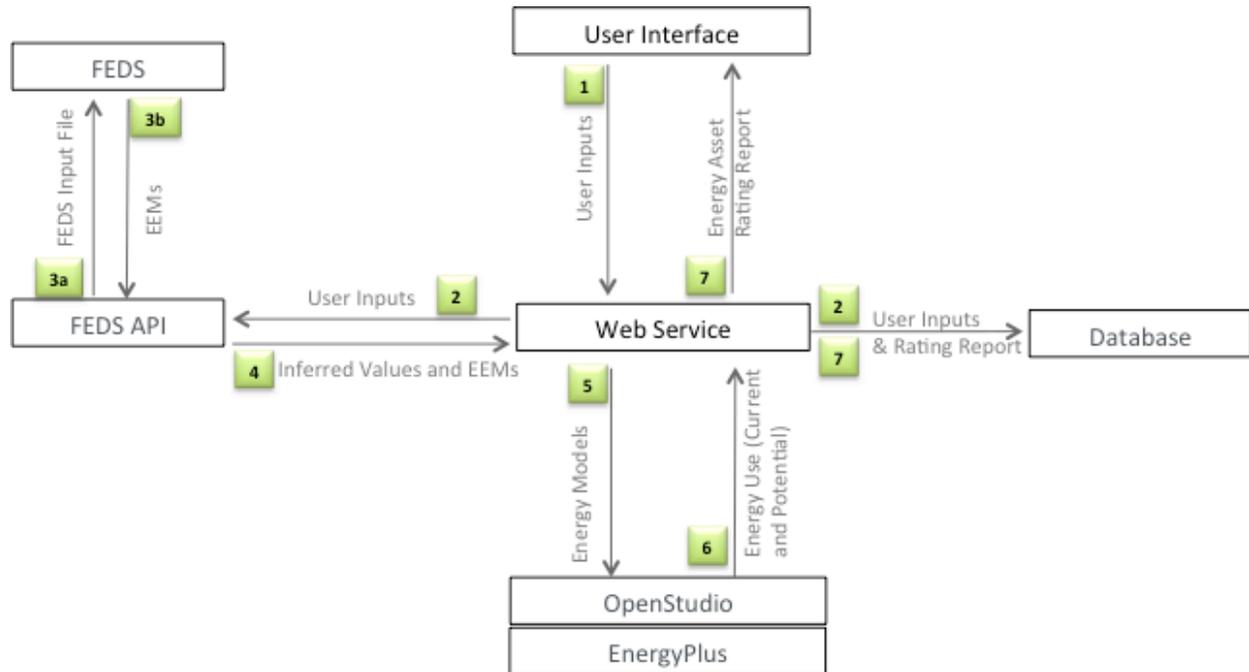


Figure 4.4. Asset Scoring Tool architecture.

5.0 Asset Score Report

5.1 Report Structure Overview

The Asset Score Report includes four sections: score, system evaluation, example opportunities, and building assets.

- The *score* page includes basic building information (e.g., address, floor area, year built, use type), standard operating assumptions, site and source EUIs by fuel type, current Asset Score, and potential score that could be achieved with upgrades.
- The *structure and systems* page includes site and source EUIs by system, as well as evaluations of building envelope and lighting, HVAC, and hot water systems.
- The *opportunity* page provides feedback on areas and options for energy efficiency improvement, with estimated energy savings and possible payback period.
- The *building assets* page provides a list of building characteristics as input and used in the energy asset model.

A sample report can be found in Appendix F.

DOE is also considering working with interested partners to include local benchmark information on the Asset Score Report for comparison. For example, a state might wish to include information pertaining to average Asset Scores for a specific building type within the state. Additional information that is not currently in the report may be provided in the future, such as a reference point to help users understand how their building score compares to a specific energy code, indication of whether the building has systems to provide a certain amount of energy from onsite renewables, and greenhouse gas emissions.

5.2 Scores

The primary modeling output of the Asset Scoring Tool is the EUI, which is used to generate the Asset Score. No baseline or comparable buildings are needed because the calculated EUI is placed on a fixed scale. The scale development and score calculation are discussed in section 3.2.2. Two sets of scores (current and potential) and associated modeled EUIs are presented on the same energy asset scoring scale (Figure 5.1).

The Asset Scoring Tool identifies and reports generalized building upgrade considerations based on LCC analyses of potentially applicable EEMs. While standard operating conditions are applied for the development of the score, users are able to specify select operation parameters (total occupants, temperature set points, operating hours, and miscellaneous loads), for the purpose of evaluating recommendations that are more applicable to their buildings than under the standard operating conditions. In many cases, the differences will likely be minor, but a slightly different set of efficiency recommendations may result when modeled with more actual operating conditions (e.g., an EEM recommended for a building operated 60 hours per week may not be cost-effective for the same building operated 30 hours per week). Once the recommendations are determined, the standard operating conditions are again applied to the model of the upgraded building to generate the potential score that

could be reached with the improvements. Although the actual operating conditions are not used to calculate the energy asset score, they may influence the potential score to some degree by affecting the LCC analysis of the upgrade package.

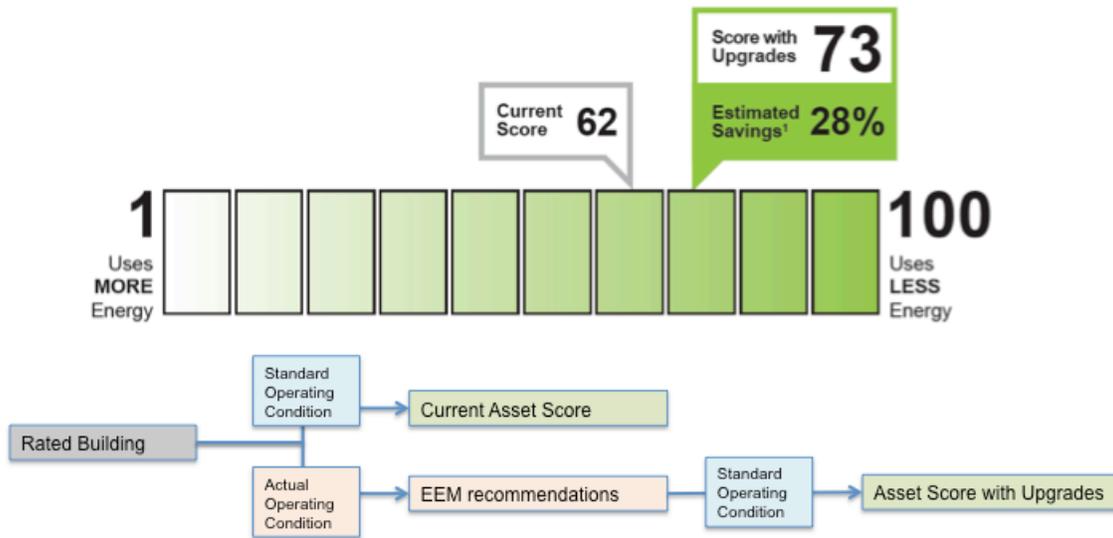


Figure 5.1. Current and potential scores.

5.3 Structure and Systems

Although the whole building EUI indicates the overall building efficiency as an integrated system, it is inadequate to fully understand the effect of individual characteristics. A building with a well-insulated envelope and low-efficiency HVAC equipment could, theoretically, use the same amount of energy as a building with a poorly insulated envelope and high-efficiency HVAC equipment. System evaluations are provided for the building envelope (roof, walls, windows, floor), lighting, HVAC, and service hot water systems. This information can help identify the specific components of the building most in need of attention. For two buildings with the same Asset Score, the system-level evaluations can give users insight into the existing problems and point to potential improvements for the two buildings.

Both prescriptive and performance approaches have been used in energy standards to design and evaluate building systems. The prescriptive approach specifies some minimum acceptable construction or system standards, such as minimum R-value (or maximum U-value) for building envelopes or required equipment efficiencies for mechanical systems. A prescriptive approach is easy to use, especially for building or system design. However, for existing system evaluations, a prescriptive approach can be restrictive, for several reasons:

- A prescriptive approach is generally limited to single variable input comparisons. More complex systems with multiple input characteristics and/or different configurations need to be modeled to understand how the different characteristics operate in concert. For example, a chiller is defined both by its design condition coefficient of performance and characteristic part-load performance curves of its compressor.
- It is difficult to compare different HVAC systems using a prescriptive approach. For example, in ASHRAE Standard 90.1-2007, Tables 6.8.1A through D specify the minimum efficiency ratings for

54 cooling equipment types. For some equipment types, multiple ratings are given based on the equipment size. The efficiency ratings are presented in different units—including EER (energy efficiency ratio), SEER (seasonal energy efficiency ratio), kW/ton, COP (coefficient of performance), IPLV (integrated part load value), and HSPF (heating seasonal performance factor)—depending on the test procedures. There is no industry standard against which to rank different mechanical systems because they have their advantages in various applications. For instance, the minimum efficiency for an air-cooled air conditioner with a capacity of 240 to 760 kBtu/h is 10.0 EER, while the minimum efficiency is 11.0 EER when the equipment capacity is lower (ASHRAE 90.1-2007, Table 6.8.1A). To make a proper system evaluation, the HVAC equipment size needs to be examined first. Developing such a standard goes beyond the scope of the Asset Score; therefore, a prescriptive approach was not chosen.

- A prescriptive approach isolates a system from the evaluated building. For example, a building with a low thermal mass due to its envelope characteristics may force its HVAC system to handle more extreme operating conditions and use more energy than another building with the same HVAC system but more thermal mass.

Due to the multivariate nature of most systems examined by the Asset Scoring Tool and considering the appropriate level of data that can be collected by users, DOE selected a model-based performance approach as the primary system evaluation method for envelope, lighting, HVAC, and service hot water systems. A performance approach compares the energy use of a building or system with that of a baseline or reference design. It allows a high level flexibility and considers a building as a single system. The following metrics are used as indicators of system performance (Table 5.1).

Table 5.1. Performance indicators for building systems

Building Systems	Performance Indicators	Calculation Methods	Evaluations
Window	kBtu/ft ²	Heating and cooling load through windows / total window area	Higher value indicates more heat transfer through windows, and therefore represents poor thermal performance
Wall	kBtu/ft ²	Heating and cooling load through walls / total wall area	Higher value indicates more heat transfer through walls, and therefore represents poor thermal performance
Window + Wall (account for window-wall ratio)	kBtu/ft ²	Heating and cooling load through walls and windows / total wall plus window area	Higher value indicates more heat transfer through walls and windows, and therefore represents poor thermal performance
Roof	kBtu/ft ²	Heating and cooling load through roof / total roof area	Higher value indicates more heat transfer through roof, and therefore represents poor thermal performance
Floor	kBtu/ft ²	Heating and cooling load through floor / total floor area	Higher value indicates more heat transfer through floor, and therefore represents poor thermal performance
Lighting System	kBtu/ft ²	Lighting energy use / total floor area	Higher value indicates more lighting EUI, and therefore represents low-efficiency lighting system
Heating System	Annual heating system efficiency (no unit)	Annual heating load / annual heating energy use	Lower value indicates more heating energy use to meet the load, and therefore represents low-efficiency heating system
Cooling System	Annual cooling system efficiency (no unit)	Annual cooling load / annual cooling energy use	Lower value indicates more cooling energy use to meet the load, and therefore represents low-efficiency cooling system
Overall HVAC System	Annual HVAC system efficiency (no unit)	Heating and cooling load / heating and cooling energy use	Lower value indicates more heating and cooling energy use to meet the load, and therefore represents low-efficiency HVAC system
Service Hot Water System	Annual hot water system efficiency (no unit)	Hot water energy load / hot water use	Lower value indicates more hot water energy use to meet the load, and therefore represents low-efficiency hot water system

Note: Source energy is used in the above calculations.

5.3.1 Building Envelope

For the envelope assessment, the heating and cooling loads due to envelope gains are extracted from the energy model. The loads are divided by the exterior surface area of the particular envelope component being examined to calculate the net heat gain or heat loss per unit area of the component (measured in kBtu/ft²). A higher value indicates more heat transfer across the envelope and therefore reflects poor thermal performance. This method goes beyond typical prescriptive standards, which simply use assembly U-values, because it reflects the overall effect of the envelope on the heating and cooling loads, considering such factors as orientation, layout, and non-conductive heat transfer properties. The same evaluation method is applied to windows, walls, combination of windows and walls, roof, and floor to separately evaluate their performances. The combination of windows and walls accounts for window-wall ratio. Because thermal resistance is usually much lower for windows than it is for walls, a

building envelope with well-insulated walls and windows may not have good overall performance if the window-wall ratio is high. Table 5.2 shows a few examples of envelope evaluation scenarios.

Table 5.2. Examples of envelope evaluation.

	Walls	Windows	Window-Wall Ratio	Walls and Windows Combination
Building A	Good	Good	High	Good
Building B	Good	Good	Low	Superior
Building C	Poor	Poor	High or Low	Fair
Building D	Good	Poor	High	Good
Building E	Good	Poor	Low	Superior
Building F	Poor	Good	High or Low	Fair

A technical barrier at this moment is that EnergyPlus output files do not specify the heat transfer through an envelope component (windows, walls, roof, floor). However, EnergyPlus is expected to provide such output function in the near future. Until then, the interim approach used to evaluate building envelope is a prescriptive method. The U-values (of windows, walls, roof, or floor) are directly compared to the minimum required U-value specified in ASHRAE Standard 90.1-2004.

5.3.2 Lighting System

For the lighting system assessment, the lighting EUI is used. A higher value indicates more lighting energy use based on the standard assumptions of operating schedules. Therefore, it represents less efficient lighting systems. Compared to lighting power density (W/ft^2), which only considers installed lighting load, lighting EUI ($kBtu/ft^2$) includes the effects of lighting controls and daylighting in the building, considering each component of the system together, rather than just looking at a single aspect. Source energy is used to account for the production and transmission loss of electricity.

5.3.3 HVAC Systems

For the HVAC systems, annual system efficiency is used. Annual system efficiency is defined as a ratio of the total heating and cooling energy load and the total energy consumed by the HVAC system. Source energy is used to account for the production and transmission loss of different fuel types. The concept of annual system efficiency is similar to COP. The rated COP is obtained from the typical tests performed at fixed standard conditions, accounting for part load performance as loads fluctuate throughout the year and the distribution system efficiency. Annual system efficiency is calculated from a building's Asset Score model. Annual cooling system efficiency, annual heating system efficiency, and annual HVAC system efficiency are separately calculated to provide a comprehensive evaluation of heating, cooling, and the integrated HVAC systems. A higher value indicates less heating and cooling energy use, and therefore represents a more efficient HVAC system. Fan energy used to provide outdoor air ventilation is assigned to either cooling or heating energy use based on the mode of operation of the system while the ventilation air is delivered.

5.3.4 Service Hot Water System

Service hot water systems are evaluated using the ratio of the energy delivered in the form of hot water to energy input. Source energy is used to account for the production and transmission loss of different fuel types. A higher value indicates that less energy is used to deliver a unit of hot water, and therefore represents a more efficient hot water system.

5.3.5 Baseline Development Methodology

Reference values are provided to communicate the meaning of the system performance indicators. If a system's performance is within the reference range, its performance is considered "Good." A value that is below or above the range indicates systems are "Fair" or "Superior," respectively.

Three sets of prototype buildings (compliant with ASHRAE Standard 90.1-2004, 2007, and 2010) are used to calculate the reference ranges. The prototype buildings represent 80% (Thornton et al. 2011) of the commercial building floor area in the United States for new construction, including both commercial buildings and mid- to high-rise residential buildings. These prototype buildings—derived from DOE's Commercial Reference Building Models—cover all the reference building types except supermarkets.¹ They were selected to provide consistency and transparency and to provide an industry accepted baseline for the performance indicator comparison. The characteristics of the prototype buildings are well documented and the models are readily available online.

Table 5.3 shows an example of system performance levels for office buildings. The ranges are developed based on the best and the worst results obtained by modeling all prototype buildings available for a particular building use type. Typically the 90.1-2004 model corresponds to the minimum efficiency level considered "Good," and the 90.1-2010 model corresponds to the minimum efficiency level considered "Superior." Under the current method, any system with efficiency less than the minimum level allowed for "Good" would be characterized as "Fair."

¹ https://www.energycodes.gov/development/commercial/90.1_models.

Table 5.3. Example of baseline system development for climate zone 5A.

		Prototype Buildings									Baseline Values		Candidate Building Evaluation Method
		Small Office			Medium Office			Large Office			Range		
		2004	2007	2010	2004	2007	2010	2004	2007	2010	Low	High	
Window U (Btu/ft ² h °F)	Non-metal	0.67 ^(a)	0.35	0.35	0.67 ^(a)	0.35	0.35	0.67 ^(a)	0.35	0.35	0.35	0.67	More efficient than range: Superior Within range: Good Less efficient than range: Fair
	Metal		0.45	0.45		0.45	0.45		0.45	0.45			
Window Solar Heat Gain Coefficient		0.49 ^(a)	0.40	0.40	0.49 ^(a)	0.40	0.40	0.49 ^(a)	0.40	0.40	0.40	0.49	
Wall U (Btu/ft ² h °F)	Mass	0.123	0.090	0.090	0.123	0.090	0.090	0.123	0.090	0.090	0.064	0.123	
	Metal	0.113	0.113	0.069	0.113	0.113	0.069	0.113	0.113	0.069			
	Steel-farmed	0.084	0.064	0.064	0.084	0.064	0.064	0.084	0.064	0.064			
	Wood-framed	0.089	0.064	0.064	0.089	0.064	0.064	0.089	0.064	0.064			
Window + Wall (Btu/ft ² h °F) ^(b)		0.17	0.13	0.13	0.20	0.16	0.16	0.29	0.24	0.24	0.13	0.29	
Roof (Btu/ft ² h °F)	Insulation above deck	0.063	0.048	0.048	0.063	0.048	0.048	0.063	0.048	0.048	0.027	0.065	
	Metal building	0.065	0.065	0.055	0.065	0.065	0.055	0.065	0.065	0.055			
	Attic and other	0.034	0.027	0.027	0.034	0.027	0.027	0.034	0.027	0.027			
Floor (Exposed to Unconditioned Air) (Btu/ft ² h °F)	Mass	0.087	0.074	0.074	0.087	0.074	0.074	0.087	0.074	0.074	0.033	0.087	
	Steel-joist	0.052	0.038	0.038	0.052	0.038	0.038	0.052	0.038	0.038			
	Wood-framed and other	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033			
Floor (Slab on Grade) (Btu/ft h °F)	Unheated	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	0.730	
Lighting System (kBtu/ft ²) ^(c)		38.74	38.74	29.82	30.96	30.96	21.29	30.96	30.96	23.04	21.99	38.74	
Service Hot Water System ^(c)		0.70	0.70	0.70	0.75	0.75	0.75	0.76	0.76	0.76	0.70	0.76	
Heating System ^(c)		0.18	0.14	0.15	0.14	0.13	0.16	0.13	0.12	0.11	0.11	0.18	
Cooling System ^(c)		0.46	0.55	0.53	0.95	1.01	1.08	0.96	0.98	1.32	0.46	1.32	
Overall HAVC System ^(c)		0.31	0.33	0.33	0.43	0.50	0.56	0.70	0.75	0.97	0.31	0.97	

(a) The highest u-value for all window-wall ratios.

(b) Based on the window-wall ratio and construction type of prototype buildings.

(c) Based on source energy use.

5.4 Opportunities

The Asset Scoring Tool is intended to provide users with a consistent approach for evaluating the energy efficiency of their buildings. The current score highlights the relative efficiency of the buildings compared to peers, while the potential score provides a measure to indicate how much the score might increase if cost-effective upgrades were implemented. The purpose of this is to enhance the value of the scoring process to provide easy and low-cost assistance, via providing preliminary and generalized guidance on possible upgrade opportunities and how to prioritize the activities. Based on the building information entered, the tool provides feedback on potential opportunities in areas of HVAC equipment, envelope, glazing, service hot water, and lighting. The recommendations provided by the tool are based on a building's specific characteristics as entered into the Asset Scoring Tool. They are, however, not intended to replace detailed engineering evaluation or to guide decisions to purchase specific equipment or materials. Rather, the Asset Scoring Tool can help users recognize the types of projects that may enhance building energy performance, so that they can seek additional assistance in understanding what is best for their specific situation.

The Asset Scoring Tool follows a two-step process to generate a list of upgrade considerations. First, the tool performs an LCC assessment of retrofit measures, using a modified version of the life-cycle methodology¹ required for federal buildings, as specified in 10 CFR part 436. The LCC relies on existing algorithms and capital and operating costs defined in the FEDS software. This approach accounts for the effects of the recommendations on operations and maintenance costs and on changes in the energy consumption to determine the cost effectiveness of potential candidate measures.

The economic assumptions used in the LCC analysis were selected to consider a diverse range of EEMs, rather than attempt to match a user's unique set of economic expectations. Building owners and operators should bear this in mind when deciding whether to pursue specific types of recommendations further. The primary LCC assumptions are as follows.

- **Discount Rate:** A discount rate of 0% was selected to ensure that a broad range of deep energy retrofit options would be considered. That is, this approach results in a list of all recommendations where savings over the life of the equipment (not discounted) are greater than the upfront cost of the improvement. Commercial property owners typically will apply a higher discount rate; however, an LCC analysis based on a higher rate may exclude valid options from the list of identified opportunities. Furthermore, since different property owners apply different discount rates to their investment decisions, there is no way to pick a rate that will satisfy all users. Based on the information provided in the Asset Score Report, building owners can develop their own financial models outside of the Asset Scoring Tool or seek professional assistance to evaluate the specific design and cost details of a potential project.
- **Life-Cycle Period:** For evaluating and ranking alternative recommendations for existing buildings, the study period is set to the expected life of the retrofit (for example, 20 years for a furnace or a chiller) or 25 years from the beginning of beneficial use, whichever is shorter. For technologies with more use-dependent service lives, for example fluorescent lighting, the analysis calculates

¹ This methodology provides “a systemic analysis of relevant costs, excluding sunk costs, over a study period, relating initial costs to future costs by the technique of discounting future costs to present value” (10 CFR part 436, p. 421).

incremental replacement of components over the 25-year study period using standard operating assumptions, or actual operating hours if provided by the user.

- **Non-fuel Costs:** The relevant non-fuel costs include investment cost, replacement cost, and operating and maintenance costs. Material and labor costs are adjusted for state-level differences and consist of stage averages (PNNL 2008). Data sources vary and include industry construction cost manuals and information from vendors, suppliers, and contractors. Typically, the FEDS database undergoes a major update every 3 to 5 years; more targeted updates of specific technologies (e.g., lighting technologies) may occur more frequently.
- **Energy Costs:** Energy costs are derived from COMNET default time-of-use (TOU) prices. COMNET TOU prices estimate the present value of energy costs at different time periods (on-peak, mid-peak, off-peak, weekdays, weekends) in 15 climate zones by calculating the marginal electricity cost based on the sum of energy value components (including generation energy, losses, ancillary series, system capacity, transmission and distribution capacity, and environment). Considering that the cost structures vary greatly between service providers and over time, COMNET TOU prices provide more accurate estimates of long-term energy cost savings than using a flat national price or state average prices. The COMNET present values of energy cost savings were converted into the current costs of energy. Appendix F shows the energy costs used in the Asset Scoring Tool.

This scope of this high level LCC evaluation of candidate EEMs covers the following system types:

- opaque envelope elements
- fenestration
- cooling equipment
- heating equipment
- lighting
- hot water.

Candidate EEMs are evaluated within the context of the entire building performance of all systems, and all interactive effects between energy systems are explicitly modeled. For example, when a lighting retrofit is under consideration, the FEDS energy model evaluates the corresponding change to energy consumption across all building energy systems, such as heating and cooling. And subsequently any changes to heating and cooling loads are considered when evaluating potential upgrade or replacement options for those end uses (see Figure 5.2). This provides more accurate savings estimates and thus more useful and integrated considerations.

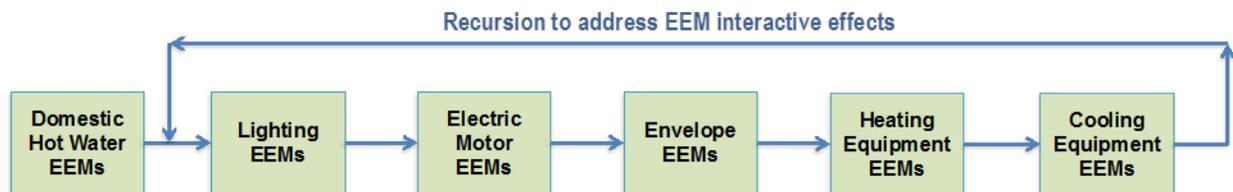


Figure 5.2. Energy efficiency measure ranks.

After the initial LCC analysis, a second group of candidate EEMs is evaluated using a separate method. These are EEMs with limited interactive effects and simple yes/no user inputs. Examples or options that will be addressed using this secondary methodology are:

- variable frequency drives
- economizers
- heat recovery
- individual high efficiency HVAC control options such as direct digital control system.

Based on a user's indication as to whether their building has a particular type of technology, and based on a building's specific systems, a group of appropriate measures is selected for application to the model. This set of measures is combined with those identified in the initial LCC approach and then applied to the current building model to create a potential building model. The potential building model includes all identified EEMs applied and is run through EnergyPlus. The predicted EUIs of the current and potential buildings are then compared to give the user an estimate of the energy savings that might be possible if all of the EEMs were implemented as modeled in their building.

A list of recommendations can be found in Appendix H. As stated already, these recommendations are general guidelines of the types of upgrades that may be considered to improve the efficiency of the building, and based on the combination of technical and economic parameters applied by the model. For a number of reasons, there is no express or implied warranty as to the applicability of some of the options to a specific building or situation, or that the measures will respond exactly as modeled. Further, and due to the number of economic variables and the likelihood of the ones used by the tool not aligning with those of the user, it will be left to the user to perform the final assessment, either by following the additional guide (DOE 2013) or by engaging a third party specialist.

5.5 Building Assets

The Asset Score Report provides a summary of building characteristics used in the energy asset model to generate the Asset Score and system evaluations. If a value has been inferred, the inferred input will be shown. This energy asset summary page can help users quickly check their input values and document their building information for future use. In the instance of a validated score, this summary can provide a detailed list of important building characteristics for building evaluators, financiers, and tenants.

6.0 References

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Appendix A

Building Type Classifications

CBECS Building Types ^(a)	CBECS Subcategories from 2003 CBECS Questionnaire ^(b)	DOE Commercial Reference Buildings and Prototype Buildings ^(c)	Portfolio Manager ^(d)	COMNET
Education	Elementary or middle school	Primary School	K-12 School	K-12 School
	High school	Secondary School		
	College or university			College/ University
	Preschool or daycare			
	Adult education			
	Career or vocational training			
	Religious education			
Food Sales	Grocery store or food market	Supermarket	Supermarket	
	Gas station with a convenience store			
	Convenience store			
Food Service	Fast food	Quick Service Restaurant		Dining, Bar/Cocktail Lounge
	Restaurant or cafeteria	Full Service Restaurant		Dining, Cafeteria/Fast Food Dining, Family
Health Care (Inpatient)	Hospital	Hospital	Hospital (General Medical and Surgical)	Hospital
	Inpatient rehabilitation			
Health Care (Outpatient)	Medical office (with diagnostic medical equipment)	Outpatient Health Care	Medical Office	
	Clinic or other outpatient health care			
	Outpatient rehabilitation			
	Veterinarian			
Lodging	Motel or inn	Small Hotel	Hotel	Motel
	Hotel	Large Hotel		Hotel
	Dormitory, fraternity, or sorority			Dormitory
	Retirement home			
	Nursing home, assisted living, or other residential care			
	Convent or monastery			
	Shelter, orphanage, or children's home			
	Halfway house			
Mercantile (Retail Other Than Mall)	Retail store	Stand-alone Retail	Retail Store	Retail
	Beer, wine, or liquor store			
	Rental center			
	Dealership or showroom for vehicles or boats			

CBECS Building Types ^(a)	CBECS Subcategories from 2003 CBECS Questionnaire ^(b)	DOE Commercial Reference Buildings and Prototype Buildings ^(c)	Portfolio Manager ^(d)	COMNET
	Studio/gallery			
Mercantile (Enclosed and Strip Malls)	Enclosed mall Strip shopping center	Strip Mall		
Office	Administrative or professional office Government office Mixed-use office Bank or other financial institution Medical office (no diagnostic medical equipment) sales office Contractor's office (e.g., construction, plumbing, HVAC) Non-profit or social services Research and development City hall or city center Religious office Call center	Large Office Medium Office Small Office	Office Bank/Financial Institution Town Hall	Office
Public Assembly	Social or meeting (e.g., community center, lodge, meeting hall, convention center, senior center) Recreation (e.g., gymnasium, health club, bowling alley, ice rink, field house, indoor racquet sports) Entertainment or culture (e.g., museum, theater, cinema, sports arena, casino, night club) Library Funeral home Student activities center Armory Exhibition hall Broadcasting studio Transportation terminal			Gymnasium Museum- General Performing Arts Theater Motion Picture Theater Library Sports Arena Exercise Center Transportation
Public Order and Safety	Police station			Police/Fire Station

CBECS Building Types ^(a)	CBECS Subcategories from 2003 CBECS Questionnaire ^(b)	DOE Commercial Reference Buildings and Prototype Buildings ^(c)	Portfolio Manager ^(d)	COMNET
	Fire station			
	Jail, reformatory, or penitentiary			Penitentiary
	Courthouse or probation office		Courthouse	Court House
Religious Worship	No subcategories collected.		House of Worship	Religious Building
Service	Vehicle service or vehicle repair shop			Auto Repair
	Vehicle storage/ maintenance (car barn)			
	Repair shop			Workshop
	Dry cleaner or laundromat			
	Post office or postal center			Post Office
	Car wash			
	Gas station			
	Photo processing shop			
	beauty parlor or barber shop			
	Tanning salon			
	Copy center or printing shop			
	Kennel			
Warehouse and Storage	Refrigerated warehouse	Warehouse	Warehouse (refrigerated and non-refrigerated)	Warehouse
	Non-refrigerated warehouse			
	Distribution or shipping center			
Other	Airplane hangar			
	Crematorium			
	Laboratory			
	Telephone switching			
	Agricultural with some retail space			
	Manufacturing or industrial with some retail space			Manufacturing Facility
	Data center or server farm		Data Center	
			Municipal Wastewater Treatment Plant	
		Midrise Apartment, High-rise Apartment	Residence Hall/Dormitory	Multi-Family
			Senior Care Facility	
				Parking Garage

CBECS Building Types ^(a)	CBECS Subcategories from 2003 CBECS Questionnaire ^(b)	DOE Commercial Reference Buildings and Prototype Buildings ^(c)	Portfolio Manager ^(d)	COMNET
(a) http://www.eia.gov/emeu/cbecs/building_types.html	(b) http://www.eia.gov/emeu/cbecs/cbecs2003/detailed_tables_2003/2003set1/2003pdf/a1.pdf	(c) http://www1.eere.energy.gov/buildings/commercial/ref_buildings.html , http://www.energycodes.gov/development/commercial/90.1_models	(d) http://www.energystar.gov/index.cfm?c=eligibility.bus_portfoliomanager_eligibility	

Appendix B
Weather Adjustments

Appendix B

Weather Adjustments

B.1 Prototype Buildings

Nine prototype buildings shown in Table B.1 were chosen to develop weather coefficients. Table B.1. Characteristics of chosen prototype buildings.

Prototype Building	Total Building Area (ft ²)	Total Building Area (m ²)	Cooling System	Heating System	Fan	Economizer	Lighting Power Density (W/ft ²)	Plug Load Density (W/ft ²)	Window-Wall Ratio (%)
Large Office	498,633	46,320	Chiller, Multi Zone Chilled Water Cooling Coil AND Water-to-Air Heat Pump Cooling Coil	Boiler, Hot Water Heating Coil	Variable Volume AND Single Zone Constant Volume	Fixed Dry Bulb Economizer	1.00	2.54	40.00
Apartment Midrise	33,748	3,135	Single Zone DX Cooling Coil Single Speed	Single Zone Gas Heating Coil	Single Zone Constant Volume	None	0.39	1.04	19.90
Strip Mall	22,499	2,090	Single Zone DX Cooling Coil Two Speed	Single Zone Gas Heating Coil	Single Zone Constant Volume	None	1.64	0.30	10.50
Secondary School	210,907	19,592	Chiller, Multi Zone Chilled Water Cooling Coil AND Single Zone DX Cooling Coil Two Speed	Coil: Heating: Water AND Single Zone Gas Heating Coil	Variable Volume AND Single Zone Constant Volume	None	1.13	3.02	35.00
Small Hotel	43,211	4,014	Single Zone DX Cooling Coil Single Speed	Single Zone Electric Resistance and Single Zone Gas Heating Coil	Single Zone Constant Volume	None	0.97	2.62	10.87
Primary School	73,966	6,871	DX Cooling Coil Single Speed AND Two Speed	Boiler, Hot Water Heating Coil AND Gas Heating Coil	Single Zone Constant Volume and Single Zone Variable Volume	None	1.21	3.69	35.00
Stand Alone Retail	24,695	2,294	Single Zone DX Cooling Coil Two Speed	Single Zone Gas Heating Coil	Single Zone Constant Volume	None	1.55	0.33	7.13
Small Office	5,501	511	Single Zone DX Cooling Coil Single Speed	Single Zone DX Heating Coil Single Speed with Supplementary Gas Heating Coil	Single Zone Constant Volume	None	1.00	0.63	21.20
Warehouse	52,049	4,835	Single Zone DX Cooling Coil Single Speed	Single Zone Gas Heating Coil	Single Zone Constant Volume	None	1.05	0.19	0.58

B.2 Weather Stations

Table B.2 lists the numbers of weather stations and data observations in each climate zone. Each data observation refers to an individual simulation of a prototype building. Since only some prototype buildings have pumps, the numbers of data observations for pumps are less than those listed in the table.

Table B.2. Number of weather stations and observations within each climate zone.

Climate Zone	Weather Stations	Total Observations (Except for Pumps)
1A	19	171
2A	87	783
2B	15	135
3A	108	972
3B	65	585
3C	19	171
4A	134	1206
4B	14	126
4C	30	270
5A	168	1512
5B	76	684
6A	112	1008
6B	37	333
7	90	810
8	34	306
Total	1008	9072

B.3 Testing of Weather Coefficients

B.3.1 Test Case I: DOE Commercial Reference Buildings

The first test case involved testing weather coefficients on DOE commercial reference buildings. Reference buildings and prototype buildings are very similar in terms of design and construction. The prototype buildings are derived from the reference buildings. The primary difference between them is that as ASHRAE Standard 90.1 evolved, PNNL substantially modified the characteristics of energy systems to develop prototype building models for 2004 and beyond to better reflect latest technologies and design.

Five reference buildings (2004 small office, pre-1980 small office, 2004 warehouse, 2004 stand-alone retail, 2004 primary school) were selected for this testing. Each reference building was modeled using all weather files. Results of applying weather coefficients on reference buildings are shown as distribution curves in Figure B.1. Means and standard deviations of before and after weather adjustment are shown on each graph. The weather coefficients reduced the standard deviations by at least 50%. After the

adjustment, the standard deviations ranged from 4 to 8 kBtu/ft² (source energy), which is equivalent to a value from 1 to 4 points on the Asset Score scale, depending on the use type.

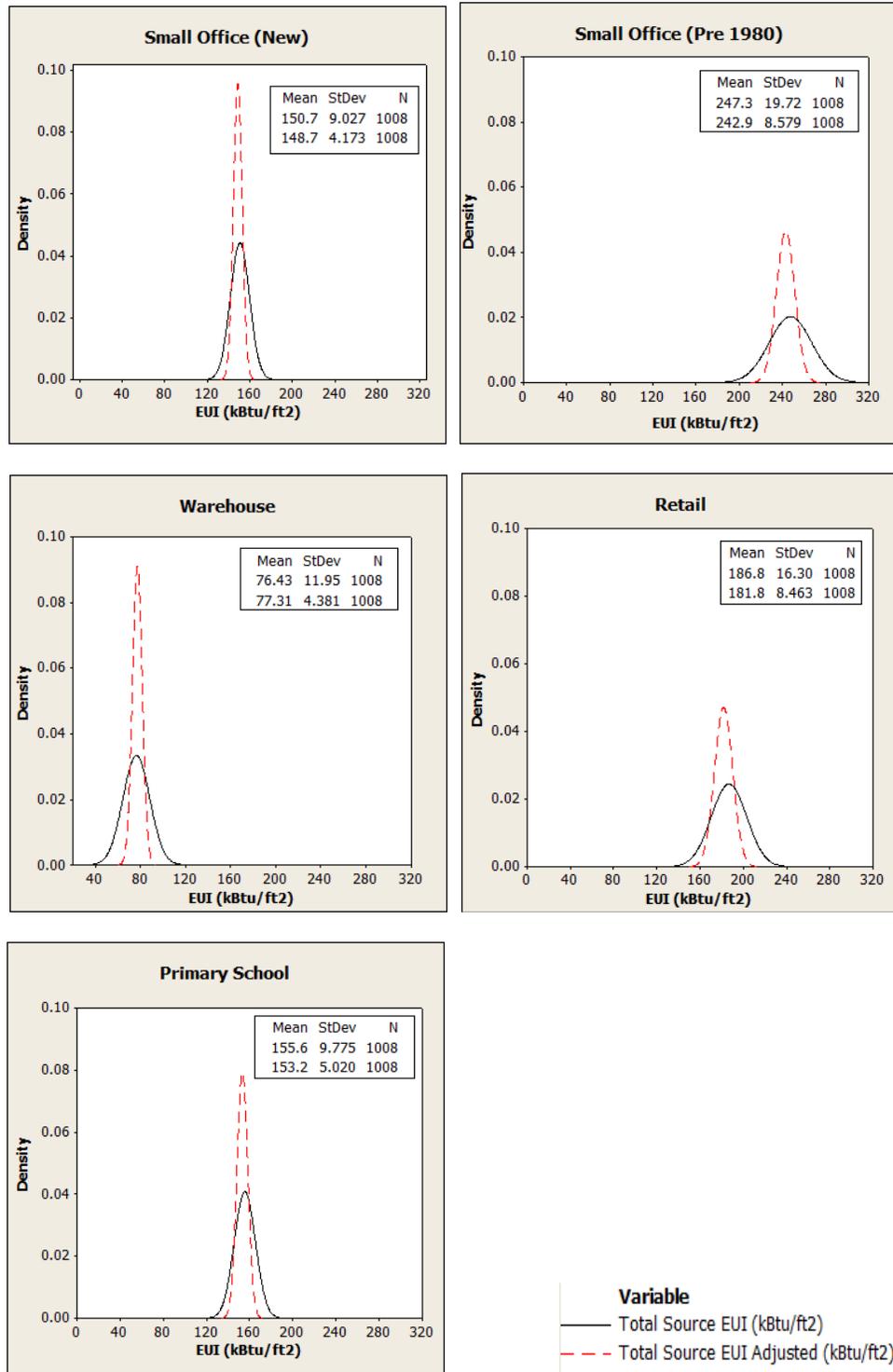


Figure B.1. Distribution curves showing total source EUI before and after normalization.

B.3.2 Test Case II: Variations of Selected Asset Score Pilot Buildings (3 samples)

The second test case involved applying weather coefficients on 2012 Pilot I buildings, which are more varied in their design, size, thermal properties, and mechanical systems compared to reference buildings, which have a certain level of similarity with the prototype buildings. Three buildings were selected for this test. Building and system properties selected for this test are shown in Figure B.2. To examine if weather coefficients are more effective on building characteristics (e.g., size, insulation, design) or on mechanical systems, the three pilot buildings were modified to keep either building characteristics or their mechanical systems constant (Figure B.3).

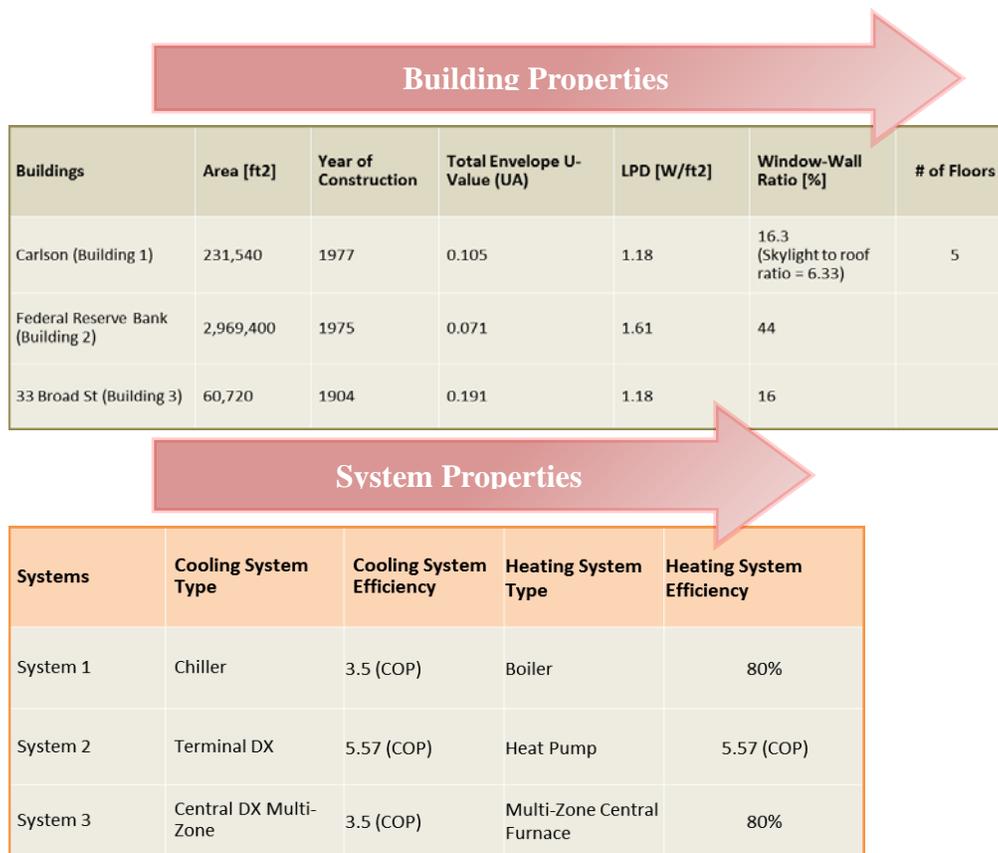


Figure B.2. Building and system properties of pilot buildings selected for testing.

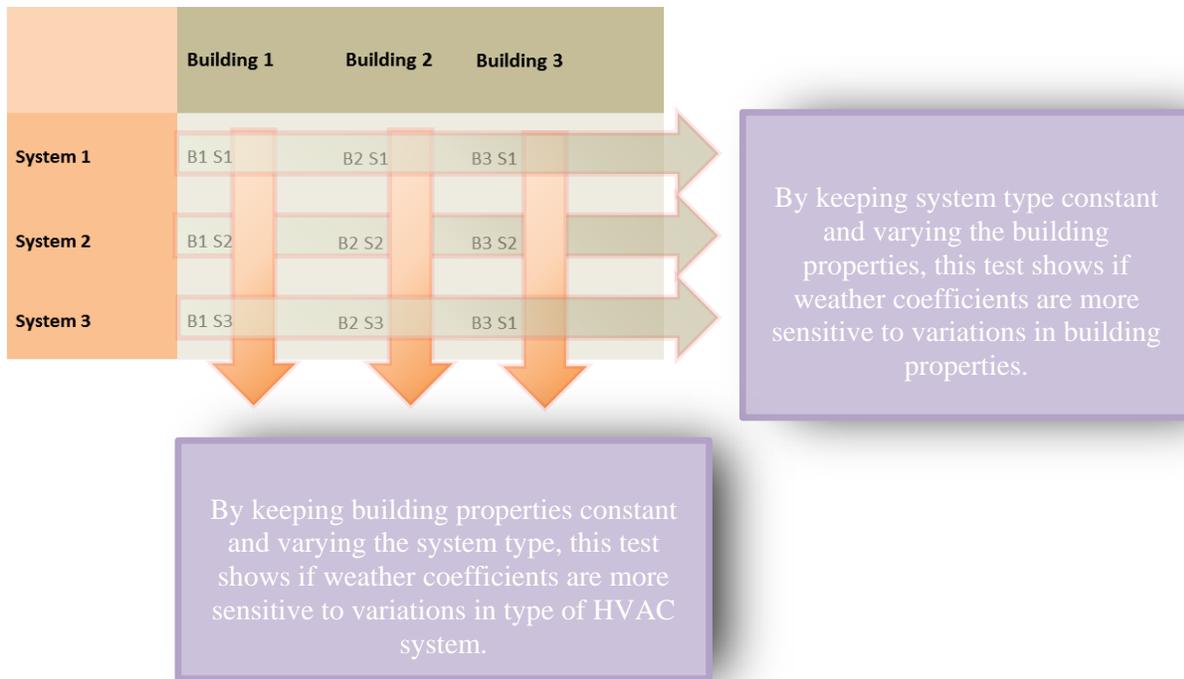


Figure B.3. Testing procedure to evaluate sensitivity of weather coefficients.

In the first set of tests, the original building characteristics entered by the pilot users remained unchanged, three different types of HVAC systems (chiller and boiler, central multi-zone DX and furnace, terminal DX and heat pump) were applied to the three building models. Nine building models were created. Each model was simulated with all weather files. The source EUIs after weather adjustments shown in Figure B.4 through Figure B.6 show that the weather coefficients are equally effective if applied to the three buildings when they have the same mechanical systems. Note that a flatter line indicates a better weather adjustment result.

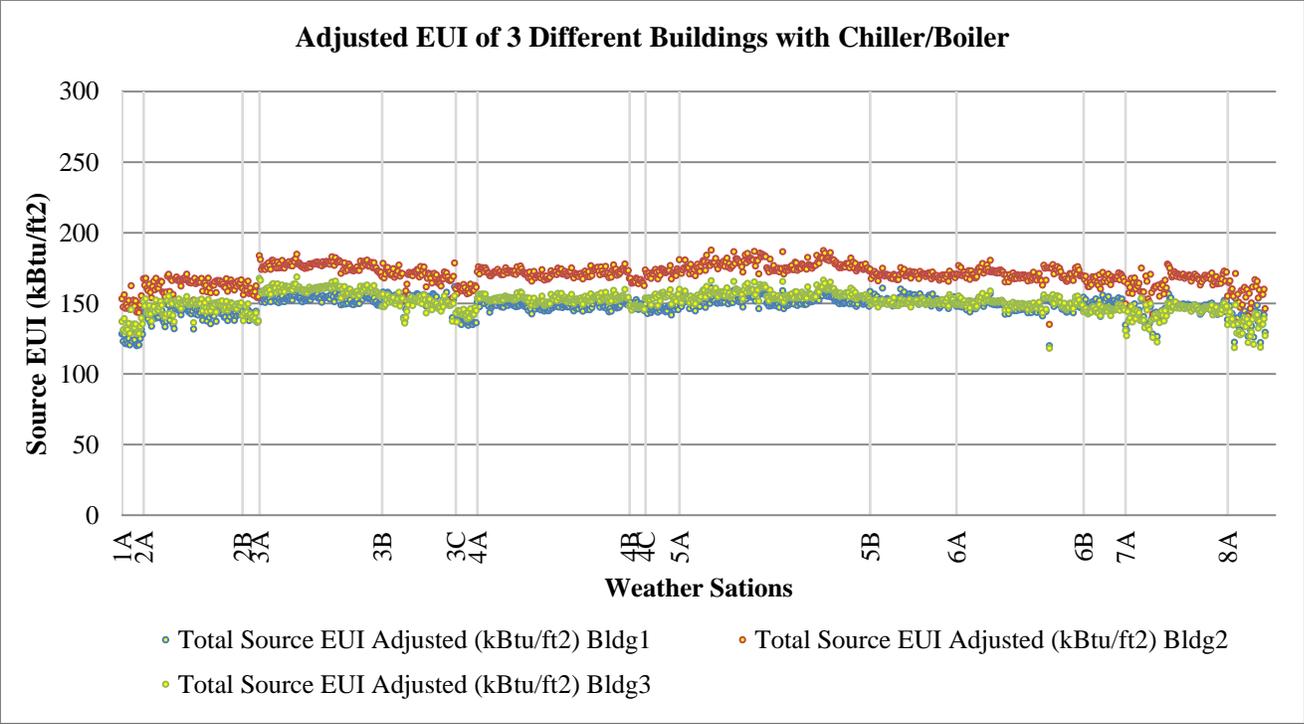


Figure B.4. Assessing impact of weather coefficients in regard to building properties (System 1).

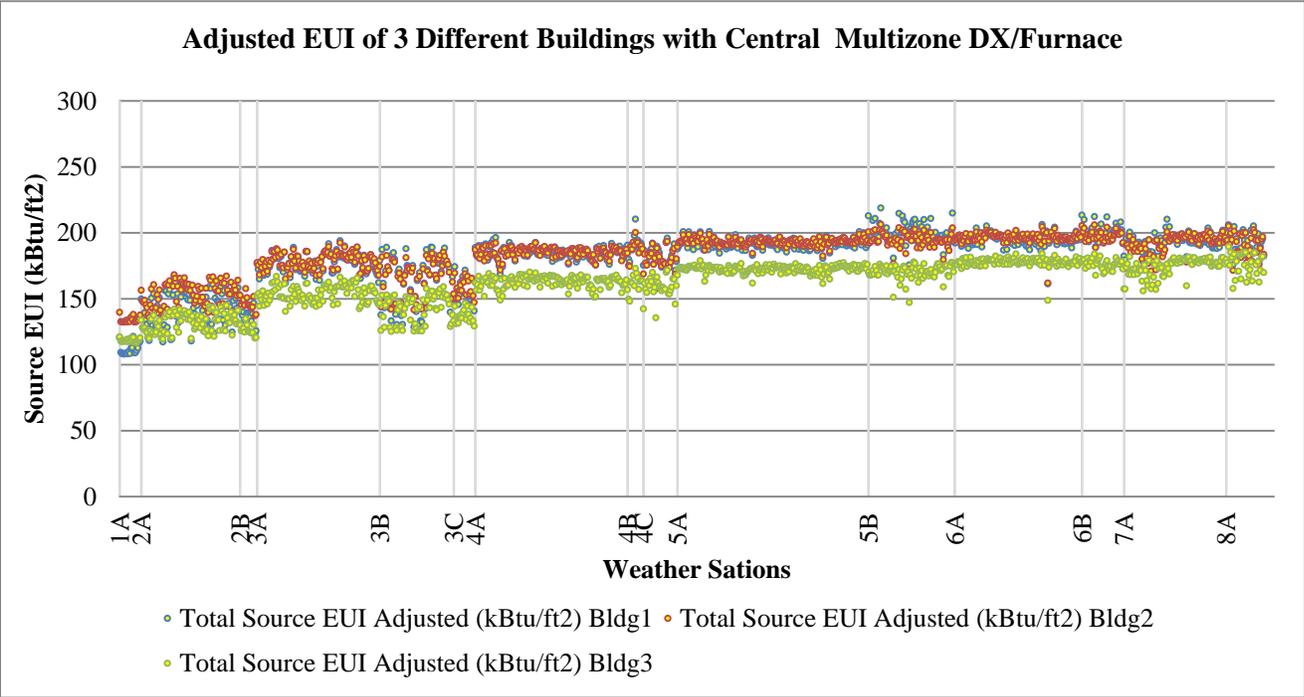


Figure B.5. Assessing impact of weather coefficients in regard to building properties (System 2).

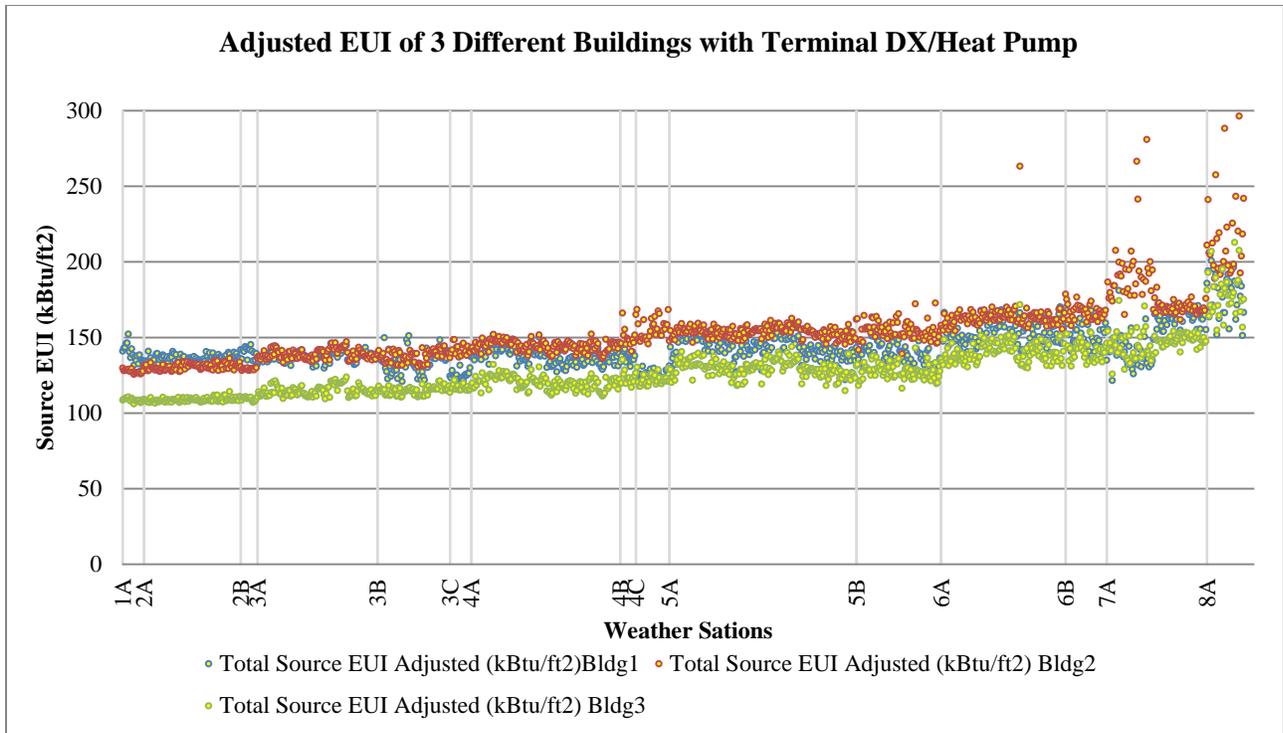


Figure B.6. Assessing impact of weather coefficients in regard to building properties (System 3).

In the second set of tests, comparisons were made between mechanical systems within each of the three buildings. The source EUIs after weather adjustments shown in Figure B.7 through Figure B.9 show that different mechanical system types introduced some level of discrepancy. For example, system 1 (chiller and boiler) has the best results across the three buildings: the EUI standard deviations of the three buildings were reduced to 6.5, 7.6, and 7.4 (Table B.3). The heat pump in building 2 has abnormal system behavior in the coldest climate zones. This caused an even higher standard deviation after weather adjustment. This requires further testing and investigation. If consistent results are observed in the future work, weather coefficients can be improved by being categorized based on system type. However, using a heat pump in very cold climate zones is not an efficient choice and is not recommended. Therefore, abnormal behavior observed is not only because of limitations of weather adjustment coefficients but also because of inherently poor performance of heat pumps in cold climate zones.

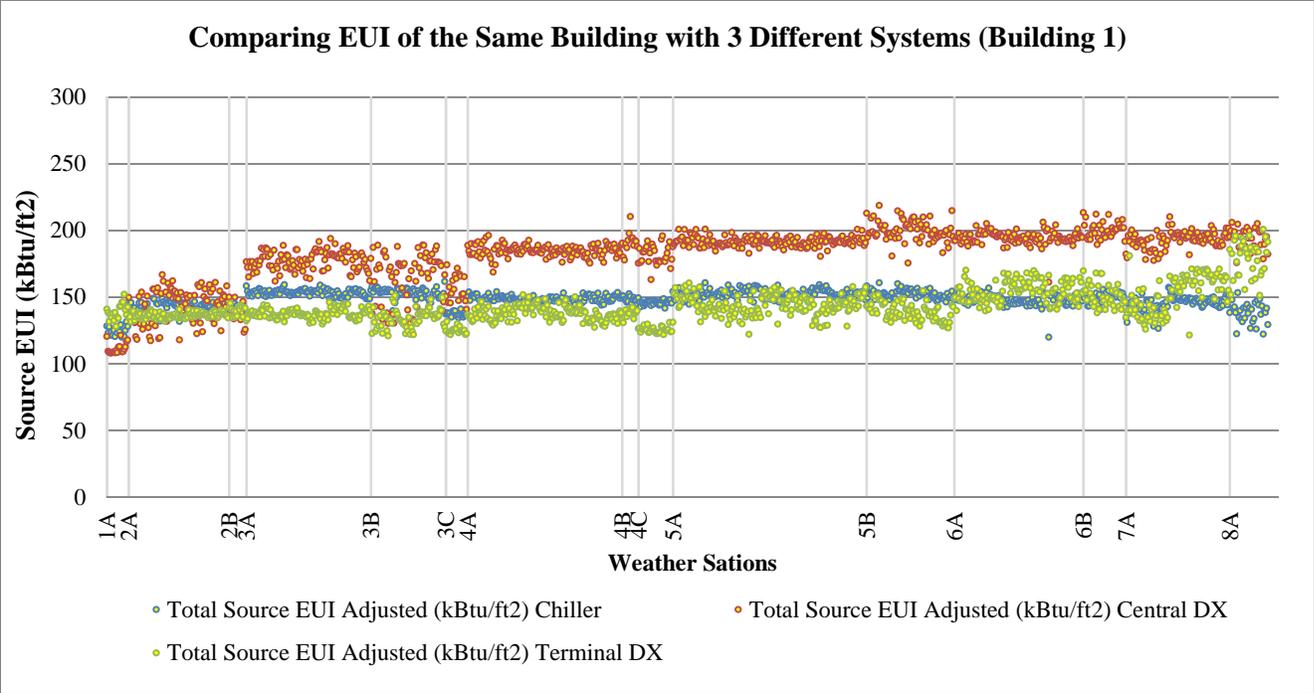


Figure B.7. Assessing impact of weather coefficients in regard to system properties (Building 1)

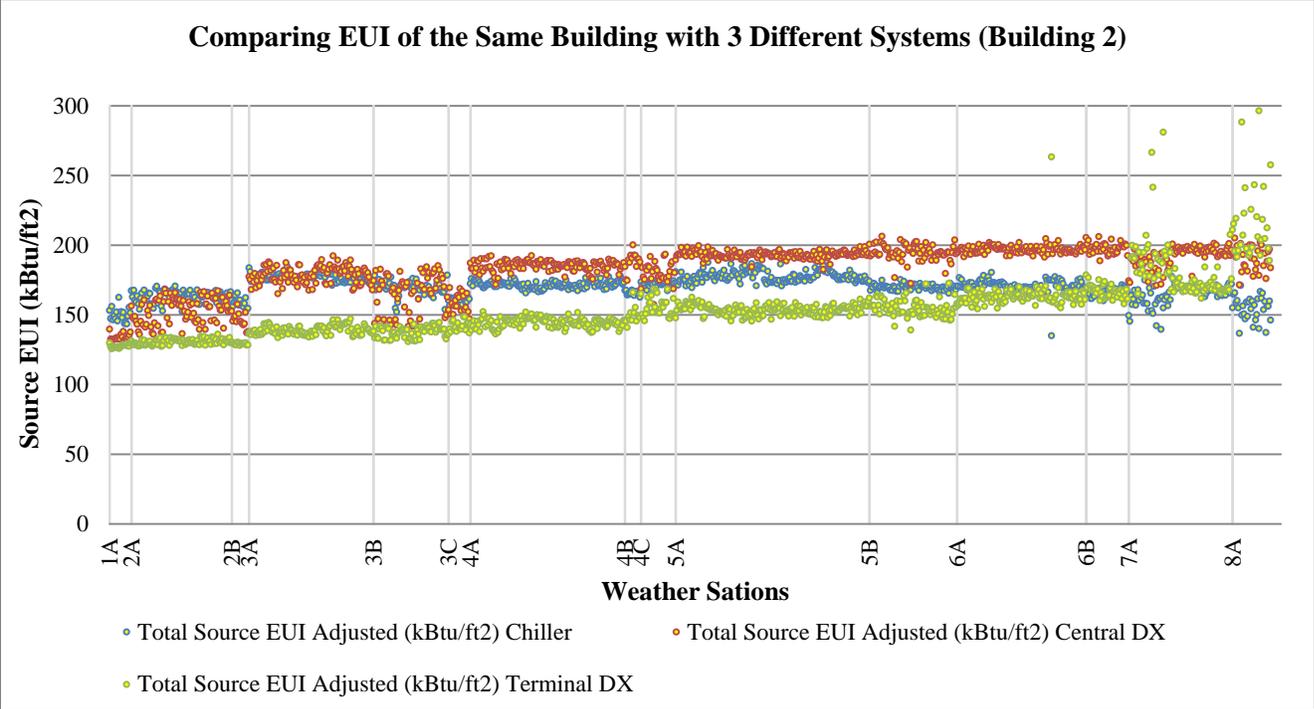


Figure B.8. Assessing impact of weather coefficients in regard to system properties (Building 2)

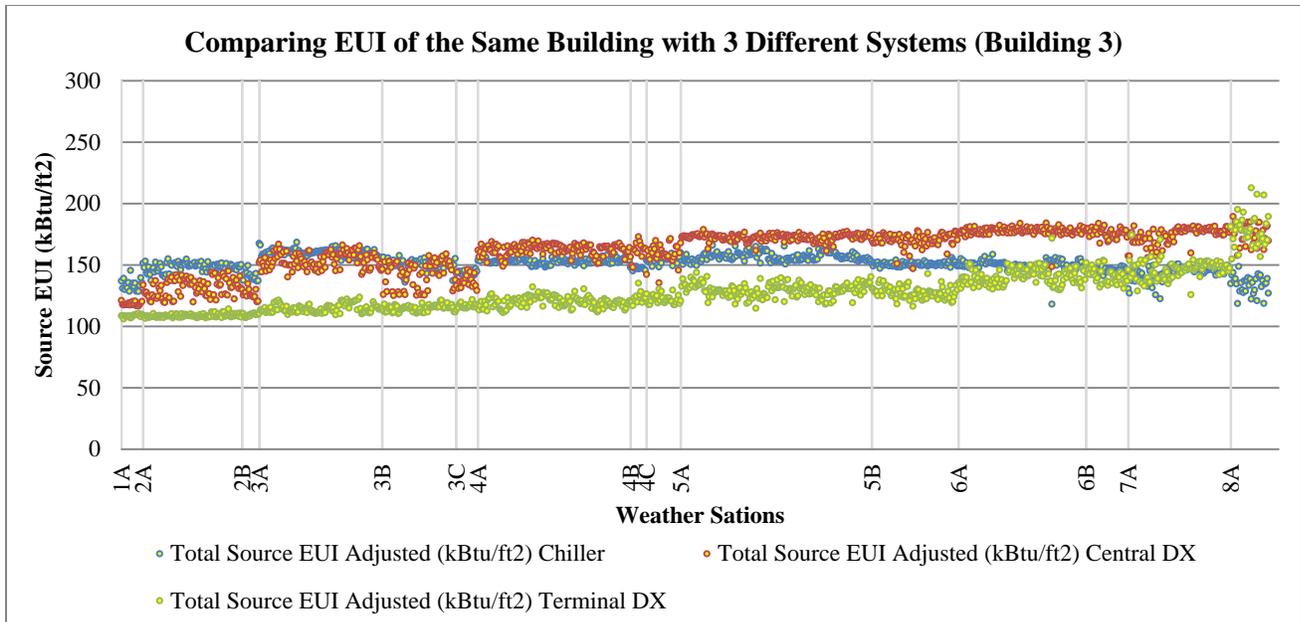


Figure B.9. Assessing impact of weather coefficients in regard to system properties (Building 3).

Table B.3. Statistics of three buildings before and after weather adjustment.

Building 1						
	System 1		System 2		System 3	
	Before	After	Before	After	Before	After
Min	108.8	119.9	115.6	108.1	96.4	120.9
Max	265.9	161.7	530.7	218.7	430.0	200.8
Mean	149.4	148.2	188.9	181.6	134.0	143.0
Std. Dev.	16.7	6.5	50.5	20.9	33.0	12.5
Building 2						
	System 1		System 2		System 3	
	Before	After	Before	After	Before	After
Min	128.7	135.0	129.1	132.2	120.0	125.6
Max	271.1	187.6	452.9	206.4	320.2	466.0
Mean	172.2	169.9	190.2	182.8	152.0	154.4
Std. Dev.	15.5	7.6	35.0	16.8	18.7	27.8
Building 3						
	System 1		System 2		System 3	
	Before	After	Before	After	Before	After
Min	113.1	118.1	114.1	116.6	95.6	106.0
Max	244.1	168.6	433.1	189.5	354.8	212.8
Mean	153.2	150.8	170.0	161.7	130.6	127.4
Std. Dev.	14.3	7.4	34.6	16.9	24.3	16.0

This test by no means represents a complete sensitivity analysis; it is just a quick way to try to determine whether any building property can cause a larger discrepancy between weather locations after weather adjustment. Overall, the results show that the weather coefficients can reduce the EUI standard deviation by 50%, which is consistent with the finding in Test Case I.

B.3.3 Test Case III: Asset Score 2012 Pilot Buildings (all buildings)

Figure B.10 shows the heating, cooling, fans, and overall source EUIs of all 2012 pilot buildings before and after weather adjustments. These are represented respectively with bars and dots in Figure B.10. This test is intended to demonstrate the impact of weather adjustment on the scoring of a set of random buildings across the country. Weather stations are shown across the x-axis in Figure B.10, starting with warmer climates (at origin) and moving toward colder climate zones. In general (regardless of system type), this chart shows that cooling loads in warmer climate zones are higher than the national average and therefore are adjusted to be lower; a similar relationship also holds true for heating loads in colder climate locations. For example, the cooling load in the office building located in climate 3B_54 (warmer climate zone) exhibits a cooling load much higher than national average because of weather differences and therefore it was adjusted to lower its comparable cooling EUI. However, its heating load was lower than the national average, and after weather adjustment, it increased, as seen in Figure B.10. These adjustments combine to result in a lower total EUI. There are exceptions, however. Taking the office building in climate 5B_17 as an example, it can be seen from the figure that both heating and cooling EUIs in this weather location (red and blue bars) are below the national average. Therefore, after applying weather adjustment (shown by red and blue dots), heating and cooling source EUIs increase and, as a result, total adjusted source EUI also increases.

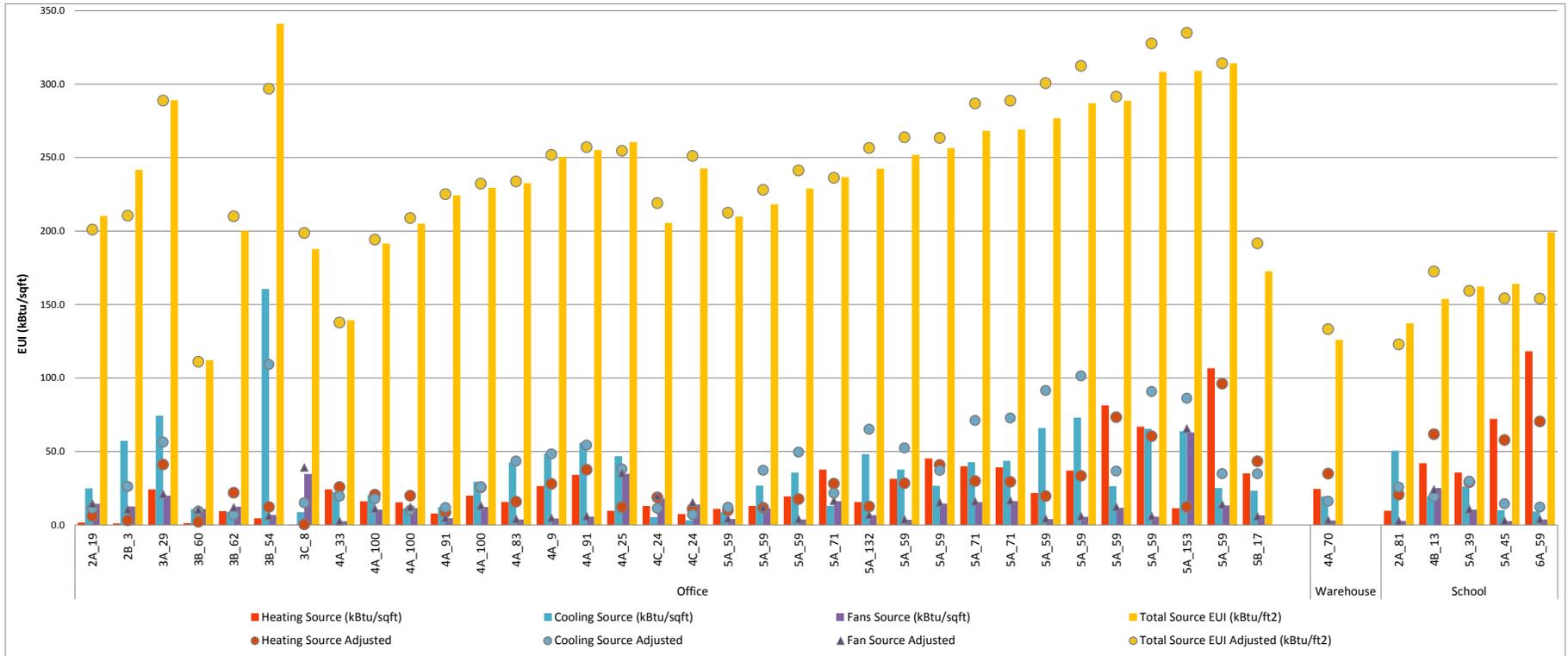


Figure B.10. Source EUIs of all 2012 pilot buildings before and after weather adjustment.

B.3.4 Test Case IV: Test on Variations of Prototype Buildings

In the test, weather coefficients were applied to a large number of buildings sampled by computer. The base models are prototype buildings. The building characteristics were randomly modified, therefore, more variations of prototype buildings with various envelope, lighting, and mechanical system characteristics were generated. These buildings were modeled at the representative cities of each climate zone, the source EUI before and after weather adjustments are plotted in Figure B.11. The figure shows that after weather normalization, the EUI distribution curves across the 16 climate zone are closer to each other (if not overlapping), which means that their Asset Scores will become more comparable after the weather impact is minimized by the coefficients.

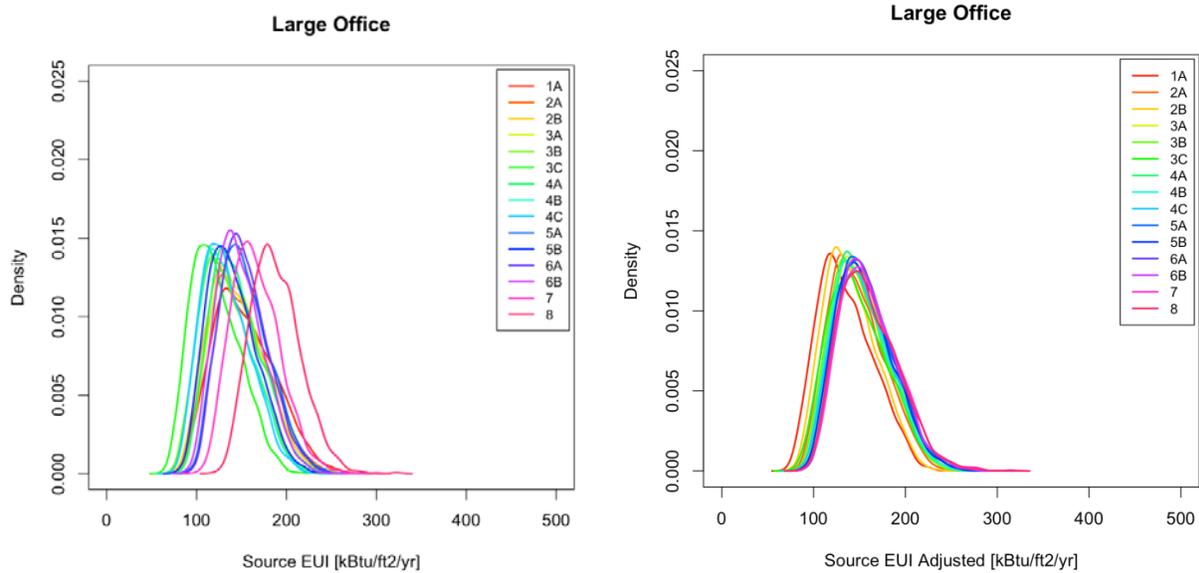


Figure B.11. Variations of prototype buildings before and after weather adjustment.

Appendix C

Weather Coefficient Table

Appendix C

Weather Coefficient Table

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Aberdeen Regional Arpt SD USA TMY3 WMO#=726590	1.68	0.72	1.01	1.81	0.17	0.93	6A
Abilene Dyess Afb TX USA TMY3 WMO#=690190	0.49	1.63	1.11	0.44	2.96	1.26	3B
Abilene Regional ApTX USA TMY3 WMO#=722660	0.56	1.37	1.07	0.52	2.23	1.14	3B
Abington VA USA TMY3 WMO#=724058	0.80	0.98	0.99	0.81	0.68	0.86	4A
Adak Nas AK USA TMY3 WMO#=704540	1.63	0.05	0.98	1.66	0.01	1.14	7
Adirondack Rgnl NY USA TMY3 WMO#=726228	1.50	0.48	1.00	1.35	0.10	0.93	6A
Ainsworth Municipal NE USA TMY3 WMO#=725556	1.05	0.77	1.03	1.22	0.43	1.08	5A
Aitkin Ndb Awos MN USA TMY3 WMO#=727504	1.74	0.53	1.03	1.57	0.05	1.09	7
Akron Akron Canton Reg Ap OH USA TMY3 WMO#=725210	1.21	0.77	0.98	1.27	0.35	1.03	5A
Akron Washington Co Ap CO USA TMY3 WMO#=724698	0.92	0.77	1.10	1.02	0.42	0.97	5B
Alamosa San Luis Valley Rgnl CO USA TMY3 WMO#=724620	1.01	0.52	1.16	1.27	0.07	1.60	6B
Albany County Ap NY USA TMY3 WMO#=725180	1.27	0.69	0.96	1.34	0.33	1.01	5A
Albany Dougherty County Ap GA USA TMY3 WMO#=722160	0.37	1.68	0.93	0.39	2.09	1.05	3A
Albert LeaMN USA TMY3 WMO#=726589	1.38	0.78	0.99	1.38	0.22	0.89	6A
Albuquerque Intl ArptNM USA TMY3 WMO#=723650	0.55	0.91	1.10	0.60	0.79	1.05	4B
Alexandria Esler Regional Ap LA USA TMY3 WMO#=722487	0.46	1.76	0.99	0.31	2.86	0.88	2A
Alexandria Municipal Ap MN USA TMY3 WMO#=726557	2.10	0.65	1.03	2.22	0.15	0.96	6A
Algona IA USA TMY3 WMO#=725457	1.37	0.74	0.98	1.46	0.19	0.89	6A
Alice Intl Ap TX USA TMY3 WMO#=722517	0.33	2.40	1.02	0.26	3.94	0.98	2A
Allentown Lehigh Valley Intl PA USA TMY3 WMO#=725170	1.05	0.81	0.96	1.12	0.38	0.98	5A
Alliance Municipal NE USA TMY3 WMO#=725635	1.10	0.78	1.08	1.29	0.54	1.13	5A
Alma Bacon County Ap GA USA TMY3 WMO#=722135	0.46	1.73	0.99	0.30	2.75	1.00	2A
Alpena County Regional Ap MI USA TMY3 WMO#=726390	1.53	0.54	0.97	1.52	0.11	0.91	6A
Altoona Blair Co Arpt PA USA TMY3 WMO#=725126	1.01	0.75	0.98	1.02	0.33	1.01	5A
Alturas CA USA TMY3 WMO#=725958	0.77	0.67	1.10	0.79	0.40	0.97	5B
Altus Afb OK USA TMY3 WMO#=723520	0.63	1.59	1.00	0.70	2.79	1.41	3A
Amarillo International ApTX USA TMY3 WMO#=723630	0.68	1.01	1.04	0.73	0.87	1.00	4B
Ambler AK USA TMY3 WMO#=701718	3.23	0.16	1.08	2.77	0.01	1.20	8
Anaktuvuk Pass AK USA TMY3 WMO#=701625	3.85	0.09	1.17	3.59	0.00	1.34	8
Anchorage Elmendorf AK USA TMY3 WMO#=702720	1.67	0.28	1.01	1.45	0.01	1.08	7
Anchorage Intl Ap AK USA TMY3 WMO#=702730	2.01	0.23	1.02	1.70	0.01	1.12	7
Anchorage Merrill Field AK USA TMY3 WMO#=702735	1.63	0.27	1.00	1.20	0.01	1.02	7

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Anderson County Ap SC USA TMY3 WMO#=-723125	0.58	1.29	0.95	0.58	1.79	1.11	3A
Andrews Afb MD USA TMY3 WMO#=-745940	0.85	1.05	0.94	0.95	0.73	0.82	4A
Aniak Airport AK USA TMY3 WMO#=-702320	2.09	0.16	1.02	1.82	0.01	1.16	8
Ann Arbor Municipal MI USA TMY3 WMO#=-725374	1.16	0.71	0.98	1.24	0.32	1.01	5A
Annette Island Ap AK USA TMY3 WMO#=-703980	1.06	0.23	0.96	1.01	0.01	0.98	7
Anniston Metropolitan Ap AL USA TMY3 WMO#=-722287	0.47	1.40	0.94	0.46	1.75	1.04	3A
Antigo Lang Awos WI USA TMY3 WMO#=-726626	1.73	0.66	1.01	1.69	0.15	0.93	6A
Anvik AK USA TMY3 WMO#=-702075	2.22	0.18	1.05	2.08	0.01	1.17	8
Appleton Outagamie WI USA TMY3 WMO#=-726457	1.28	0.63	0.97	1.34	0.14	0.89	6A
Arcata Airport CA USA TMY3 WMO#=-725945	0.58	0.31	0.90	0.54	0.01	0.51	4C
Asheville Regional Arpt NC USA TMY3 WMO#=-723150	0.70	1.01	0.98	0.80	0.61	0.82	4A
Aspen Pitkin Co Sar CO USA TMY3 WMO#=-724676	0.96	0.49	1.19	1.08	0.03	1.21	7
Astoria Regional Airport OR USA TMY3 WMO#=-727910	0.70	0.35	0.90	0.65	0.03	0.54	4C
Athens Ben Epps Ap GA USA TMY3 WMO#=-723110	0.49	1.38	0.95	0.51	1.80	1.09	3A
Atlanta Hartsfield Intl Ap GA USA TMY3 WMO#=-722190	0.52	1.39	0.96	0.56	1.90	1.14	3A
Atlantic City Intl Ap NJ USA TMY3 WMO#=-724070	0.89	0.96	0.93	0.98	0.64	0.81	4A
Atlantic IA USA TMY3 WMO#=-725453	1.27	0.89	0.99	1.20	0.46	1.02	5A
Auburn Lewiston ME USA TMY3 WMO#=-726184	1.28	0.51	0.95	1.14	0.12	0.85	6A
Auburn Opelika Apt AL USA TMY3 WMO#=-722284	0.49	1.34	0.95	0.51	1.67	1.07	3A
Augusta Airport ME USA TMY3 WMO#=-726185	1.56	0.55	0.96	1.60	0.10	0.88	6A
Augusta Bush Field GA USA TMY3 WMO#=-722180	0.46	1.52	0.94	0.47	2.14	1.09	3A
Aurora Buckley Field Angb CO USA TMY3 WMO#=-724695	0.86	0.75	1.13	0.97	0.34	1.01	5B
Aurora Municipal IL USA TMY3 WMO#=-744655	1.39	0.83	0.98	1.48	0.45	1.04	5A
Aurora State OR USA TMY3 WMO#=-726959	0.66	0.57	0.92	0.60	0.07	0.53	4C
Austin Mueller Municipal ApTX USA TMY3 WMO#=-722540	0.38	1.97	1.01	0.29	3.14	1.04	2A
Austin Muni MN USA TMY3 WMO#=-727566	1.63	0.70	1.00	1.65	0.16	0.91	6A
Baker Municipal Ap OR USA TMY3 WMO#=-726886	0.96	0.56	1.06	0.95	0.30	0.96	5B
Bakersfield Meadows Field CA USA TMY3 WMO#=-723840	0.36	1.30	0.98	0.31	2.25	1.07	3B
Baltimore Blt Washngtn Intl MD USA TMY3 WMO#=-724060	0.85	1.07	0.94	0.91	0.77	0.80	4A
Bangor International Ap ME USA TMY3 WMO#=-726088	1.46	0.55	0.95	1.45	0.14	0.88	6A
Bar Harbor ME USA TMY3 WMO#=-726077	1.37	0.37	0.93	1.27	0.06	0.87	6A
Barbers Point Nas HI USA TMY3 WMO#=-911780	0.20	2.58	0.99	0.09	5.27	1.47	1A
Barksdale Afb LA USA TMY3 WMO#=-722485	0.52	1.62	0.94	0.54	2.12	1.09	3A
Barnstable Muni Boa MA USA TMY3 WMO#=-725067	0.98	0.66	0.93	0.98	0.26	0.97	5A
Barrow W Post W Rogers ArptAK USA TMY3 WMO#=-700260	5.78	0.03	1.17	5.40	0.00	1.32	8
Bartlesville Philli OK USA TMY3 WMO#=-723565	0.72	1.25	0.96	0.68	1.74	1.21	3A
Batesville AR USA TMY3 WMO#=-723448	0.63	1.28	0.95	0.59	1.81	1.10	3A
Baton Rouge Ryan Arpt LA USA TMY3 WMO#=-722317	0.45	1.86	0.99	0.32	2.78	0.87	2A
Battle Creek Kellogg Ap MI USA TMY3 WMO#=-725396	1.20	0.74	0.98	1.24	0.30	1.02	5A
Baudette International Ap MN USA TMY3 WMO#=-727476	1.80	0.55	1.04	1.78	0.04	1.11	7

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Beale Afb CA USA TMY3 WMO#=724837	0.44	1.14	0.97	0.35	2.00	1.06	3B
Beatrice Municipal NE USA TMY3 WMO#=725515	0.99	0.95	0.99	1.04	0.61	1.00	5A
Beaufort Mcas SC USA TMY3 WMO#=722085	0.40	1.61	0.93	0.43	2.03	1.04	3A
Beckley Raleigh Co Mem Ap WV USA TMY3 WMO#=724120	0.89	0.80	1.00	0.89	0.30	1.02	5A
Belleville Scott Afb IL USA TMY3 WMO#=724338	1.02	1.07	0.95	1.05	0.88	0.84	4A
Bellevue Offutt Afb NE USA TMY3 WMO#=725540	1.25	0.91	0.99	1.31	0.54	1.02	5A
Bellingham Intl Ap WA USA TMY3 WMO#=727976	0.89	0.35	0.92	0.76	0.02	0.56	4C
Belmar Asc NJ USA TMY3 WMO#=724084	0.93	0.87	0.94	1.01	0.62	0.82	4A
Bemidji Municipal MN USA TMY3 WMO#=727550	1.89	0.57	1.04	1.89	0.05	1.13	7
Benson Muni MN USA TMY3 WMO#=727507	1.79	0.65	1.00	1.84	0.20	0.94	6A
Benton Harbor Ross MI USA TMY3 WMO#=726355	1.23	0.78	0.97	1.20	0.42	1.01	5A
BentonvilleAR USA TMY3 WMO#=723444	0.71	1.21	0.97	0.76	1.02	0.85	4A
Berlin Municipal NH USA TMY3 WMO#=726160	1.46	0.46	0.97	1.20	0.08	0.89	6A
Bethel Airport AK USA TMY3 WMO#=702190	2.74	0.14	1.06	3.23	0.01	1.21	8
Bettles Field AK USA TMY3 WMO#=701740	3.70	0.24	1.12	3.22	0.01	1.22	8
Beverly Muni MA USA TMY3 WMO#=725088	1.26	0.63	0.96	1.32	0.30	1.01	5A
Big Delta Allen Aaf AK USA TMY3 WMO#=702670	2.88	0.30	1.12	2.87	0.01	1.23	8
Big River Lake AK USA TMY3 WMO#=702986	1.97	0.23	1.02	1.87	0.01	1.08	7
Billings Logan Intl Arpt MT USA TMY3 WMO#=726770	1.16	0.61	1.07	1.43	0.11	1.40	6B
Binghamton Edwin A Link Field NY USA TMY3 WMO#=725150	1.26	0.56	0.99	1.39	0.11	0.91	6A
Birchwood AK USA TMY3 WMO#=702746	1.62	0.25	1.01	1.25	0.01	1.03	7
Birmingham Municipal Ap AL USA TMY3 WMO#=722280	0.46	1.47	0.95	0.48	2.00	1.10	3A
Bishop Airport CA USA TMY3 WMO#=724800	0.52	1.01	1.07	0.58	1.10	1.07	4B
Bismarck Municipal ArptND USA TMY3 WMO#=727640	1.74	0.63	1.02	1.85	0.18	0.96	6A
Blanding UT USA TMY3 WMO#=724723	0.71	0.79	1.13	0.80	0.43	1.02	5B
Block Island State Arpt RI USA TMY3 WMO#=725058	0.91	0.64	0.93	0.99	0.24	0.97	5A
Blue Canyon Ap CA USA TMY3 WMO#=725845	0.68	0.69	1.10	0.74	0.21	0.96	5B
Bluefield Mercer CoWV USA TMY3 WMO#=724125	0.76	0.88	1.00	0.80	0.43	0.84	4A
Blythe Riverside Co Arpt CA USA TMY3 WMO#=747188	0.27	2.05	1.05	0.23	4.16	1.40	3B
Boise Air TerminalID USA TMY3 WMO#=726810	0.81	0.70	1.04	0.83	0.35	0.90	5B
Boone Muni IA USA TMY3 WMO#=725486	1.30	0.83	0.99	1.33	0.46	1.05	5A
Boston Logan Intl Arpt MA USA TMY3 WMO#=725090	1.11	0.72	0.95	1.25	0.36	1.00	5A
Bowling Green Warren Co Ap KY USA TMY3 WMO#=746716	0.82	1.21	0.94	0.81	0.87	0.80	4A
Bozeman Gallatin Field MT USA TMY3 WMO#=726797	1.21	0.51	1.09	1.21	0.11	1.45	6B
Bradford Regional Ap PA USA TMY3 WMO#=725266	1.46	0.50	1.00	1.48	0.10	0.95	6A
Brainerd Wieland MN USA TMY3 WMO#=726555	1.75	0.59	1.03	1.61	0.05	1.09	7
Bremerton National WA USA TMY3 WMO#=727928	0.80	0.39	0.92	0.67	0.04	0.55	4C
Brewster Field Arpt NE USA TMY3 WMO#=725628	1.19	0.81	1.02	1.26	0.47	1.07	5A
Bridgeport Sikorsky Memorial CT USA TMY3 WMO#=725040	1.03	0.76	0.94	1.18	0.32	0.98	5A
Bristol Tri City Airport TN USA TMY3 WMO#=723183	0.75	1.04	0.96	0.78	0.64	0.80	4A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Broken Bow Muni NE USA TMY3 WMO#=725555	1.26	0.80	1.04	1.42	0.49	1.10	5A
BrookingsSD USA TMY3 WMO#=726515	1.60	0.64	1.01	1.69	0.13	0.94	6A
Broomfield JeffcoCO USA TMY3 WMO#=724699	0.78	0.70	1.12	0.88	0.31	0.99	5B
Brownsville S Padre Isl Intl TX USA TMY3 WMO#=722500	0.31	2.43	1.00	0.24	3.82	0.91	2A
Brunswick Golden Is GA USA TMY3 WMO#=722136	0.46	1.86	0.99	0.33	2.84	0.86	2A
Brunswick Malcolm Mckinnon Ap GA USA TMY3 WMO#=722137	0.35	1.90	0.98	0.26	2.54	0.78	2A
Bryce Cnyn Faa Ap UT USA TMY3 WMO#=724756	1.08	0.49	1.19	1.28	0.18	1.16	5B
Buffalo Niagara Intl Ap NY USA TMY3 WMO#=725280	1.30	0.63	0.98	1.44	0.27	1.05	5A
Burbank Glendale Pasadena Ap CA USA TMY3 WMO#=722880	0.31	1.22	0.97	0.26	1.57	0.89	3B
Burke Lakefront OH USA TMY3 WMO#=725245	1.25	0.74	0.97	1.41	0.29	1.02	5A
Burley Municipal Arpt ID USA TMY3 WMO#=725867	0.89	0.69	1.09	0.99	0.35	0.99	5B
Burlington International Ap VT USA TMY3 WMO#=726170	1.44	0.59	0.96	1.47	0.13	0.88	6A
Burlington Municipal Ap IA USA TMY3 WMO#=725455	1.15	1.09	0.99	1.20	0.71	0.99	5A
Burns Municipal ArptOR USA TMY3 WMO#=726830	0.92	0.54	1.08	0.92	0.29	0.98	5B
Butler CoAwos PA USA TMY3 WMO#=725124	1.07	0.72	0.98	0.98	0.31	1.00	5A
Butte Bert Mooney Arpt MT USA TMY3 WMO#=726785	1.15	0.41	1.13	1.18	0.07	1.53	6B
Cadillac Wexford Co Ap MI USA TMY3 WMO#=726384	1.32	0.58	0.98	1.23	0.12	0.88	6A
Cahokia StIL USA TMY3 WMO#=725314	0.86	1.18	0.95	0.89	0.92	0.83	4A
Cairns Field Fort Rucker AL USA TMY3 WMO#=722269	0.46	1.60	0.94	0.48	2.03	1.04	3A
Caldwell Essex Co NJ USA TMY3 WMO#=724094	0.86	0.85	0.93	0.88	0.49	0.79	5B
CaldwellID USA TMY3 WMO#=726813	0.86	0.69	1.04	0.85	0.35	0.91	4A
CamarilloCA USA TMY3 WMO#=723926	0.39	0.86	0.90	0.37	0.03	0.56	3C
Cambridge Muni MN USA TMY3 WMO#=727503	1.73	0.63	0.99	1.49	0.14	0.90	6A
Camp Mabry TX USA TMY3 WMO#=722544	0.44	1.93	1.02	0.34	3.12	0.97	2A
Camp Pendleton Mcas CA USA TMY3 WMO#=722926	0.33	0.98	0.93	0.27	0.94	0.77	3B
Cape Girardeau Municipal Ap MO USA TMY3 WMO#=723489	0.87	1.16	0.95	0.87	0.89	0.78	4A
Cape Hatteras Nws Bldg NC USA TMY3 WMO#=723040	0.49	1.46	0.93	0.51	1.86	1.01	3A
Cape May Co NJ USA TMY3 WMO#=745966	0.71	0.99	0.93	0.78	0.70	0.80	4A
Caribou Municipal Arpt ME USA TMY3 WMO#=727120	1.99	0.43	1.02	2.12	0.04	1.14	7
Carlsbad Cavern City Air Term NM USA TMY3 WMO#=722687	0.44	1.33	1.07	0.39	2.29	1.17	3B
Carlsbad Palomar CA USA TMY3 WMO#=722927	0.31	0.89	0.94	0.25	0.57	0.74	3B
Carroll IA USA TMY3 WMO#=725468	1.36	0.88	1.01	1.44	0.54	1.05	5A
Casa GrandaAZ USA TMY3 WMO#=722748	0.35	2.02	1.19	0.18	3.30	1.61	2B
Casper Natrona Co Intl Ap WY USA TMY3 WMO#=725690	1.15	0.59	1.13	1.54	0.13	1.52	6B
Cedar City Municipal Ap UT USA TMY3 WMO#=724755	0.72	0.77	1.12	0.81	0.38	0.98	5B
Cedar Rapids Municipal Ap IA USA TMY3 WMO#=725450	1.55	0.82	0.99	1.65	0.38	1.05	5A
Central Illinois Rg IL USA TMY3 WMO#=724397	1.23	0.82	0.98	1.34	0.43	1.04	5A
Chadron Municipal Ap NE USA TMY3 WMO#=725636	1.06	0.79	1.06	1.19	0.56	1.09	5A
Chan Gurney Muni SD USA TMY3 WMO#=726525	1.49	0.84	1.02	1.63	0.55	1.09	5A
Chanute Martin Johnson Ap KS USA TMY3 WMO#=724507	0.92	1.35	0.98	0.96	1.14	0.85	4A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Chariton IA USA TMY3 WMO#=725469	1.15	0.99	0.99	1.15	0.61	1.01	5A
Charles City IA USA TMY3 WMO#=725463	1.39	0.77	0.98	1.43	0.19	0.89	6A
Charleston Intl Arpt SC USA TMY3 WMO#=722080	0.41	1.67	0.94	0.43	2.23	1.05	3A
Charleston Yeager Arpt WV USA TMY3 WMO#=724140	0.87	1.07	0.96	0.87	0.70	0.82	4A
Charlotte Douglas Intl Arpt NC USA TMY3 WMO#=723140	0.52	1.31	0.95	0.52	1.78	1.11	3A
Charlottesville Faa VA USA TMY3 WMO#=724016	0.64	1.12	0.94	0.68	0.65	0.76	4A
Chattanooga Lovell Field Ap TN USA TMY3 WMO#=723240	0.57	1.33	0.95	0.61	0.95	0.76	4A
Cherry Point Mcas NC USA TMY3 WMO#=723090	0.60	1.36	0.93	0.62	1.87	1.08	3A
Cheyenne Municipal Arpt WY USA TMY3 WMO#=725640	1.05	0.51	1.16	1.47	0.09	1.58	6B
Chicago Midway Ap IL USA TMY3 WMO#=725340	1.17	0.90	0.98	1.27	0.49	1.00	5A
Chicago Ohare Intl Ap IL USA TMY3 WMO#=725300	1.24	0.84	0.98	1.29	0.46	1.03	5A
Chicago Waukegan IL USA TMY3 WMO#=725347	1.25	0.70	0.97	1.22	0.35	1.04	5A
Chicopee Falls Westo MA USA TMY3 WMO#=744910	1.09	0.70	0.95	1.04	0.32	0.98	5A
Childress Municipal Ap TX USA TMY3 WMO#=723604	0.56	1.25	1.07	0.49	2.28	1.18	3B
China Lake Naf CA USA TMY3 WMO#=746120	0.40	1.36	1.10	0.37	2.79	1.26	3B
Chino Airport CA USA TMY3 WMO#=722899	0.32	1.19	0.96	0.27	1.78	0.94	3B
Chippewa Co Intl MI USA TMY3 WMO#=727344	1.73	0.39	1.01	1.74	0.03	1.11	7
Chula Vista Brown Field Naas CA USA TMY3 WMO#=722904	0.31	0.96	0.95	0.26	0.79	0.76	3B
Chulitna AK USA TMY3 WMO#=702606	1.96	0.14	1.05	1.74	0.01	1.16	7
Cincinnati Municipal Ap Lunken OH USA TMY3 WMO#=724297	0.87	0.99	0.94	0.86	0.69	0.82	4A
Cincinnati Northern Ky Ap KY USA TMY3 WMO#=724210	1.02	0.97	0.96	1.06	0.63	0.83	4A
Clarinda IA USA TMY3 WMO#=725479	1.11	1.10	0.99	1.07	0.67	0.98	5A
Clayton Municipal Airpark NM USA TMY3 WMO#=723600	0.67	0.93	1.09	0.75	0.88	1.08	4B
Cleveland Hopkins Intl Ap OH USA TMY3 WMO#=725240	1.20	0.80	0.97	1.24	0.41	1.01	5A
Clinton Muni IA USA TMY3 WMO#=725473	1.42	0.89	0.99	1.47	0.53	1.05	5A
Clinton Sherman OK USA TMY3 WMO#=723526	0.77	1.34	1.00	0.82	2.08	1.28	3A
Cloquet MN USA TMY3 WMO#=726558	1.76	0.53	1.03	1.74	0.06	1.12	7
Clovis Cannon Afb NM USA TMY3 WMO#=722686	0.73	1.04	1.08	0.82	1.08	1.09	4B
Clovis Muni Awos NM USA TMY3 WMO#=722689	0.68	0.99	1.06	0.78	0.98	1.07	4B
Cody Muni WY USA TMY3 WMO#=726700	0.95	0.54	1.10	1.10	0.10	1.48	6B
Coeur D Alene Awos ID USA TMY3 WMO#=727834	1.06	0.54	1.04	1.04	0.29	0.94	5B
Cold Bay Arpt AK USA TMY3 WMO#=703160	1.82	0.06	1.00	2.15	0.01	1.21	7
College Station Easterwood Fl TX USA TMY3 WMO#=722445	0.41	1.83	0.99	0.29	2.90	0.90	2A
Colorado Springs Muni Ap CO USA TMY3 WMO#=724660	0.80	0.69	1.13	0.96	0.29	1.02	5B
Columbia Metro Arpt SC USA TMY3 WMO#=723100	0.47	1.51	0.94	0.48	2.04	1.09	3A
Columbia Regional Airport MO USA TMY3 WMO#=724450	1.05	1.08	0.97	1.12	0.86	0.86	4A
Columbus Afb MS USA TMY3 WMO#=723306	0.63	1.48	0.94	0.61	2.21	1.14	3A
Columbus Metropolitan Arpt GA USA TMY3 WMO#=722255	0.42	1.65	0.95	0.43	2.32	1.17	3A
Columbus Muni NE USA TMY3 WMO#=725565	1.27	0.90	1.01	1.34	0.51	1.04	5A
Columbus Port Columbus Intl A OH USA TMY3 WMO#=724280	1.03	0.83	0.96	1.02	0.36	0.97	5A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Concord Concord Buchanan Fiel CA USA TMY3 WMO#=724936	0.41	0.84	0.94	0.33	1.10	0.88	3B
Concord Municipal Arpt NH USA TMY3 WMO#=726050	1.30	0.64	0.95	1.24	0.16	0.85	6A
Concordia Blosser Muni Ap KS USA TMY3 WMO#=724580	0.94	1.11	1.00	1.03	0.79	1.03	5A
Cordova AK USA TMY3 WMO#=702960	1.55	0.18	0.99	1.20	0.01	1.02	7
Corpus Christi Intl ArptTX USA TMY3 WMO#=722510	0.33	2.25	1.00	0.27	3.59	0.91	2A
Corpus Christi Nas TX USA TMY3 WMO#=722515	0.29	2.45	1.01	0.23	3.72	0.88	2A
Cortez Montezuma Co CO USA TMY3 WMO#=724767	0.71	0.79	1.13	0.82	0.36	1.00	5B
Corvallis Muni OR USA TMY3 WMO#=726945	0.66	0.61	0.92	0.60	0.09	0.53	4C
Cotulla Faa Ap TX USA TMY3 WMO#=722526	0.33	2.34	1.12	0.16	3.07	1.24	2B
Council Bluffs IA USA TMY3 WMO#=725497	1.10	0.92	0.99	1.07	0.48	1.00	5A
Cox Fld TX USA TMY3 WMO#=722587	0.59	1.47	0.95	0.63	2.19	1.16	3A
Craig Moffat CO USA TMY3 WMO#=725700	1.14	0.54	1.18	1.19	0.09	1.56	6B
Crane LakeMN USA TMY3 WMO#=727473	1.89	0.45	1.03	1.47	0.04	1.08	7
Crescent City Faa Ai CA USA TMY3 WMO#=725946	0.60	0.28	0.90	0.60	0.01	0.53	4C
Creston IA USA TMY3 WMO#=725474	1.19	0.94	1.00	1.24	0.49	1.02	5A
Crestview Bob Sikes Ap FL USA TMY3 WMO#=722215	0.41	1.80	0.98	0.29	2.56	0.81	2A
Crookston Muni Fld MN USA TMY3 WMO#=727452	1.94	0.58	1.04	2.11	0.06	1.14	7
Crossville Memorial Ap TN USA TMY3 WMO#=723265	0.66	1.07	0.97	0.65	0.59	0.77	4A
Cut Bank Muni Ap MT USA TMY3 WMO#=727796	1.30	0.41	1.07	1.58	0.06	1.45	6B
Daggett Barstow Daggett Ap CA USA TMY3 WMO#=723815	0.36	1.46	1.11	0.33	2.87	1.25	3B
Dalhart Municipal Ap TX USA TMY3 WMO#=722636	0.81	0.85	1.05	0.87	0.77	1.06	4B
Dallas Addison Arpt TX USA TMY3 WMO#=722598	0.56	1.65	0.97	0.58	2.67	1.28	3A
Dallas Fort Worth Intl Ap TX USA TMY3 WMO#=722590	0.46	1.72	0.96	0.50	2.72	1.27	3A
Dallas Love Field TX USA TMY3 WMO#=722583	0.46	1.86	0.97	0.47	2.99	1.28	3A
Dallas Redbird Arpt TX USA TMY3 WMO#=722599	0.43	1.80	0.97	0.45	2.72	1.20	3A
Danbury Municipal CT USA TMY3 WMO#=725086	1.03	0.73	0.96	1.02	0.33	0.97	5A
Danville Faa Ap VA USA TMY3 WMO#=724106	0.64	1.25	0.94	0.69	0.86	0.78	4A
Dare Co Rgnl NC USA TMY3 WMO#=723046	0.56	1.33	0.93	0.58	1.74	1.04	3A
Davis Monthan Afb AZ USA TMY3 WMO#=722745	0.32	1.92	1.21	0.17	2.81	1.40	2B
Davison Aaf VA USA TMY3 WMO#=724037	0.81	1.15	0.94	0.84	0.84	0.79	4A
Dayton International Airport OH USA TMY3 WMO#=724290	1.14	0.88	0.98	1.19	0.42	1.00	5A
Dayton Wright Patterson Afb OH USA TMY3 WMO#=745700	1.06	0.81	0.97	1.03	0.41	0.94	5A
Daytona Beach Intl Ap FL USA TMY3 WMO#=722056	0.29	2.10	0.99	0.24	2.91	0.89	2A
Deadhorse AK USA TMY3 WMO#=700637	5.33	0.06	1.15	4.83	0.00	1.29	8
Decatur IL USA TMY3 WMO#=725316	1.04	0.98	0.97	1.12	0.62	0.99	5A
Decorah IA USA TMY3 WMO#=725476	1.09	0.87	0.98	1.02	0.22	0.83	6A
Deer Valley Phoenix AZ USA TMY3 WMO#=722784	0.33	2.09	1.20	0.18	3.29	1.57	2B
Dekalb Peachtree GA USA TMY3 WMO#=722196	0.59	1.32	0.95	0.59	1.70	1.10	3A
Del Rio Laughlin Afb TX USA TMY3 WMO#=722615	0.33	2.30	1.15	0.17	3.32	1.38	2B
Del RioTX USA TMY3 WMO#=722610	0.37	1.97	1.12	0.18	2.76	1.35	2B

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Delaware Co Johnson IN USA TMY3 WMO#=725336	1.08	0.91	0.97	1.10	0.43	0.99	5A
Delta UT USA TMY3 WMO#=724795	0.78	0.74	1.10	0.84	0.42	0.99	5B
Deming Muni NM USA TMY3 WMO#=722725	0.39	1.25	1.11	0.39	2.03	1.21	3B
Denison IA USA TMY3 WMO#=725477	1.27	0.94	1.00	1.28	0.55	1.04	5A
Denver CentennialCO USA TMY3 WMO#=724666	0.81	0.67	1.13	0.93	0.27	1.02	5B
Denver Intl Ap CO USA TMY3 WMO#=725650	0.76	0.79	1.12	0.89	0.35	1.00	5B
Des Moines Intl Ap IA USA TMY3 WMO#=725460	1.30	0.94	1.00	1.39	0.53	1.03	5A
Detroit City Airport MI USA TMY3 WMO#=725375	1.19	0.77	0.97	1.21	0.42	1.00	5A
Detroit Lakes Awos MN USA TMY3 WMO#=727457	1.77	0.62	1.04	1.79	0.07	1.11	7
Detroit Metropolitan Arpt MI USA TMY3 WMO#=725370	1.30	0.76	0.98	1.45	0.39	1.04	5A
Detroit Willow Run Ap MI USA TMY3 WMO#=725376	1.29	0.82	0.98	1.34	0.42	1.03	5A
Devils Lake Awos ND USA TMY3 WMO#=727573	2.13	0.54	1.06	2.36	0.03	1.16	7
Dickinson Municipal Ap ND USA TMY3 WMO#=727645	2.06	0.59	1.07	2.35	0.18	1.03	6A
Dillant Hopkins NH USA TMY3 WMO#=726165	1.26	0.65	0.97	1.10	0.31	1.00	5A
DillinghamAK USA TMY3 WMO#=703210	1.89	0.13	1.00	1.92	0.01	1.18	8
Dinwiddie Co VA USA TMY3 WMO#=724014	0.58	1.32	0.94	0.61	0.91	0.72	4A
Dodge City Regional Ap KS USA TMY3 WMO#=724510	0.93	1.12	1.03	1.11	1.02	0.98	4A
Dothan Municipal Ap AL USA TMY3 WMO#=722268	0.41	1.68	0.94	0.44	2.14	1.05	3A
Douglas Bisbee Douglas Intl A AZ USA TMY3 WMO#=722735	0.36	1.29	1.09	0.33	1.90	1.14	3B
Dover Afb DE USA TMY3 WMO#=724088	0.95	0.99	0.93	1.04	0.69	0.82	4A
Draughon Miller Cen TX USA TMY3 WMO#=722577	0.57	1.81	1.02	0.40	3.10	1.08	2A
Dubois Faa Ap PA USA TMY3 WMO#=725125	1.30	0.61	1.00	1.31	0.23	1.07	5A
Dubuque Regional Ap IA USA TMY3 WMO#=725470	1.57	0.71	1.00	1.68	0.31	1.09	5A
Duluth International Arpt MN USA TMY3 WMO#=727450	2.00	0.46	1.05	2.23	0.04	1.17	7
Durango La Plata Co CO USA TMY3 WMO#=724625	0.82	0.66	1.15	0.90	0.26	1.04	5B
Dutch Harbor AK USA TMY3 WMO#=704890	1.63	0.06	0.98	1.56	0.01	1.10	7
Dyersburg Municipal Ap TN USA TMY3 WMO#=723347	0.66	1.37	0.95	0.66	2.05	1.19	3A
Eagle County Ap CO USA TMY3 WMO#=724675	0.98	0.52	1.12	1.08	0.08	1.53	6B
Eau Claire County Ap WI USA TMY3 WMO#=726435	1.71	0.65	0.99	1.62	0.17	0.91	6A
Edwards Afb CA USA TMY3 WMO#=723810	0.44	1.09	1.06	0.37	2.20	1.12	3B
El Dorado Goodwin Field AR USA TMY3 WMO#=723419	0.49	1.70	0.95	0.46	2.59	1.14	3A
El Paso International ApTX USA TMY3 WMO#=722700	0.36	1.30	1.08	0.34	2.07	1.23	3B
Elizabeth City Coast Guard Ai NC USA TMY3 WMO#=746943	0.48	1.44	0.93	0.50	1.94	1.05	3A
Elkins Elkins Randolph Co Arp WV USA TMY3 WMO#=724170	0.99	0.72	0.98	0.93	0.29	1.00	5A
Elko Municipal Arpt NV USA TMY3 WMO#=725825	0.88	0.65	1.11	0.89	0.38	1.02	5B
Ellsworth Afb SD USA TMY3 WMO#=726625	1.45	0.65	1.05	1.65	0.22	0.98	6A
Elmira Corning Regional Ap NY USA TMY3 WMO#=725156	1.02	0.60	0.96	0.95	0.22	0.99	5A
Ely Muni MN USA TMY3 WMO#=727459	1.86	0.55	1.04	1.53	0.04	1.09	7
Ely Yelland Field NV USA TMY3 WMO#=724860	0.91	0.58	1.14	1.13	0.30	1.08	5B
Emmonak AK USA TMY3 WMO#=702084	2.51	0.12	1.03	2.61	0.01	1.20	8

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Emporia Municipal Ap KS USA TMY3 WMO#=724556	1.23	1.16	0.99	1.29	1.00	0.90	4A
England Afb LA USA TMY3 WMO#=747540	0.43	1.85	0.99	0.31	2.82	0.90	2A
Ephrata Ap Fcwos WA USA TMY3 WMO#=727826	0.92	0.77	1.01	0.90	0.43	0.88	5B
Erie International Ap PA USA TMY3 WMO#=725260	1.23	0.69	0.97	1.30	0.28	1.03	5A
EscanabaMI USA TMY3 WMO#=726480	1.61	0.42	0.97	1.54	0.07	0.90	6A
Estherville Muni IA USA TMY3 WMO#=726499	1.99	0.70	1.02	2.29	0.19	0.97	6A
Eugene Mahlon Sweet ArptOR USA TMY3 WMO#=726930	0.76	0.54	0.92	0.69	0.09	0.55	4C
Evanston Burns Fld WY USA TMY3 WMO#=725775	1.17	0.49	1.16	1.45	0.07	1.60	6B
Evansville Regional Ap IN USA TMY3 WMO#=724320	0.85	1.19	0.95	0.88	0.91	0.80	4A
Eveleth MuniMN USA TMY3 WMO#=727474	1.96	0.52	1.05	1.80	0.05	1.13	7
Fair Field IA USA TMY3 WMO#=726498	1.19	0.97	0.99	1.23	0.57	1.00	5A
Fairbanks Eielson A AK USA TMY3 WMO#=702650	2.46	0.25	1.05	1.99	0.01	1.19	8
Fairbanks Intl Arpt AK USA TMY3 WMO#=702610	2.99	0.31	1.08	2.31	0.01	1.18	8
Fairchild Afb WA USA TMY3 WMO#=727855	1.19	0.51	1.05	1.18	0.31	0.96	5B
Fairmont Muni Awos MN USA TMY3 WMO#=726586	1.52	0.68	1.00	1.66	0.19	0.92	6A
Fallon Naas NV USA TMY3 WMO#=724885	0.66	0.90	1.09	0.75	0.51	0.94	5B
Falls City Brenner NE USA TMY3 WMO#=725533	1.19	0.93	0.99	1.27	0.44	1.00	5A
Fargo Hector International Ap ND USA TMY3 WMO#=727530	2.15	0.65	1.05	2.37	0.07	1.13	7
Faribault Muni Awos MN USA TMY3 WMO#=726563	1.47	0.69	0.98	1.43	0.16	0.89	6A
Farmington Four Corners Regl NM USA TMY3 WMO#=723658	0.67	0.87	1.12	0.79	0.44	0.97	5B
Farmington MO USA TMY3 WMO#=724454	0.81	1.13	0.97	0.84	0.87	0.82	4A
Farmville VA USA TMY3 WMO#=724017	0.69	1.17	0.94	0.66	0.84	0.73	4A
Fayetteville Drake Field AR USA TMY3 WMO#=723445	0.66	1.36	0.97	0.71	1.11	0.83	4A
Fayetteville Pope Afb NC USA TMY3 WMO#=723030	0.60	1.35	0.94	0.58	1.90	1.11	3A
Fayetteville Rgnl G NC USA TMY3 WMO#=723035	0.63	1.28	0.93	0.62	1.69	1.08	3A
Felts Fld WA USA TMY3 WMO#=727856	0.91	0.61	1.02	0.82	0.33	0.89	5B
Fergus Falls Awos MN USA TMY3 WMO#=726560	1.60	0.68	1.03	1.62	0.09	1.08	7
Findlay Airport OH USA TMY3 WMO#=725366	1.02	0.73	0.96	1.04	0.30	0.98	5A
Flagstaff Pulliam Arpt AZ USA TMY3 WMO#=723755	0.74	0.57	1.14	0.83	0.21	1.05	5B
Flint Bishop Intl Arpt MI USA TMY3 WMO#=726370	1.34	0.70	0.98	1.40	0.31	1.04	5A
FlippinAR USA TMY3 WMO#=723447	0.64	1.24	0.96	0.67	0.90	0.80	4A
Florence Regional Ap SC USA TMY3 WMO#=723106	0.44	1.58	0.94	0.45	2.11	1.06	3A
Flying Cloud MN USA TMY3 WMO#=726579	1.65	0.76	1.00	1.62	0.24	0.91	6A
Fort Benning Lawson GA USA TMY3 WMO#=722250	0.53	1.43	0.93	0.54	1.88	1.07	3A
Fort Bragg Simmons Aaf NC USA TMY3 WMO#=746930	0.56	1.40	0.94	0.55	1.91	1.09	3A
Fort Campbell Aaf KY USA TMY3 WMO#=746710	0.85	1.28	0.95	0.86	1.02	0.81	4A
Fort CollinsCO USA TMY3 WMO#=724769	1.01	0.64	1.11	1.04	0.31	0.99	5B
Fort DodgeIA USA TMY3 WMO#=725490	1.40	0.80	0.99	1.38	0.23	0.88	6A
Fort Drum Wheeler S NY USA TMY3 WMO#=743700	1.42	0.54	0.96	1.36	0.12	0.89	6A
Fort Hood TX USA TMY3 WMO#=722570	0.54	1.86	1.03	0.40	3.15	1.03	2A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Fort Knox Godman Aaf KY USA TMY3 WMO#=724240	0.92	1.10	0.95	0.92	0.76	0.82	4A
Fort Lauderdale FL USA TMY3 WMO#=722039	0.24	2.51	0.98	0.10	4.96	1.19	1A
Fort Lauderdale Hollywood Int FL USA TMY3 WMO#=722025	0.21	2.72	1.00	0.09	5.58	1.26	1A
Fort Madison IA USA TMY3 WMO#=725483	0.94	1.00	0.97	0.94	0.56	0.96	5A
Fort Myers Page Field FL USA TMY3 WMO#=722106	0.25	2.53	1.00	0.19	3.21	0.83	2A
Fort Polk Aaf LA USA TMY3 WMO#=722390	0.48	1.72	0.94	0.49	2.10	1.05	3A
Fort Riley Marshall Aaf KS USA TMY3 WMO#=724550	0.80	1.24	0.98	0.84	1.03	0.83	4A
Fort Sill Post Field Af OK USA TMY3 WMO#=723550	0.64	1.48	0.98	0.68	2.52	1.31	3A
Fort Smith Regional Ap AR USA TMY3 WMO#=723440	0.68	1.45	0.96	0.68	2.24	1.18	3A
Fort Wayne Intl Ap IN USA TMY3 WMO#=725330	1.34	0.81	0.98	1.45	0.40	1.03	5A
Fort Worth Alliance TX USA TMY3 WMO#=722594	0.50	1.60	0.96	0.51	2.30	1.16	3A
Fort Worth Meacham TX USA TMY3 WMO#=722596	0.49	1.65	0.96	0.51	2.68	1.24	3A
Fort Worth Nas TX USA TMY3 WMO#=722595	0.42	1.68	0.96	0.45	2.47	1.24	3A
Fort Yukon AK USA TMY3 WMO#=701940	3.66	0.26	1.11	2.82	0.01	1.20	8
Fosston Awos MN USA TMY3 WMO#=727505	2.13	0.54	1.05	2.08	0.04	1.13	7
Franklin Naas VA USA TMY3 WMO#=723083	0.53	1.35	0.94	0.61	1.00	0.76	4A
Franklin PA USA TMY3 WMO#=725267	1.15	0.61	0.99	1.07	0.24	1.04	5A
Fremont Muni Arpt NE USA TMY3 WMO#=725564	1.44	0.84	1.01	1.45	0.41	1.02	5A
Fresno Yosemite Intl Ap CA USA TMY3 WMO#=723890	0.40	1.25	0.98	0.33	2.19	1.10	3B
Ft Lnrnd Wd Aaf MO USA TMY3 WMO#=724457	0.90	1.18	0.98	0.93	0.92	0.87	4A
Fullerton Municipal CA USA TMY3 WMO#=722976	0.30	1.17	0.94	0.25	1.44	0.84	3B
Fulton Co Arpt Brow GA USA TMY3 WMO#=722195	0.51	1.31	0.94	0.50	1.61	1.11	3A
Gadsen MuniAL USA TMY3 WMO#=722285	0.51	1.29	0.94	0.50	1.70	1.11	3A
Gage Airport OK USA TMY3 WMO#=723527	0.70	1.37	1.01	0.74	2.38	1.39	3A
Gainesville Regional Ap FL USA TMY3 WMO#=722146	0.36	1.92	0.98	0.28	2.72	0.84	2A
Gallup Sen Clarke Fld NM USA TMY3 WMO#=723627	0.67	0.74	1.13	0.77	0.27	1.00	5B
Galveston Scholes TX USA TMY3 WMO#=722420	0.34	2.09	0.99	0.26	3.20	0.86	2A
Gambell AK USA TMY3 WMO#=702040	3.44	0.03	1.09	4.30	0.00	1.28	8
Garden City Municipal Ap KS USA TMY3 WMO#=724515	0.91	1.06	1.03	1.05	0.89	0.92	4A
GeorgetownTX USA TMY3 WMO#=722547	0.50	1.78	1.02	0.36	2.99	0.98	2A
Gillette Gillette C WY USA TMY3 WMO#=726650	1.08	0.67	1.08	1.29	0.18	1.43	6B
Glasgow Intl Arpt MT USA TMY3 WMO#=727680	1.59	0.58	1.10	1.79	0.12	1.36	6B
Glendive Awos MT USA TMY3 WMO#=726676	1.66	0.56	1.10	1.80	0.15	1.38	6B
Glens Falls Ap NY USA TMY3 WMO#=725185	1.31	0.64	0.95	1.19	0.14	0.84	6A
GlenwoodMN USA TMY3 WMO#=726547	1.77	0.66	1.02	1.84	0.16	0.94	6A
Golden Tri Awos MS USA TMY3 WMO#=723307	0.60	1.46	0.94	0.58	2.10	1.12	3A
Goldsboro Seymour Johnson Afb NC USA TMY3 WMO#=723066	0.65	1.33	0.94	0.64	1.87	1.10	3A
Goodland Renner Field KS USA TMY3 WMO#=724650	1.02	0.88	1.06	1.25	0.58	1.10	5A
Grand Canyon Natl P AZ USA TMY3 WMO#=723783	0.72	0.67	1.14	0.82	0.25	1.03	5B
Grand Forks Af ND USA TMY3 WMO#=727575	1.88	0.54	1.03	2.15	0.06	1.14	7

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Grand Forks International Ap ND USA TMY3 WMO#=727576	2.34	0.67	1.06	2.52	0.08	1.14	7
Grand Island Central Ne Regio NE USA TMY3 WMO#=725520	1.34	0.90	1.03	1.56	0.58	1.09	5A
Grand Junction Walker Field CO USA TMY3 WMO#=724760	0.72	0.87	1.12	0.80	0.47	0.98	5B
Grand Rapids Awos MN USA TMY3 WMO#=727458	1.83	0.56	1.04	1.76	0.05	1.12	7
Grand Rapids Kent County Int MI USA TMY3 WMO#=726350	1.36	0.72	0.98	1.40	0.32	1.04	5A
Gray Aaf WA USA TMY3 WMO#=742070	0.88	0.42	0.92	0.74	0.04	0.56	4C
Great BendKS USA TMY3 WMO#=724517	0.92	1.12	1.01	1.06	0.99	0.89	4A
Great Falls Intl Arpt MT USA TMY3 WMO#=727750	1.35	0.50	1.08	1.55	0.10	1.42	6B
Greeley WeldCO USA TMY3 WMO#=724768	0.94	0.66	1.10	1.00	0.30	0.99	5B
Green Bay Austin Straubel Int WI USA TMY3 WMO#=726450	1.56	0.66	0.98	1.65	0.16	0.91	6A
Greensboro Piedmont Triad Int NC USA TMY3 WMO#=723170	0.70	1.21	0.96	0.76	0.82	0.79	4A
Greenville Downtown Ap SC USA TMY3 WMO#=723119	0.62	1.22	0.96	0.60	1.62	1.11	3A
Greenville Majors TX USA TMY3 WMO#=722588	0.55	1.63	0.96	0.56	2.46	1.23	3A
Greenville Municipal MS USA TMY3 WMO#=722356	0.47	1.65	0.95	0.48	2.44	1.11	3A
Greenwood Leflore Arpt MS USA TMY3 WMO#=722359	0.47	1.59	0.94	0.47	2.29	1.15	3A
Greer GreenvL Spartanbrg Ap SC USA TMY3 WMO#=723120	0.54	1.28	0.95	0.55	1.72	1.12	3A
Grissom Arb IN USA TMY3 WMO#=725335	1.23	0.81	0.98	1.38	0.39	1.02	5A
Groton New London Ap CT USA TMY3 WMO#=725046	0.97	0.65	0.93	0.99	0.23	0.96	5A
Gulfport Biloxi Int MS USA TMY3 WMO#=747685	0.40	1.90	0.98	0.29	2.81	0.84	2A
Gulkana Intermediate Field AK USA TMY3 WMO#=702710	2.79	0.20	1.11	2.02	0.01	1.22	7
Gunnison CoAwos CO USA TMY3 WMO#=724677	1.10	0.47	1.18	1.11	0.02	1.20	7
Gustavus AK USA TMY3 WMO#=703670	1.38	0.20	0.98	1.11	0.01	1.00	7
Hagerstown Rgnl Ric MD USA TMY3 WMO#=724066	0.89	0.99	0.95	0.93	0.63	0.81	4A
Hailey Friedman Mem ID USA TMY3 WMO#=725865	0.96	0.59	1.12	1.08	0.16	1.47	6B
Hallock MN USA TMY3 WMO#=727478	2.23	0.64	1.05	2.37	0.07	1.13	7
Hancock Houghton Co Ap MI USA TMY3 WMO#=727440	1.86	0.48	1.03	1.95	0.04	1.13	7
Hanford WA USA TMY3 WMO#=727840	0.99	0.77	1.01	0.95	0.47	0.86	5B
Hanksville UT USA TMY3 WMO#=724735	0.68	0.96	1.10	0.70	0.64	0.98	5B
Harlingen Rio Grande Valley I TX USA TMY3 WMO#=722505	0.28	2.44	1.00	0.22	3.92	0.92	2A
Harrisburg Capital City Arpt PA USA TMY3 WMO#=725118	1.01	0.94	0.95	1.03	0.62	0.82	4A
Harrison Faa Ap AR USA TMY3 WMO#=723446	0.71	1.25	0.97	0.76	0.94	0.84	4A
Harrison Marion Rgn WV USA TMY3 WMO#=724175	0.88	0.89	0.97	0.84	0.40	0.95	5A
Hartford Bradley Intl Ap CT USA TMY3 WMO#=725080	1.04	0.77	0.95	1.04	0.41	0.97	5A
Hartford Brainard Fd CT USA TMY3 WMO#=725087	0.99	0.74	0.94	0.96	0.31	0.94	5A
Hastings Municipal NE USA TMY3 WMO#=725525	1.16	0.93	1.02	1.28	0.59	1.06	5A
Hattiesburg Laurel MS USA TMY3 WMO#=722348	0.43	1.55	0.94	0.44	1.99	1.06	3A
Havre City County Ap MT USA TMY3 WMO#=727770	1.48	0.55	1.09	1.61	0.13	1.37	6B
Hayden YampaCO USA TMY3 WMO#=725715	1.13	0.52	1.16	1.27	0.04	1.19	7
Hayes River AK USA TMY3 WMO#=702495	1.78	0.21	1.03	1.31	0.01	1.08	7
Hays MuniKS USA TMY3 WMO#=724518	0.83	1.05	1.01	0.94	0.87	1.06	5A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Hayward Air Term CA USA TMY3 WMO#=724935	0.45	0.73	0.90	0.39	0.04	0.57	3C
Healy River Airport AK USA TMY3 WMO#=702647	1.93	0.19	1.05	1.69	0.01	1.21	8
Helena Regional Airport MT USA TMY3 WMO#=727720	1.12	0.49	1.07	1.18	0.09	1.40	6B
Henderson City KY USA TMY3 WMO#=724238	0.91	0.99	0.94	0.96	0.71	0.83	4A
Hibbing Chisholm Hibbing Ap MN USA TMY3 WMO#=727455	2.03	0.52	1.04	1.99	0.05	1.14	7
Hickory Regional Ap NC USA TMY3 WMO#=723145	0.58	1.23	0.96	0.65	0.78	0.77	4A
Hill City Municipal Ap KS USA TMY3 WMO#=724655	1.00	0.95	1.02	1.13	0.64	1.05	5A
Hillsville VA USA TMY3 WMO#=724107	0.93	0.89	1.01	1.02	0.59	0.89	4A
Hilo International Ap HI USA TMY3 WMO#=912850	0.21	2.30	0.96	0.09	3.79	1.08	1A
Hobart Municipal Ap OK USA TMY3 WMO#=723525	0.68	1.49	1.00	0.73	2.68	1.34	3A
Holloman Afb NM USA TMY3 WMO#=747320	0.45	1.16	1.09	0.41	2.00	1.19	3B
Homer Arpt AK USA TMY3 WMO#=703410	1.76	0.17	1.01	1.71	0.01	1.10	7
Homestead Afb FL USA TMY3 WMO#=722026	0.23	2.59	0.99	0.10	5.30	1.25	1A
Hondo Municipal Ap TX USA TMY3 WMO#=722533	0.43	1.92	1.11	0.21	2.63	1.25	2B
Honolulu Intl Arpt HI USA TMY3 WMO#=911820	0.20	2.60	0.99	0.09	4.99	1.26	1A
Hoonah AK USA TMY3 WMO#=702607	1.47	0.24	0.98	1.33	0.01	1.03	7
Hooper Bay AK USA TMY3 WMO#=702186	2.51	0.06	1.04	3.06	0.01	1.25	8
Hoquiam Ap WA USA TMY3 WMO#=727923	0.77	0.32	0.91	0.70	0.02	0.54	4C
Hot Springs Ingalls VA USA TMY3 WMO#=724115	1.19	0.64	1.05	1.32	0.29	0.95	4A
Houghton Lake Roscommon Co Ar MI USA TMY3 WMO#=726380	1.50	0.56	0.98	1.48	0.12	0.91	6A
Houlton Intl Arpt ME USA TMY3 WMO#=727033	1.87	0.50	1.00	1.80	0.04	1.09	7
Houma Terrebonne LA USA TMY3 WMO#=722406	0.42	1.99	0.99	0.30	2.96	0.94	2A
Houston Bush Intercontinental TX USA TMY3 WMO#=722430	0.38	1.98	0.99	0.29	3.08	0.90	2A
Houston D WTX USA TMY3 WMO#=722429	0.37	2.05	1.00	0.27	3.04	0.88	2A
Houston Ellington AfbL TX USA TMY3 WMO#=722436	0.40	2.04	0.99	0.30	3.01	0.86	2A
Houston William P Hobby Ap TX USA TMY3 WMO#=722435	0.32	2.01	0.99	0.24	3.02	0.94	2A
Howell MI USA TMY3 WMO#=725378	1.11	0.81	0.98	1.06	0.44	1.00	5A
Hunter Aaf GA USA TMY3 WMO#=747804	0.52	1.71	0.99	0.37	2.70	0.96	2A
Huntingburg IN USA TMY3 WMO#=724365	0.74	1.17	0.95	0.77	0.82	0.79	4A
Huntington Tri State Arpt WV USA TMY3 WMO#=724250	0.86	1.05	0.95	0.86	0.67	0.80	4A
Huntsville Intl Jones Field AL USA TMY3 WMO#=723230	0.61	1.33	0.95	0.61	1.88	1.12	3A
Huron Regional Arpt SD USA TMY3 WMO#=726540	1.71	0.69	1.01	1.83	0.21	0.92	6A
Huslia AK USA TMY3 WMO#=702225	3.01	0.17	1.07	2.50	0.01	1.19	8
Hutchinson Municipal Ap KS USA TMY3 WMO#=724506	0.80	1.23	0.99	0.86	1.05	0.86	6A
HutchinsonMN USA TMY3 WMO#=726569	1.66	0.68	1.00	1.68	0.19	0.92	4A
Hydaburg Seaplane AK USA TMY3 WMO#=703884	1.16	0.47	1.00	1.05	0.29	1.06	7
Idaho Falls Fanning Field ID USA TMY3 WMO#=725785	1.15	0.55	1.10	1.28	0.12	1.47	6B
Iliamna Arpt AK USA TMY3 WMO#=703400	1.90	0.18	1.02	1.94	0.01	1.14	7
Imperial CA USA TMY3 WMO#=747185	0.29	2.34	1.15	0.17	3.93	1.52	2B
Imperial Faa Ap NE USA TMY3 WMO#=725626	0.91	0.89	1.04	1.03	0.62	1.07	5A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Indianapolis Intl Ap IN USA TMY3 WMO#=724380	1.18	0.95	0.98	1.23	0.51	0.99	5A
International Falls Intl Ap MN USA TMY3 WMO#=727470	2.26	0.52	1.05	2.23	0.05	1.15	7
Iron Mountain Ford MI USA TMY3 WMO#=727437	1.59	0.63	0.99	1.46	0.14	0.92	6A
IronwoodMI USA TMY3 WMO#=727445	1.72	0.53	1.03	1.71	0.05	1.10	7
Islip Long Isl Macarthur Ap NY USA TMY3 WMO#=725035	0.91	0.95	0.94	0.99	0.67	0.82	4A
Jack Northrop Fld H CA USA TMY3 WMO#=722956	0.29	0.99	0.93	0.22	0.78	0.71	3B
Jackson Hole WY USA TMY3 WMO#=725776	1.33	0.39	1.17	1.41	0.03	1.24	7
Jackson International Ap MS USA TMY3 WMO#=722350	0.45	1.62	0.94	0.46	2.28	1.09	3A
Jackson Julian Carroll Ap KY USA TMY3 WMO#=724236	0.70	1.09	0.96	0.72	0.67	0.79	4A
Jackson Mckellar Sipes Regl A TN USA TMY3 WMO#=723346	0.62	1.30	0.94	0.60	1.75	1.12	3A
Jackson Reynolds Field MI USA TMY3 WMO#=725395	1.22	0.79	0.98	1.22	0.36	1.02	5A
Jacksonville Craig FL USA TMY3 WMO#=722068	0.32	1.93	0.98	0.25	2.66	0.79	3A
Jacksonville Intl Arpt FL USA TMY3 WMO#=722060	0.36	1.91	0.99	0.28	2.80	0.85	2A
Jacksonville Nas FL USA TMY3 WMO#=722065	0.34	2.03	0.99	0.26	2.80	0.83	2A
JacksonvilleNC USA TMY3 WMO#=723069	0.62	1.29	0.93	0.60	1.78	1.13	2A
Jamestown Municipal Arpt ND USA TMY3 WMO#=727535	2.25	0.62	1.07	2.49	0.08	1.18	5A
JamestownNY USA TMY3 WMO#=725235	1.26	0.54	1.00	1.23	0.21	1.07	7
Janesville Rock Co WI USA TMY3 WMO#=726415	1.18	0.57	0.95	1.20	0.10	0.87	6A
Jefferson City Mem MO USA TMY3 WMO#=724458	0.83	1.21	0.96	0.85	0.92	0.81	4A
Johnstown Cambria County Ap PA USA TMY3 WMO#=725127	1.25	0.65	1.01	1.39	0.24	1.09	5A
Jonesboro Muni AR USA TMY3 WMO#=723407	0.81	1.38	0.95	0.72	2.03	1.11	3A
Joplin Municipal Ap MO USA TMY3 WMO#=723495	0.74	1.39	0.97	0.81	1.21	0.83	4A
Joslin Fld Magic VaFall ID USA TMY3 WMO#=725866	0.90	0.68	1.09	1.01	0.36	1.01	5B
Juneau Intl Arpt AK USA TMY3 WMO#=703810	1.47	0.23	0.98	1.33	0.01	1.04	7
Kahului Airport HI USA TMY3 WMO#=911900	0.20	2.53	0.98	0.09	4.78	1.24	1A
Kaiser MemMO USA TMY3 WMO#=724459	0.82	1.21	0.96	0.81	1.00	0.83	4A
Kake Seaplane Base AK USA TMY3 WMO#=703855	1.37	0.21	0.97	1.19	0.01	1.02	7
Kalamazoo Battle Cr MI USA TMY3 WMO#=726357	1.19	0.74	0.97	1.19	0.33	1.00	5A
Kalispell Glacier Pk IntL Ar MT USA TMY3 WMO#=727790	1.18	0.46	1.05	1.16	0.08	1.36	6B
Kaneohe Bay Mcas HI USA TMY3 WMO#=911760	0.20	2.55	0.98	0.09	4.58	1.35	1A
Kansas City Downtown Ap MO USA TMY3 WMO#=724463	0.78	1.31	0.97	0.81	1.10	0.87	4A
Kansas City Intl Arpt MO USA TMY3 WMO#=724460	1.09	1.11	0.98	1.18	0.90	0.87	4A
Kapalua HI USA TMY3 WMO#=911904	0.20	2.30	0.97	0.09	3.88	1.14	1A
Kearney MuniNE USA TMY3 WMO#=725526	1.13	0.83	1.02	1.28	0.47	1.07	5A
Keesler Afb MS USA TMY3 WMO#=747686	0.45	1.88	0.99	0.33	2.88	0.94	2A
Kelso Wb Ap WA USA TMY3 WMO#=727924	0.71	0.47	0.91	0.63	0.04	0.53	4C
Kenai Municipal Ap AK USA TMY3 WMO#=702590	1.79	0.19	1.01	1.59	0.01	1.10	7
Ketchikan Intl Ap AK USA TMY3 WMO#=703950	1.36	0.24	0.98	1.24	0.01	1.03	7
Key West Intl Arpt FL USA TMY3 WMO#=722010	0.20	2.90	1.01	0.09	6.20	1.34	1A
Key West Nas FL USA TMY3 WMO#=722015	0.20	2.87	1.01	0.09	6.08	1.30	1A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Killeen MuniTX USA TMY3 WMO#=722575	0.53	1.78	1.02	0.39	2.90	0.97	2A
King Salmon Arpt AK USA TMY3 WMO#=703260	2.21	0.14	1.02	2.13	0.01	1.15	7
KingmanAZ USA TMY3 WMO#=723700	0.43	1.29	1.09	0.39	2.55	1.31	3B
Kingsville TX USA TMY3 WMO#=722516	0.33	2.25	1.00	0.25	3.62	0.93	2A
Kinston Stallings Afb NC USA TMY3 WMO#=723067	0.59	1.37	0.93	0.58	1.86	1.08	3A
Kirksville Regional Ap MO USA TMY3 WMO#=724455	1.37	0.95	0.99	1.43	0.51	1.02	5A
Klamath Falls Intl ApOR USA TMY3 WMO#=725895	0.86	0.57	1.07	0.85	0.29	0.96	5B
Knoxville IA USA TMY3 WMO#=725493	1.15	1.04	1.00	1.20	0.55	1.01	5A
Knoxville Mcghee Tyson Ap TN USA TMY3 WMO#=723260	0.69	1.22	0.95	0.73	0.85	0.81	4A
Kodiak Airport AK USA TMY3 WMO#=703500	1.46	0.16	0.99	1.54	0.01	1.09	7
Kona Intl At Keahol HI USA TMY3 WMO#=911975	0.20	2.62	0.99	0.09	4.77	1.43	1A
Kotzebue Ralph Wein Memorial AK USA TMY3 WMO#=701330	3.89	0.11	1.10	3.88	0.01	1.24	8
La Crosse Municipal Arpt WI USA TMY3 WMO#=726430	1.49	0.73	0.98	1.49	0.21	0.88	6A
La Grande Muni Ap OR USA TMY3 WMO#=726884	0.91	0.57	1.04	1.00	0.29	0.94	5B
La Junta Municipal Ap CO USA TMY3 WMO#=724635	0.82	0.90	1.07	0.84	0.92	1.09	4B
Laconia MuniNH USA TMY3 WMO#=726155	1.27	0.59	0.96	1.19	0.12	0.86	6A
Lafayette Purdue Univ Ap IN USA TMY3 WMO#=724386	1.22	0.89	0.97	1.22	0.48	0.98	5A
Lafayette Regional Ap LA USA TMY3 WMO#=722405	0.41	1.90	0.99	0.31	2.98	0.97	2A
Lake Charles Regional Arpt LA USA TMY3 WMO#=722400	0.41	1.90	0.99	0.31	2.99	0.96	2A
Lake Charles Wb Airp LA USA TMY3 WMO#=722404	0.48	1.93	1.00	0.34	2.89	0.88	2A
Lake Hood Seaplane AK USA TMY3 WMO#=702725	1.56	0.26	1.01	1.26	0.01	1.03	7
Lakeland Linder Rgn FL USA TMY3 WMO#=722119	0.31	2.18	1.00	0.25	2.92	0.83	2A
LakeviewOR USA TMY3 WMO#=725976	0.89	0.55	1.10	0.94	0.28	1.02	5B
Lamar Municipal CO USA TMY3 WMO#=724636	0.84	0.98	1.08	0.95	0.58	0.95	5B
Lanai HI USA TMY3 WMO#=911905	0.22	2.03	0.99	0.09	3.41	1.09	1A
Lancaster Gen Wm Fox Field CA USA TMY3 WMO#=723816	0.41	1.17	1.08	0.37	2.22	1.15	3B
Lancaster PA USA TMY3 WMO#=725116	0.83	0.86	0.94	0.84	0.39	0.93	5A
Lander Hunt Field WY USA TMY3 WMO#=725760	1.04	0.57	1.13	1.15	0.10	1.49	6B
Langley Afb VA USA TMY3 WMO#=745980	0.77	1.18	0.93	0.86	0.83	0.80	4A
Lansing Capital City Arpt MI USA TMY3 WMO#=725390	1.37	0.73	0.99	1.44	0.37	1.05	5A
Laramie General Brees Field WY USA TMY3 WMO#=725645	1.03	0.50	1.16	1.44	0.08	1.62	6B
Laredo Intl ApTX USA TMY3 WMO#=722520	0.38	2.25	1.12	0.21	3.14	1.37	2B
Las Cruces Intl NM USA TMY3 WMO#=722695	0.40	1.25	1.11	0.38	2.16	1.23	3B
Las Vegas Mccarran Intl Ap NV USA TMY3 WMO#=723860	0.37	1.47	1.11	0.35	3.05	1.34	3B
Las Vegas Municipal Arpt NM USA TMY3 WMO#=723677	0.64	0.73	1.14	0.82	0.27	1.02	5B
Lawrence Muni MA USA TMY3 WMO#=744904	1.09	0.70	0.95	1.10	0.30	0.98	5A
Lawton Municipal OK USA TMY3 WMO#=723575	0.53	1.46	0.97	0.55	2.25	1.20	3A
Le Mars IA USA TMY3 WMO#=725484	1.18	0.94	0.99	1.16	0.21	0.84	6A
Leadville Lake Co CO USA TMY3 WMO#=724673	1.10	0.32	1.25	1.35	0.01	1.35	7
Lebanon Municipal NH USA TMY3 WMO#=726116	1.29	0.60	0.95	1.13	0.13	0.85	6A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Leesburg Godfrey VA USA TMY3 WMO#=724055	0.89	1.04	0.95	0.91	0.80	0.81	4A
Lemoore Reeves Nas CA USA TMY3 WMO#=747020	0.43	1.19	0.97	0.35	2.16	1.07	3B
Lewisburg Greenbrie WV USA TMY3 WMO#=724127	1.01	0.72	1.00	0.98	0.30	1.04	5A
Lewiston Nez Perce Cnty Ap ID USA TMY3 WMO#=727830	0.82	0.71	1.01	0.74	0.41	0.83	5B
Lewistown Municipal Arpt MT USA TMY3 WMO#=726776	1.22	0.44	1.08	1.43	0.07	1.47	6B
Lexington Bluegrass Ap KY USA TMY3 WMO#=724220	0.92	1.07	0.96	0.95	0.72	0.82	4A
Lihue Airport HI USA TMY3 WMO#=911650	0.20	2.51	0.97	0.09	4.39	1.16	1A
Limon CO USA TMY3 WMO#=724665	0.91	0.69	1.12	1.08	0.30	1.03	5B
Lincoln Municipal Arpt NE USA TMY3 WMO#=725510	1.12	0.99	1.00	1.16	0.63	1.00	5A
Litchfield Muni MN USA TMY3 WMO#=726583	1.72	0.70	1.00	1.71	0.13	0.90	6A
Little FallsMN USA TMY3 WMO#=726578	1.77	0.58	1.00	1.53	0.14	0.92	6A
Little Rock Adams Field AR USA TMY3 WMO#=723403	0.60	1.51	0.95	0.60	2.28	1.14	3A
Little Rock Afb AR USA TMY3 WMO#=723405	0.64	1.49	0.95	0.64	2.13	1.15	3A
Livermore Municipal CA USA TMY3 WMO#=724927	0.54	0.78	0.92	0.46	0.08	0.60	3C
Livingston Mission Field MT USA TMY3 WMO#=726798	1.14	0.54	1.10	1.53	0.13	1.48	6B
LompocCA USA TMY3 WMO#=722895	0.50	0.50	0.87	0.45	0.01	0.59	3C
London Corbin Ap KY USA TMY3 WMO#=724243	0.82	1.06	0.96	0.80	0.70	0.80	4A
Lone Rock Faa Ap WI USA TMY3 WMO#=726416	1.18	0.69	0.95	1.17	0.16	0.85	6A
Long Beach Daugherty Fld CA USA TMY3 WMO#=722970	0.30	1.11	0.93	0.25	1.10	0.81	3B
Longview Gregg County ApTX USA TMY3 WMO#=722470	0.41	1.65	0.95	0.44	2.34	1.14	3A
Los Angeles Intl Arpt CA USA TMY3 WMO#=722950	0.30	0.99	0.93	0.24	0.63	0.73	3B
Louisville Bowman Field KY USA TMY3 WMO#=724235	0.73	1.17	0.94	0.74	0.73	0.77	4A
Louisville Standiford Field KY USA TMY3 WMO#=724230	0.86	1.17	0.95	0.92	0.83	0.82	4A
Lovelock Derby Field NV USA TMY3 WMO#=725805	0.69	0.87	1.08	0.76	0.53	0.94	5B
Lubbock International Ap TX USA TMY3 WMO#=722670	0.56	1.16	1.06	0.54	1.84	1.15	3B
Lufkin Angelina Co TX USA TMY3 WMO#=722446	0.45	1.82	1.00	0.32	2.94	0.90	2A
Luke Afb AZ USA TMY3 WMO#=722785	0.33	2.19	1.20	0.18	3.79	1.60	2B
Lynchburg Regional Arpt VA USA TMY3 WMO#=724100	0.72	1.15	0.96	0.72	0.82	0.76	4A
Macdill Afb FL USA TMY3 WMO#=747880	0.30	2.22	0.99	0.24	3.05	0.87	2A
Macon Middle Ga Regional Ap GA USA TMY3 WMO#=722170	0.44	1.58	0.94	0.45	2.16	1.09	3A
Madison Dane Co Regional Arpt WI USA TMY3 WMO#=726410	1.55	0.72	0.98	1.60	0.20	0.90	6A
Malad City ID USA TMY3 WMO#=725786	0.93	0.65	1.08	1.01	0.17	1.41	6B
Manassas Muni Awos VA USA TMY3 WMO#=724036	0.86	1.00	0.94	0.86	0.72	0.79	4A
Manchester Airport NH USA TMY3 WMO#=743945	1.10	0.68	0.96	1.02	0.33	0.94	5A
Manhattan Rgnl KS USA TMY3 WMO#=724555	0.92	1.24	0.99	0.89	1.13	0.85	4A
ManisteeMI USA TMY3 WMO#=726385	1.37	0.63	0.96	1.36	0.14	0.86	6A
Manitowac Muni Awos WI USA TMY3 WMO#=726455	1.38	0.55	0.96	1.47	0.12	0.89	6A
Mankato Awos MN USA TMY3 WMO#=726585	1.62	0.69	0.99	1.68	0.18	0.92	6A
Mansfield Lahm Municipal Arpt OH USA TMY3 WMO#=725246	1.29	0.75	0.99	1.32	0.32	1.01	5A
Marathon Airport FL USA TMY3 WMO#=722016	0.21	3.05	1.03	0.09	6.52	1.40	1A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
March Afb CA USA TMY3 WMO#=722860	0.36	1.21	1.06	0.31	1.93	1.03	3B
Marfa Ap TX USA TMY3 WMO#=722640	0.45	1.02	1.10	0.42	1.47	1.15	3B
Marietta Dobbins Afb GA USA TMY3 WMO#=722270	0.68	1.20	0.96	0.69	1.55	1.11	3A
Marion Regional IL USA TMY3 WMO#=724339	0.81	1.09	0.94	0.82	0.88	0.81	4A
MarionWytheville VA USA TMY3 WMO#=724056	0.86	0.94	1.00	0.94	0.58	0.86	4A
Marshall Ryan Awos MN USA TMY3 WMO#=726559	1.61	0.68	1.00	1.77	0.17	0.92	6A
Marshfield Muni WI USA TMY3 WMO#=726574	1.42	0.63	0.98	1.37	0.13	0.90	6A
Marthas Vineyard MA USA TMY3 WMO#=725066	0.95	0.65	0.93	0.99	0.26	0.97	5A
Martinsburg Eastern Wv Reg Ap WV USA TMY3 WMO#=724177	0.75	0.95	0.94	0.77	0.55	0.78	4A
Martinsville VA USA TMY3 WMO#=745985	0.72	1.15	0.96	0.75	0.88	0.82	4A
Mason City Municipal Arpt IA USA TMY3 WMO#=725485	1.73	0.73	1.01	1.93	0.20	0.93	6A
Massena Ap NY USA TMY3 WMO#=726223	1.59	0.59	0.97	1.61	0.14	0.89	6A
Maxwell Afb AL USA TMY3 WMO#=722265	0.49	1.62	0.94	0.52	2.25	1.10	3A
Mayport Ns FL USA TMY3 WMO#=722066	0.31	1.95	0.99	0.25	2.70	0.80	2A
Mc GregorTX USA TMY3 WMO#=722563	0.57	1.77	1.02	0.42	3.10	1.10	2A
Mcalester Municipal Ap OK USA TMY3 WMO#=723566	0.58	1.53	0.96	0.58	2.27	1.22	3A
Mcallen Miller Intl ApTX USA TMY3 WMO#=722506	0.31	2.37	1.01	0.23	3.89	0.95	2A
Mccomb Pike County Ap MS USA TMY3 WMO#=722358	0.41	1.69	0.94	0.44	2.16	1.06	3A
Mcconnell Afb KS USA TMY3 WMO#=724505	0.93	1.21	0.99	1.02	1.08	0.92	4A
Mccook Municipal NE USA TMY3 WMO#=725625	1.00	0.99	1.04	1.10	0.67	1.05	5A
Mcgrath Arpt AK USA TMY3 WMO#=702310	3.12	0.23	1.07	2.47	0.01	1.20	8
Mcguire Afb NJ USA TMY3 WMO#=724096	0.95	1.01	0.94	0.99	0.65	0.81	4A
Medford Rogue Valley Intl Ap OR USA TMY3 WMO#=725970	0.67	0.67	0.98	0.60	0.10	0.56	4C
Mekoryuk AK USA TMY3 WMO#=702185	2.32	0.05	1.03	2.83	0.01	1.25	8
Melbourne Regional Ap FL USA TMY3 WMO#=722040	0.26	2.28	0.99	0.20	2.83	0.76	2A
Melfa Accomack Arpt VA USA TMY3 WMO#=724026	0.67	1.23	0.94	0.77	0.91	0.78	4A
Memorial Fld AR USA TMY3 WMO#=723415	0.56	1.45	0.95	0.53	2.12	1.14	3A
Memphis International Ap TN USA TMY3 WMO#=723340	0.57	1.49	0.95	0.59	2.23	1.15	3A
MenomineeMI USA TMY3 WMO#=726487	1.45	0.56	0.97	1.42	0.12	0.89	6A
Merced Macready Fld CA USA TMY3 WMO#=724815	0.39	1.14	0.96	0.30	1.87	0.99	3B
Mercury Desert Rock ApNV USA TMY3 WMO#=723870	0.44	1.29	1.08	0.56	0.88	0.90	5B
Meridian Key Field MS USA TMY3 WMO#=722340	0.45	1.55	0.94	0.46	2.09	1.08	3A
Meridian Naas MS USA TMY3 WMO#=722345	0.41	1.60	0.94	0.44	2.10	1.12	3A
Miami Intl Ap FL USA TMY3 WMO#=722020	0.21	2.60	0.99	0.09	5.24	1.23	1A
Miami Kendall Tamia FL USA TMY3 WMO#=722029	0.23	2.37	0.97	0.10	4.67	1.14	1A
Miami Opa Locka FL USA TMY3 WMO#=722024	0.23	2.59	0.99	0.10	5.44	1.33	1A
Middleton Island Aut AK USA TMY3 WMO#=703430	1.49	0.15	0.99	1.68	0.01	1.11	7
Middletown Harrisburg Intl Ap PA USA TMY3 WMO#=725115	1.17	0.89	0.96	1.17	0.50	0.98	5A
Midland International Ap TX USA TMY3 WMO#=722650	0.43	1.30	1.05	0.39	2.12	1.15	3B
Miles City Municipal Arpt MT USA TMY3 WMO#=742300	1.42	0.64	1.10	1.61	0.15	1.35	6B

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Millinocket Municipal Ap ME USA TMY3 WMO#=726196	1.51	0.54	0.96	1.42	0.10	0.88	6A
Millville Municipal Ap NJ USA TMY3 WMO#=724075	0.78	1.02	0.93	0.84	0.67	0.78	4A
Milwaukee Mitchell Intl Ap WI USA TMY3 WMO#=726400	1.45	0.65	0.97	1.61	0.16	0.91	6A
Minchumina AK USA TMY3 WMO#=702460	2.72	0.29	1.07	1.93	0.01	1.16	8
Mineral Wells Municipal Ap TX USA TMY3 WMO#=722597	0.46	1.61	0.96	0.48	2.38	1.18	3A
Minneapolis Crystal MN USA TMY3 WMO#=726575	1.76	0.63	0.99	1.70	0.13	0.91	6A
Minneapolis St Paul IntL Arp MN USA TMY3 WMO#=726580	1.61	0.70	0.99	1.71	0.19	0.91	6A
Minocqua Woodruff WI USA TMY3 WMO#=726404	1.68	0.59	1.04	1.56	0.06	1.11	7
Minot Afb ND USA TMY3 WMO#=727675	1.81	0.53	1.06	2.08	0.06	1.17	7
Minot Faa Ap ND USA TMY3 WMO#=727676	1.97	0.58	1.07	2.25	0.06	1.17	7
Missoula International Ap MT USA TMY3 WMO#=727730	1.07	0.49	1.04	1.06	0.08	1.36	6B
MitchellSD USA TMY3 WMO#=726545	1.69	0.77	1.01	1.82	0.28	0.93	6A
Moab CanyonlandsUT USA TMY3 WMO#=724776	0.67	0.91	1.06	0.71	0.50	0.91	5B
Mobile Downtown Ap AL USA TMY3 WMO#=722235	0.40	1.81	0.98	0.29	2.78	0.84	2A
Mobile Regional Ap AL USA TMY3 WMO#=722230	0.43	1.81	0.98	0.32	2.65	0.84	2A
Mobridge SD USA TMY3 WMO#=726685	1.80	0.70	1.03	1.86	0.25	0.96	6A
Modesto City County Ap CA USA TMY3 WMO#=724926	0.40	1.08	0.96	0.32	1.71	0.99	3B
Moline Quad City Intl Ap IL USA TMY3 WMO#=725440	1.24	0.89	0.98	1.30	0.51	1.02	5A
MolokaiHI USA TMY3 WMO#=911860	0.21	2.36	0.99	0.10	4.30	1.20	1A
Monroe Co IN USA TMY3 WMO#=724375	1.06	0.99	0.96	1.04	0.70	0.83	4A
Monroe Regional Ap LA USA TMY3 WMO#=722486	0.45	1.66	0.94	0.46	2.29	1.08	3A
Monterey Naf CA USA TMY3 WMO#=724915	0.48	0.50	0.89	0.43	0.02	0.59	3C
Montgomery Dannelly Field AL USA TMY3 WMO#=722260	0.42	1.62	0.94	0.44	2.21	1.07	3A
Monticello Awos NY USA TMY3 WMO#=725145	1.23	0.62	0.97	1.24	0.13	0.89	6A
Monticello Muni IA USA TMY3 WMO#=725475	1.43	0.86	0.99	1.41	0.41	1.03	5A
Montpelier Ap VT USA TMY3 WMO#=726145	1.37	0.54	0.97	1.27	0.11	0.89	6A
Montrose CoCO USA TMY3 WMO#=724765	0.79	0.76	1.12	0.87	0.31	0.99	5B
Moody Afb Valdosta GA USA TMY3 WMO#=747810	0.47	1.67	0.99	0.34	2.49	0.88	2A
Mora MuniMN USA TMY3 WMO#=727475	1.72	0.64	1.02	1.51	0.06	1.05	7
Morgantown Hart Field WV USA TMY3 WMO#=724176	0.93	0.82	0.96	0.87	0.29	0.95	5A
Morris MuniMN USA TMY3 WMO#=726565	1.81	0.58	1.00	1.92	0.12	0.95	6A
Moses Lake Grant County Ap WA USA TMY3 WMO#=727827	0.85	0.75	1.00	0.84	0.39	0.85	5B
Mosinee Central Wi WI USA TMY3 WMO#=726465	1.83	0.60	1.00	1.82	0.13	0.95	6A
Mount Clemens Selfridge Fld MI USA TMY3 WMO#=725377	1.02	0.66	0.96	1.00	0.31	0.98	5A
Mount VernonIL USA TMY3 WMO#=724335	0.88	1.16	0.95	0.86	0.94	0.80	4A
Mount Washington NH USA TMY3 WMO#=726130	3.22	0.07	1.21	4.38	0.01	1.41	6A
Mountain Home Afb ID USA TMY3 WMO#=726815	0.93	0.72	1.07	1.01	0.45	0.98	5B
Mountain View Moffett Fld Nas CA USA TMY3 WMO#=745090	0.45	0.76	0.91	0.40	0.04	0.57	3C
Muscatine IA USA TMY3 WMO#=725487	1.21	0.96	0.98	1.20	0.50	0.99	5A
Muscle Shoals Regional Ap AL USA TMY3 WMO#=723235	0.54	1.37	0.94	0.52	1.69	1.05	3A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Muskegon County Arpt MI USA TMY3 WMO#=726360	1.34	0.67	0.97	1.36	0.30	1.03	5A
Myrtle Beach Afb SC USA TMY3 WMO#=747910	0.44	1.53	0.93	0.46	1.95	1.02	3A
NacogdochesTX USA TMY3 WMO#=722499	0.45	1.63	0.94	0.44	2.19	1.08	3A
Nantucket Memorial Ap MA USA TMY3 WMO#=725063	0.93	0.62	0.94	1.04	0.22	0.96	5A
Napa CoCA USA TMY3 WMO#=724955	0.55	0.65	0.89	0.47	0.04	0.59	3C
Naples Municipal FL USA TMY3 WMO#=722038	0.25	2.32	1.00	0.20	2.95	0.81	2A
Nasa Shuttle Fclty FL USA TMY3 WMO#=747946	0.30	2.12	0.98	0.24	2.79	0.80	2A
Nashville International Ap TN USA TMY3 WMO#=723270	0.67	1.34	0.95	0.74	1.02	0.79	4A
Natchez Hardy Awos MS USA TMY3 WMO#=722357	0.39	1.64	0.94	0.38	2.05	1.00	3A
Naval Air Station ME USA TMY3 WMO#=743920	1.31	0.55	0.94	1.22	0.11	0.85	6A
Needles Airport CA USA TMY3 WMO#=723805	0.28	2.00	1.07	0.25	4.13	1.45	3B
Nellis Afb NV USA TMY3 WMO#=723865	0.36	1.59	1.12	0.33	3.45	1.42	3B
Nenana Municipal Ap AK USA TMY3 WMO#=702600	2.66	0.25	1.06	2.30	0.01	1.19	8
New Bedford Rgnl MA USA TMY3 WMO#=725065	0.97	0.74	0.94	1.02	0.36	0.96	5A
New Bern Craven Co Regl Ap NC USA TMY3 WMO#=723095	0.43	1.46	0.93	0.44	1.83	1.03	3A
New Haven Tweed Airport CT USA TMY3 WMO#=725045	0.95	0.74	0.94	0.97	0.33	0.96	5A
New Iberia Naas LA USA TMY3 WMO#=722314	0.42	1.84	0.98	0.31	2.82	0.85	2A
New Orleans Alvin Callender F LA USA TMY3 WMO#=722316	0.33	1.93	0.98	0.25	2.77	0.89	2A
New Orleans Intl Arpt LA USA TMY3 WMO#=722310	0.38	1.99	0.99	0.29	2.96	0.94	2A
New Orleans Lakefront Ap LA USA TMY3 WMO#=722315	0.37	1.98	0.98	0.28	2.99	0.95	2A
New River Mcaf NC USA TMY3 WMO#=723096	0.55	1.46	0.93	0.56	1.83	1.09	3A
New Ulm MuniMN USA TMY3 WMO#=726567	1.58	0.72	1.00	1.71	0.20	0.91	6A
New York Central Prk Obs Belv NY USA TMY3 WMO#=725033	0.99	0.98	0.95	1.11	0.66	0.83	4A
New York J F Kennedy Intl Ar NY USA TMY3 WMO#=744860	0.92	0.98	0.94	1.04	0.71	0.82	4A
New York Laguardia Arpt NY USA TMY3 WMO#=725030	0.88	1.02	0.94	1.02	0.75	0.83	4A
Newark International Arpt NJ USA TMY3 WMO#=725020	0.98	0.99	0.94	1.06	0.71	0.84	4A
Newport News VA USA TMY3 WMO#=723086	0.62	1.33	0.94	0.69	0.98	0.76	4A
Newton Muni IA USA TMY3 WMO#=725464	1.25	0.85	0.98	1.24	0.42	1.02	4A
NewtonKS USA TMY3 WMO#=724509	0.94	1.11	0.99	1.08	0.86	0.88	5A
Niagara Falls Af NY USA TMY3 WMO#=725287	1.27	0.68	0.97	1.34	0.31	1.03	5A
Nome Municipal Arpt AK USA TMY3 WMO#=702000	2.88	0.11	1.07	2.94	0.01	1.22	8
Norfolk International Ap VA USA TMY3 WMO#=723080	0.64	1.29	0.94	0.75	0.98	0.80	4A
Norfolk Karl Stefan Mem Arpt NE USA TMY3 WMO#=725560	1.48	0.86	1.03	1.71	0.53	1.09	5A
Norfolk Nas VA USA TMY3 WMO#=723085	0.58	1.28	0.93	0.68	0.82	0.74	4A
North Adams MA USA TMY3 WMO#=725075	1.14	0.62	0.96	1.06	0.24	1.00	5A
North Bend Muni Airport OR USA TMY3 WMO#=726917	0.61	0.34	0.90	0.60	0.01	0.52	4C
North Myrtle Beach Grand Stra SC USA TMY3 WMO#=747915	0.44	1.50	0.93	0.45	1.88	1.02	3A
North Platte Regional Ap NE USA TMY3 WMO#=725620	1.07	0.80	1.04	1.18	0.48	1.09	5A
Northern Aroostook ME USA TMY3 WMO#=726083	1.95	0.40	1.03	2.02	0.03	1.15	7
Northway Airport AK USA TMY3 WMO#=702910	3.37	0.23	1.12	2.54	0.01	1.26	8

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Norwood Memorial MA USA TMY3 WMO#=725098	1.05	0.75	0.94	1.02	0.37	0.96	5A
O Neill Baker Field NE USA TMY3 WMO#=725566	1.68	0.77	1.05	1.92	0.46	1.13	5A
Oakland Co Intl MI USA TMY3 WMO#=726375	1.15	0.78	0.98	1.16	0.39	1.01	5A
Oakland Metropolitan Arpt CA USA TMY3 WMO#=724930	0.47	0.57	0.89	0.42	0.02	0.58	3C
Ocala MuniFL USA TMY3 WMO#=722055	0.35	1.96	0.99	0.26	2.75	0.85	2A
Oceana Nas VA USA TMY3 WMO#=723075	0.60	1.28	0.93	0.68	0.93	0.75	4A
Oelwen IA USA TMY3 WMO#=725488	1.23	0.75	0.97	1.27	0.17	0.87	6A
Ogden Hill Afb UT USA TMY3 WMO#=725755	0.92	0.73	1.12	1.03	0.38	1.02	5B
Ogden Hinkley Airport UT USA TMY3 WMO#=725750	0.79	0.81	1.11	0.82	0.43	0.97	5B
Ohio State Universi OH USA TMY3 WMO#=724288	0.95	0.94	0.97	0.98	0.51	0.97	5A
Oklahoma City Tinker Afb OK USA TMY3 WMO#=723540	0.74	1.38	0.98	0.77	2.21	1.28	3A
Oklahoma City Wiley OK USA TMY3 WMO#=723544	0.74	1.35	0.98	0.76	2.14	1.27	3A
Oklahoma City Will Rogers Wor OK USA TMY3 WMO#=723530	0.69	1.41	0.98	0.76	2.23	1.30	3A
Olathe Johnson Co Industrial KS USA TMY3 WMO#=724475	0.97	1.19	0.98	1.07	1.00	0.87	4A
Olathe Johnson Co KS USA TMY3 WMO#=724468	0.87	1.18	0.98	0.94	0.93	0.85	4A
Olympia Airport WA USA TMY3 WMO#=727920	0.81	0.43	0.92	0.69	0.04	0.55	4C
Omaha Eppley Airfield NE USA TMY3 WMO#=725500	1.16	1.03	0.99	1.20	0.65	1.01	5A
Omaha Wsfo NE USA TMY3 WMO#=725530	1.25	0.97	1.01	1.36	0.57	1.03	5A
Orange City IA USA TMY3 WMO#=725489	1.35	0.79	0.99	1.38	0.23	0.89	6A
Ord Sharp Field NE USA TMY3 WMO#=725524	1.11	0.86	1.02	1.17	0.47	1.05	5A
Orlando Executive Ap FL USA TMY3 WMO#=722053	0.28	2.22	1.00	0.23	3.00	0.84	2A
Orlando Intl Arpt FL USA TMY3 WMO#=722050	0.28	2.14	0.99	0.23	2.86	0.88	2A
Orlando Sanford Airport FL USA TMY3 WMO#=722057	0.30	2.09	0.99	0.23	2.97	0.84	2A
Orr MN USA TMY3 WMO#=726544	2.11	0.47	1.04	1.77	0.03	1.12	7
Oscoda Wurtsmith Afb MI USA TMY3 WMO#=726395	1.28	0.59	0.96	1.29	0.15	0.87	6A
Otis Angb MA USA TMY3 WMO#=725060	1.05	0.69	0.94	1.13	0.33	1.00	5A
Ottumwa Industrial Ap IA USA TMY3 WMO#=725465	1.46	0.83	0.99	1.61	0.45	1.05	5A
OwatonnaMN USA TMY3 WMO#=726568	1.59	0.72	0.99	1.58	0.18	0.91	6A
OxfordCT USA TMY3 WMO#=725029	1.09	0.70	0.96	1.08	0.35	0.99	5A
Oxnard Airport CA USA TMY3 WMO#=723927	0.37	0.79	0.89	0.36	0.02	0.56	3C
Paducah Barkley Regional Ap KY USA TMY3 WMO#=724350	0.71	1.25	0.95	0.76	0.95	0.80	4A
Page MuniAZ USA TMY3 WMO#=723710	0.49	1.09	1.10	0.57	0.52	0.90	5B
Palacios Municipal Ap TX USA TMY3 WMO#=722555	0.42	2.12	0.99	0.32	3.14	0.87	2A
Palm Springs Intl CA USA TMY3 WMO#=722868	0.26	2.00	1.04	0.22	3.74	1.32	3B
Palm Springs Thermal Ap CA USA TMY3 WMO#=747187	0.29	1.98	1.01	0.26	3.79	1.29	3B
Palmdale Airport CA USA TMY3 WMO#=723820	0.40	1.19	1.08	0.38	2.33	1.23	3B
Palmer Municipal AK USA TMY3 WMO#=702740	1.54	0.24	1.00	1.32	0.01	1.05	7
Panama City Bay Co FL USA TMY3 WMO#=722245	0.36	2.05	0.99	0.27	2.96	0.84	2A
Park Rapids Municipal Ap MN USA TMY3 WMO#=727453	1.95	0.56	1.04	1.96	0.05	1.14	7
Parkersburg Wood County Ap WV USA TMY3 WMO#=724273	0.94	1.01	0.95	0.92	0.65	0.81	4A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Pasco WA USA TMY3 WMO#=727845	0.78	0.82	0.98	0.76	0.44	0.82	5B
Paso Robles Municipal Arpt CA USA TMY3 WMO#=723965	0.49	0.92	0.95	0.45	0.12	0.60	3C
Patterson Memorial LA USA TMY3 WMO#=722329	0.36	1.83	0.98	0.27	2.78	0.84	2A
Patuxent River Nas MD USA TMY3 WMO#=724040	0.61	1.24	0.93	0.70	0.88	0.76	4A
PawtucketRI USA TMY3 WMO#=725054	1.10	0.66	0.96	1.10	0.31	0.99	5A
Pease Intl Tradepor NH USA TMY3 WMO#=726055	1.24	0.64	0.95	1.23	0.30	1.00	5A
Pellston Emmet County Ap MI USA TMY3 WMO#=727347	1.39	0.63	0.97	1.35	0.13	0.88	6A
Pendleton E Or Regional Ap OR USA TMY3 WMO#=726880	0.80	0.65	1.00	0.79	0.31	0.85	5B
Pensacola Forest Sherman Nas FL USA TMY3 WMO#=722225	0.37	1.96	0.99	0.29	2.97	0.94	2A
Pensacola Regional Ap FL USA TMY3 WMO#=722223	0.35	1.98	0.98	0.28	2.81	0.82	2A
Peoria Greater Peoria Ap IL USA TMY3 WMO#=725320	1.23	0.88	0.98	1.31	0.48	1.01	5A
Petersburg AK USA TMY3 WMO#=703860	1.37	0.20	0.97	1.06	0.01	0.99	7
Philadelphia International Ap PA USA TMY3 WMO#=724080	0.91	1.03	0.94	0.98	0.75	0.81	4A
Philadelphia Ne Philadelphia PA USA TMY3 WMO#=724085	0.87	1.02	0.94	0.91	0.79	0.81	4A
Phillips Price Co WI USA TMY3 WMO#=726468	1.53	0.61	1.03	1.42	0.05	1.08	7
Phoenix Sky Harbor Intl Ap AZ USA TMY3 WMO#=722780	0.32	2.26	1.20	0.17	3.64	1.68	2B
Pierre Municipal Ap SD USA TMY3 WMO#=726686	1.46	0.76	1.01	1.64	0.25	0.93	6A
Pine Bluff Faa Ap AR USA TMY3 WMO#=723417	0.62	1.60	0.95	0.61	2.42	1.18	3A
PipestoneMN USA TMY3 WMO#=726566	1.95	0.72	1.03	2.03	0.19	0.96	6A
Pitt Greenville Arp NC USA TMY3 WMO#=723065	0.56	1.33	0.93	0.55	1.74	1.05	3A
Pittsburgh Allegheny Co Ap PA USA TMY3 WMO#=725205	0.93	0.74	0.96	0.95	0.25	0.98	5A
Pittsburgh International Ap PA USA TMY3 WMO#=725200	1.06	0.78	0.97	1.10	0.37	1.00	5A
Plymouth Municipal MA USA TMY3 WMO#=725064	1.01	0.66	0.94	1.01	0.25	0.95	5A
Pocatello Regional Ap ID USA TMY3 WMO#=725780	1.05	0.63	1.11	1.12	0.32	1.03	5B
Point HopeAK USA TMY3 WMO#=701043	3.69	0.03	1.11	4.18	0.00	1.29	8
Point Mugu Nf CA USA TMY3 WMO#=723910	0.39	0.76	0.89	0.37	0.02	0.57	3C
Ponca City Municipal ApOK USA TMY3 WMO#=723546	0.68	1.50	0.98	0.63	2.58	1.28	3A
Poplar Bluff Amos MO USA TMY3 WMO#=723300	0.73	1.30	0.95	0.75	1.02	0.80	4A
Port Arthur Jefferson County TX USA TMY3 WMO#=722410	0.38	2.02	0.99	0.30	3.14	0.88	2A
Port Heiden AK USA TMY3 WMO#=703330	1.93	0.07	1.00	2.07	0.01	1.19	7
PortervilleCA USA TMY3 WMO#=723895	0.39	1.13	0.97	0.32	1.96	1.06	3B
Portland Hillsboro OR USA TMY3 WMO#=726986	0.71	0.54	0.92	0.62	0.06	0.53	4C
Portland International Ap OR USA TMY3 WMO#=726980	0.70	0.55	0.91	0.63	0.06	0.53	4C
Portland Intl Jetport ME USA TMY3 WMO#=726060	1.35	0.53	0.94	1.35	0.12	0.86	6A
Portland Troutdale OR USA TMY3 WMO#=726985	0.74	0.56	0.92	0.68	0.07	0.54	4C
Poughkeepsie Dutchess Co Ap NY USA TMY3 WMO#=725036	1.03	0.76	0.94	0.96	0.31	0.94	5A
Prescott Love Field AZ USA TMY3 WMO#=723723	0.54	0.90	1.08	0.59	0.72	1.03	4B
Presque Isle Municip ME USA TMY3 WMO#=727130	1.71	0.43	1.00	1.69	0.04	1.09	7
Providence T F Green State Ar RI USA TMY3 WMO#=725070	1.05	0.75	0.94	1.11	0.37	0.98	5A
ProvincetownMA USA TMY3 WMO#=725073	1.01	0.62	0.94	1.08	0.29	0.97	5A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Provo MuniUT USA TMY3 WMO#=725724	0.77	0.76	1.10	0.82	0.40	0.98	5B
Pueblo Memorial Ap CO USA TMY3 WMO#=724640	0.74	0.92	1.11	0.85	0.46	0.96	5B
Pulaski VA USA TMY3 WMO#=724116	0.88	0.87	0.99	0.92	0.51	0.85	4A
Pullman Moscow Rgnl WA USA TMY3 WMO#=727857	0.95	0.57	1.04	0.95	0.28	0.92	5B
Quantico Mcas VA USA TMY3 WMO#=724035	0.73	1.14	0.93	0.78	0.79	0.76	4A
Quillayute State Airport WA USA TMY3 WMO#=727970	0.79	0.30	0.91	0.68	0.02	0.55	4C
Quincy Muni Baldwin Fld IL USA TMY3 WMO#=724396	1.01	0.96	0.97	1.05	0.46	0.97	5A
Raleigh Durham International NC USA TMY3 WMO#=723060	0.61	1.30	0.94	0.68	0.94	0.78	4A
Randolph Afb TX USA TMY3 WMO#=722536	0.47	1.97	1.02	0.36	3.16	0.97	2A
Rapid City Regional Arpt SD USA TMY3 WMO#=726620	1.27	0.68	1.04	1.55	0.20	0.96	6A
Rawlins Municipal Ap WY USA TMY3 WMO#=725745	0.97	0.54	1.14	1.35	0.10	1.56	6B
Reading Spaatz Field PA USA TMY3 WMO#=725103	0.91	0.91	0.95	0.96	0.38	0.94	5A
Red Bluff Municipal Arpt CA USA TMY3 WMO#=725910	0.46	1.14	0.98	0.38	2.17	1.12	3B
Red Oak IA USA TMY3 WMO#=725494	1.10	1.00	0.99	1.09	0.63	1.00	5A
Red Wing MN USA TMY3 WMO#=726564	1.55	0.74	0.98	1.43	0.21	0.89	6A
Redding Municipal Arpt CA USA TMY3 WMO#=725920	0.45	1.11	0.99	0.35	2.09	1.11	3B
Redmond Roberts Field OR USA TMY3 WMO#=726835	0.86	0.55	1.05	0.88	0.25	0.94	5B
Redwood Falls Muni MN USA TMY3 WMO#=726556	1.81	0.67	1.00	1.84	0.17	0.89	6A
Reno Tahoe International Ap NV USA TMY3 WMO#=724880	0.70	0.78	1.10	0.74	0.43	0.94	5B
Renton Muni WA USA TMY3 WMO#=727934	0.69	0.48	0.91	0.62	0.04	0.53	4C
Republic NY USA TMY3 WMO#=744864	0.82	0.91	0.93	0.91	0.63	0.81	4A
Rhineland Oneida WI USA TMY3 WMO#=727415	1.75	0.65	1.04	1.65	0.07	1.12	7
Rice Lake Municipal WI USA TMY3 WMO#=726467	1.73	0.65	1.00	1.55	0.13	0.91	6A
Richmond International Ap VA USA TMY3 WMO#=724010	0.68	1.23	0.94	0.76	0.91	0.79	4A
Rifle Garfield Rgnl CO USA TMY3 WMO#=725717	0.80	0.77	1.12	0.80	0.36	0.98	5B
Riverside Muni CA USA TMY3 WMO#=722869	0.32	1.20	0.97	0.27	1.78	0.95	3B
Riverton Municipl Ap WY USA TMY3 WMO#=725765	1.08	0.63	1.14	1.24	0.14	1.48	6B
Roanoke Regional Ap VA USA TMY3 WMO#=724110	0.75	1.08	0.96	0.84	0.72	0.80	4A
Robert Gray Aaf TX USA TMY3 WMO#=722576	0.51	1.87	1.04	0.40	3.05	0.99	2A
Rochester Greater Rochester I NY USA TMY3 WMO#=725290	1.28	0.76	0.97	1.30	0.33	1.02	5A
Rochester International Arpt MN USA TMY3 WMO#=726440	1.90	0.63	1.01	2.13	0.14	0.97	6A
Rock Springs ArptRiver WY USA TMY3 WMO#=725744	1.26	0.46	1.05	1.53	0.07	1.41	6B
Rockford Greater Rockford Ap IL USA TMY3 WMO#=725430	1.46	0.80	0.99	1.50	0.41	1.05	5A
Rockland Knox Awos ME USA TMY3 WMO#=726079	1.27	0.45	0.93	1.18	0.08	0.85	6A
Rockport Aransas Co TX USA TMY3 WMO#=722524	0.29	2.41	1.01	0.22	3.75	0.96	2A
Rocky Mount Wilson NC USA TMY3 WMO#=723068	0.53	1.28	0.93	0.59	0.75	0.72	4A
RogersAR USA TMY3 WMO#=723449	0.76	1.26	0.98	0.81	1.06	0.85	4A
Rome R B Russell Ap GA USA TMY3 WMO#=723200	0.56	1.33	0.94	0.61	0.98	0.76	4A
Roseau MuniMN USA TMY3 WMO#=727477	2.05	0.49	1.04	2.04	0.04	1.13	7
Roseburg Regional Ap OR USA TMY3 WMO#=726904	0.59	0.62	0.93	0.54	0.07	0.52	4C

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Roswell Industrial Air Park NM USA TMY3 WMO#=722680	0.41	1.25	1.07	0.38	2.09	1.22	3B
Russell Municipal Ap KS USA TMY3 WMO#=724585	0.99	1.09	1.00	1.10	1.01	0.93	4A
Rutland State VT USA TMY3 WMO#=725165	1.48	0.63	0.97	1.40	0.14	0.88	6A
Sacramento Executive Arpt CA USA TMY3 WMO#=724830	0.43	0.98	0.95	0.35	1.63	1.01	3B
Sacramento Metropolitan Ap CA USA TMY3 WMO#=724839	0.44	1.04	0.95	0.35	1.73	0.99	3B
SaffordAZ USA TMY3 WMO#=722747	0.34	1.48	1.09	0.31	2.48	1.21	3B
Saginaw Tri City Intl Ap MI USA TMY3 WMO#=726379	1.39	0.66	0.98	1.47	0.27	1.03	5A
Saint GeorgeUT USA TMY3 WMO#=724754	0.40	1.32	1.10	0.34	2.64	1.34	3B
Saint Mary SAK USA TMY3 WMO#=702005	2.39	0.09	1.04	2.70	0.01	1.23	8
Salem Mcnary Field OR USA TMY3 WMO#=726940	0.74	0.56	0.92	0.67	0.07	0.54	4C
Salina Municipal Ap KS USA TMY3 WMO#=724586	0.93	1.26	0.99	1.00	1.19	0.92	4A
Salinas Municipal Ap CA USA TMY3 WMO#=724917	0.48	0.57	0.89	0.44	0.02	0.59	3C
Salisbury Wicomico Co Ap MD USA TMY3 WMO#=724045	0.64	1.20	0.93	0.70	0.86	0.76	4A
Salmon LemhiID USA TMY3 WMO#=726865	0.99	0.54	1.07	0.97	0.10	1.39	6B
Salt Lake City Intl ArptUT USA TMY3 WMO#=725720	0.76	0.80	1.10	0.82	0.45	0.97	5B
San Angelo Mathis Field TX USA TMY3 WMO#=722630	0.46	1.42	1.07	0.40	2.28	1.16	3B
San Antonio Intl Ap TX USA TMY3 WMO#=722530	0.39	1.99	1.02	0.31	3.25	1.09	2A
San Antonio Kelly Field Afb TX USA TMY3 WMO#=722535	0.42	2.08	1.02	0.33	3.36	1.01	2A
San Antonio Stinson TX USA TMY3 WMO#=722523	0.37	1.94	1.01	0.28	2.99	0.93	2A
San Diego Lindbergh Field CA USA TMY3 WMO#=722900	0.28	1.11	0.93	0.23	0.85	0.73	3B
San Diego Miramar Nas CA USA TMY3 WMO#=722930	0.31	1.06	0.95	0.27	1.15	0.81	3B
San Diego Montgomer CA USA TMY3 WMO#=722903	0.30	1.00	0.94	0.24	0.92	0.76	3B
San Diego North Island Nas CA USA TMY3 WMO#=722906	0.29	1.02	0.94	0.24	0.62	0.72	3B
San Francisco Intl Ap CA USA TMY3 WMO#=724940	0.47	0.53	0.88	0.43	0.02	0.59	3C
San Jose Intl Ap CA USA TMY3 WMO#=724945	0.45	0.77	0.91	0.40	0.04	0.57	3C
San Luis Co Rgnl CA USA TMY3 WMO#=722897	0.43	0.71	0.90	0.40	0.03	0.58	3C
Sand Point AK USA TMY3 WMO#=703165	1.63	0.09	0.99	1.79	0.01	1.11	7
Sandberg CA USA TMY3 WMO#=723830	0.48	0.78	1.09	0.47	1.26	1.14	3B
Sanford MuniME USA TMY3 WMO#=726064	1.24	0.48	0.94	1.12	0.12	0.84	6A
Santa Ana John Wayne Ap CA USA TMY3 WMO#=722977	0.29	1.10	0.94	0.23	0.91	0.74	3B
Santa Barbara Municipal Ap CA USA TMY3 WMO#=723925	0.40	0.78	0.89	0.38	0.02	0.57	3C
Santa Maria Public Arpt CA USA TMY3 WMO#=723940	0.47	0.62	0.89	0.44	0.02	0.59	3C
Santa Monica Muni CA USA TMY3 WMO#=722885	0.30	0.99	0.94	0.24	0.75	0.74	3B
Santa RosaCA USA TMY3 WMO#=724957	0.54	0.73	0.91	0.44	0.07	0.59	3C
Sarasota Bradenton FL USA TMY3 WMO#=722115	0.27	2.28	0.99	0.23	2.95	0.80	2A
Sata Fe County Municipal Ap NM USA TMY3 WMO#=723656	0.67	0.78	1.13	0.84	0.29	1.00	5B
Sault Ste Marie Sanderson Fie MI USA TMY3 WMO#=727340	1.77	0.43	1.01	1.76	0.03	1.11	7
Savannah Intl Ap GA USA TMY3 WMO#=722070	0.44	1.79	0.99	0.33	2.72	0.87	2A
Savoonga AK USA TMY3 WMO#=702035	2.92	0.05	1.06	3.24	0.00	1.26	8
Scottsbluff W B Heilig Field NE USA TMY3 WMO#=725660	1.06	0.78	1.07	1.19	0.48	1.11	5A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Scottsdale Muni AZ USA TMY3 WMO#=-722789	0.32	2.12	1.21	0.17	3.28	1.60	2B
Seattle Boeing Field WA USA TMY3 WMO#=-727935	0.69	0.47	0.91	0.61	0.04	0.53	4C
Seattle Seattle Tacoma Intl A WA USA TMY3 WMO#=-727930	0.74	0.43	0.92	0.68	0.04	0.55	4C
Selawik AK USA TMY3 WMO#=-700197	3.62	0.13	1.09	3.37	0.01	1.22	8
Seward AK USA TMY3 WMO#=-702770	1.72	0.18	1.01	1.83	0.01	1.10	7
Sexton Summit OR USA TMY3 WMO#=-725975	0.79	0.52	1.03	0.78	0.06	0.63	4C
Shannon Arpt VA USA TMY3 WMO#=-724033	0.79	1.18	0.94	0.79	0.95	0.79	4A
Sheldon IA USA TMY3 WMO#=-725495	1.33	0.79	1.00	1.43	0.24	0.90	6A
Shemya Afb AK USA TMY3 WMO#=-704140	1.98	0.03	1.00	2.26	0.01	1.26	7
Shenandoah Muni IA USA TMY3 WMO#=-725467	1.16	1.01	0.99	1.14	0.60	1.00	5A
Sheridan County Arpt WY USA TMY3 WMO#=-726660	1.10	0.60	1.07	1.26	0.13	1.43	6B
Shishmaref AK USA TMY3 WMO#=-701195	3.49	0.05	1.09	3.72	0.00	1.26	8
Show Low Municipal AZ USA TMY3 WMO#=-723747	0.57	0.81	1.13	0.69	0.27	0.94	5B
Shreveport Downtown LA USA TMY3 WMO#=-722484	0.49	1.67	0.95	0.47	2.49	1.14	3A
Shreveport Regional Arpt LA USA TMY3 WMO#=-722480	0.45	1.67	0.94	0.46	2.35	1.10	3A
Sidney Municipal Ap NE USA TMY3 WMO#=-725610	1.13	0.69	1.08	1.32	0.40	1.14	5A
Sidney Richland MT USA TMY3 WMO#=-727687	2.02	0.55	1.11	2.09	0.12	1.37	6B
Sierra Blanca Rgnl NM USA TMY3 WMO#=-722683	0.51	0.78	1.16	0.55	0.48	1.06	4B
Siloam Spring Awos AR USA TMY3 WMO#=-723443	0.68	1.25	0.97	0.75	1.00	0.82	4A
Silver Bay MN USA TMY3 WMO#=-727556	1.82	0.40	1.02	1.55	0.02	1.09	7
Sioux City Sioux Gateway Ap IA USA TMY3 WMO#=-725570	1.44	0.88	1.01	1.69	0.52	1.07	5A
Sioux Falls Foss Field SD USA TMY3 WMO#=-726510	1.58	0.74	1.01	1.73	0.20	0.92	6A
Sitka Japonski Ap AK USA TMY3 WMO#=-703710	1.29	0.19	0.98	1.23	0.01	1.02	7
Skagway Airport AK USA TMY3 WMO#=-703620	1.62	0.24	1.00	1.72	0.01	1.06	7
Sleetmute AK USA TMY3 WMO#=-703407	2.23	0.27	1.03	1.67	0.01	1.13	8
Snohomish Co WA USA TMY3 WMO#=-727937	0.76	0.37	0.93	0.68	0.03	0.56	4C
Soda Springs Tigert ID USA TMY3 WMO#=-725868	1.20	0.49	1.15	1.42	0.09	1.55	6B
Soldotna AK USA TMY3 WMO#=-702595	1.70	0.24	1.01	1.32	0.01	1.04	7
Somerset Awos KY USA TMY3 WMO#=-724354	0.71	1.23	0.96	0.71	0.85	0.78	4A
South Bend Michiana Rgnl Ap IN USA TMY3 WMO#=-725350	1.15	0.85	0.98	1.21	0.43	1.01	5A
South Lake Tahoe CA USA TMY3 WMO#=-725847	0.89	0.46	1.12	0.79	0.37	1.12	4B
South St Paul Muni MN USA TMY3 WMO#=-726603	1.68	0.76	0.99	1.55	0.18	0.89	6A
Southern Illinois IL USA TMY3 WMO#=-724336	0.84	1.28	0.95	0.87	0.98	0.80	4A
Southern Pines Awos NC USA TMY3 WMO#=-723143	0.58	1.21	0.94	0.56	1.64	1.09	3A
Southwest Florida I FL USA TMY3 WMO#=-722108	0.26	2.32	0.99	0.20	2.93	0.80	2A
Spencer IA USA TMY3 WMO#=-726500	1.86	0.68	1.01	2.03	0.18	0.95	6A
Spokane International Ap WA USA TMY3 WMO#=-727850	1.03	0.54	1.04	1.05	0.24	0.94	5B
Springdale Muni AR USA TMY3 WMO#=-723434	0.75	1.23	0.97	0.85	0.95	0.84	4A
Springfield Capital Ap IL USA TMY3 WMO#=-724390	1.08	1.01	0.97	1.14	0.57	0.98	5A
Springfield Hartnes VT USA TMY3 WMO#=-726115	1.27	0.58	0.95	1.05	0.11	0.84	6A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Springfield Regional Arpt MO USA TMY3 WMO#=724400	0.87	1.13	0.98	0.94	0.88	0.84	4A
St Clair County Int MI USA TMY3 WMO#=725384	1.14	0.77	0.97	1.06	0.42	0.98	5A
St Cloud Regional Arpt MN USA TMY3 WMO#=726550	1.84	0.62	1.00	1.77	0.15	0.93	6A
St Joseph Rosecrans Memorial MO USA TMY3 WMO#=724490	0.99	1.05	0.98	1.07	0.70	0.98	5A
St Louis Lambert Intl Arpt MO USA TMY3 WMO#=724340	0.95	1.15	0.96	1.00	0.90	0.84	4A
St Louis Spirit Of St Louis A MO USA TMY3 WMO#=724345	0.81	1.16	0.95	0.83	0.87	0.80	4A
St Lucie Co Intl FL USA TMY3 WMO#=722103	0.29	2.10	0.98	0.22	2.67	0.82	2A
St Paul Downtown Ap MN USA TMY3 WMO#=726584	1.71	0.69	0.98	1.64	0.16	0.90	6A
St Paul Island Arpt AK USA TMY3 WMO#=703080	2.13	0.04	1.02	2.52	0.01	1.27	7
St Petersburg Albert Whitted FL USA TMY3 WMO#=722104	0.26	2.40	1.00	0.20	3.29	0.86	2A
St Petersburg Clear FL USA TMY3 WMO#=722116	0.30	2.29	1.00	0.25	3.23	0.86	2A
Stampede Pass WA USA TMY3 WMO#=727815	1.23	0.30	1.08	1.08	0.12	1.03	5B
State CollegeStateSu PA USA TMY3 WMO#=725128	1.03	0.70	0.98	1.01	0.29	1.00	5A
Staunton Shenandoah VA USA TMY3 WMO#=724105	0.78	1.10	0.97	0.80	0.84	0.82	4A
Sterling Rockfalls IL USA TMY3 WMO#=725326	1.25	0.84	0.98	1.25	0.43	1.00	5A
Stewart Field NY USA TMY3 WMO#=725038	1.09	0.74	0.96	1.16	0.40	0.99	5A
Stillwater Rgnl OK USA TMY3 WMO#=723545	0.70	1.47	0.98	0.69	2.53	1.27	3A
Stockton Metropolitan Arpt CA USA TMY3 WMO#=724920	0.42	1.08	0.96	0.34	1.78	0.99	3B
Storm Lake IA USA TMY3 WMO#=725496	1.43	0.77	1.00	1.56	0.20	0.92	6A
Sturgeon Bay WI USA TMY3 WMO#=726458	1.42	0.55	0.97	1.51	0.10	0.88	6A
StuttgartAR USA TMY3 WMO#=723416	0.52	1.53	0.94	0.54	2.16	1.10	3A
Sumter Shaw Afb SC USA TMY3 WMO#=747900	0.56	1.36	0.93	0.52	1.84	1.03	3A
Syracuse Hancock Intl Arpt NY USA TMY3 WMO#=725190	1.25	0.70	0.96	1.27	0.30	1.01	5A
Tacoma Mcchord Afb WA USA TMY3 WMO#=742060	0.88	0.42	0.92	0.74	0.04	0.56	4C
Tacoma Narrows WA USA TMY3 WMO#=727938	0.73	0.41	0.92	0.65	0.03	0.54	4C
Talkeetna State Arpt AK USA TMY3 WMO#=702510	2.16	0.25	1.04	1.85	0.01	1.12	7
Tallahassee Regional ApFL USA TMY3 WMO#=722140	0.38	1.82	0.98	0.29	2.71	0.93	2A
Tampa International Ap FL USA TMY3 WMO#=722110	0.29	2.28	1.00	0.23	3.16	0.87	2A
Tanana Ralph M Calhoun Mem Ap AK USA TMY3 WMO#=701780	2.98	0.18	1.06	2.52	0.01	1.19	8
Taos Muni Apt Awos NM USA TMY3 WMO#=723663	0.75	0.63	1.16	0.88	0.24	1.06	5B
TekamahNE USA TMY3 WMO#=725527	1.39	0.91	1.00	1.46	0.58	1.04	5A
Terre Haute Hulman Regional A IN USA TMY3 WMO#=724373	1.05	1.03	0.97	1.06	0.64	0.95	5A
Teterboro Airport NJ USA TMY3 WMO#=725025	0.84	0.77	0.93	0.91	0.32	0.93	5A
Texarkana Webb Field AR USA TMY3 WMO#=723418	0.47	1.64	0.95	0.48	2.34	1.20	3A
The Dalles Municipal Arpt WA USA TMY3 WMO#=726988	0.71	0.77	0.96	0.69	0.39	0.80	5B
Thief River Awos MN USA TMY3 WMO#=727555	2.03	0.54	1.04	2.13	0.05	1.14	7
Togiac Village Awos AK USA TMY3 WMO#=703606	1.92	0.13	1.00	2.10	0.01	1.19	8
Toledo Express Airport OH USA TMY3 WMO#=725360	1.28	0.75	0.97	1.34	0.33	1.02	5A
Toledo Winlock Mem WA USA TMY3 WMO#=727926	0.89	0.40	0.92	0.69	0.04	0.56	4C
Tonopah Airport NV USA TMY3 WMO#=724855	0.68	0.79	1.11	0.84	0.45	1.01	5B

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Topeka Forbes Field KS USA TMY3 WMO#=724565	0.93	1.19	0.98	0.99	0.86	0.83	4A
Topeka Municipal Ap KS USA TMY3 WMO#=724560	0.94	1.16	0.97	1.00	0.94	0.84	4A
Traverse City Cherry Capital MI USA TMY3 WMO#=726387	1.45	0.56	0.96	1.42	0.13	0.88	6A
Travis Field Afb CA USA TMY3 WMO#=745160	0.45	0.96	0.95	0.38	1.56	0.95	3B
Trenton Mercer County Ap NJ USA TMY3 WMO#=724095	0.91	0.97	0.95	0.97	0.52	0.94	5A
Trinidad Las Animas County Ap CO USA TMY3 WMO#=724645	0.75	0.76	1.11	0.80	0.58	1.08	4B
Troy Af AL USA TMY3 WMO#=722267	0.42	1.63	0.94	0.43	2.08	1.05	3A
Truckee Tahoe CA USA TMY3 WMO#=725846	0.90	0.50	1.12	0.88	0.27	1.03	5B
Truth Or Consequences Muni Ap NM USA TMY3 WMO#=722710	0.43	1.12	1.09	0.50	0.91	1.00	4B
Tucson International Ap AZ USA TMY3 WMO#=722740	0.37	1.79	1.20	0.20	2.72	1.41	2B
Tucumcari Faa Ap NM USA TMY3 WMO#=723676	0.64	1.02	1.05	0.69	0.93	1.03	4B
Tulsa International Airport OK USA TMY3 WMO#=723560	0.72	1.43	0.96	0.75	2.32	1.22	3A
Tupelo C D Lemons Arpt MS USA TMY3 WMO#=723320	0.55	1.44	0.94	0.54	2.11	1.14	3A
Tuscaloosa Municipal Ap AL USA TMY3 WMO#=722286	0.48	1.52	0.93	0.48	2.04	1.08	3A
Twentynine Palms CA USA TMY3 WMO#=690150	0.33	1.59	1.12	0.28	3.11	1.27	3B
Two Harbors MN USA TMY3 WMO#=727444	1.70	0.50	1.02	1.52	0.04	1.09	7
Tyler Pounds Fld TX USA TMY3 WMO#=722448	0.44	1.61	0.95	0.45	2.20	1.11	3A
Tyndall Afb FL USA TMY3 WMO#=747750	0.45	1.76	0.98	0.33	2.55	0.80	2A
Ukiah Municipal Ap CA USA TMY3 WMO#=725905	0.57	0.88	0.95	0.46	0.10	0.60	3C
Unalakleet Field AK USA TMY3 WMO#=702070	2.69	0.09	1.05	3.03	0.01	1.22	8
Univ Of Illinois Will USA TMY3 WMO#=725315	1.19	0.93	0.98	1.30	0.56	1.00	5A
Utica Oneida County Ap NY USA TMY3 WMO#=725197	1.32	0.61	0.95	1.27	0.11	0.87	6A
Valdez Pioneer Fiel AK USA TMY3 WMO#=702756	1.49	0.17	0.99	1.07	0.01	0.99	7
Valdez Wso AK USA TMY3 WMO#=702750	1.73	0.16	1.00	1.59	0.01	1.07	7
Valdosta Wb Airport GA USA TMY3 WMO#=722166	0.37	1.95	1.00	0.28	2.96	0.90	2A
Valentine Miller Field NE USA TMY3 WMO#=725670	1.12	0.80	1.04	1.16	0.49	1.08	5A
Valparaiso Elgin Afb FL USA TMY3 WMO#=722210	0.48	1.76	0.98	0.36	2.70	0.93	2A
Valparaiso Hurlburt FL USA TMY3 WMO#=747770	0.46	1.89	0.99	0.35	2.95	0.87	2A
Van Nuys Airport CA USA TMY3 WMO#=722886	0.30	1.24	0.97	0.25	1.69	0.92	3B
Vance Afb OK USA TMY3 WMO#=723535	0.81	1.31	0.99	0.84	2.22	1.31	3A
Vernal UT USA TMY3 WMO#=725705	0.85	0.68	1.11	0.93	0.14	1.40	6B
Vero Beach Municipal Arpt FL USA TMY3 WMO#=722045	0.25	2.35	0.99	0.20	2.88	0.76	2A
Vichy Rolla Natl Arpt MO USA TMY3 WMO#=724456	0.91	0.98	0.96	0.95	0.62	0.83	4A
Victoria Regional Ap TX USA TMY3 WMO#=722550	0.38	2.08	0.99	0.29	3.29	0.91	2A
Virginia Tech Arpt VA USA TMY3 WMO#=724113	0.85	0.93	0.98	0.88	0.56	0.85	4A
Visalia MuniCA USA TMY3 WMO#=723896	0.47	1.12	0.97	0.37	1.90	1.05	3B
Waco Regional Ap TX USA TMY3 WMO#=722560	0.53	1.82	1.02	0.39	3.29	1.10	5A
Walla Walla City County Ap WA USA TMY3 WMO#=727846	0.78	0.73	0.99	0.78	0.38	0.86	2A
Walnut RidgeAR USA TMY3 WMO#=723406	0.66	1.29	0.94	0.65	1.92	1.18	5B
Warner Robins Afb GA USA TMY3 WMO#=722175	0.56	1.49	0.94	0.56	2.03	1.10	3A

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Washington Dc Dulles Intl Ar VA USA TMY3 WMO#=724030	0.85	1.06	0.94	0.89	0.75	0.80	3A
Washington Dc Reagan Ap VA USA TMY3 WMO#=724050	0.78	1.14	0.94	0.85	0.90	0.83	5A
Washington IA USA TMY3 WMO#=725454	1.20	0.91	0.98	1.24	0.52	1.02	4A
WashingtonPA USA TMY3 WMO#=725117	0.93	0.77	0.96	0.85	0.32	0.97	4A
Waterloo Municipal Ap IA USA TMY3 WMO#=725480	1.51	0.78	0.98	1.61	0.21	0.89	5A
Watertown Ap NY USA TMY3 WMO#=726227	1.40	0.60	0.95	1.34	0.12	0.87	6A
Watertown Municipal Ap SD USA TMY3 WMO#=726546	2.00	0.62	1.03	2.11	0.15	0.98	6A
Watertown WI USA TMY3 WMO#=726464	1.24	0.77	0.97	1.23	0.19	0.87	6A
WatervilleME USA TMY3 WMO#=726073	1.41	0.55	0.95	1.29	0.14	0.87	6A
Wausau Municipal Arpt WI USA TMY3 WMO#=726463	1.53	0.68	0.99	1.47	0.17	0.92	6A
WDu Page IL USA TMY3 WMO#=725305	1.12	0.83	0.97	1.14	0.42	1.01	6A
Webster City IA USA TMY3 WMO#=725478	1.24	0.90	0.99	1.30	0.28	0.87	6A
Wenatchee Pangborn WA USA TMY3 WMO#=727825	0.91	0.71	1.00	0.81	0.34	0.86	5B
Wendover Usaf Auxiliary Field UT USA TMY3 WMO#=725810	0.78	0.79	1.10	0.82	0.43	0.95	5B
West Palm Beach Intl Arpt FL USA TMY3 WMO#=722030	0.25	2.48	1.00	0.19	3.24	0.89	2A
Westfield Barnes Muni Ap MA USA TMY3 WMO#=744915	1.24	0.68	0.96	1.23	0.28	0.99	5A
Westhampton Gabreski Ap NY USA TMY3 WMO#=744865	0.90	0.78	0.92	0.92	0.46	0.81	4A
Wheaton NdbMN USA TMY3 WMO#=727533	1.93	0.64	1.01	1.95	0.17	0.94	6A
Wheeling Ohio County Ap WV USA TMY3 WMO#=724275	1.02	0.77	0.97	0.99	0.28	0.99	5A
Whidbey Island Nas WA USA TMY3 WMO#=690230	0.79	0.29	0.91	0.72	0.01	0.55	4C
White Plains Westchester Co A NY USA TMY3 WMO#=725037	1.03	0.79	0.94	1.08	0.47	0.83	4A
Whiteman Afb MO USA TMY3 WMO#=724467	0.95	1.11	0.97	1.03	0.89	0.85	4A
Whiting Field Naas FL USA TMY3 WMO#=722226	0.43	1.78	0.99	0.31	2.67	0.84	2A
Whittier AK USA TMY3 WMO#=702757	1.80	0.15	1.01	1.89	0.01	1.10	7
Wichita ColKS USA TMY3 WMO#=724504	0.92	1.21	0.99	1.00	1.10	0.89	4A
Wichita Falls Municipal Arpt TX USA TMY3 WMO#=723510	0.54	1.55	0.97	0.58	2.55	1.23	3A
Wichita Mid Continent Ap KS USA TMY3 WMO#=724500	0.82	1.19	0.98	0.94	1.04	0.86	4A
Wilkes Barre Scranton Intl Ap PA USA TMY3 WMO#=725130	1.10	0.72	0.97	1.08	0.31	1.00	5A
William R Fairchild WA USA TMY3 WMO#=727885	0.81	0.31	0.92	0.68	0.02	0.55	4C
Williamsport Regional Ap PA USA TMY3 WMO#=725140	1.04	0.82	0.96	1.01	0.38	0.96	5A
Williston Sloulin Intl Ap ND USA TMY3 WMO#=727670	1.67	0.61	1.06	1.68	0.07	1.13	7
Willmar MN USA TMY3 WMO#=726576	1.55	0.70	0.99	1.61	0.18	0.91	6A
Willow Grove Nas PA USA TMY3 WMO#=724086	0.77	0.99	0.94	0.80	0.69	0.79	4A
Wilmington International Arpt NC USA TMY3 WMO#=723013	0.44	1.50	0.93	0.46	1.94	1.04	3A
Wilmington New Castle Cnty Ap DE USA TMY3 WMO#=724089	0.95	1.01	0.94	1.02	0.71	0.81	4A
Winchester Rgnl VA USA TMY3 WMO#=724053	0.89	1.03	0.96	0.91	0.80	0.84	4A
Wink Winkler County Ap TX USA TMY3 WMO#=722656	0.41	1.52	1.08	0.36	2.68	1.25	3B
Winnemucca Municipal Arpt NV USA TMY3 WMO#=725830	0.79	0.76	1.10	0.89	0.47	0.99	5B
Winona MuniMN USA TMY3 WMO#=726588	1.55	0.69	0.97	1.37	0.16	0.87	6A
Winslow Municipal Ap AZ USA TMY3 WMO#=723740	0.57	0.97	1.09	0.69	0.47	0.92	5B

Weather Station	All Building types except warehouse			Warehouse			Climate Zone
	Heating Coefficient	Cooling Coefficient	Fans Coefficient	Heating Coefficient	Cooling Coefficient	Fans Coefficient	
Winston Salem Reynolds Ap NC USA TMY3 WMO#=723193	0.56	1.21	0.95	0.63	0.68	0.75	4A
Wiscasset ME USA TMY3 WMO#=727135	1.13	0.55	0.93	0.99	0.12	0.82	6A
Wise Lonesome Pine VA USA TMY3 WMO#=724117	0.82	0.95	1.01	0.86	0.53	0.87	4A
Wittman Rgnl WI USA TMY3 WMO#=726456	1.66	0.59	0.98	1.68	0.13	0.91	6A
Wolf Point IntlPeckS MT USA TMY3 WMO#=727686	1.64	0.51	1.09	1.70	0.09	1.36	6B
Worcester Regional Arpt MA USA TMY3 WMO#=725095	1.34	0.60	0.98	1.44	0.24	1.06	5A
Worland Municipal WY USA TMY3 WMO#=726665	1.07	0.63	1.08	1.14	0.14	1.42	6B
WorthingtonMN USA TMY3 WMO#=726587	1.70	0.69	1.01	1.97	0.17	0.96	6A
Wrangell AK USA TMY3 WMO#=703870	1.32	0.22	0.97	1.19	0.01	1.00	7
Yakima Air Terminal WA USA TMY3 WMO#=727810	0.94	0.65	0.99	0.92	0.30	0.86	5B
Yakutat State Arpt AK USA TMY3 WMO#=703610	1.51	0.17	0.98	1.26	0.01	1.05	7
Youngstown Regional Airport OH USA TMY3 WMO#=725250	1.24	0.72	0.98	1.31	0.35	1.04	5A
Yuba Co CA USA TMY3 WMO#=724838	0.43	1.10	0.96	0.32	1.88	0.99	3B
Yuma Intl Arpt AZ USA TMY3 WMO#=722800	0.28	2.30	1.16	0.16	3.63	1.52	2B
Yuma Mcas AZ USA TMY3 WMO#=699604	0.29	2.28	1.16	0.16	3.50	1.49	2B
Zanesville Municipal Ap OH USA TMY3 WMO#=724286	0.86	0.82	0.95	0.82	0.32	0.94	5A

Appendix D
Energy Asset Score Tables

Appendix D

Energy Asset Score Tables

D.1 Building Type: Office

Table D.1. Energy Asset Score table for office buildings.

EUI	Score	EUI	Score
70	100	170	50
72	99	172	49
74	98	174	48
76	97	176	47
78	96	178	46
80	95	180	45
82	94	182	44
84	93	184	43
86	92	186	42
88	91	188	41
90	90	190	40
92	89	193	39
94	88	196	38
96	87	199	37
98	86	202	36
100	85	205	35
102	84	208	34
104	83	211	33
106	82	214	32
108	81	217	31
110	80	220	30
112	79	223	29
114	78	226	28
116	77	229	27
118	76	232	26
120	75	235	25
122	74	238	24
124	73	241	23
126	72	244	22
128	71	247	21
130	70	250	20
132	69	254	19
134	68	258	18
136	67	262	17
138	66	266	16
140	65	270	15
142	64	274	14
144	63	278	13
146	62	282	12
148	61	286	11
150	60	290	10
152	59	294	9
154	58	298	8
156	57	302	7
158	56	306	6
160	55	310	5
162	54	314	4
164	53	318	3
166	52	322	2
168	51	326	1

D.2 Building Type: Library

Table D.2. Energy Asset Score table for libraries.

EUI	Score	EUI	Score
120	100	220	50
122	99	222	49
124	98	224	48
126	97	226	47
128	96	228	46
130	95	230	45
132	94	232	44
134	93	234	43
136	92	236	42
138	91	238	41
140	90	240	40
142	89	242	39
144	88	244	38
146	87	246	37
148	86	248	36
150	85	250	35
152	84	252	34
154	83	254	33
156	82	256	32
158	81	258	31
160	80	260	30
162	79	262	29
164	78	264	28
166	77	266	27
168	76	268	26
170	75	270	25
172	74	272	24
174	73	274	23
176	72	276	22
178	71	278	21
180	70	280	20
182	69	282	19
184	68	284	18
186	67	286	17
188	66	288	16
190	65	290	15
192	64	292	14
194	63	294	13
196	62	296	12
198	61	298	11
200	60	300	10
202	59	302	9
204	58	304	8
206	57	306	7
208	56	308	6
210	55	310	5
212	54	312	4
214	53	314	3
216	52	316	2
218	51	318	1

D.3 Building Type: School

Table D.3. Energy Asset Score table for school buildings.

EUI	Score	EUI	Score
115	100	215	50
117	99	217	49
119	98	219	48
121	97	221	47
123	96	223	46
125	95	225	45
127	94	227	44
129	93	229	43
131	92	231	42
133	91	233	41
135	90	235	40
137	89	237	39
139	88	239	38
141	87	241	37
143	86	243	36
145	85	245	35
147	84	247	34
149	83	249	33
151	82	251	32
153	81	253	31
155	80	255	30
157	79	257	29
159	78	259	28
161	77	261	27
163	76	263	26
165	75	265	25
167	74	268	24
169	73	271	23
171	72	274	22
173	71	277	21
175	70	280	20
177	69	283	19
179	68	286	18
181	67	289	17
183	66	292	16
185	65	295	15
187	64	298	14
189	63	301	13
191	62	304	12
193	61	307	11
195	60	310	10
197	59	314	9
199	58	318	8
201	57	322	7
203	56	326	6
205	55	330	5
207	54	334	4
209	53	338	3
211	52	342	2
213	51	346	1

D.4 Building Type: Retail

Table D.4. Energy Asset Score table for retail buildings.

EUI	Score	EUI	Score
90	100	240	50
93	99	244	49
96	98	248	48
99	97	252	47
102	96	256	46
105	95	260	45
108	94	264	44
111	93	268	43
114	92	272	42
117	91	276	41
120	90	280	40
123	89	284	39
126	88	288	38
129	87	292	37
132	86	296	36
135	85	300	35
138	84	304	34
141	83	308	33
144	82	312	32
147	81	316	31
150	80	320	30
153	79	324	29
156	78	328	28
159	77	332	27
162	76	336	26
165	75	340	25
168	74	344	24
171	73	348	23
174	72	352	22
177	71	356	21
180	70	360	20
183	69	364	19
186	68	368	18
189	67	372	17
192	66	376	16
195	65	380	15
198	64	384	14
201	63	388	13
204	62	392	12
207	61	396	11
210	60	400	10
213	59	404	9
216	58	408	8
219	57	412	7
222	56	416	6
225	55	420	5
228	54	424	4
231	53	428	3
234	52	432	2
237	51	436	1

D.5 Building Type: Warehouse (non-refrigerated)

Table D.5. Energy Asset Score table for non-refrigerated warehouse.

EUI	Score	EUI	Score
45	100	145	50
47	99	147	49
49	98	149	48
51	97	151	47
53	96	153	46
55	95	155	45
57	94	157	44
59	93	159	43
61	92	161	42
63	91	163	41
65	90	165	40
67	89	167	39
69	88	169	38
71	87	171	37
73	86	173	36
75	85	175	35
77	84	177	34
79	83	179	33
81	82	181	32
83	81	183	31
85	80	185	30
87	79	187	29
89	78	189	28
91	77	191	27
93	76	193	26
95	75	195	25
97	74	197	24
99	73	199	23
101	72	201	22
103	71	203	21
105	70	205	20
107	69	207	19
109	68	209	18
111	67	211	17
113	66	213	16
115	65	215	15
117	64	217	14
119	63	219	13
121	62	221	12
123	61	223	11
125	60	225	10
127	59	227	9
129	58	229	8
131	57	231	7
133	56	233	6
135	55	235	5
137	54	237	4
139	53	239	3
141	52	241	2
143	51	243	1

D.6 Building Type: Apartment

Table D.6. Energy Asset Score table for apartment.

EUI	Score	EUI	Score
80	100	180	50
82	99	182	49
84	98	184	48
86	97	186	47
88	96	188	46
90	95	190	45
92	94	192	44
94	93	194	43
96	92	196	42
98	91	198	41
100	90	200	40
102	89	202	39
104	88	204	38
106	87	206	37
108	86	208	36
110	85	210	35
112	84	212	34
114	83	214	33
116	82	216	32
118	81	218	31
120	80	220	30
122	79	222	29
124	78	224	28
126	77	226	27
128	76	228	26
130	75	230	25
132	74	232	24
134	73	234	23
136	72	236	22
138	71	238	21
140	70	240	20
142	69	242	19
144	68	244	18
146	67	246	17
148	66	248	16
150	65	250	15
152	64	252	14
154	63	254	13
156	62	256	12
158	61	258	11
160	60	260	10
162	59	262	9
164	58	264	8
166	57	266	7
168	56	268	6
170	55	270	5
172	54	272	4
174	53	274	3
176	52	276	2
178	51	278	1

D.7 Building Type: Courthouse

Table D.7. Energy Asset Score table for courthouse.

EUI	Score	EUI	Score
140	100	250	50
142	99	253	49
144	98	256	48
146	97	259	47
148	96	262	46
150	95	265	45
152	94	268	44
154	93	271	43
156	92	274	42
158	91	277	41
160	90	280	40
162	89	283	39
164	88	286	38
166	87	289	37
168	86	292	36
170	85	295	35
172	84	298	34
174	83	301	33
176	82	304	32
178	81	307	31
180	80	310	30
182	79	313	29
184	78	316	28
186	77	319	27
188	76	322	26
190	75	325	25
192	74	328	24
194	73	331	23
196	72	334	22
198	71	337	21
200	70	340	20
202	69	343	19
204	68	346	18
206	67	349	17
208	66	352	16
210	65	355	15
212	64	358	14
214	63	361	13
216	62	364	12
218	61	367	11
220	60	370	10
223	59	374	9
226	58	378	8
229	57	382	7
232	56	386	6
235	55	390	5
238	54	394	4
241	53	398	3
244	52	402	2
247	51	406	1

D.8 Building Type: Lodging

Table D.8. Energy Asset Score table for lodging.

EUI	Score	EUI	Score
55	100	205	50
58	99	209	49
61	98	213	48
64	97	217	47
67	96	221	46
70	95	225	45
73	94	229	44
76	93	233	43
79	92	237	42
82	91	241	41
85	90	245	40
88	89	249	39
91	88	253	38
94	87	257	37
97	86	261	36
100	85	265	35
103	84	269	34
106	83	273	33
109	82	277	32
112	81	281	31
115	80	285	30
118	79	290	29
121	78	295	28
124	77	300	27
127	76	305	26
130	75	310	25
133	74	315	24
136	73	320	23
139	72	325	22
142	71	330	21
145	70	335	20
148	69	340	19
151	68	345	18
154	67	350	17
157	66	355	16
160	65	360	15
163	64	365	14
166	63	370	13
169	62	375	12
172	61	380	11
175	60	385	10
178	59	391	9
181	58	397	8
184	57	403	7
187	56	409	6
190	55	415	5
193	54	421	4
196	53	427	3
199	52	433	2
202	51	439	1

Appendix E

Energy Asset Score Data Collection Form

U.S. Department of Energy Commercial Building Energy Asset Score 2013 Pilot

Data Collection Form

Version: 6/14/2013

ALL SHADED FIELDS ARE REQUIRED

Building Name:	
Data collected by:	
Email, phone:	
Date of Data Collection:	

HOW TO USE THIS DATA COLLECTION FORM

This form is intended to facilitate your data collection. The Energy Asset Scoring Tool uses the "block" concept to simplify your building geometry. Most buildings can be scored as one block unless at least one of the follow situations applies:

- The building has sections with different numbers of floors
Example: A portion of the building is 3 story and the other portion is 10 story.
- Different parts of the building are served by different HVAC systems
Example: A portion of the building uses a local chiller, the other portion uses packaged DX units.
- The building is mixed-use
Example: A portion of the building is retail, the other portion is office.
- The building footprint cannot be simplified by the basic footprint shapes, such as rectangular, L-, T-, or U-shapes.

If your building contains more than one block, some data may need to be collected and recorded for each block. Make additional copies of the related sections of this data collection form as needed. See each section for detailed instructions.

REQUIRED DATA:

In order to generate a score for the building, all fields shaded in green are required. Users are encouraged to provide information where available for the other data fields as well.

OPTIONAL DATA:

The asset scoring tool can estimate a building's thermal properties based on other information provided (e.g., roof type, floor type, wall type, building location, and year of construction). If the roof, floor, or walls have been altered since the year of construction, it is preferable to provide additional relevant information in order to get credit for potentially improved envelope thermal performance.

The asset scoring tool can also estimate equipment capacity and efficiency (heating, cooling, fans, service hot water) based on other information provided (e.g. equipment type, year of manufacture, number of pieces of equipment, and building location). If year of manufacture is not specified by users, it is assumed that the vintage of the equipment is the same as that of the building.

General Building Information

ALL SHADED FIELDS ARE REQUIRED

Building type

For mixed-use buildings, choose as many fields as apply.

If this building includes use types not listed here, exclude that portion of the building when entering data.

Choose "Office" for a college/university building containing mostly offices.

Choose "Library" for a college/university

- | | | |
|---|---|---|
| <input type="checkbox"/> City Hall | <input type="checkbox"/> Library | <input type="checkbox"/> Retail |
| <input type="checkbox"/> Community Center | <input type="checkbox"/> Lodging | <input type="checkbox"/> Senior Center |
| <input type="checkbox"/> Courthouse | <input type="checkbox"/> Medical Office | <input type="checkbox"/> Warehouse – Non-refrigerated |
| <input type="checkbox"/> Education (K-12 School, College/University, Training Facilities) | <input type="checkbox"/> Multi-family (4 stories +) | |
| | <input type="checkbox"/> Office | |
| | <input type="checkbox"/> Post Office | |

Year completed

YEAR IN WHICH THE BUILDING WAS COMPLETED

Building location

STREET

CITY

STATE

POSTAL CODE

Gross floor area

ft²

This refers to the total square footage of the building, with the exception of parking areas which should be excluded. To calculate gross floor area, use the external dimensions of the enclosing fixed walls of the buildings, including structures, partitions, corridors, stairs, and conditioned below-grade spaces. Atriums should only include the base floor area that it occupies.

For mixed-use buildings that include a space not listed above, exclude the square footage of that space.

Footprint shape

Select one or more of the following options in combination to approximate the shape of the building's footprint.

- | | | |
|--|----------------------------------|----------------------------------|
| <input type="checkbox"/> Rectangular or square | <input type="checkbox"/> L-Shape | <input type="checkbox"/> T-Shape |
| | <input type="checkbox"/> H-Shape | <input type="checkbox"/> U-Shape |

Footprint dimensions

See attached Footprint and Window Layout sheet to assist in recording data.

Orientation

CLOCKWISE DEGREE FROM NORTH

Orientation of the main long axis. North=0, North East=45, East=90, South East=120, South=180, South West=225, West=270, North West=315.

Number of floors (above ground)

For mixed-use buildings that include a use type not listed above (e.g., restaurant, cafeteria), exclude any floors that are used exclusively for that purpose.

Number of floors (below ground)

Average floor-to-ceiling height

ft

Average floor-to-floor height

ft

Construction Properties

ALL SHADED FIELDS ARE REQUIRED

Make additional copies of this page if your building has more than one type of roof or floor.

<p>Roof type</p> <p>Choose all applicable roof types.</p>	<input type="checkbox"/> Built-up/EPDM with Concrete Deck <input type="checkbox"/> Built-up/EPDM with Metal Deck <input type="checkbox"/> Built-up/EPDM with Wood Deck <input type="checkbox"/> Metal Surfacing <input type="checkbox"/> Shingles/Shakes										
<p>Roof insulation and assembly</p> <p>If the roof has been altered since the year of building construction, users are encouraged to provide one of the following data points to get credit for improved envelope thermal performance. Fill in ONLY ONE of the following three data fields. If the building has multiple roof types, record each type separately.</p>	<table border="1"> <tbody> <tr> <td>ROOF INSULATION R-VALUE</td> <td>°F•ft²•h/Btu</td> </tr> <tr> <td colspan="2" style="text-align: center;">OR</td> </tr> <tr> <td>ROOF INSULATION THICKNESS</td> <td>in</td> </tr> <tr> <td colspan="2" style="text-align: center;">OR</td> </tr> <tr> <td>ROOF ASSEMBLY U-VALUE</td> <td>Btu/°F•ft²•h</td> </tr> </tbody> </table>	ROOF INSULATION R-VALUE	°F•ft ² •h/Btu	OR		ROOF INSULATION THICKNESS	in	OR		ROOF ASSEMBLY U-VALUE	Btu/°F•ft ² •h
ROOF INSULATION R-VALUE	°F•ft ² •h/Btu										
OR											
ROOF INSULATION THICKNESS	in										
OR											
ROOF ASSEMBLY U-VALUE	Btu/°F•ft ² •h										
<p>Floor</p> <p>Choose all applicable floor types.</p>	<input type="checkbox"/> Concrete (over Unconditioned Space) <input type="checkbox"/> Slab on Grade <input type="checkbox"/> Steel Joist <input type="checkbox"/> Wood Frame										
<p>Floor insulation and assembly</p> <p>If the floor insulation or assembly has been altered since the year of building construction, users are encouraged to provide one of the following data points to get credit for improved envelope thermal performance. Fill in ONLY ONE of the following three fields.</p>	<table border="1"> <tbody> <tr> <td>FLOOR INSULATION R-VALUE</td> <td>°F•ft²•h/Btu</td> </tr> <tr> <td colspan="2" style="text-align: center;">OR</td> </tr> <tr> <td>FLOOR INSULATION THICKNESS</td> <td>in</td> </tr> <tr> <td colspan="2" style="text-align: center;">OR</td> </tr> <tr> <td>FLOOR ASSEMBLY U-VALUE</td> <td>Btu/°F•ft²•h</td> </tr> </tbody> </table>	FLOOR INSULATION R-VALUE	°F•ft ² •h/Btu	OR		FLOOR INSULATION THICKNESS	in	OR		FLOOR ASSEMBLY U-VALUE	Btu/°F•ft ² •h
FLOOR INSULATION R-VALUE	°F•ft ² •h/Btu										
OR											
FLOOR INSULATION THICKNESS	in										
OR											
FLOOR ASSEMBLY U-VALUE	Btu/°F•ft ² •h										
<p>Applicable for slab on grade ONLY</p>	<p>SLAB ON GRADE INSULATION TYPE</p> <input type="checkbox"/> No insulation <input type="checkbox"/> Vertical (Perimeter) insulation										

The scoring tool allows you to edit wall and window properties by each wall surface. Make additional copies of the following section for the wall surface that has a very different construction type, window type, or window-to-wall ratio from other walls.

<p>Exterior wall type <i>Choose all applicable wall types.</i></p>	<input type="checkbox"/> Brick/stone on Masonry <input type="checkbox"/> Brick/stone on Steel Frame <input type="checkbox"/> Brick/stone on Wood Frame <input type="checkbox"/> Metal Panel/Curtain Wall <input type="checkbox"/> Siding on Steel Frame <input type="checkbox"/> Siding on Wood Frame
---	--

<p>Wall insulation and assembly <i>If the wall insulation or assembly has been altered since the year of building construction, users are encouraged to provide one of the following data points to get credit for improved envelope thermal performance. Fill in ONLY ONE of the following three data fields. If the building has multiple wall types, record each type separately.</i></p>	<p>WALL INSULATION R-VALUE °F•ft²•h/Btu</p> <p style="text-align: center;">OR</p>
	<p>WALL INSULATION THICKNESS in</p> <p style="text-align: center;">OR</p>
	<p>WALL ASSEMBLY U-VALUE Btu/°F•ft²•h</p>

<p>Window framing type <i>If a wall surface has various window framing types, choose predominant type in that wall.</i></p>	<input type="checkbox"/> Wood/Vinyl/Fiberglass <input type="checkbox"/> Metal <input type="checkbox"/> Metal with Thermal Breaks
--	--

<p>Window glass type <i>If a wall surface has various window glass types, choose predominant type in that wall.</i></p>	<input type="checkbox"/> Single-pane <input type="checkbox"/> Double-pane <input type="checkbox"/> Double-pane w/ Low-E <input type="checkbox"/> Triple-pane <input type="checkbox"/> Triple-pane w/ Low-E
--	--

<p>Window gas fill type</p>	<input type="checkbox"/> Air <input type="checkbox"/> Other
------------------------------------	--

<p>Window U-value</p>	Btu/°F•ft ² •h
------------------------------	---------------------------

<p>Window solar heat gain coefficient (SHGC)</p>	(range 0-1)
---	-------------

<p>Window layout <i>If your building has both Continuous and Discrete windows, Choose "Various."</i></p>	<input type="checkbox"/> Continuous <input type="checkbox"/> Discrete <input type="checkbox"/> Various
---	--

Window to wall ratio
Select one of the following two approaches to calculate window-to-wall ratio for the building. If the window-to-wall ratio varies by orientation, you can use the attached Footprint and Window Layout sheet to assist in recording data.

<p>FOR "CONTINUOUS" OR "VARIOUS" WINDOW LAYOUT</p> <table border="1" style="width: 100%;"> <tr> <td style="width: 80%;">WINDOW-TO-WALL RATIO</td> <td style="width: 20%; text-align: center;">%</td> </tr> </table>	WINDOW-TO-WALL RATIO	%	OR	<p>FOR "DISCRETE" WINDOW LAYOUT</p> <table border="1" style="width: 100%;"> <tr> <td style="width: 80%;">WIDTH OF A TYPICAL WINDOW</td> <td style="width: 20%; text-align: center;">ft</td> </tr> <tr> <td>HEIGHT OF A TYPICAL WINDOW</td> <td style="text-align: center;">ft</td> </tr> <tr> <td>NUMBER OF WINDOWS</td> <td></td> </tr> </table>	WIDTH OF A TYPICAL WINDOW	ft	HEIGHT OF A TYPICAL WINDOW	ft	NUMBER OF WINDOWS	
WINDOW-TO-WALL RATIO	%									
WIDTH OF A TYPICAL WINDOW	ft									
HEIGHT OF A TYPICAL WINDOW	ft									
NUMBER OF WINDOWS										

Exterior shading type <i>Choose all applicable shading types. See attached Shading Diagrams for shading types and dimensions.</i>	<input type="checkbox"/> No shading <input type="checkbox"/> External overhangs <input type="checkbox"/> Vertical fins <input type="checkbox"/> Light shelves
Overhang: Height above window	ft
Overhang: Projection	ft
Vertical fins: Fin depth	ft
Vertical fins: Distance between fins	ft
Vertical fins: Edge fin only	<input type="checkbox"/> Yes <input type="checkbox"/> No
Light shelves: Distance from top	ft
Light shelves: Exterior protrusion	ft
Light shelves: Interior protrusion	ft
Skylight U-value	Btu/°F•ft²•h
Skylight glazing type	<input type="checkbox"/> Plastic <input type="checkbox"/> Glass
Skylight solar heat gain coefficient (SHGC)	(range 0-1)
Skylight layout	<input type="checkbox"/> All Zones <input type="checkbox"/> Core Only
Percent of roof area <i>Estimate the percent of the roof area covered in skylights.</i>	%

Lighting

ALL SHADED FIELDS ARE REQUIRED

Make additional copies of this page if your building has more than one type of lighting.

Lighting type <i>Choose all applicable lighting types.</i>	<input type="checkbox"/> Compact fluorescent <input type="checkbox"/> Fluorescent T5 <input type="checkbox"/> Fluorescent T5 - High Output <input type="checkbox"/> Fluorescent T8 <input type="checkbox"/> Fluorescent T8 - High Efficiency <input type="checkbox"/> Fluorescent T12 <input type="checkbox"/> High-pressure sodium <input type="checkbox"/> Incandescent/Halogen <input type="checkbox"/> LED <input type="checkbox"/> Mercury vapor <input type="checkbox"/> Metal halide
Mounting type	<input type="checkbox"/> Recessed <input type="checkbox"/> Surface <input type="checkbox"/> Pendant
Lighting power density <i>Select one of the following two approaches to calculate lighting power density.</i>	OPTION 1: PERCENTAGE OF TOTAL FLOOR AREA SERVED % OR OPTION 2: NUMBER OF LAMPS PER FIXTURE OPTION 2: LAMP WATTAGE W OPTION 2: TOTAL NUMBER OF FIXTURES
Occupancy sensors	<input type="checkbox"/> Yes <input type="checkbox"/> No
Daylighting sensors	<input type="checkbox"/> Yes <input type="checkbox"/> No

HVAC

ALL SHADED FIELDS ARE REQUIRED

Thermal zone layout	<input type="checkbox"/> Perimeter <input type="checkbox"/> Perimeter and core <input type="checkbox"/> Single zone
----------------------------	---

Plant Equipment: Heating*

ALL SHADED FIELDS ARE REQUIRED

This section is ONLY for buildings with a heating plant.

Heating fuel	<input type="checkbox"/> Electricity <input type="checkbox"/> Gas
Heating plant type	<input type="checkbox"/> District Hot Water <input type="checkbox"/> Boiler
Boiler draft type	<input type="checkbox"/> Mechanical <input type="checkbox"/> Other draft
Boiler distribution type	<input type="checkbox"/> Fan coil <input type="checkbox"/> Single-zone AHU <input type="checkbox"/> Multi-zone AHU
Number of pieces of heating equipment <i>Total number of equipment regardless of size.</i>	
Heating equipment efficiency <i>For multiple pieces of equipment with various efficiencies, enter the efficiency of the predominant equipment or the weighted average based on equipment size.</i>	INCLUDE EFFICIENCY LEVEL AND SELECT THE APPLICABLE UNIT <input type="checkbox"/> COP <input type="checkbox"/> % OR
Year of manufacture	YEAR
Heating equipment capacity <i>For multiple pieces of equipment, enter the total capacity.</i>	KBtu/hr

* If your building has district heating or cooling, a boiler, or a chiller, you need to fill out the relevant "Plant Equipment" section(s) as well as the sections on conventional "Air-Side Equipment". Otherwise, skip the "Plant Equipment" sections and go directly to the "Air-Side Equipment" that cover conventional heating and cooling systems.

Plant Equipment: Cooling

ALL SHADED FIELDS ARE REQUIRED

This section is ONLY for buildings with a cooling plant.

<p>Cooling plant type <i>Required only for buildings with a cooling plant.</i></p>	<input type="checkbox"/> Chiller <input type="checkbox"/> District Chilled Water
<p>Chiller compressor type</p>	<input type="checkbox"/> Reciprocating <input type="checkbox"/> Screw/scroll <input type="checkbox"/> Centrifugal
<p>Chiller distribution type</p>	<input type="checkbox"/> Single Zone AHU <input type="checkbox"/> Multi Zone AHU <input type="checkbox"/> Fan coil
<p>Chiller condenser type</p>	<input type="checkbox"/> Air <input type="checkbox"/> Water
<p>Number of pieces of cooling equipment <i>Total number of equipment regardless of size.</i></p>	
<p>Cooling equipment efficiency <i>For multiple pieces of equipment with various efficiencies, enter the efficiency of the predominant equipment or the weighted average based on equipment size.</i></p>	<p>INCLUDE EFFICIENCY LEVEL AND SELECT THE APPLICABLE UNIT</p> <p style="text-align: center;"> <input type="checkbox"/> COP <input type="checkbox"/> EER <input type="checkbox"/> kW/ton </p> <p style="text-align: center;"><i>OR</i></p>
<p>Year of manufacture</p> <p><i>If any cooling plant equipment was installed or replaced after the building was constructed, indicate the year of manufacture. Otherwise, the asset scoring tool will assume that the year of manufacture is the same as the year in which the building was constructed. If you specify the equipment's efficiency, the year of manufacture will not be used.</i></p>	<p>YEAR</p>
<p>Cooling equipment capacity <i>For multiple pieces of equipment, enter the total capacity.</i></p>	<p>tons</p>

Equipment: Heating

ALL SHADED FIELDS ARE REQUIRED

Heating fuel

- Electricity
- Gas

Heating type

Choose all applicable heating types.

- No heating
- Central furnace
- Heat pump

Distribution type

- Radiators
- Single-zone AHU
- Multi-zone AHU

Heat pump sink/source type

- Air

Number of pieces of heating equipment

Total number of equipment regardless of size.

Heating equipment efficiency

For multiple pieces of equipment with various efficiencies, enter the efficiency of the predominant equipment or the weighted average based on equipment size.

INCLUDE EFFICIENCY LEVEL AND SELECT THE APPLICABLE UNIT

COP %

OR

Year of manufacture

YEAR

If any heating equipment was installed or replaced after the building was constructed, indicate the year of manufacture. Otherwise, the asset scoring tool will assume that the year of manufacture is the same as the year in which the building was constructed. If you specify the equipment's efficiency, the year of manufacture will not be used.

Heating equipment capacity

For multiple pieces of equipment, enter the total capacity.

MMBtu/hr

Equipment: Cooling

ALL SHADED FIELDS ARE REQUIRED

Cooling type

Choose all applicable heating types.

- No cooling
- Terminal DX
- Central DX

Number of pieces of cooling equipment

Total number of equipment regardless of size.

Cooling equipment efficiency

For multiple pieces of equipment with various efficiencies, enter the efficiency of the predominant equipment or the weighted average based on equipment size.

SELECT THE APPLICABLE UNIT

- COP
- EER
- kW/ton

OR

Year of manufacture

YEAR

If any cooling equipment was installed or replaced after the building was constructed, indicate the year of manufacture. Otherwise, the asset scoring tool will assume that the year of manufacture is the same as the year in which the building was constructed. If you specify the equipment's efficiency, the year of manufacture will not be used.

Cooling equipment capacity

For multiple pieces of equipment, enter the total capacity.

tons

Fan Systems

ALL SHADED FIELDS ARE REQUIRED

Fan motor efficiency

%

Fan efficiency

%

Fan control

- Constant Air Volume
- Variable Air Volume

Economizer

- Yes
- No

Terminal Systems

ALL SHADED FIELDS ARE REQUIRED

Terminal type

Applicable ONLY for systems with Multi-zone AHU

- VAV with Reheat
- Powered Induction Unit

Service Hot Water

ALL SHADED FIELDS ARE REQUIRED

Fuel type	<input type="checkbox"/> Electric <input type="checkbox"/> Gas
Use of heat pump equipment	<input type="checkbox"/> Yes <input type="checkbox"/> No
Distribution type	<input type="checkbox"/> Looped <input type="checkbox"/> Distributed <input type="checkbox"/> Instantaneous
Water heater efficiency	%
Tank volume	gallons
Tank insulation thickness	in
Tank insulation R-value	°F·ft ² ·h/Btu

Building Operation

ALL SHADED FIELDS ARE REQUIRED

Information about your building's operation can help inform the Scoring Tool's recommendations for energy efficiency upgrades; however, this information will not be used to calculate your building's current asset score.

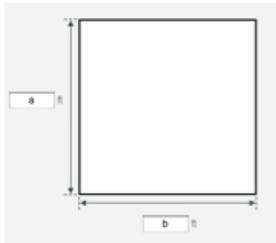
Miscellaneous electric load	W/ft ²
Miscellaneous gas load	kBtu/ft ²
Opening time - closing time (weekdays)	to
Opening time - closing time (Saturday)	to
Opening time - closing time (Sunday)	to
Total occupants	
<i>Provide weighted average of full-time equivalent occupants. If this building includes use types not listed in the current version of the tool, EXCLUDE occupants associated with that portion of the building.</i>	
Setpoint, heating	°F
Setpoint, cooling	°F
Operating season	<input type="checkbox"/> 10-Month Occupancy <input type="checkbox"/> 12-Month Occupancy
<i>For "Education" use type only.</i>	

Footprint and Window Layout

Instructions: (1) Choose applicable footprint shape and indicate footprint dimensions. (2) Mark the North orientation next to the sketch of the shape selected. (3) Record window-to-wall ratio for each wall on each wall of the shapes selected. If window-to-wall ratios are equivalent on all sides, you only need to record this information once.

If your building contains more than one block, make additional copies as needed.

Rectangular

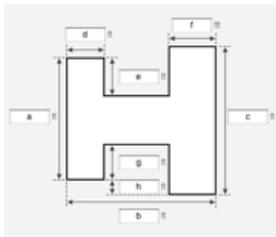


Footprint dimensions

a = _____ ft

b = _____ ft

'H' Shape



Footprint dimensions

a = _____ ft

b = _____ ft

c = _____ ft

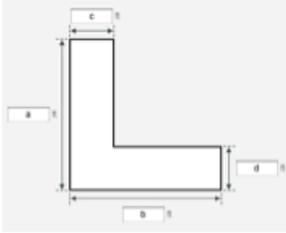
d = _____ ft

e = _____ ft

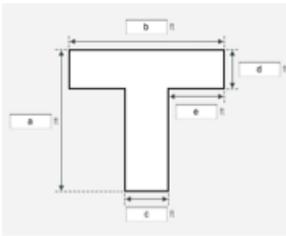
f = _____ ft

g = _____ ft

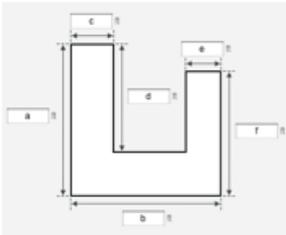
h = _____ ft

L-Shape**Footprint dimensions**

a =	ft
b =	ft
c =	ft
d =	ft

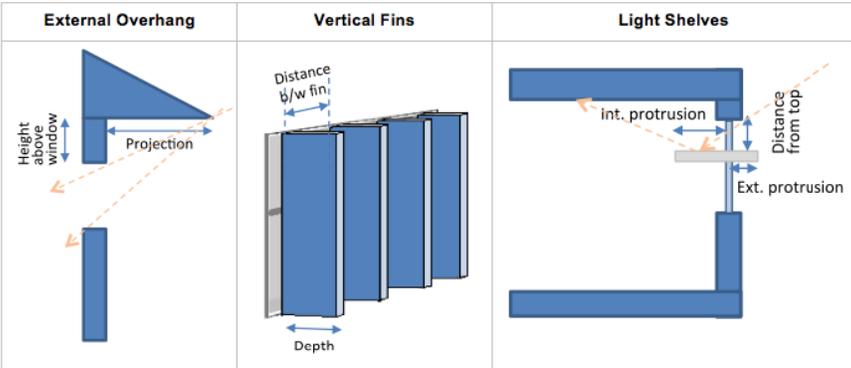
T-Shape**Footprint dimensions**

a =	ft
b =	ft
c =	ft
d =	ft
e =	ft

U-Shape**Footprint dimensions**

a =	ft
b =	ft
c =	ft
d =	ft
e =	ft
f =	ft

Shading Diagrams



Appendix F
Energy Asset Score Report

COMMERCIAL BUILDING ENERGY ASSET SCORE SUMMARY

1

BUILDING INFORMATION

Example Building
2000 A St.,
Chicago, IL 60601

Building Type: **Mixed-Use**
Gross Floor Area: **140,000 ft²**
Year Built: **2005**

Report #: **WA-1234567**
Score Date: **02/2013**
Building ID #: **XXXXX**

ASSET SCORE DATA LEVEL:

- Simple Score
- Advanced Score
- Advanced Score is Verified

BUILDING ASSET SCORE:

Current Building Score **62**

Score with Upgrades **73**

BUILDING USE TYPES:

Office: **100,000 ft²**
Retail: **40,000 ft²**

Each use type has a separate Score page included after the full building Score page.

CONTENTS

- Summary Page 1
- Score Page 2-4
- Upgrade Opportunities Page 5
- Structures and Systems Page 6
- Building Assets Page 7-8

The **Commercial Building Energy Asset Score** is a national rating system developed by the U.S. Department of Energy. The **Score** reflects the energy efficiency of a commercial building based on the building's structure, heating, cooling, ventilation, and hot water systems. The **Structure and Systems** are the details on the current structure and systems for the building. The **Opportunities** show how to improve the energy efficiency of the building to achieve a higher score and save energy and money.

<http://www1.eere.energy.gov/buildings/commercial/assetscore.html>



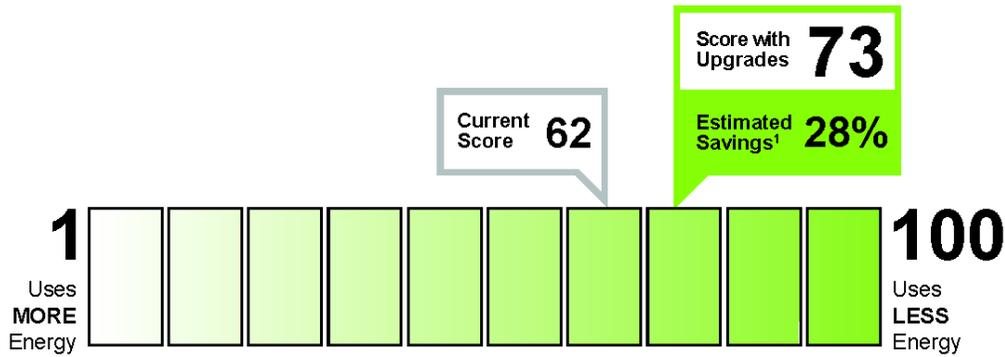
COMMERCIAL BUILDING ENERGY ASSET SCORE

SCORE: FULL BUILDING

2

Building ID #: XXXXX

Gross Floor Area: 140,000 ft²



Assumed Building Occupancy and Operating Conditions	Estimated Source Energy Use Under Building Assumptions ² (kBtu/ft ²)	Energy Use Intensity by Fuel Type
Number of Assumed Occupants: Various ³	Current Building: 200	Site Energy Use (kBtu/ft²) Source Energy Use (kBtu/ft²) Legend: Fuel Oil (Black), Gas (Yellow), Electricity (Grey), District Heating (Red), District Cooling (Cyan)
Hours of Operation: Various ³	Upgraded Building: 154	
Cooling Set Point: Various ³		
Heating Set Point: Various ³		
Misc. Energy Loads: Various ³		

¹The savings are based on standard operating conditions as defined in the Model Assumptions above and reflect source energy savings. The upgrade opportunities are identified on the Opportunities page.

²Modeled energy use assume typical operating and normal weather conditions as defined in the Model Assumptions for this Building Type.

³See individual use type score pages for occupancy and operating condition assumptions.



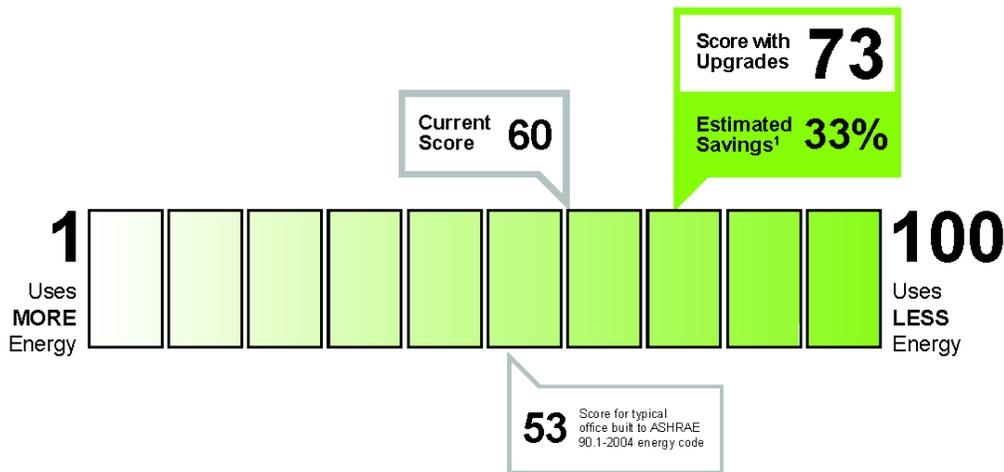
COMMERCIAL BUILDING ENERGY ASSET SCORE

SCORE: OFFICE PORTION

3

Building ID #: XXXXX

Gross Floor Area: 100,000 ft²



Assumed Building Occupancy and Operating Conditions	Estimated Source Energy Use Under Building Assumptions ² (kBtu/ft ²)	Energy Use Intensity by Fuel Type
Number of Assumed Occupants: 500 Hours of Operation: 49 hrs/wk Cooling Set Point: 73°F Heating Set Point: 70°F Misc. Energy Loads: 0.75 W/ft ²	Current Building: 159 Upgraded Building: 107 Typical Office: 187 • 3 Story, 54,740 ft ² • Modeled under the same climatic conditions	Site Energy Use (kBtu/ft ²) 16.5 (Gas) 42.5 (Electricity) Source Energy Use (kBtu/ft ²) 17.3 (Gas) 142.1 (Electricity)
		Fuel Oil (Black), Gas (Yellow), Electricity (Grey), District Heating (Red), District Cooling (Cyan)

¹The savings are based on standard operating conditions as defined in the Model Assumptions above and reflect source energy savings. The upgrade opportunities are identified on the **Opportunities** page.

²Modeled energy use assume typical operating and normal weather conditions as defined in the Model Assumptions for this Building Type.



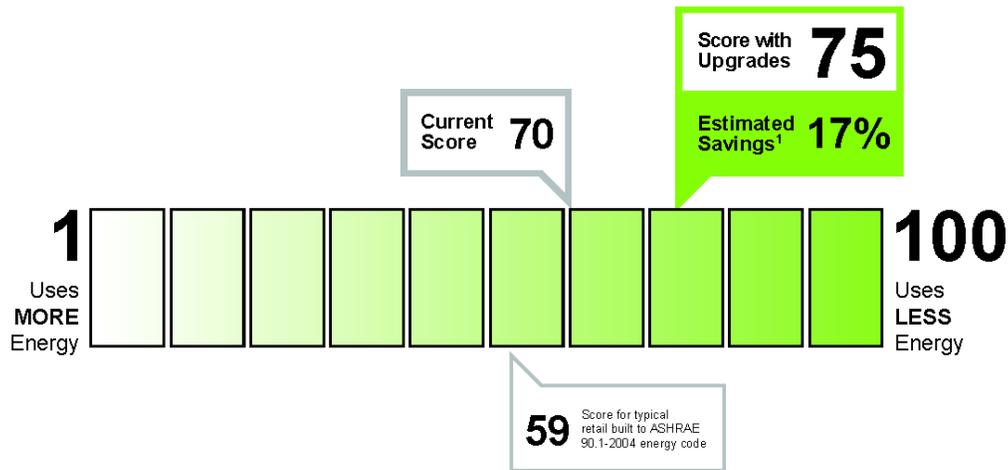
COMMERCIAL BUILDING ENERGY ASSET SCORE

SCORE: RETAIL PORTION

4

Building ID #: XXXXX

Gross Floor Area: 40,000 ft²



Assumed Building Occupancy and Operating Conditions	Estimated Source Energy Use Under Model Assumptions ² (kBtu/ft ²)	Energy Use Intensity by Fuel Type
Number of Assumed Occupants: 597 Hours of Operation: 46 hrs/wk Cooling Set Point: 73°F Heating Set Point: 70°F Misc. Energy Loads: 1.01 W/ft ²	Current Building: 240 Upgraded Building: 200 Typical Retail: 328 • 1 Story, 40,000 ft ² • Modeled under the same climatic conditions	Site Energy Use (kBtu/ft ²) 19.1 (Gas) 65.9 (Electricity) Source Energy Use (kBtu/ft ²) 20 (Gas) 220.1 (Electricity)
		Fuel Oil Gas Electricity District Heating District Cooling

¹The savings are based on standard operating conditions as defined in the Model Assumptions above and reflect source energy savings. The upgrade opportunities are identified on the Opportunities page.

²Modeled energy use assume typical operating and normal weather conditions as defined in the Model Assumptions for this Building Type.



COMMERCIAL BUILDING ENERGY ASSET SCORE

UPGRADE OPPORTUNITIES

5

Building ID #: XXXXX

Gross Floor Area: 140,000 ft²

COST EFFECTIVE UPGRADE OPPORTUNITIES

	Energy Savings ¹	Simple Pay Back
Building Envelope		
• Add roof insulation in Office and Retail	5 - 10%	15 - 25 yrs
• Upgrade windows in Office with high performance double pane windows	5 - 10%	10 - 15 yrs
Interior Lighting		
• Upgrade Incandescent lighting in Office and Retail to compact fluorescent lighting	10 - 15%	1.5 - 5 yrs
HVAC Systems		
• Upgrade cooling system in Office and Retail with high efficiency electric DX	10 - 15%	5 - 10 yrs
Hot Water Systems		
• Upgrade service hot water system in Office and Retail with improved system efficiency	0 - 5%	< 1.5 yrs

¹The percent savings range reflects the expected incremental savings associated with the specific EEM assuming all other recommended EEMs have already been implemented. This assumption is made to avoid double counting of savings. The estimated savings reflect site energy savings and are based on the actual building operating conditions that the user entered.



COMMERCIAL BUILDING ENERGY ASSET SCORE

STRUCTURE AND SYSTEMS

6

Building ID #: XXXXX

Gross Floor Area: 140,000 ft²

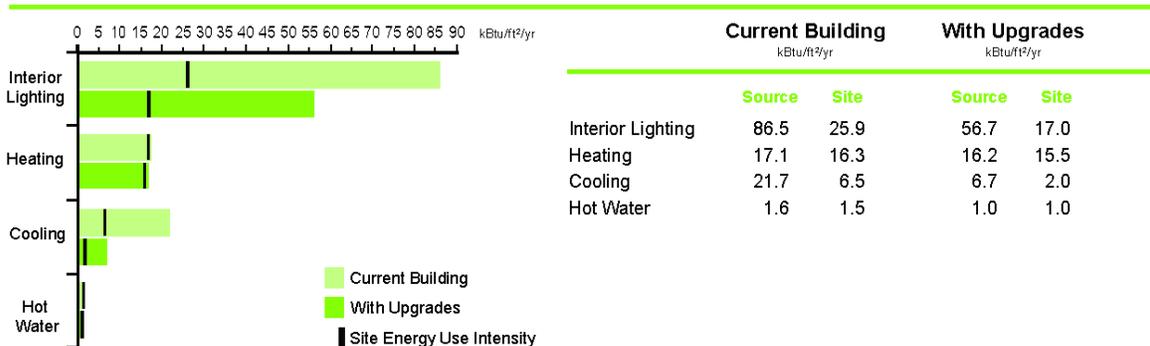
ABOUT THE BUILDING ENVELOPE

	Current Building	With Upgrades	Reference Range	Ranking ²	Upgrade Opportunity Identified ³
Roof U-Value, Non-Attic (Btu/ft ² h °F)	0.056	0.033	0.027 - 0.065	Good	✓
Floor U-Value, Mass (Btu/ft ² h °F)	0.052	—	0.033 - 0.087	Good	
Walls U-Value, Framed (Btu/ft ² h °F)	0.077*	—	0.064 - 0.113	Good	
Windows U-Value (Btu/ft ² h °F)	0.68	0.30	0.35 - 0.67	Fair	✓
Walls + Windows U-Value (Btu/ft ² h °F)	0.38	0.19	0.13 - 0.30	Fair	
Window Solar Heat Gain Coefficient	0.60	—	0.40 - 0.49	Fair	

ABOUT THE BUILDING SYSTEMS

	Current Building	With Upgrades	Reference Range	Ranking	Upgrade Opportunity Identified
Interior Lighting ⁴ (kBtu/ft ²)	50.40	30.00	21.99 - 38.74	Fair	✓
Heating ⁵	0.32	—	0.11 - 0.18	Superior	
Cooling ⁵	0.50*	1.10	0.46 - 1.32	Good	✓
Overall HVAC Systems ⁵	0.46	0.80	0.31 - 0.97	Good	
Hot Water ⁵	0.65	0.71	0.70 - 0.76	Fair	✓

SOURCE ENERGY USE INTENSITY BY END USE



¹ Range defined by ASHRAE 90.1 prototype building compliant with ANSI/ASHRAE/IESNA Standard 90.1. For the building envelope 90.1-2004 and 90.1-2013 define Fair and Superior performance thresholds, respectively. For the building systems the thresholds are defined by 90.1-2004 and 90.1-2010, respectively.

² Fair: less efficient than the reference value range.
Good: within the reference value range.
Superior: more efficient than the reference value range.

³ Energy Efficiency Measure (EEM) identified on the Opportunities page.

⁴ Source energy use.

⁵ Ratio showing the level of service (heating, cooling, etc.) supplied by 1 unit of source energy. A higher ratio indicates a more efficient system.

^{*} Value not directly entered by user. Value estimated from building properties entered by the user.



COMMERCIAL BUILDING ENERGY ASSET SCORE

BUILDING ASSETS

7

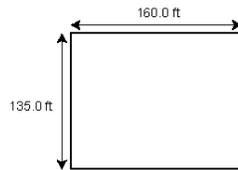
Building ID #: XXXXX

Gross Floor Area: 140,000 ft²

BUILDING SYSTEM CHARACTERISTICS SUMMARY

Geometry

Above Ground: 2 floor
 Below Ground: 0 floor
 Floor-to-Floor Height
 • Floor 1: 14 ft
 • Floor 2: 10 ft
 Drop Ceiling Installed: No
 Floor-to-Ceiling Height: 9.0 ft
 Orientation: 0.0° from North



Current Building

Roof

Roof Type: Built-up/EPDM w/metal deck
 Roof U-Value: U-0.056

Wall

Exterior Wall Type: Mass Wall-8" HW Concrete
 Wall U-Value: U-0.077*

Floor

Ground Coupling: Slab
 Carpet Installed: No

Current Building

Windows

Window Frame Type: Metal
 Glass Type: Single pane
 Gas Fill Type: None
 Operable Windows: No
 Window Layout: Discrete
 Window to Wall Ratio: 0.4
 Window U-Value: U-0.68
 Window SHGC: 0.8
 Window VT: 0.7*

Shading

Exterior Shading Type: External overhang
 Height Above Window: 0 ft
 Projection: 2 ft

Skylight

Skylights Installed: No

Indoor Lighting

Lighting Type: Incandescent
 Mounting Type: Recessed
 Percent of Total Floor Area Served: 100%
 Occupancy Controls: Yes
 Daylighting Controls: No
 EMCS/Timer: No
 Lighting Power Density: 2 W/ft²*

*Value not directly entered by user. Value estimated from building properties entered by the user.



COMMERCIAL BUILDING ENERGY ASSET SCORE

BUILDING ASSETS

8

Building ID #: XXXXX

Building Type: Mixed-Use

Gross Floor Area: 140,000 ft²

BUILDING SYSTEM CHARACTERISTICS SUMMARY

Current Building

Cooling

Cooling Type: Packaged single zone DX
Year of Manufacture: 2005
Efficiency (COP): 2.54*

Heating

Heating Type: Boiler
Year of Manufacture: 2005
Pieces of Equipment: 1
Efficiency: 82%
Fuel Type: Gas

Ventilation

Fan Efficiency: 80%

Service Hot Water

Fuel Type: Gas
Heat Pump Installed: No
Distribution Type: Distributed
Water Heater Efficiency: 80%
Tank Volume: 80 Gallon*
Tank Insulation Thickness: 2 in.*

Facility Operation

The information in this section does not affect the current energy asset score. It is only used to identify upgrade opportunities. If the fields are left blank, standard schedules and operating conditions are used to identify upgrade opportunities.

Miscellaneous Electric Load: 4W/ft²
Miscellaneous Gas Load: 0 kBtu/ft²
Number of Days Open per Week: 5
Opening Time - Closing Time: 8AM – 7PM
Total Occupants: 450
Setpoint, Heating: 76°F
Setpoint, Cooling: 72°F

*Value not directly entered by user. Value estimated from building properties entered by the user.



Appendix G

Energy Costs Used in the Energy Asset Scoring Tool

Appendix G

Energy Costs Used in the Energy Asset Scoring Tool

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
1A	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	12-21	\$0.239
				Mid-Peak	9-11, 22-24	\$0.076
				Off-Peak	1-8	\$0.071
		Weekends/Holidays	Off-Peak	1-24	\$0.071	
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.080
				Mid-Peak	8-11,22-23	\$0.068
	Off-Peak			24-7	\$0.063	
	Weekends/Holidays	Off-Peak	1-24	\$0.063		
	Gas (\$/therm)	All Months	All	All	1-24	\$0.85
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.26
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.11	
2A	Electricity (\$/kWh)	Summer (June-September)	Weekdays	Peak	14-21	\$0.210
				Mid-Peak	22-1, 11-13	\$0.071
				Off-Peak	2-10	\$0.068
		Weekends/Holidays	Off-Peak	1-24	\$0.068	
		Non-Summer (October-May)	Weekdays	Peak	12-21	\$0.080
				Mid-Peak	8-11,22-23	\$0.072
	Off-Peak			24-7	\$0.066	
	Weekends/Holidays	Off-Peak	1-24	\$0.065		
	Gas (\$/therm)	All Months	All	All	1-24	\$0.83
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.96

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)	
2B	Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
				Peak	9-21	\$0.207	
	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Mid-Peak	NA	NA	
				Off-Peak	22-8	\$0.062	
				Weekends/Holidays	Off-Peak	1-24	\$0.062
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.075	
				Mid-Peak	8-11,22-23	\$0.069	
				Off-Peak	24-7	\$0.066	
	Weekends/Holidays	Off-Peak	1-24	\$0.066			
	Gas (\$/therm)	All Months	All	All	1-24	\$0.82	
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.77	
	3A	Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10
					Peak	12-19	\$0.292
		Electricity (\$/kWh)	Summer (June-August)	Weekdays	Mid-Peak	8-11, 20-23	\$0.075
Off-Peak					24-7	\$0.069	
Weekends/Holidays					Off-Peak	1-24	\$0.069
Non-Summer (September-May)			Weekdays	Peak	12-21	\$0.075	
				Mid-Peak	8-11,22-23	\$0.068	
				Off-Peak	24-7	\$0.065	
Weekends/Holidays		Off-Peak	1-24	\$0.064			
Gas (\$/therm)		All Months	All	All	1-24	\$0.85	
Hot Water (\$/MMBtu)		All Months	All	All	1-24	\$12.22	
Chilled Water (\$/ton-hr)		All Months	All	All	1-24	\$0.11	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
3B (LA)	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	13-19	\$0.301
				Mid-Peak	9-12, 20-23	\$0.079
				Off-Peak	24-8	\$0.049
		Weekends/Holidays	Off-Peak	1-24	\$0.049	
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.097
				Mid-Peak	8-11,22-23	\$0.086
	Off-Peak			24-7	\$0.058	
	Weekends/Holidays	Off-Peak	1-24	\$0.058		
	Gas (\$/therm)	All Months	All	All	1-24	\$0.82
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.77
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
3B	Electricity (\$/kWh)	Summer (June-September)	Weekdays	Peak	14-20	\$0.30
				Mid-Peak	9-13, 21-22	\$0.070
				Off-Peak	23-8	\$0.059
		Weekends/Holidays	Off-Peak	1-24	\$0.059	
		Non-Summer (October-May)	Weekdays	Peak	12-21	\$0.075
				Mid-Peak	8-11,22-23	\$0.069
	Off-Peak			24-7	\$0.065	
	Weekends/Holidays	Off-Peak	1-24	\$0.065		
	Gas (\$/therm)	All Months	All	All	1-24	\$0.85
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.16
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
3C	Electricity (\$/kWh)	Summer (July-September)	Weekdays	Peak	NA	NA
				Mid-Peak	8-11, 17-18	\$0.128
				Off-Peak	19-7, 12-16	\$0.093
			Weekends/Holidays	Off-Peak	1-24	\$0.093
		Non-Summer (October-May)	Weekdays	Peak	12-21	\$0.088
				Mid-Peak	8-11,22-23	\$0.082
				Off-Peak	24-7	\$0.061
			Weekends/Holidays	Off-Peak	1-24	\$0.061
	Gas (\$/therm)	All Months	All	All	1-24	\$0.85
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.16
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
4A	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	12-20	\$0.286
				Mid-Peak	8-11, 21-23	\$0.085
				Off-Peak	24-7	\$0.070
			Weekends/Holidays	Off-Peak	1-24	\$0.070
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.078
				Mid-Peak	8-11,22-23	\$0.076
				Off-Peak	24-7	\$0.066
			Weekends/Holidays	Off-Peak	1-24	\$0.065
	Gas (\$/therm)	All Months	All	All	1-24	\$0.86
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.36
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.11	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
4B	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	11-20	\$0.255
				Mid-Peak	8-10, 21-22	\$0.072
			Off-Peak	23-7	\$0.071	
			Weekends/Holidays	Off-Peak	1-24	\$0.071
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.075
				Mid-Peak	8-11,22-23	\$0.069
			Off-Peak	24-7	\$0.065	
			Weekends/Holidays	Off-Peak	1-24	\$0.064
	Gas (\$/therm)	All Months	All	All	1-24	\$0.80
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.42
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
4C	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	10-18	\$0.189
				Mid-Peak	7-9, 19-23	\$0.080
			Off-Peak	24-6	\$0.054	
			Weekends/Holidays	Off-Peak	1-24	\$0.054
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.083
				Mid-Peak	8-11,22-23	\$0.084
			Off-Peak	24-7	\$0.059	
			Weekends/Holidays	Off-Peak	1-24	\$0.059
	Gas (\$/therm)	All Months	All	All	1-24	\$0.83
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.87
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
5A	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	13-21	\$0.258
				Mid-Peak	10-12, 22-24	\$0.088
			Off-Peak	1-9	\$0.064	
			Weekends/Holidays	Off-Peak	1-24	\$0.064
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.093
				Mid-Peak	8-11,22-23	\$0.080
			Off-Peak	24-7	\$0.066	
			Weekends/Holidays	Off-Peak	1-24	\$0.064
	Gas (\$/therm)	All Months	All	All	1-24	\$0.85
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.18
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
5B	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	11-20	\$0.225
				Mid-Peak	8-10, 21-22	\$0.068
			Off-Peak	23-7	\$0.064	
			Weekends/Holidays	Off-Peak	1-24	\$0.064
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.076
				Mid-Peak	8-11,22-23	\$0.073
			Off-Peak	24-7	\$0.065	
			Weekends/Holidays	Off-Peak	1-24	\$0.063
	Gas (\$/therm)	All Months	All	All	1-24	\$0.78
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.16
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
6A	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	12-20	\$0.278
				Mid-Peak	9-11, 21-24	\$0.081
			Off-Peak	1-8	\$0.065	
			Weekends/Holidays	Off-Peak	1-24	\$0.065
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.086
				Mid-Peak	8-11,22-23	\$0.078
			Off-Peak	24-7	\$0.065	
			Weekends/Holidays	Off-Peak	1-24	\$0.065
	Gas (\$/therm)	All Months	All	All	1-24	\$0.84
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.98
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
6B	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	12-21	\$0.190
				Mid-Peak	8-11, 22-23	\$0.066
			Off-Peak	24-7	\$0.064	
			Weekends/Holidays	Off-Peak	1-24	\$0.064
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.078
				Mid-Peak	8-11,22-23	\$0.081
			Off-Peak	24-7	\$0.067	
			Weekends/Holidays	Off-Peak	1-24	\$0.067
	Gas (\$/therm)	All Months	All	All	1-24	\$0.78
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.15
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	

Climate Zone	Fuel	Seasons	Day Types	Time Periods	Hours in TOU Period (1-24)	Actual Energy Cost (\$/Unit)
7	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	10-21	\$0.208
				Mid-Peak	7-9, 22-23	\$0.065
				Off-Peak	24-6	\$0.052
			Weekends/Holidays	Off-Peak	1-24	\$0.052
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.090
				Mid-Peak	8-11,22-23	\$0.085
				Off-Peak	24-7	\$0.064
			Weekends/Holidays	Off-Peak	1-24	\$0.063
	Gas (\$/therm)	All Months	All	All	1-24	\$0.84
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$11.98
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	
8	Electricity (\$/kWh)	Summer (June-August)	Weekdays	Peak	9-23	\$0.065
				Mid-Peak	NA	NA
				Off-Peak	24-8	\$0.054
			Weekends/Holidays	Off-Peak	1-24	\$0.054
		Non-Summer (September-May)	Weekdays	Peak	12-21	\$0.089
				Mid-Peak	8-11,22-23	\$0.088
				Off-Peak	24-7	\$0.059
			Weekends/Holidays	Off-Peak	1-24	\$0.059
	Gas (\$/therm)	All Months	All	All	1-24	\$0.85
	Hot Water (\$/MMBtu)	All Months	All	All	1-24	\$12.24
Chilled Water (\$/ton-hr)	All Months	All	All	1-24	\$0.10	

Notes:

1. The energy costs are based on COMNET Table 18 through Table 33. The present value of energy costs were converted to annual energy costs assuming 3% discount rate and 15 years of life time.
2. The energy costs of non-summer months are the averages of the fall, winter, and spring months in COMNET Table 18 through Table 33.
3. The costs of hot water are based on the costs of steam in COMNET Table 18 through Table 33.

Appendix H

Asset Score Upgrade Recommendations

Appendix H

Asset Score Upgrade Recommendations

The following recommendations are included in the Asset Scoring Tool. More building upgrade options will be added to the tool in the future.

ENVELOPE

- Add Roof Insulation
- Add Wall Insulation
- Add Floor Insulation
- Upgrade Single Pane Windows to Double Pane Windows
- Upgrade to High Performance Double Pane Windows
- Improve Performance of Existing Windows

LIGHTING SYSTEMS

- Upgrade to Compact Fluorescent Lighting
- Upgrade to T5 Fluorescent Lighting
- Upgrade to High Output T5 Fluorescent Lighting
- Upgrade to T8 Fluorescent Lighting
- Upgrade to High Efficacy T8 Fluorescent Lighting
- Upgrade to High-Pressure Sodium Lighting
- Upgrade to Metal Halide Lighting
- Upgrade to LED Lighting

HVAC SYSTEMS

Heating

- Upgrade to High-Efficiency Fossil Fuel Furnace / Boiler
- Upgrade to New Conventional Fossil Fuel Furnace / Boiler
- Upgrade to New Electric Furnace
- Upgrade to High-Efficiency Fossil Fuel Infrared Heating System
- Upgrade to New Fossil Fuel Infrared Heating System*
- Upgrade to New Electric Infrared Heating System
- Upgrade to High-Efficiency Dual Fuel Heat Pump

- Upgrade to New Dual Fuel Heat Pump
- Upgrade to High-Efficiency Heat Pump
- Upgrade to New Heat Pump*

Cooling

- Upgrade to High-Efficiency Electric Chiller
- Upgrade to New Electric Chiller*
- Upgrade to High-Efficiency Electric DX
- Upgrade to New Electric DX*
- Upgrade to High-Efficiency Terminal Electric DX
- Upgrade to New Terminal Electric DX*

SERVICE HOT WATER SYSTEMS

- Upgrade to High-Efficiency Fossil Fuel Service Hot Water Boiler
- Upgrade to New Fossil Fuel Service Hot Water Boiler*
- Upgrade to High-Efficiency Fossil Fuel Water Heater
- Upgrade to New Fossil Fuel Water Heater
- Upgrade to New Electric Heat Pump Water Heater

** When a “High Efficiency” unit is not specified in an Asset Score Report that unit may not be cost effective. However, it is recommended to consider installing the highest efficiency level when economically feasible.*

The recommendations below are currently not included in the Asset Scoring Tool but in the recommendation guide (http://www1.eere.energy.gov/buildings/commercial/assetscore_tool.html). They will be implemented into the next version of the Asset Scoring Tool.

BUILDING CONTROL SYSTEMS

1. Implement Optimal Start / Stop Strategy for HVAC Equipment
2. Install Occupancy Sensor and Implement Weekend & Holiday Scheduling
3. Implement Setpoint Scheduling / Setback
4. Implement Staged Cooling
5. Implement Supply Air Temperature Reset
6. Upgrade Fan Motors and Install Variable Frequency Drive or Multi-speed Control on Fans
7. Install Dedicated Outdoor Air System

8. Implement Duct Static Pressure Reset in Air Handling Units
9. Add Variable Frequency Drive to Cooling Tower or Condenser Unit Fan
10. Add Air-Side Economizer (Based on Climate Zone)
11. Implement Enthalpy Economizer Mode on Existing AHUs with Economizers (Based on Climate Zone)
12. Control Outside Air Damper
13. Implement Demand Controlled Ventilation
14. Exhaust Air Energy Recovery (All Climate Zones)
15. Recover Heat from Dry Cooler
16. Replace Boilers and Change Heating Plant Pumping System to Variable Flow Primary
17. Control Perimeter System Dispatch, Precool/Preheat Perimeter Zone
18. Implement Chilled Water Temperature Reset
19. Implement Chilled Water Differential Pressure Reset
20. Implement Condenser Outdoor Air Temperature Water Reset Strategy and Optimization
21. Add Variable Frequency Drive to Condenser Pumps
22. Add Variable Frequency Drive to chilled water pumps
23. Upgrade Constant Speed Chiller to Variable Speed Chiller
24. Upgrade Cooling Plant Pumping System to Variable Primary
25. Add Waterside Economizer (Based on Climate Zone)



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