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Prepared for the U.S. Department of Energy
under Contract DE-AC05-76RL01830

Building Energy Asset Score

Program Overview and Technical Protocol (Version 1.2)

N Wang
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V Srivastava
A Makhmalbaf

September 2015

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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 and multi-family residential buildings to help building owners and managers assess a building's energy-related systems independent of operations. The goal of the score is to encourage cost-effective investment in energy efficiency improvements for these types of buildings. The system, known as the Building Energy Asset Score, will allow building owners and managers to compare their building infrastructure against peers and track energy efficiency impacts of 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.

Prior to developing the Asset Score, DOE performed a market study[1] 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. In 2013, DOE continued to assess the Asset Score through additional pilot testing and a variety of technical evaluations and performance analyses. Those efforts improved the tool, training materials, and other aspects of the program. Over 200 buildings were scored and analyzed, as of the end of the 2013 pilot. Results from these efforts were released through a public webinar.[2]

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. This report will be updated periodically to reflect changes to the scoring methodology, the Asset Scoring Tool, and other aspects of the program. The alternative methods that were considered prior to developing the current approach are described in the Program Overview and Technical Protocol Version 1.0[3] and Version 1.1.[4]

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).

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[1] McCabe MJ and N Wang. 2012. *Commercial Building Energy Asset Rating Program – Market Research*. PNNL-12310, Pacific Northwest National Laboratory, Richland, WA.
[2] http://energy.gov/eere/buildings/commercial-building-energy-asset-score-2013-pilot
[3] Wang N and WJ Gorrissen. 2012. *Commercial Building Energy Asset Score System: Program Overview and Technical Protocol (Version 1.0)*. PNNL-22045, Pacific Northwest National Laboratory, Richland, WA.
[4] Wang N, S Goel, and A Makhmalbaf. 2013. *Commercial Building Energy Asset Score System: Program Overview and Technical Protocol (Version 1.1)*. PNNL-22045, Pacific Northwest National Laboratory, Richland, WA.

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 10-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 and multi-family residential building stock and allows for energy efficiency improvements to all buildings from inefficient to high-performance. 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 most 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 and multi-family residential 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.

To generate an Asset Score, the user must provide a minimum number of necessary data inputs. Users are encouraged to provide additional building characteristics if available. To minimize data requirements, the Asset Scoring Tool applies inferred values to any unrequired building fields not specified by the user. Along with the building's current Asset Score, the Asset Scoring Tool identifies areas for building improvement and estimates their potential for improving the Asset Score. Users who do not have access to the minimum required data can use a Preview version of the tool that relies on a much greater number of defaults to generate a model. This version provides a limited assessment of the building but does not provide an 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; rather, it is meant 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 based on implementation of identified upgrades.
- 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 5.3 of this report. A related guide on what to consider when implementing select classes of building upgrades is also provided to tool users (https://buildingenergyscore.energy.gov/assets/energy_asset_score_recommendations_guide.pdf).
- Building assets. The report provides a 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 pilot, in 2012, included buildings in the office, education, retail, and unrefrigerated warehouse categories.
- The second pilot, in 2013, included the assisted living, city hall, community center, courthouse, library, medical office, multi-family housing (4 stories and more), post office, police station, religious building, and senior center categories, as well as mixed-use buildings that incorporate the abovementioned use types. Multi-family housing (less than 4 stories) and parking garages were added after the second pilot.
- The initial rollout (public launch expected in 2015) will include all of these use types.
- 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 future development.

This protocol document focuses on the building types to be included in the public launch, 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.

Acknowledgments

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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
GFA	gross floor area
HVAC	heating, ventilating, and air conditioning
IESNA	Illuminating Engineering Society of North America
kBtu	thousand British thermal units
LCC	life-cycle cost
LHS	Latin hypercube sampling
LEED	Leadership in Energy and Environmental Design
MBtu	million British thermal units
PNNL	Pacific Northwest National Laboratory
SPR	system performance ratio
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.

prototype buildings – A set of EnergyPlus models developed by Pacific Northwest National Laboratory as part of DOE's support of ANSI/ASHRAE/IES Standard 90.1. The prototype models include 16 commercial building types in 17 climate locations (across all 8 U.S. climate zones) for recent editions of Standard 90.1. The Asset Score uses the 2004 version of the prototype buildings as seed models for various analyses, including sensitivity analysis, scoring scale development, climate normalization, and building systems evaluations.

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.

climate normalization – The practice of removing the impact of weather variables from building energy simulation results to facilitate comparison between different regions.

Contents

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Tables

1.0 Introduction

The U.S. Department of Energy (DOE) is developing a national Building Energy Asset Score and an Asset Scoring Tool to evaluate the physical characteristics and as-built energy efficiency of commercial and multi-family residential buildings and to identify potential energy efficiency improvements. The goal of the Asset Score and Asset Scoring Tool is to encourage cost-effective investment in energy efficiency and reduce energy use within these building sectors. 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).

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

- 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
- scoring scale development
- Asset Scoring Tool development
- 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 K provide additional details on the following topics:
  - Appendix A: building type classifications

– Appendix B: 2004 prototype buildings
– Appendix C: climate normalization coefficients
– Appendix D: scoring scales for building types that have been incorporated in the Asset Scoring Tool
– Appendix E: a list of building data input of the Asset Scoring Tool
– Appendix F: a sample Asset Score Report
– Appendix G: energy costs used in the Asset Scoring Tool
– Appendix H: a list of building upgrade measures
– Appendix I: a list of automated data validation in the Asset Scoring Tool
– Appendix J: operational assumptions and equipment sizing
– Appendix K: performance benchmarks for system evaluation
– Appendix L: Asset Score sensitivity analysis results
– Appendix M: model documentation

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.

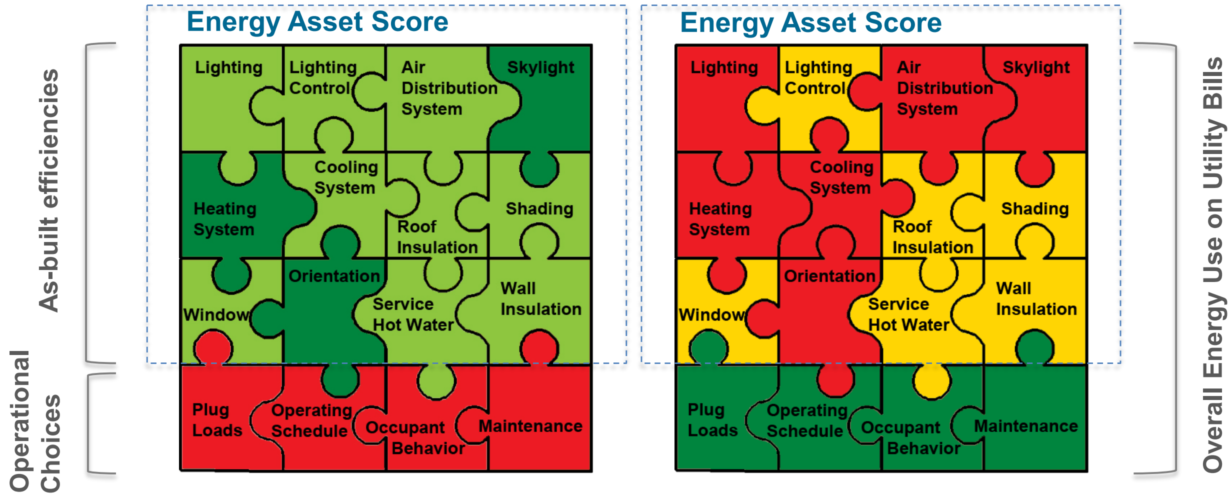
An Asset Score can help commercial and multi-family residential building stakeholders decipher the extent to which their usage is being driven by operational choices or by the actual energy systems of a building. By applying consistent operational assumptions, an Asset Score allows evaluation of the 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 efficiently 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, ventilating, 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.

Regional energy asset rating initiatives, such as California Assembly Bill No. 758[1] 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
High Efficiency Systems
Poor Operation
Poor Maintenance
High plug loads from occupants

Building B
Low Efficiency Systems
Good Operation
Good Maintenance
Normal plug loads from occupants

Low Efficiency Or More Energy Use — High Efficiency or Less Energy Use

	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 some of these control systems, assumptions are made based on the average savings. For example, ASHRAE 90.1-2010 Appendix G (Table G3.2) allows by default a 10% reduction in lighting power density for areas that incorporate occupancy sensor control of lighting. Some control systems are explicitly modeled to quantify savings. For instance, daylighting controls are modeled in EnergyPlus based on user input of spaces with these controls. 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 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 identified 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.

In the example 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.

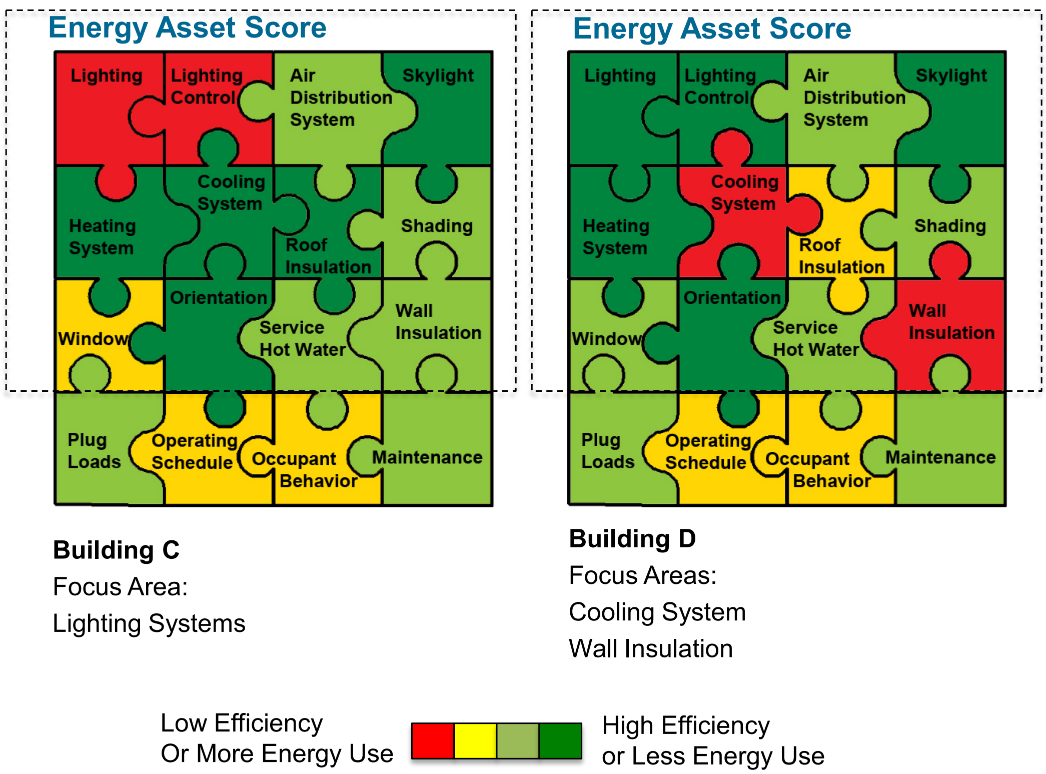


Figure 2.2. Example building scenarios highlighting the importance of system evaluations.

DOE has designed the building Asset Score such that it can be applied broadly to both new and existing commercial and multi-family residential 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, which 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.

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 efficiency over time.

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 and multi-family 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 energy efficiency measures (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 part of the building's energy assets. 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, and 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, energy service providers, 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 and multi-family residential 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 developed in multiple phases, each focusing on different groups of building types. The initial launch in early 2015 included the following building use types:

- **Assisted Living Facility:** Individual buildings and campuses of buildings that house and provide care and assistance for elderly residents, including skilled nursing and other residential care buildings.
- **City Hall**: Municipal buildings used for general, professional, or administrative offices.
- **Community Center**: Buildings used for social or recreational activities, whether in private or non-private meeting halls.
- **Courthouse:** Buildings used for federal, state, or local courts, and associated administrative office space.
- **Education**: Buildings used for academic or technical classroom instruction, such as elementary, middle, or high schools, and classroom buildings on college or university campuses. Buildings on education campuses for which the main use is not classroom are included in the category relating to their use. For example, administration buildings are part of "Office."
- **Library**: Buildings that contain collections of books, periodicals, and sometimes films and recorded music for people to read, borrow, or refer to, including public libraries, college/university libraries, and other libraries.
- **Lodging**: Buildings used to offer multiple accommodations for short-term or long-term residents, including dormitory, fraternity/sorority housing, hotel, motel, inn, and other lodging.
- **Medical Office**: Medical offices that do not use any type of diagnostic medical equipment. Otherwise they are categorized as outpatient health care buildings, which are not currently included as an Asset Score option.
- **Multi-family (low-rise)**: Residential buildings of three stories or fewer above grade.
- **Multi-family (high-rise)**: Residential buildings greater than three stories above grade.
- **Office**: Buildings used for general office space, professional office, or administrative offices, including administrative/professional, bank/other financial, government, and other office. (Note that Medical Office is defined as a different use type than Office.)
- **Parking Garage**: A parking structure that is completely enclosed on all four sides and has a roof. For example, this includes an underground parking structure or a fully enclosed structure on the first few stories of another building.
- **Police Station:** Buildings used for public order and safety. These can include offices, meeting rooms, and holding cells, and usually operate 24 hours a day, 7 days a week.
- **Post Office**: Buildings used for the receiving, sorting, and delivering of mail, and the sale of stamps and other postal materials.
- **Religious Building:** Buildings in which people gather for religious activities, such as chapels, churches, mosques, synagogues, and temples.
- **Retail:** Buildings used for the sale and display of goods other than food, including strip shopping malls, enclosed malls, vehicle dealership/showrooms, retail stores, and other retail establishments.

- **Senior Center**: Buildings used for social or recreational activities, whether in private or non-private meeting halls.
- **Warehouse (non-refrigerated)**: Buildings used to store goods, manufactured products, merchandise, raw materials, or personal belongings (such as self-storage), including non-refrigerated warehouses, distribution/shipping centers, and self-storage.
- **Mixed-use** of any the above building types.

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 future development.

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 EEMs would still apply.

2.4 User Levels

The Asset Scoring Tool generates different types of information depending on the amount of data provided by the user.

- To generate a full Asset Score Report, users must provide data on all required building characteristics. As long as this minimum dataset is provided, the Asset Scoring Tool generates an Asset Score based on modeled building efficiency, identifies candidate improvement opportunities, and estimates the energy impact of those improvements.
- Beyond the required minimum dataset, users may enter additional pertinent building characteristics where applicable and known. Real estate transactions would likely require at least some inputs beyond the minimum required dataset, along with validation by a qualified professional.
- A *Preview* option is available as a starting point for users with buildings that have a simple geometry and simple HVAC system. This option applies default values for all unspecified building characteristics. With this option, the Asset Scoring Tool provides limited feedback on building efficiency and improvement potential, but does not generate a numeric score, EEMs, or other information found in the full Asset Score Report.

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.

For a building's Asset Score Report to be considered "valid," users may want to have data inputs validated by an objective and qualified professional. DOE expects to develop validation requirements or protocols in the future.

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 energy performance tools for commercial and multi-family residential buildings, 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, are discussed in the previous versions of the protocol (Wang and Gorrissen 2012; Wang et al. 2013).

The selection of scoring scales is discussed in Section 3.2. After examining numeric scales reflecting physical units (e.g., kBtu/ft^2), 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 10-point scale with half-point intervals. The pros and cons of other considered scales can be reviewed in the previous versions of the protocol (Wang and Gorrissen 2012; Wang et al. 2013). The score calculation method for single-use and mixed-use building types is also discussed in this section.

Climate 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 3.2.5.

A series of rating scales was developed for each building type. The methodology is discussed in Section 3.2.6. 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. Source EUI is used 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. The Asset Score uses the national average conversion factor for each fuel type, as also applied by EPA in the Portfolio Manager. 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 previous versions of the protocol (Wang and Gorrissen 2012; Wang et al. 2013) can be referenced for additional discussions about the national, state, and regional energy conversion factors.

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 2013). 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 2013).

Source	Ratio
Electricity (grid purchase)	3.14
Electricity (onsite solar or wind installation)	1.00
Natural gas	1.05
Fuel oil (1, 2, 4, 5, 6, diesel, kerosene)	1.01
Propane and liquid propane	1.01
Steam[a]	1.20
Hot water	1.20
Chilled water[b]	1.00
Wood	1.00
Coal/coke	1.00
Other (e.g., waste biomass)	1.00

(a) The weighted average of two source-site factors: 1.35 for conventional steam generation and 1.01 for steam produced by CHP (combined heat and power) (EPA 2013).
(b) The weighted average of two source-site factors: 0.98 for electric chiller and 1.11 for steam-driven chiller (EPA 2013).

When renewable energy is produced at a building through solar photovoltaic panels or wind turbines, DOE is currently undecided on 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 calculates the source energy use; however, it requires more complicated energy simulation. A comparison of these methods is discussed in the Version 1.1 of the protocol (Wang et al. 2013).

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 by end use
- energy cost savings potential
- system-level performance indicators.

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 Range of Energy Cost Savings

The Asset Score uses cost information 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 (LCC) analysis to suggest a package of EEM considerations and associated ranges of energy cost savings (low, medium, and high). The Asset Score uses the COMNET (2010) energy cost data, which are time-of-use (TOU) rate schedules for electricity, gas, steam, and chilled water. These cost data are based on climate zones and consider the cost savings related to high cost times of the day and year.

The cost savings are 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.

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 does not fully explain 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 10-Point Interval Scale

The Asset Score uses a scoring system that does not rely on baseline buildings but instead simply converts modeled source EUI into a score. The score ranges from 1 to 10 with 0.5-point intervals. A higher score corresponds to lower EUI. Different use types have different scales. Each scale is divided into multiple sections. In the low score sections, the EUI range is larger. This means that a building with a lower score (higher EUI) needs to achieve relatively greater EUI reduction to obtain an additional half-point. As a building becomes more efficient, it is usually more difficult and costly to further reduce its energy use; therefore, a smaller incremental EUI reduction can increase the score at the higher end of the scale. The scale development method is discussed in Section 3.2.6.

The Asset Scoring Tool evaluates as-built systems, not operation of the building. Therefore, a building's Asset Score cannot be compared directly to its ENERGY STAR Portfolio Manager score. In some cases, a building's Asset Score and 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), a combined understanding of a building's Asset Score and Portfolio Manager score can provide valuable information and insights to building owners and operators.

3.2.2 Score Calculation

To develop an easy-to-understand and standardized score, DOE is using a predefined scale for each building type, where each point on the 10-point scale corresponds to a source energy use value (expressed as EUI). A building's score is calculated based on the Asset Scoring Tool's estimated energy use for that building 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 running a whole-building energy simulation using the Asset Scoring Tool.

The whole-building energy simulation is performed via the Asset Scoring Tool—a web-based application. The tool chooses the weather station having the most similar climate to the user-entered zip code using a mapping of zip code to weather station developed by Pacific Northwest National Laboratory (PNNL) based on the climate similarity and the Monte Carlo sifting methods (Hathaway et al. 2013; Hathaway et al. [in review]). If no climate-similar station is found, the tool will select the nearest weather station.

The Asset Scoring 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 must submit all required data to receive an Asset Score Report through the online tool. The Asset Scoring Tool reduces modeling time and expertise requirements while supporting the variability and complexity of commercial and multi-family residential buildings. The methodology used in developing the Asset Scoring Tool 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 climate coefficients is discussed in Section 3.2.5.2.

$$
\begin{aligned}
&Adjusted\ EUI_{Weather\ Site\ \mathrm{A}} \\
&\quad = Heating\ Coefficent_{Weather\ Site\ \mathrm{A}} \times\ Heating\ EUI \\
&\quad + Cooling\ Coefficent_{Weather\ Site\ \mathrm{A}} \times\ Cooling\ EUI \\
&\quad + Fan\ Coefficent_{Weather\ Site\ \mathrm{A}} \times\ Fan\ EUI \\
&\quad +\ Other\ EUI\ (not\ weather\ dependent)
\end{aligned}
$$

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 3.2.6.

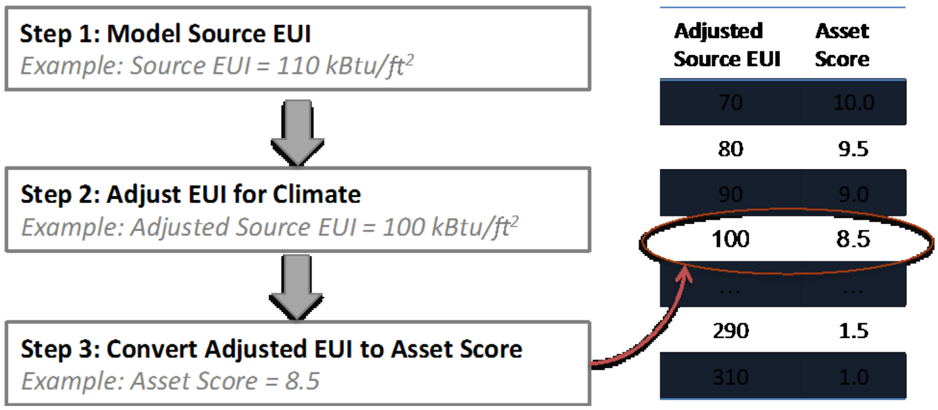


Figure 3.1. Asset Score calculation steps.

3.2.3 Scoring for Non-Conditioned Space and Specific Loads

3.2.3.1 Parking Garage

A parking garage in the Asset Score refers to a parking structure that is completely enclosed on all four sides and has a roof. The enclosed parking garage is considered a use type. Buildings with an attached parking garage (for example, an underground parking structure or a fully enclosed structure on the first few stories of a building) are scored as mixed-use buildings. Open parking garages (two or more sides comprise walls that are at least 50% open to the outside) and parking lots, which only have lighting energy use, are not currently included in Asset Score.

An enclosed parking garage is modeled as a facility with a heating-only system or ventilation-only (no heating and cooling) systems. A mechanical ventilation system is modeled in enclosed vehicle parking garages and portions thereof that do not meet the definition of open parking garages. ASHRAE 62.1-2004 requires an exhaust rate of 0.75 cfm/ft^2 for enclosed parking garages. Carbon monoxide sensing control of exhaust fans ranges from 75% to 90% (ASHRAE 2004).

The Asset Score calculates full airflow energy as follows:

Maximum flow rate = 0.75 cfm/ft^2 * floor area (or zone area)

The fan static pressure is set to 0.5 inches w.c. (i.e., 124.5 Pa). Where a "Carbon Monoxide Controls" input is indicated, fan use is assumed to be at 20% of the full airflow. For heated parking garages, supply fans with gas-fired duct heaters (temperature setpoint 50°F) are modeled.

3.2.3.2 Elevators

Per Americans with Disabilities Act requirements, elevators are required for buildings with an accessible floor above the third floor. Elevator energy consumption in office buildings with central air conditional system is about 5% of building electricity use (Sachs 2005). To ensure a fair comparison between buildings with and without elevators, the Asset Score only takes into account the difference between the standard elevator energy use (assumptions) and modeled elevator energy use of the candidate buildings. If a candidate building has a standard set of elevators, it will have the same score as another building without elevators. If a candidate building has less efficient elevators, the extra energy use (in addition to the standard energy use) will be added to the whole building energy use for scoring, which will result in a lower score. For buildings with more efficient elevators, a higher score results.

Standard elevator power consumption is modeled in accordance to the 2004 prototype buildings:

Power consumption of hydraulic elevators = 14,610 W / Elevator × Number of Elevators

Power consumption of traction elevators = 18,537 W / Elevator × Number of Elevators

To limit the data collection requirement, Asset Score does not consider additional energy-efficiency features of the elevators, such as variable frequency drives, gearless traction, and regenerative drive systems. The typical energy savings associated with these advanced features will be considered during future development by further adjusting the elevator motor power consumption default values.

Elevators are modeled as "exterior equipment," which will not affect HVAC load in the building. It is assumed that the machine room is located outside of the building and not conditioned. Some machine rooms may have a unit heater for freeze protection, but its energy use is ignored in this calculation. Elevator lighting and fan energy use is insignificant compared with the total building lighting and fan energy use; therefore, it is not modeled or included in the Asset Score. Elevator schedule of operation is based on the corresponding building use types.

3.2.4 Scoring for Mixed-Use Buildings

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 3.2 provides an example of an office/retail mixed-use building. Comparing to a weighting factor in proportion to the total energy use, 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. A comparison of these two weighting factors is discussed in Version 1.1 of the protocol (Wang et al. 2013).

Table 3.2. An example of prorated scores for a mixed-use building.

	Example Building		With 20% Energy Reduction in Office Portion		With 20% Energy Reduction in Retail Portion	
Total Floor Area (ft^2)	100,000		100,000		100,000	
Use Type	Office	Retail	Office	Retail	Office	Retail
Floor Area (ft^2)	70,000	30,000	70,000	30,000	70,000	30,000
Source Energy Use (MBtu)[a]	7000	9000	5600	9000	7000	7200
Total Energy Saving (MBtu)	N/A		1400		1800	
Source EUI (kBtu/ft^2)	100	300	80	300	100	240
Asset Score by Use Type	8.5	2.5	9.5	2.5	8.5	4.5
% of Floor Area	70%	30%	70%	30%	70%	30%
Overall Score by Floor Area	**6.5**		**7.0**		**7.0**	
Additional Points After Savings	N/A		***0.5***		***0.5***	

(a) MBtu is million British thermal units.

To ensure a consistent definition of mixed-use buildings, rules are developed and incorporated in the Asset Scoring Tool. These rules (Table 3.3) define the maximum number of use types that can be present in a building as well as the minimum area for each use type. Creating separate blocks for building use types occupying a minimal percentage of the total building gross floor area may have little influence on the overall building energy use and score. Hence, these rules are intended to prevent a user from defining a building using a space-by-space approach, as well as to provide guidance on the level of granularity that is optimal for defining a mixed-use building.

Table 3.3. Mixed use building rules.

Total Building Gross Floor Area (GFA)	Minimum Area for Each Use Type (5% of GFA)	Maximum Number of Use Types
50,000 ft^2 and above	2,500 ft^2 +	5
10,000 – 50,000 ft^2	500 – 2,500 ft^2	4
5,000 – 10,000 ft^2	250 – 500 ft^2	2
Up To 5,000 ft^2	250 ft^2	2

3.2.5 Climate Normalization

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. EPA defines the temporal adjustment (which deals with evaluating building energy use at a specific location over a time period) as weather normalization and the geographic adjustment (which deals with evaluating buildings energy use at various locations) as climate normalization (EPA 2014). These definitions are adopted in this protocol. In some context, “weather” refers local weather characteristics associated with climate normalization. The terms “weather station,” “weather site,” and “weather-sensitive variables” are also used to describe climate normalization.

A series of corresponding coefficients have been developed and applied to the modeled site HVAC EUI values (Makhmalbaf et al. 2013). The method is discussed in this section.

3.2.5.1 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 climate normalization. A prototype building was simulated using all available weather station data files (typical meteorological year 3 [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.

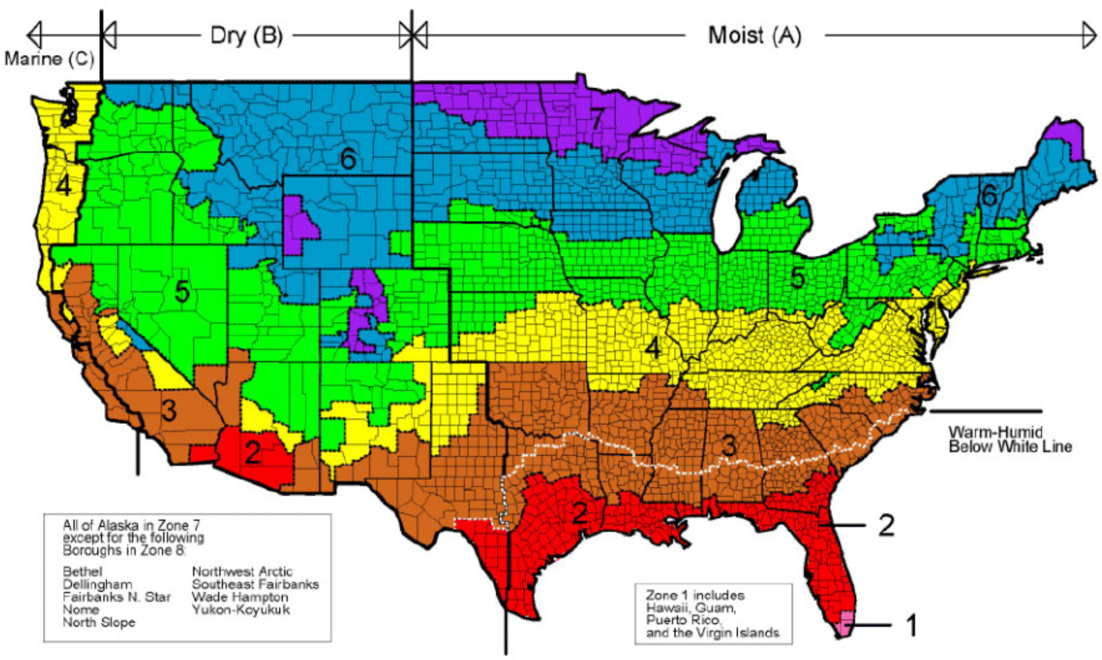


Figure 3.2. U.S. climate zone classification (NREL 2011, p. 7).

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 climate normalization 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 climate normalization 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 adjusted less 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 especially important for buildings in hot or cold climates.

To develop climate normalization coefficients, several building types representing typical commercial and multi-family residential 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 nine 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 climate 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.

3.2.5.2 Development of Climate Coefficients

Climate 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 chosen 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 climate 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 climate 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 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.

$$EUI\ Ratio_{Prototye\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1} = \frac{EUI_{Prototye\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1}}{Average\ EUI_{Prototye\ Building\ 1,\ All\ Weather\ Sites,\ End\ Use\ 1}}$$

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 climate 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.

$$Coefficient_{Prototye\ Building\ 1,\ Weather\ Site\ 1,\ End\ Use\ 1} = \frac{1}{EUI\ Ratio_{Prototye\ Building\ 1,\ All\ Weather\ Sites,\ End\ Use\ 1}}$$

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

Results of EUI ratios calculated from all chosen prototype buildings[1] 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 in some limited weather station locations (for example, within climate zone 8A for heating). These individual models with extremely high heating energy use will need to be further investigated.

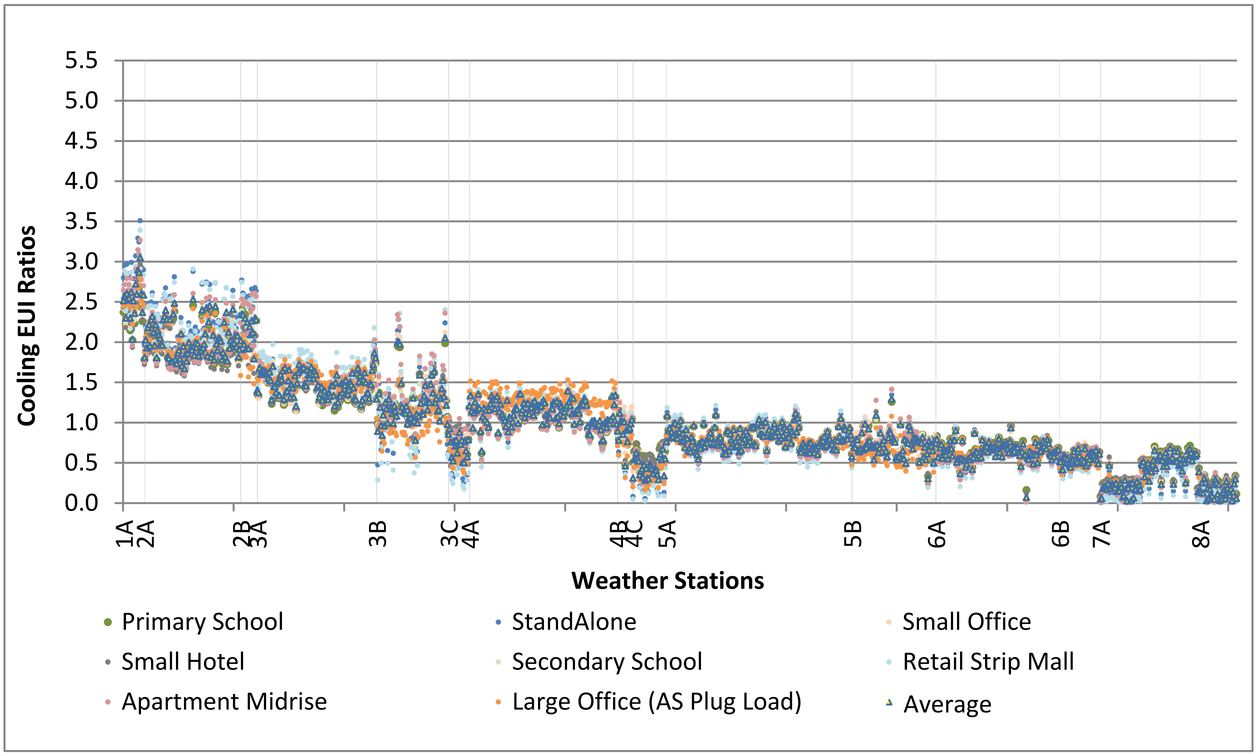


Figure 3.3. Cooling EUI ratios of eight prototype buildings and their average.

[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.

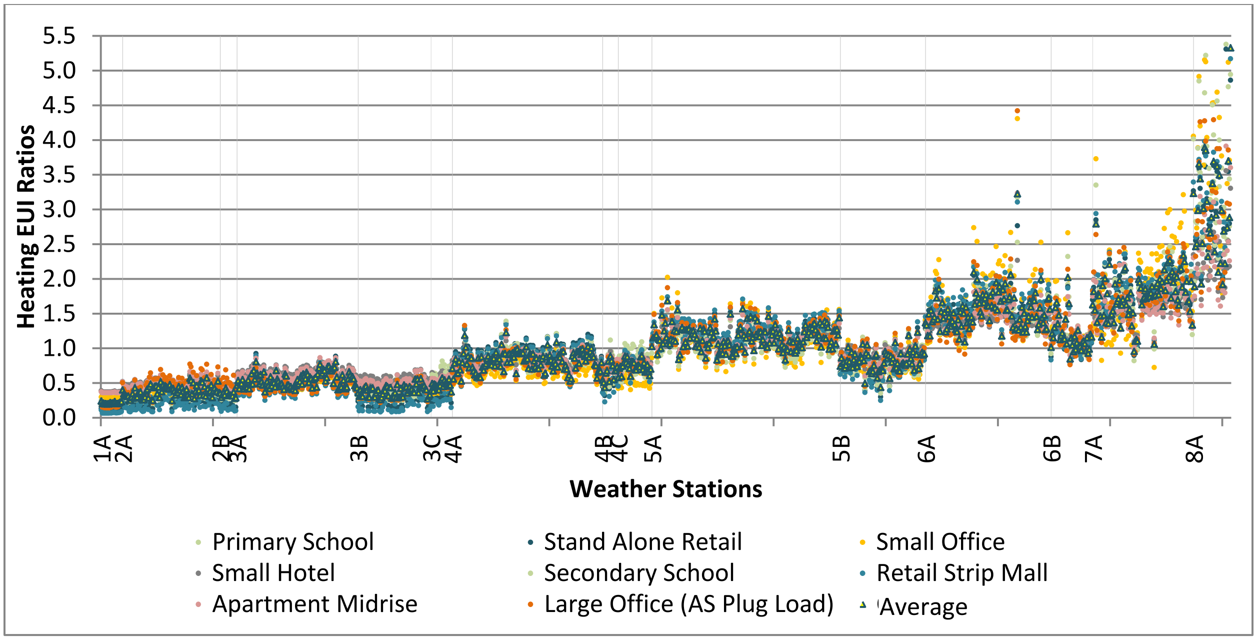


Figure 3.4. Heating EUI ratios of eight prototype buildings and their average.

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 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 climate normalization.

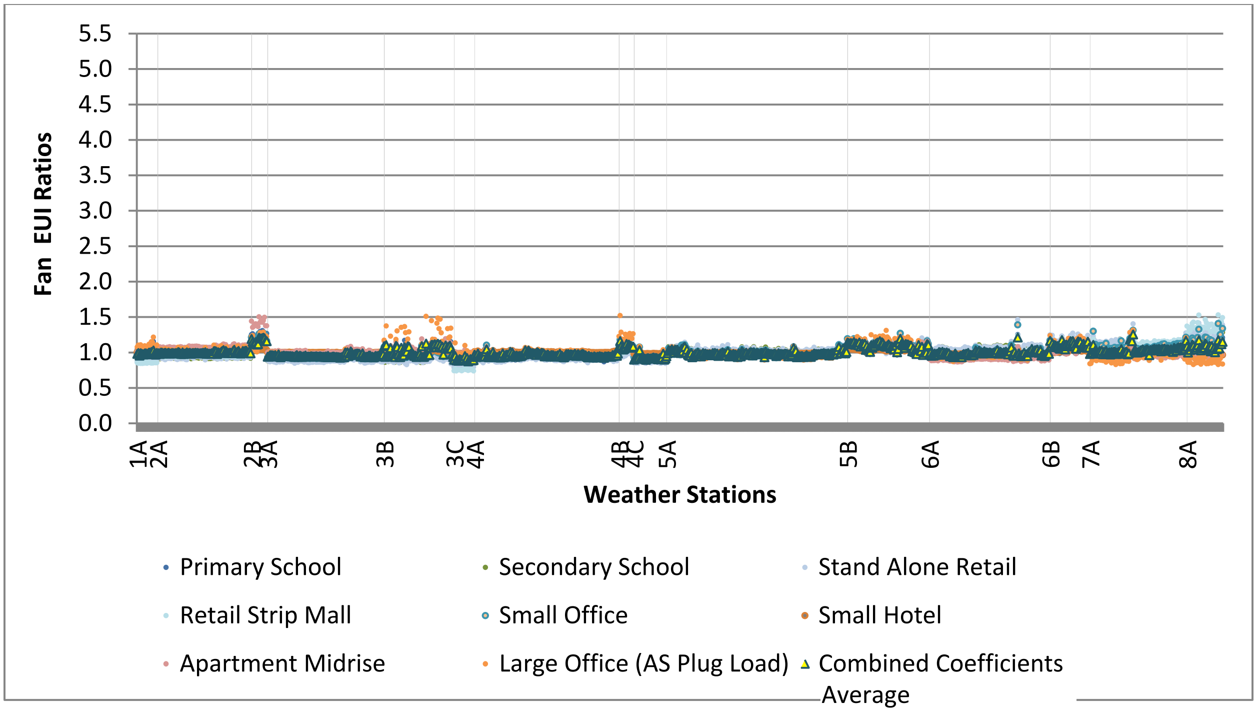


Figure 3.5. Fan EUI ratios of eight prototype buildings and their average.

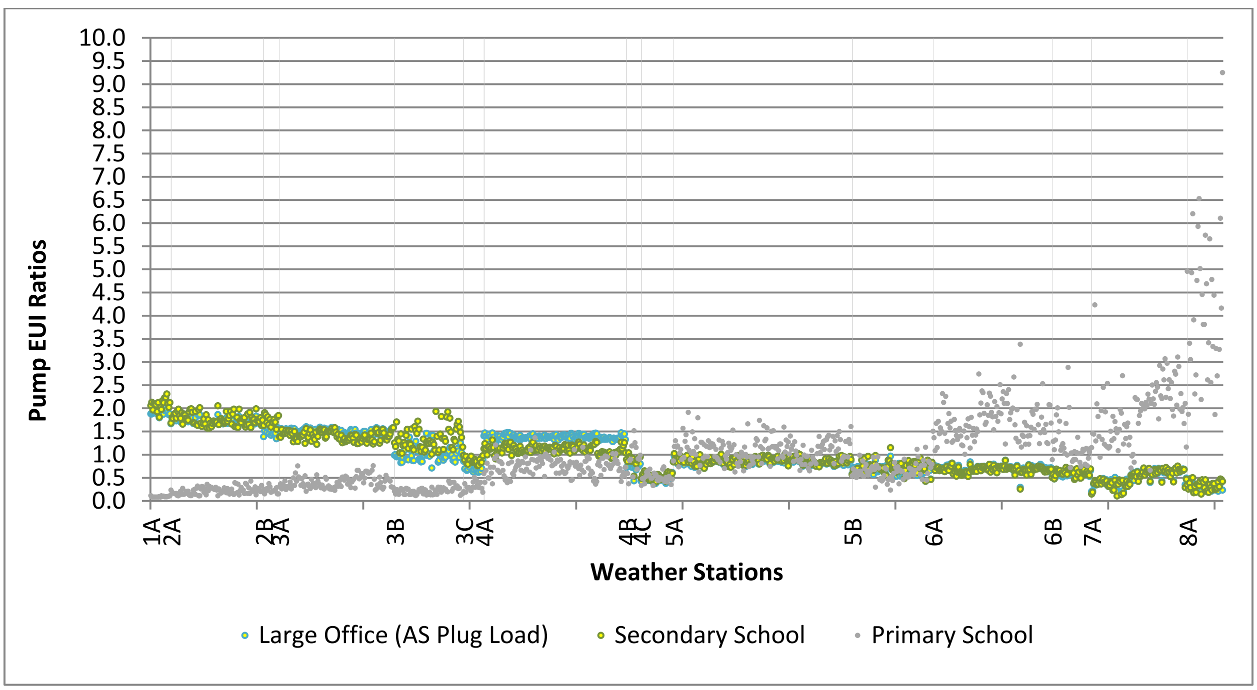


Figure 3.6. Pump EUI ratios of three building types.

Based on results observed, to simplify climate normalization, 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 climate 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.

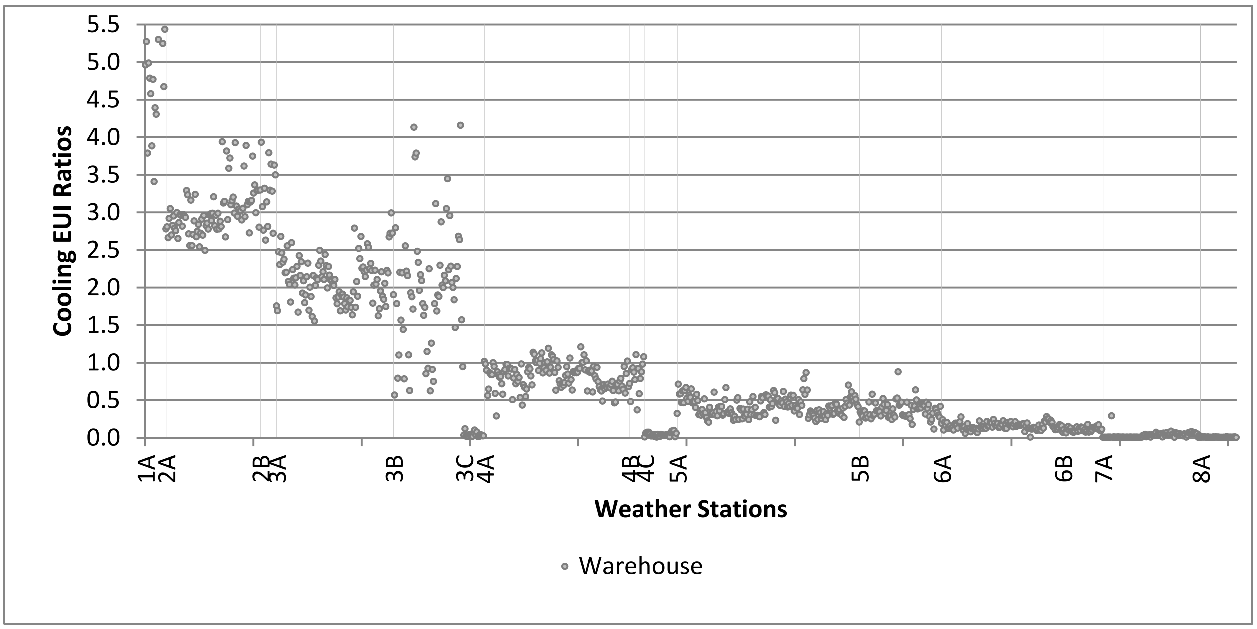


Figure 3.7. Cooling EUI ratios of warehouse (separated because of observed difference in response to weather when compared to other building types).

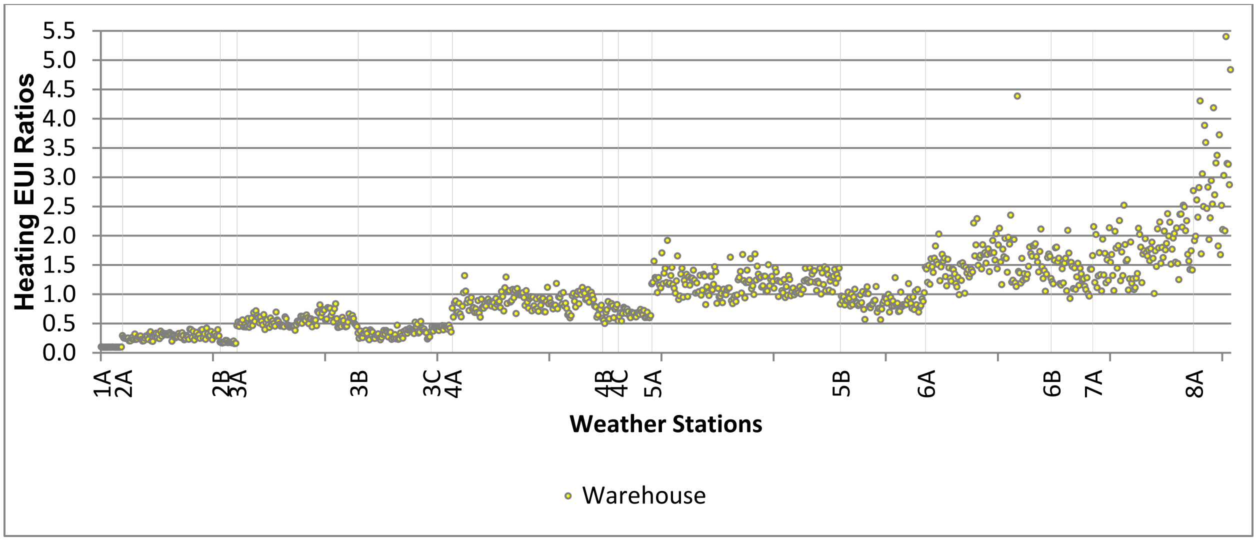


Figure 3.8. Heating EUI ratios of warehouse (separated because of observed difference in response to weather when compared to other building types).

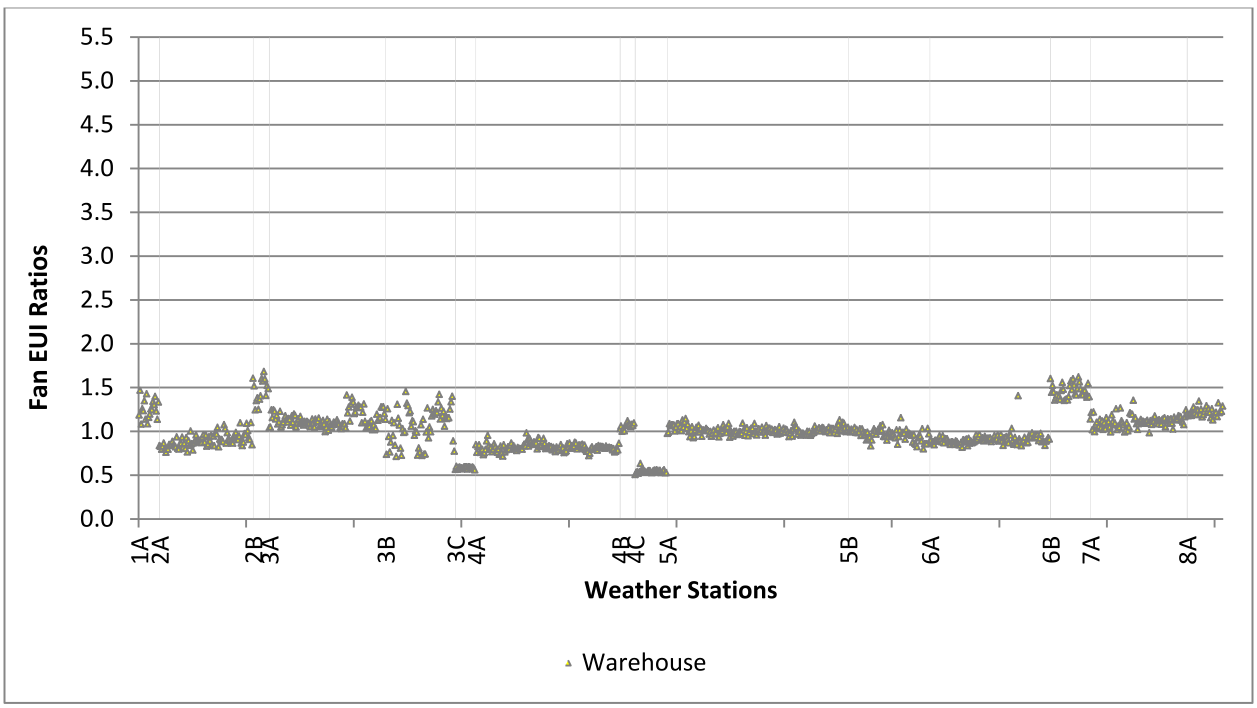


Figure 3.9. Fan EUI ratios of warehouse (separated because of discrepancy in response of fan load to weather when compared to other building types).

The climate coefficients were tested on prototype buildings and a selection of pilot buildings. The test results show that this climate normalization method can effectively reduce EUI variation due to the local climate impact and enable a fair comparison of buildings at different locations. As discussed previously, it is impossible to totally eliminate the climate impact using a predefined set of coefficients developed from the 2004 prototype buildings. The goal is to minimize the climate impact to the fullest extent possible and acceptable. The testing methodologies and results can be found in previous versions of the protocol (Wang and Gorrissen 2012; Wang et al. 2013).

3.2.5.3 Implementation of Climate Coefficients

The climate 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)
$EUI_{heating\_elec}$	×	$Coeff_{heating}$	=	$EUI_{heating\_elec\_adj}$	$EUI_{heating\_gas}$	×	$Coeff_{heating}$	=	$EUI_{heating\_gas\_adj}$
$EUI_{cooling}$	×	$Coeff_{cooling}$	=	$EUI_{cooling\_adj}$					
EUI_{fans}	×	$Coeff_{fans}$	=	EUI_{fans_adj}					
EUI_{pumps}			=	EUI_{pumps}					
$EUI_{lighting}$			=	$EUI_{lighting}$					
$EUI_{plug\ loads}$			=	$EUI_{plug\ loads}$					
		Adjusted Site EUI Total (Electricity)					**Adjusted Site EUI Total (Gas)**		

After climate normalization, the adjusted site EUIs are converted to 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 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 climate normalization.

3.2.6 Scale Development

EUI distributions for various building types were constructed as the basis for scale development. CBECS data (EIA 2006) provide useful information for understanding energy consumptions in the U.S., however, it is impossible to disaggregate CBECS data and separate out the impacts of building operation and maintenance. Moreover, CBECS data do not cover all of the Asset Score building use types. Therefore, stock modeling was used to generate EUI distributions that are more relevant in setting the scale. To simulate the large parameter space efficiently, the Latin hypercube sampling (LHS) method was used to generate the stratified samples to obtain numerical results—modeled energy use distributions, in this case.

3.2.6.1 Seed Models and Input Sampling

A series of seed models that represent various building types and their typical physical and system configurations in all climate zones was first generated. The seed models are simplified ASHRAE Standard 90.1-2004 prototype buildings generated by the Asset Scoring Tool. These models applied the same building operating assumptions (see Section 4.3) as those used to generate a building's Asset Score. The building characteristics, geometry, envelope constructions, lighting systems, and HVAC system configurations were determined through the prototype buildings, which form the baseline models for developing the score scale.

A sensitivity analysis (see Section 4.2.2) produced an initial list of variables that significantly influence building energy use. Each variable was given an input distribution representing typical efficiency range based on the vintage of existing building stock as well as current technologies in the market. The lowest- and highest-efficiency values defined the minimum and maximum limits. The mean value was defined as ASHRAE Standard 90.1-2004 code requirements. Distributions that best represent each variable across the commercial building stock in the U.S. were then developed using these identified efficiency values. These inputs ranges, along with distributions, were peer-reviewed by selected architects, mechanical engineers, and building scientists. As an example, Table 3.5 lists the evaluation ranges defined for envelope parameters.

Table 3.5. Evaluation ranges developed for envelope parameters.

Display Name	Units	Minimum Efficiency	Maximum Efficiency
Floor R-Value	$ft^2 \cdot °F \cdot hr/Btu$	R-0	R-27
Wall Metal Panel U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.23	U-0.037
Wall Wood Siding U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.23	U-0.032
Wall Masonry on Wood U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.58	U-0.032
Wall Masonry on Steel U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.58	U-0.037
Wall Masonry on Masonry U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.58	U-0.062
Roof Built-up Wood Deck U-Value	$Btu/hr.ft^2 \cdot °F$	U-1.00	U-0.016
Roof Built-up Concrete Deck U Value	$Btu/hr.ft^2 \cdot °F$	U-1.00	U-0.016
Roof Built-up Metal Deck U-Value	$Btu/hr.ft^2 \cdot °F$	U-1.00	U-0.016
Roof Metal U-Value	$Btu/hr.ft^2 \cdot °F$	U-1.28	U-0.018
Roof Shingle U-Value	$Btu/hr.ft^2 \cdot °F$	U-0.10	U-0.008
Window-To-Wall Ratio	%	85%	0%
Window U-Value	$Btu/hr.ft^2 \cdot °F$	U-1.22	U-0.120

The standard deviation was chosen so that 99.9% of the distribution is between the minimum and maximum values for each variable (i.e., standard deviation = (max-min)/6). The parameters are sampled with an LHS algorithm to ensure more uniform sampling across the probability distributions. This analysis simulated and examined each building type with various combinations of building characteristics (Asset Score inputs)—variations of the seed models. These building models represented a wide range of buildings—from the likely least efficient to the likely most efficient buildings in 15 climate regions with thousands of variations in between. After adjusting for weather, an EUI distribution for each use type was constructed and used to develop the most appropriate range of EUIs for the 1- to 10-point scale.

3.2.6.2 Definitions of the Two End Points

Developing the energy asset scoring scale begins with defining the EUI for the two end points, 1 and 10, with the high end of the scale representing the most highly-efficient buildings.

The corresponding EUI for an Asset Score of 10 reflects the lowest expected energy use achievable given current efficient building technologies and no renewables, as modeled by the current version of the tool.

The low end of the scale (an Asset Score of 1) represents the most inefficient buildings. However, DOE has chosen not to use the least efficient building in today's commercial and multi-family residential building stock to define the score of 1 because this would skew the scale toward the low-efficiency end.

An average building is expected to score approximately 5 or 6 and a high performance building is expected to score approximately 8 or 9.

3.2.6.3 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 improvement potential of both low- and high-efficiency buildings. A uniform scale is simple to implement. On a uniform scale, the EUI decrement, that is, the amount of energy reduction required to earn an additional point, is constant across the entire scale. However, because it is usually more costly to further reduce energy use in a highly-efficient building where low-cost measures have already been implemented, progressive bins are used to define the scale applied by the Asset Scoring Tool—that is, the EUI decrement is smaller at the high end of the 10-point scale and larger at the low end of the scale, and again varies according to building type.

3.2.6.4 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. More than 35,000 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 information across 17 climate zones. Figure 3.10 shows the distribution of simulated source EUIs found for the small, medium, and large office buildings.

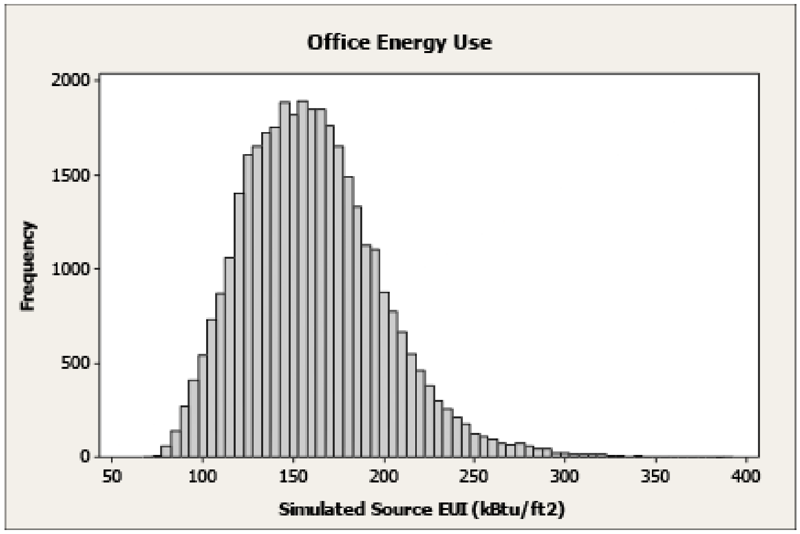


Figure 3.10. Distribution of office source EUI from simulations.

Data from the 2003 CBECS (EIA 2006) were used as another resource to understand the nation's building stock and to help benchmark the Asset Score scales. 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. If standard operational assumptions (as used to calculate Asset Score) were applied to the buildings in CBECS, the energy use of these buildings would be higher or lower than its measured value. Although less applicable than the simulations mentioned above, CBECS data nevertheless provide a good "reality check" and additional reference to validate the Asset Score scales.

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 the 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 simulations referenced above. 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 assessment of the modeled data.

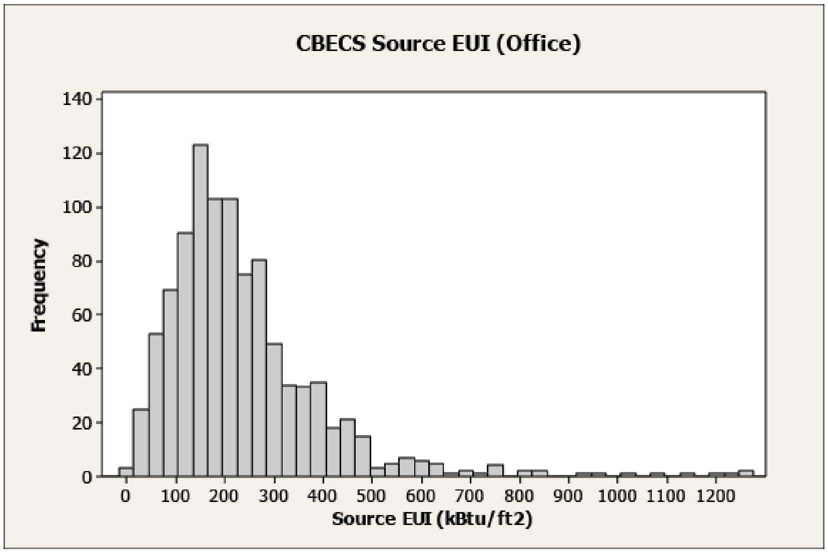


Figure 3.11. Distribution of office source EUIs from the CBECS database.

A progressive binning method was used to establish an appropriate scale for the Asset Score. To establish a standard method for developing the progression of bins across building use types, four control points were set for each building type on the Asset Score 10-point scale. These EUIs were selected based on results from the simulations explained above and 2004 prototype buildings:

1. **Minimum EUI:** Achievement of this EUI or lower entitles a building to receive a score of 10. Minimum EUI was set to be equal to the minimum EUI achieved in the simulation environment (which corresponds to upper 5th to 10th percentile within the CBECS dataset).
2. **High-performance building EUI:** Achievement of this EUI entitles a building to receive a score in the 8 to 9 range. EUI for a high-performance building was set to be equal to 30% lower than that of a prototype building complying with minimum requirements of ASHRAE Standard 90.1-2004.
3. **Average building EUI:** Achievement of this EUI entitles a building to receive a score in the 5−6 range. EUI for an average building was set to be equal to the median EUI achieved in the simulation environment.
4. **Maximum EUI:** A building with an EUI of this level or greater will receive a score of 1. Maximum EUI was set to be equal to the lower 95th percentile of simulated EUI.

A score table for office use type was developed based on this methodology. The simulated EUIs (shown in Figure 3.10) were then scored to test the developed scale. Figure 3.12 shows the score distributions of simulated data. The mean score is 5.5 with a standard deviation of 1.5. If we assume that the modeled office stock can represent the population, 95% of the buildings will be scored between 2.5 and 8.5 (within two standard deviations).

EUI	Score	Increments
70	10.0	
80	9.5	10
90	9.0	10
100	8.5	10
110	8.0	10
120	7.5	10
130	7.0	10
140	6.5	10
150	6.0	10
160	5.5	10
175	5.0	15
190	4.5	15
205	4.0	15
220	3.5	15
235	3.0	15
250	2.5	15
270	2.0	20
290	1.5	20
310	1.0	20

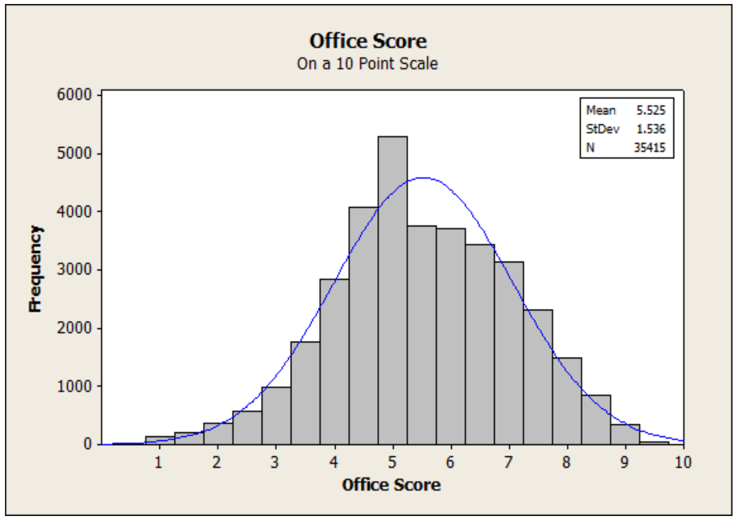


Figure 3.12. Score distributions of simulation data.

3.2.7 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 a building's score to 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 10-point scales for all considered building types, DOE expects that the scales can remain germane for at least 10 years.

3.2.7.1 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/ft^2 over the next two decades. On the current energy asset scoring scale (Appendix D), buildings need to reduce energy use by 10 to 25 kBtu/ft^2 (depending on building type) to earn an additional 0.5 point. An 8 kBtu/ft^2 variation in 20 years equates to a score change of less than 0.5 point, which is the minimum scale increment. Thus, the scale is expected to remain valid if future energy consumption variations are within the projected limits.

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

3.1.3 Commercial Delivered and Primary Energy Consumption Intensities, by Year

				Delivered Energy Consumption		Primary Energy Consumption	
		Floorspace (million SF)	Percent Post-2000 Floorspace (1)	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 8 and 10. .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, because a large fraction of existing building stock is unlikely to keep pace with the level of improvement for new construction, DOE will periodically review the latest energy consumption data to determine whether updates to the scale are needed.

3.2.7.2 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 being 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

[1] 10% to 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 construction.

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.

3.2.7.3 Major Updates to Underlying System Software

The Asset Scoring Tool is built on a platform that combines aspects of 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, and also performs 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 2001[1]; 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 Asset 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 updates of EEM modules 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 viable for more buildings. Users who have received an Asset Score will be notified about the updates and 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/ft^2 ($26.26/m^2) (DOE EERE 2011b), a 20% improvement in efficiency could yield savings of $0.49/ft^2 ($5.25/m^2). However, a comprehensive energy audit and modeling analysis can cost up to $0.50/ft^2 ($5.38/m^2) (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/ft^2 for a Level 1 audit (walkthrough analysis) and $200 plus 0.35/ft^2 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 and multi-family residential building owners. While the Asset Score is neither 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, in the past, many smaller-building owners/investors and owner-occupied building owners may have lacked the motivation to obtain an Asset Score; however, given the growing role that energy efficiency is likely to play in future real estate transactions, this is expected to change. For this group of building owners, the ability to more readily understand the energy efficiency of their buildings and possible options for reducing energy costs will add further value to the basic 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 basic guidelines for improving building performance.

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

1. give property owners and managers a way to gauge the efficiency of their properties compared both to a potential efficiency and to similar properties
2. provide guidance on asset-focused actions to motivate owners and managers to make reasoned and value-conscious investments
3. enable the targeting of limited capital resources toward areas that may 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 has its advantages, 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 applies generalized procedures using a uniform method of estimating building performance while following the applicable modeling requirements specified in Appendix G of ASHRAE Standard 90.1-2013 and COMNET (2010).

After evaluating several options, including the pre-simulation method, time series data analysis, and normative calculation method (see Wang and Gorrissen 2012), DOE selected dynamic energy simulation as the modeling approach for the Asset Scoring Tool. DOE considered two 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 FEDS[1] (PNNL 2014): This type of analysis tool often offers features lending greater scalability and ease of use, and accessibility to a broader user group. Less demanding data input requirements result in significantly reduced model development and overall analysis time and cost. While many of these features would benefit the needs of the Asset Score, a plan to follow this approach exclusively was adjusted in favor of greater modeling flexibility afforded by some of the more advanced sub-hourly simulation engines 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 could presumably have greater confidence (assuming that an established tool is 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 will be highly time consuming and costly.

To overcome the inherent drawbacks of 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. 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. More advanced users can download their energy models from the Asset Scoring tool and perform customized analysis in EnergyPlus, OpenStudio Parametric Analysis Tool[3], and other tools. This approach is in essence similar to the wizard levels (schematic and

[1] http://www.pnnl.gov/feds/
[2] http://apps1.eere.energy.gov/buildings/energyplus/
[3] http://energy.gov/eere/buildings/downloads/openstudio-0

design development) of eQUEST.[1] In the wizards, all inputs have defaults based on the California Title 24 building energy code, requiring 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. 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, 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 minimum user inputs. 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. 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, with examples highlighted in Table 4.1. As users include more detailed inputs on the way to the complete set, the energy model results reflect the added detail by becoming more tailored to the user's specific building. See Appendix E for the complete set of Asset Score data fields.

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)

[1] http://doe2.com/

The combination of a 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 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 increase 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, effect on energy consumption, and expected variability between buildings. The data selection process is described in previous versions of the protocol (Wang and Gorrissen 2012; Wang et al. 2013).

4.2.1 Input Set Levels

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

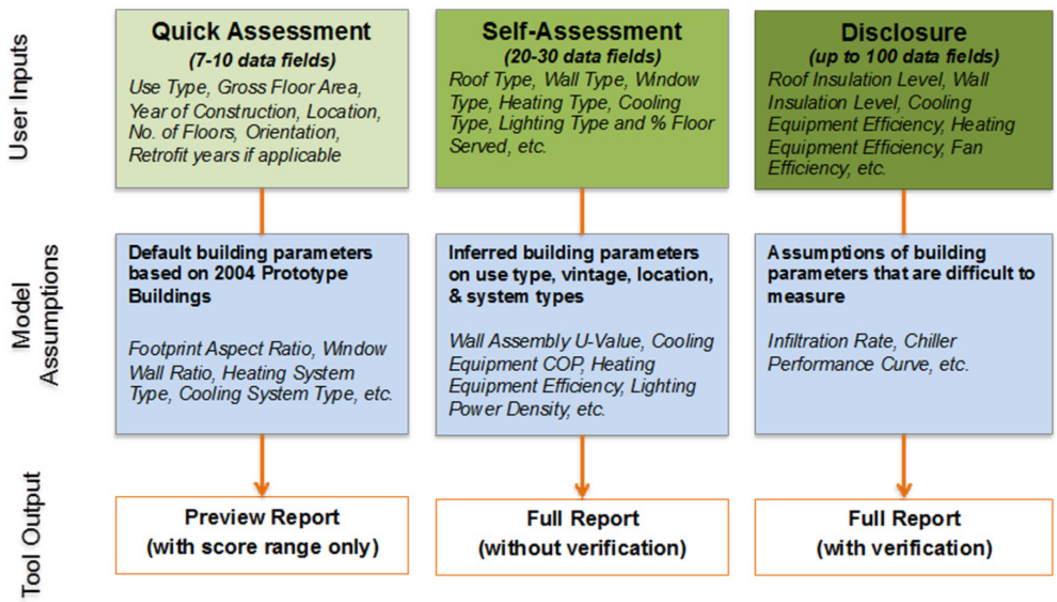


Figure 4.1. Different levels of data collection.

Quick Assessment

The light version of the Asset Scoring Tool—Asset Score Preview—allows users to enter very basic building information (building use type, location, year of construction, gross floor area, number of floors, orientation, retrofit years if applicable) to quickly assess their buildings. Users will receive a range of possible scores and potential building improvement areas as the assessment result. Buildings with more complex geometry, mix-used type, or advanced HVAC systems may not be suitable for using Asset Score Preview because oversimplification likely results in low accuracy.

Self-Assessment

A full Asset Score Report requires a minimum threshold of key building characteristics from the user. The full report with minimum data inputs 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 asset 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 highly important to accurately assessing a building's total energy consumption.

Information Disclosure

A more reliable simulation result requires more data from the user. If a user wants to use a score for official purposes, a more advanced level of data collection would be required as well as some type of validation of the data inputs. These optional 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 Asset Score dataset can provide more insight into the performance of the building being examined. Examples of these additional inputs include air infiltration rates and equipment performance curves. However, these variables are usually more difficult to capture. Currently, assumptions are based on the building construction and vintage and equipment type. Advanced users can obtain the energy models from the Asset Scoring Tool and further revise these variables for customized analysis. Revised models cannot be used for scoring purposes.

4.2.2 Sensitivity Analysis

With the assistance of the National Renewable Energy Laboratory, large-scale sensitivity analysis was performed to verify that the Asset Score dataset covers the most important building characteristics that affect a building's efficiency level. The sensitivity analysis used the commercial buildings prototype models generated through the Asset Scoring Tool as the base models. 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 multi-family residential buildings. These prototype buildings—derived from DOE's Commercial Reference Building Models—cover all the reference building types except supermarkets. Each base model was evaluated in the 15 ASHRAE climate zones, located in the United States (Briggs et al. 2003).

The 15 cities representing the climate zones are:

- 1A: Miami, Florida (very hot, humid)
- 2A: Houston, Texas (hot, humid)
- 2B: Phoenix, Arizona (hot, dry)
- 3A: Memphis, Tennessee (warm, humid)
- 3B: El Paso, Texas (warm, dry)
- 3C: San Francisco, California (warm, marine)
- 4A: Baltimore, Maryland (mixed, humid)
- 4B: Albuquerque, New Mexico (mixed, dry)
- 4C: Salem, Oregon (mixed, marine)
- 5A: Chicago, Illinois (cool, humid)
- 5B: Boise, Idaho (cool, dry)
- 6A: Burlington, Vermont (cold, humid)
- 6B: Helena, Montana (cold, dry)
- 7: Duluth, Minnesota (very cold)
- 8: Fairbanks, Alaska (subarctic)

The sensitivity analysis focused on the minimum required parameters for the Asset Score and quantified their EUI impact for each use type and climate zone. The minimum, maximum, mean, and standard deviation were defined for each parameter to construct a distribution that best represents the variable across the commercial and multi-family residential building stock in the United States. The standard deviation was chosen so that 99.9% of the distribution is between the minimum and maximum values for each variable (i.e., standard deviation = (max-min)/6). The parameters were sampled with an LHS algorithm to ensure more uniform sampling across the probability distributions. Each parameter was individually simulated (no interactive effect), within the bounds of the identified minimum and maximum values to quantify its sensitivity for each building type, within each climate zone. Appendix L shows results of this analysis in the form of tornado diagrams.

The sensitivity analysis verified that all Asset Score inputs are important to determining a building's efficiency level; however, their level of impact varies by building use type, size, and location. Overall, interior lighting power density, heating system efficiency, and air handler fan efficiency are the most sensitive parameters for most of the use types. Table 4.2 shows the top 10 sensitive variables on average. Note that the rankings may change by climate zone.

Table 4.2. Top 10 sensitive variables for various use types.

No.	Use Type	Seed model	Sensitive Variable 1	Sensitive Variable 2	Sensitive Variable 3	Sensitive Variable 4	Sensitive Variable 5	Sensitive Variable 6	Sensitive Variable 7	Sensitive Variable 8	Sensitive Variable 9	Sensitive Variable 10
1	Office	Small Office	Interior Lighting Power Density	Air Handler Fan Efficiency	Roof U-Value	Window-to-Wall Ratio	Wall U-Value	Building Area	Building Volume	Window SHGC	Window U-Value	Heating System Efficiency
		Medium Office	Interior Lighting Power Density	Supply Air Temperature Reset	Window-to-Wall Ratio	Building Volume	Window U-Value	Wall U-Value	Roof U-Value	Window SHGC	Building Area	Cooling System Efficiency
		Large Office	Interior Lighting Power Density	Window-to-Wall Ratio	Air Handler Fan Efficiency	Fan Control	Building Volume	Window SHGC	Economizer Control	Window U-Value	Aspect Ratio	Wall U-Value
2	Hotel	Small Hotel	Interior Lighting Power Density	Cooling System efficiency	Window-to-Wall Ratio	Window SHGC	Wall U-Value	Roof U-Value	Building Volume	Aspect Ratio	Wall Construction Type	Window U-Value
		Large Hotel	Interior Lighting Power Density	Window-to-Wall Ratio	Window SHGC	Cooling System Efficiency	Building Volume	Wall U-Value	Aspect Ratio	Window U-Value	Water Heater Energy Factor	Roof U-Value
3	Edu-cation	Secondary School	Interior Lighting Power Density	Air Handler Fan Efficiency	Cooling System Efficiency	Roof U-Value	Fan Control	Window-to-Wall Ratio	Building Area	Building Volume	Window U-Value	Supply Air Temperature Reset
4	Retail	Retail- Big Box	Interior Lighting Power Density	Heating System Efficiency	Heating Fuel Type	Roof U-Value	Wall U-Value	Air Handler Fan Efficiency	Building Area	Building Volume	Wall Construction Type	Aspect Ratio
		Retail- Strip Mall	Interior Lighting Power Density	Heating System Efficiency	Heating Fuel Type	Wall U-Value	Roof U-Value	Air Handler Fan Efficiency	Building Area	Building Volume	Window U-Value	Wall Construction Type
5	Apart-ments	Apartment-Mid Rise	Heating System Efficiency	Heating Fuel Type	Wall U-Value	Building Volume	Interior Lighting Power Density	Window U-Value	Building Area	Air Handler Fan Efficiency	Roof U-Value	Window-to-Wall Ratio
		Apartment High Rise	Interior Lighting Power Density	Air Handler Fan Efficiency	Window-to-Wall Ratio	Building Volume	Window SHGC	Wall U-Value	Aspect Ratio	Window U-Value	Heating System Efficiency	Cooling System Efficiency
6	Warehouse		Roof U-Value	Wall U-Value	Heating System Efficiency	Heating Fuel Type	Interior Lighting Power Density	Air Handler Fan Efficiency	Building Area	Building Volume	Wall Construction Type	Aspect Ratio
7	Post Office		Interior Lighting Power Density	Window-to-Wall Ratio	Roof U-Value	Building Area	Building Volume	Wall U-Value	Window SHGC	Window U-Value	Aspect Ratio	Wall Construction Type
8	Police Station		Interior Lighting Power Density	Air Handler Fan Efficiency	Window-to-Wall Ratio	Roof U-Value	Cooling System Efficiency	Window SHGC	Economizer Control	Perimeter Zone Depth	Building Volume	Wall U-Value
9	Medical Office		Interior Lighting Power Density	Window-to-Wall Ratio	Window U-Value	Wall U-Value	Building Volume	Aspect Ratio	Roof U-Value	Building Area	Window SHGC	Terminal DX Cooling Efficiency
10	Library		Interior Lighting Power Density	Air Handler Fan Efficiency	Window SHGC	Window-to-Wall Ratio	Cooling System Efficiency	Economizer Control	Building Volume	Perimeter Zone Depth	Window U-Value	Building Area
11	Courthouse		Heating System Efficiency	Heating Fuel Type	Air Handler Fan Efficiency	Interior Lighting Power Density	Window U-Value	Wall U-Value	Roof U-Value	Building Volume	Building Area	Window-to-Wall Ratio
12	City Hall		Interior Lighting Power Density	Window-to-Wall Ratio	Building Volume	Window U-Value	Supply Air Temperature Reset	Wall U-Value	Roof U-Value	Fan Control	Air Handler Fan Efficiency	Window SHGC
13	Assisted Living		Air Handler Fan Efficiency	Interior Lighting Power Density	Cooling System Efficiency	Wall U-Value	Window-to-Wall Ratio	Building Volume	Roof U-Value	Window SHGC	Window U-Value	Building Area

4.2.3 User Requirements

Commercial and multi-family residential 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 determine 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. The qualification criteria are under development.

4.2.4 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 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 4.3. 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 required minimum dataset and less than 20 hours for the complete dataset, based on interviews with the experienced energy auditors at PNNL. The 2012 and 2013 pilot projects showed that the average data collection time is 6 hours. This is based on surveys among a mixed group of various levels of users. The pilot participants also reported that the minimum required data were easy to collect.

Table 4.3. 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.

4.2.5 Automated Error-Checking for Quality Assurance

The accuracy of user inputs is essential for the accuracy of the modeled results. The Asset Scoring Tool warns users when automated checks suggest that data entered may be incorrect or incomplete. Validations are carried out at two levels:

- **Validation check of all required data points**. 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.
- **Validation check of user-entered values against boundary limits and typical values.** Validation of user-entered values verifies them against typical values for the respective data point and notifies the user if the value is too high or too low. Users are allowed to proceed after clicking the on-screen confirmation. A validation check is also carried out to determine if the user-entered value exceeds the hard limits of the simulation tool, which would cause the simulation to crash. In this case, users are required to modify the value in order to submit their building. If users enter an invalid value, they will be informed of the proper range of the input. Table 4.4 shows an example of the input validation. The complete data validation list is documented in Appendix I.

Table 4.4. Example of input validation.

Input Name	Data Type	Typical Ranges	Validation Range	Units
Roof U-Value	Integer	0.017–0.065	0.008–1.28	BTU/°F·ft^2·h
Wall U-Value	Integer	0.037–0.058	0.008–1.28	BTU/°F·ft^2·h
Window-to-Wall Ratio	Integer	25%–40%	<0.95	Percent
Chiller COP	Integer	2.8–6.1 (depending on condenser type)	1 to 8	Dimensionless
Boiler Heating Efficiency	Integer	78%–92%	<100%	Percent

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 and Model Assumptions

4.3.1 Assumptions of Operating Conditions

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 J of this document shows the standard operating inputs currently used in the Asset Scoring Tool. The data are derived from ASHRAE Standard 90.1-2013, Appendix C. The model assumptions that are not specified in ASHRAE Standard 90.1 follow the inputs as specified in the DOE commercial prototype buildings models (Thornton et. al 2011) or use EnergyPlus defaults (NREL 2011). The modeling approach used for energy simulation is documented in Appendix M of this document.

4.3.2 Assumptions of Infiltration Rates

Air infiltration through building envelope significantly influences building energy use, primarily for space heating (Woods and Parekh 1992). This is also one of the most difficult parameters to measure for commercial buildings and literature suggests that there is no clear correlation between infiltration rate and building characteristics, such as vintage, wall type, or window type. Further, the actual infiltration rate is often difficult to measure in a commercial building.

The Asset Score follows a simplified approach, developed by PNNL, for simulating infiltration for commercial and multi-family residential buildings. An infiltration rate of 1.8 cfm/ft² of above-grade envelope surface area at 0.3 in. w.c. (75 Pa) is assumed based on a National Institute of Standards and Technology survey of air infiltration levels in existing buildings (Emmerich et al. 2005). PNNL has developed a methodology to convert the infiltration rate at 0.3 in. w.c. (75 Pa) to a corresponding wind-driven design infiltration rate input in EnergyPlus (Gowri et al. 2009). Based on this methodology, the EnergyPlus input design infiltration (I_{design}) is calculated as 0.2016 cfm/ft² (0.001024 $m^3/s/\ m^2$) of above-grade exterior wall surface area. This infiltration rate is equivalent to the base infiltration rate of 1.8 cfm/ft² (0.00915 $m^3/s/\ m^2$) of above-grade envelope surface area at 0.3 in. w.c. (75 Pa).

4.4 Software Development

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

- **Graphical User Interface**
  - The user interface collects all pertinent data from the user. It allows the user to define the building geometry using a simplified “multi-block” approach.
- **Asset Score Web Service**
  - All user inputs are stored in a database on the Asset Score web service.
  - Inputs are translated in a standard schema format to the analytic engine.
  - The web service is the heart of the tool and coordinates data transfer from the user interface to the analytic engine, the modeling engine, and the report generator.
- **Analytic Engine**
  - The analytic engine includes a default generator to support quick assessment—Asset Score Preview.
  - The analytic engine uses a FEDS interface to infer model parameters not entered by users, including HVAC system sizing based on the calculated loads.

– FEDS evaluates building components and identifies areas and options for energy efficiency improvement. The method is explained in Section 5.3.

- **Modeling Engine**
  - The modeling engine includes the OpenStudio web service, which takes the Asset Score data models as inputs to generate EnergyPlus files.
  - The modeling engine also includes an OpenStudio EEM engine, which runs a series of control measures over the upgraded model to consider additional EEMs.
- **Report Generator**
  - The report generator runs a series of post-processing scripts to calculate building scores, evaluate building components, and generate the Asset Score Report, which is fully described in Section 5.
- **Application Program Interface (API)**
  - The Asset Score API is developed as a RESTful style web service. It allows third party tools to bypass the Asset Score graphical user interface and directly score buildings. The API structure is documented in a separate report (Elliott et al. 2013).

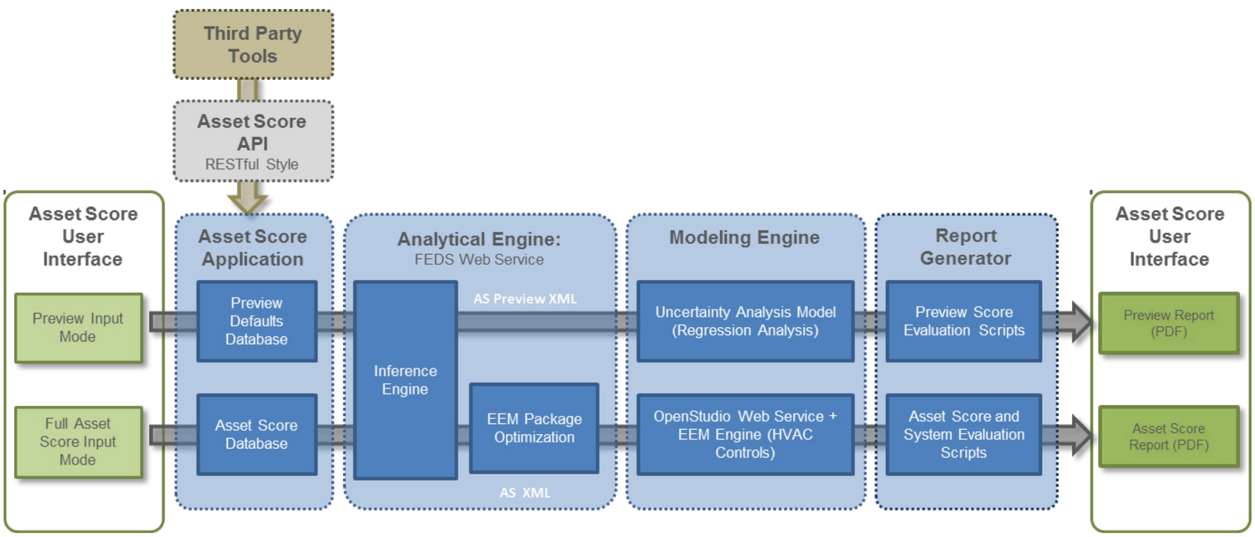


Figure 4.2. Asset Scoring Tool components.

4.4.1 Graphical User Interface

The graphical web 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, capacities, and controls
- 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.

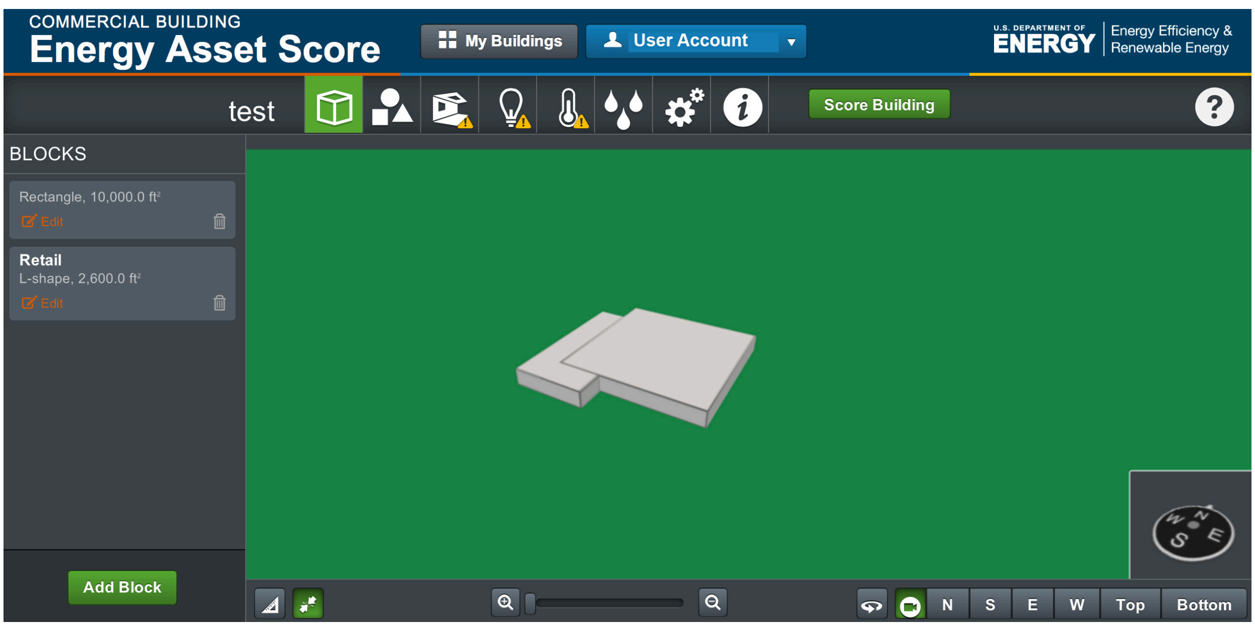


Figure 4.3. Asset Scoring Tool user interface.

4.4.2 Analytic Engine

To minimize effort for the user, a mechanism was needed to reasonably estimate a building's difficult-to-measure parameters. Many 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 was developed by PNNL to facilitate quick and scalable building energy audits and analyses over single as well as large groups of buildings (PNNL 2014). Certain similarities between the existing FEDS tool and desired features of the Asset Scoring Tool, as well as the established nature of the FEDS system and the 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 FEDS tool inferences are derived from multiple sources and techniques, including

- 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)

a wealth of PNNL experience auditing and modeling U.S. commercial building buildings. In addition to data-driven inferences, FEDS uses an internal energy modeling system to calculate 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 5.3.

4.4.3 Asset Score Preview

The Asset Score Preview allows users to enter as few as seven building characteristics to gain a quick assessment of their buildings:

- use type
- gross floor area
- year of construction
- location
- number of floors

- orientation
- retrofit years (if applicable)

Based on these seven characteristics, the Asset Scoring Tool maps the user building to the most appropriate prototype building and populates all remaining input data points based on the building characteristics of the prototype building. The data points populated address all required inputs in the Asset Scoring Tool. Users can either edit or verify these defaults. Based on user input, a regression model calculates the possible range of the building's energy use based on a pre-simulated database and an uncertainty analysis. The range of energy use will be converted to a range of Asset Score shown in the Preview report. The methodology for constructing the regression models and running the uncertainty analysis will be described in a future document.

4.4.4 Modeling Engine

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 OpenStudio[1] (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.

[1] http://openstudio.nrel.gov/

5.0 Asset Score Report

5.1 Report Structure Overview

The Asset Score Report includes four sections: score, identified opportunities, system evaluation, 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 *opportunity* page provides feedback on areas and options for energy efficiency improvement, with estimated energy savings and possible payback period.
- 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 *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).

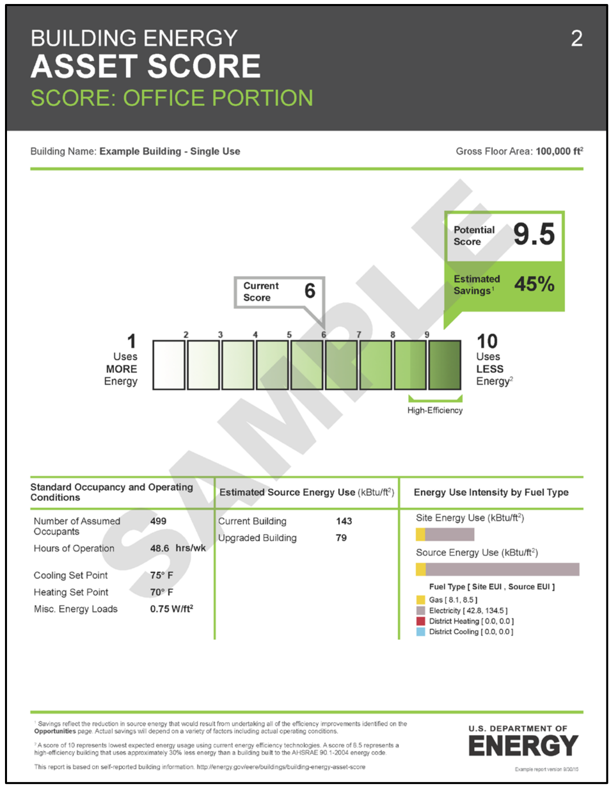


Figure 5.1. Current and potential scores.

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 can specify operation parameters (total occupants, temperature set points, operating hours, and miscellaneous loads) to obtain EEMs that are more applicable to their buildings. This flexibility is useful when a building's operation significantly deviates from the normal operating conditions, such as much longer operation hours and higher miscellaneous loads. Once an EEM package is 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 (Figure 5.2). 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.

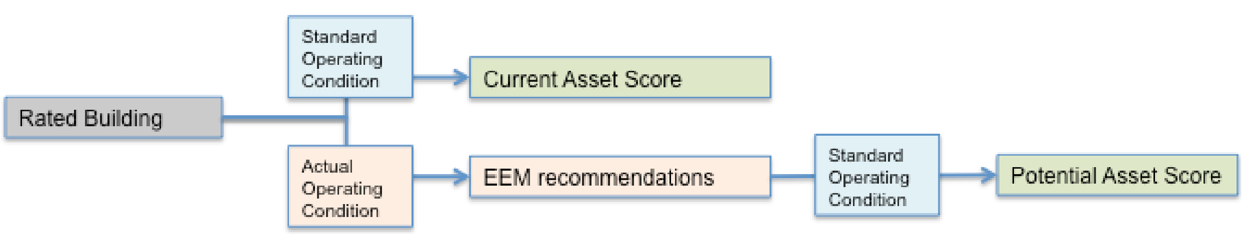


Figure 5.2. EEM package and potential score.

5.3 Upgrade 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 indicates 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 by 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 EEMs identified 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 to understand 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 methodology[1] 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 EEMs on operations and maintenance costs and on changes in 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 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 EEMs 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 EEMs 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, users 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 EEMs 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 (e.g., fluorescent lighting), the analysis calculates incremental replacement of components over the 25-year study period using standard operating assumptions, or actual operating hours if provided by the user.

[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).

- **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 2014). 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 TOU prices (COMNET 2010). 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 flat national prices 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 subsequent changes to heating and cooling loads are considered when evaluating potential upgrade or replacement options for those end uses (see Figure 5.3). This provides more accurate savings estimates and thus more useful and integrated considerations.

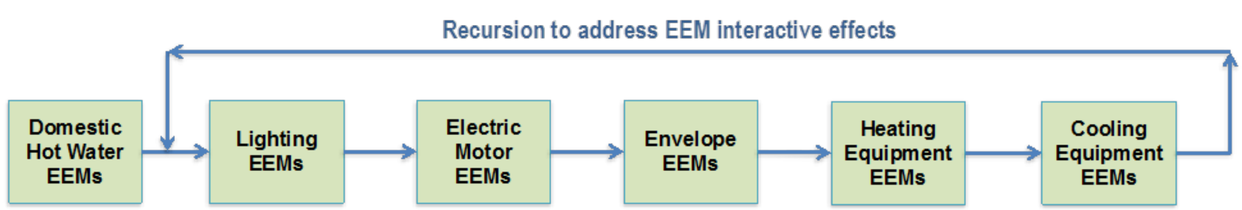


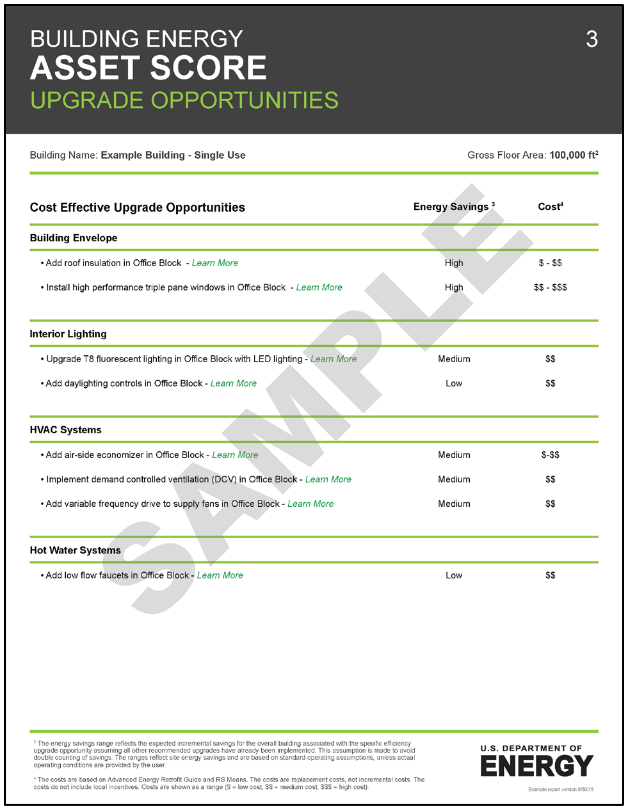
Figure 5.3. Energy efficiency measure ranks.

After the initial LCC analysis, a second group of candidate EEMs is evaluated using a separate method. These EEMs are related to building controls and are based on simple yes/no user inputs. Examples of options that are addressed using this secondary methodology are

- pump control for chiller and condenser pumps
- economizers
- fan controls such as supply air temperature reset, fan static pressure reset.

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 though 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.

An example is shown in Figure 5.4. A list of EEMs can be found in Appendix H. As stated already, these EEMs are general guidelines of the types of upgrades that may be considered to improve the efficiency of the building, and are 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 a more thorough and evaluation of savings measures for each specific scenario, by following the additional guidance outlined in the *Building Energy Asset Score: Building Upgrade Guide* (DOE EERE 2013) or by engaging a third party specialist.



BUILDING ENERGY
ASSET SCORE
UPGRADE OPPORTUNITIES
3

Building Name: **Example Building - Single Use**   Gross Floor Area: **100,000 ft²**

Cost Effective Upgrade Opportunities	Energy Savings [3]	Cost [4]
Building Envelope		
• Add roof insulation in Office Block - *Learn More*	High	$ - $$
• Install high performance triple pane windows in Office Block - *Learn More*	High	$$ - $$$
Interior Lighting		
• Upgrade T8 fluorescent lighting in Office Block with LED lighting - *Learn More*	Medium	$$
• Add daylighting controls in Office Block - *Learn More*	Low	$$
HVAC Systems		
• Add air-side economizer in Office Block - *Learn More*	Medium	$-$$
• Implement demand controlled ventilation (DCV) in Office Block - *Learn More*	Medium	$$
• Add variable frequency drive to supply fans in Office Block - *Learn More*	Medium	$$
Hot Water Systems		
• Add low flow faucets in Office Block - *Learn More*	Low	$$

[3] The energy savings range reflects the expected incremental savings for the overall building associated with the specific efficiency upgrade opportunity assuming all other recommended upgrades have already been implemented. This assumption is made to avoid double counting of savings. The ranges reflect site energy savings and are based on standard operating assumptions, unless actual operating conditions are provided by the user.

[4] The costs are based on Advanced Energy Retrofit Guide and RS Means. The costs are replacement costs, not incremental costs. The costs do not include local incentives. Costs are shown as a range ($ = low cost, $$ = medium cost, $$$ = high cost).

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Example report version 9/30/15

Figure 5.4. Upgrade opportunities.

5.4 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 (Figure 5.5). This information can help identify the efficiency levels of specific components of the building. For two buildings with the same Asset Score, the system-level evaluations can give users insight into the efficiency levels of individual systems and when analyzed along with the identified cost-effective energy efficiency upgrades, it can point to potential improvements for each building.

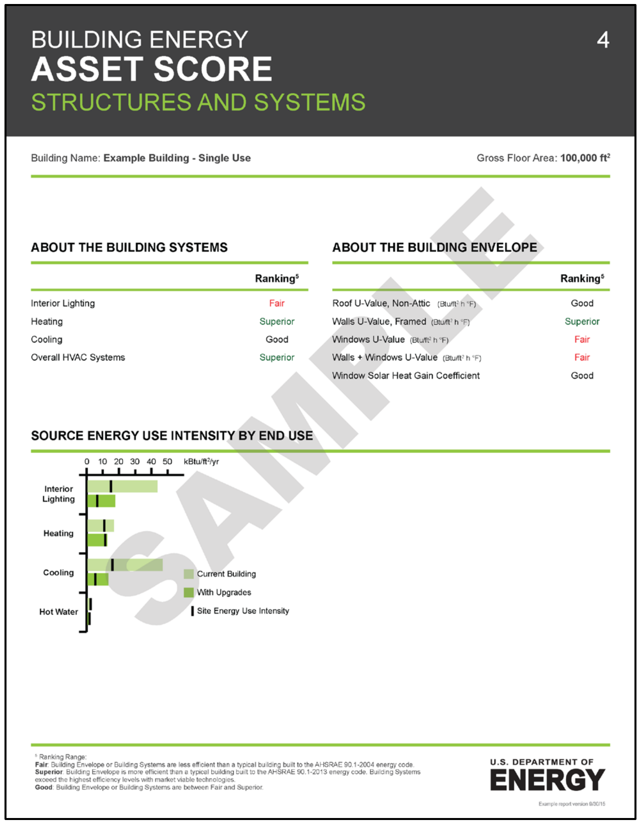


Figure 5.5. System evaluations.

Both prescriptive and performance approaches have been used in energy standards for designing and evaluating building systems. The prescriptive approach specifies a 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 evaluating existing systems, 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 COP and characteristic part-load performance curves of its compressor. Heating and cooling systems are composed of various components such as supply/return/exhaust fans, pumps, heat rejection equipment. Comparison of rated efficiencies ignores the energy use of all the additional systems, which can be quite significant depending on system configuration and controls.
- It is difficult to compare different HVAC systems using a prescriptive approach. For example, in ASHRAE Standard 90.1-2013, Tables 6.8.1 through 4 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 for ranking 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 90.1-2013, Table 6.8.11). 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 it 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 poorer 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 poorer 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 poorer 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 poorer 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 poorer thermal performance
Lighting System	$kBtu/ft^2$	Lighting energy use / total floor area	Higher value corresponds to higher lighting EUI, and therefore a lower-efficacy 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.

5.4.1 Building Envelope

For the envelope assessment, the annual heating and cooling loads due to envelope components 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 heat gain or heat loss per unit area of the component (measured in $kBtu/ft^2$). 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-to-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-to-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-to-Wall Ratio[(a)]	Walls and Windows Combination
Building A	Good	Good	High	Good or Fair
Building B	Good	Good	Low	Superior or Good
Building C	Fair	Fair	High or Low	Fair
Building D	Good	Fair	High	Fair
Building E	Good	Fair	Low	Good
Building F	Fair	Good	High or Low	Fair

(a) The evaluation of high/low is based on a comparison against the corresponding prototype building used to define the baseline evaluation range.

A technical barrier at this moment is that EnergyPlus output files do not specify the heat transfer through an envelope component (windows, walls, roof, and 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 against ranges developed using the minimum required U-value specified in ASHRAE Standard 90.1-2004, which defines the lower end of the range, and ASHRAE 90.1-2013, which defines the upper end of range. Buildings with envelope properties within the range are ranked "Good," envelope properties better than the range are ranked "Superior," and envelope properties worse than the range are ranked "Fair."

5.4.2 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 or overlit areas. 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 as a whole rather than just looking at a single aspect. Source energy is used to account for the production and transmission loss of electricity.

5.4.3 HVAC Systems

For the HVAC systems, system performance ratio (SPR) is used. SPR is defined as the ratio of the total heating and cooling load to the total energy consumed by the HVAC system to heat, cool, and ventilate the space. Source energy is used to account for the production and transmission loss of different fuel types. The concept of SPR is similar to COP. SPR is calculated from a building's Asset Score model. Cooling SPR, heating SPR, and total SPR 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.

5.4.4 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.

5.4.5 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.

Two sets of prototype buildings (compliant with ASHRAE Standard 90.1-2004 and 2013) are used to calculate the reference ranges. These prototypes were originally developed for DOE to assess the relative improvement of sequential versions of ASHRAE Standard 90.1. They represent 80% of the commercial building floor area in the United States for new construction, including both commercial buildings and mid- to high-rise residential buildings (Thornton et al. 2011). The HVAC systems in each prototype were selected based on "good design practice" for that building type. The characteristics of the prototype buildings are documented and the models are available online (PNNL 2012). The prototype models provide consistency, transparency, and an industry-accepted baseline for system evaluation in the Asset Score.

Reference ranges are developed and are unique for each climate zone. The ranges are developed based on the best and the worst results obtained by modeling prototype buildings and their variations. Typically, the ASHRAE Standard 90.1-2004 model corresponds to the minimum efficiency level that is considered "Good." The modified 90.1-2013 model corresponds to the minimum efficiency level that is considered "Superior." Any system that is less efficient than the minimum level allowed for "Good" would be characterized as "Fair" (Goel et al. 2014).

Table 5.3 shows an example of how system performance range is developed for a small office building in climate zone 5A. In this example, a heating performance ratio between 0.39 and 0.45 is considered "Good," lower than 0.39 is "Fair," and above 0.45 is "Superior." The system performance ranges for all use types are documented in Appendix K.

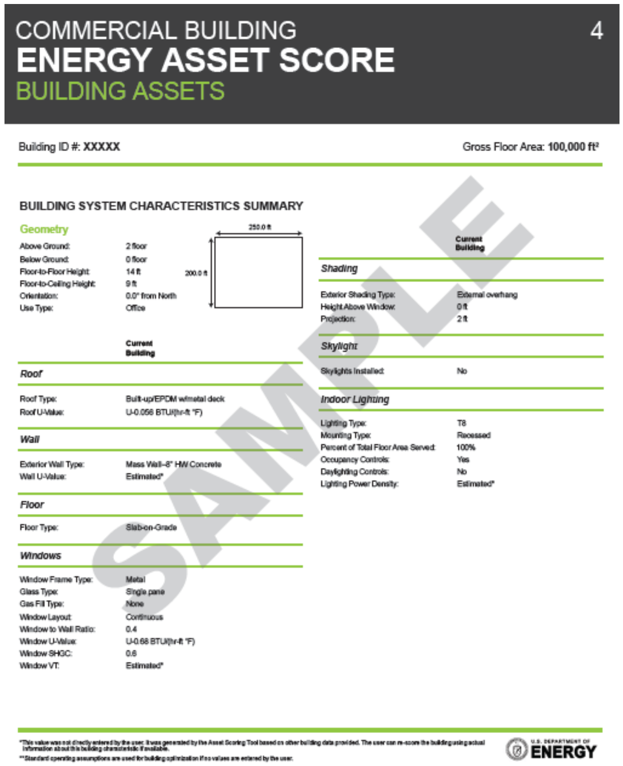
Table 5.3. Example of efficiency levels for small office in climate zone 5A.

Small Office (heat pump system)	Heating System COP	Cooling System COP
2004 model	3.0	3.14
2013 model	3.29	3.91
	Heating System Performance Ratio[(a)]	Cooling System Performance Ratio[(a)]
2004 model	0.39	0.31
Modified 2010 model (with max efficiency)	0.45	0.42

(a) System performance ratio = (Heating or Cooling Load) / (Source Energy Use for Heating or Cooling)

5.5 Building Assets

The Asset Score Report provides a summary of building characteristics (Figure 5.6) 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.


COMMERCIAL BUILDING
ENERGY ASSET SCORE
BUILDING ASSETS
4

Building ID #: XXXXX
Gross Floor Area: 100,000 ft²

BUILDING SYSTEM CHARACTERISTICS SUMMARY

Geometry

Above Ground:	2 floor
Below Ground:	0 floor
Floor-to-Floor Height:	14 ft
Floor-to-Ceiling Height:	9 ft
Orientation:	0.0° from North
Use Type:	Office

	Current Building
Roof	
Roof Type:	Built-up/EPDM w/metal deck
Roof U-Value:	U-0.056 BTU/(hr-ft °F)
Wall	
Exterior Wall Type:	Mass Wall–8" HW Concrete
Wall U-Value:	Estimated*
Floor	
Floor Type:	Slab-on-Grade
Windows	
Window Frame Type:	Metal
Glass Type:	Single pane
Gas Fill Type:	None
Window Layout:	Continuous
Window to Wall Ratio:	0.4
Window U-Value:	U-0.68 BTU/(hr-ft °F)
Window SHGC:	0.6
Window VT:	Estimated*

	Current Building
Shading	
Exterior Shading Type:	External overhang
Height Above Window:	0 ft
Projection:	2 ft
Skylight	
Skylights Installed:	No
Indoor Lighting	
Lighting Type:	T8
Mounting Type:	Recessed
Percent of Total Floor Area Served:	100%
Occupancy Controls:	Yes
Daylighting Controls:	No
Lighting Power Density:	Estimated*

*This value was not directly entered by the user. It was generated by the Asset Scoring Tool based on other building data provided. The user can re-score the building using actual information about this building characteristic if available.
**Standard operating assumptions are used for building optimization if no values are entered by the user.

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Figure 5.6. Building assets.

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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			Health Care Clinic
	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 Mall		
	Strip shopping center			
Office	Administrative or professional office	Large Office	Office	Office
	Government office	Medium Office		
	Mixed-use office	Small Office		
	Bank or other financial institution		Bank/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		Town Hall	
	Religious office			
	Call center			
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)			Gymnasium
	Entertainment or culture (e.g., museum, theater, cinema, sports arena, casino, night club)			Museum- General
				Performing Arts Theater
				Motion Picture Theater
	Library			Library
	Funeral home			Sports Arena
	Student activities center			Exercise Center
	Armory			
	Exhibition hall			
	Broadcasting studio			
	Transportation terminal			Transportation

CBECS Building Types[a]	CBECS Subcategories from 2003 CBECS Questionnaire[b]	DOE Commercial Reference Buildings and Prototype Buildings [c]	Portfolio Manager[d]	COMNET
Public Order and Safety	Police station			Police/Fire Station
	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			

CBECS Building Types[a]	CBECS Subcategories from 2003 CBECS Questionnaire[b]	DOE Commercial Reference Buildings and Prototype Buildings [c]	Portfolio Manager[d]	COMNET
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

(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

Prototype Buildings

Appendix B
Prototype Buildings

B.1 2004 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 number 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**

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 HarborME 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
BatesvilleAR 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 Passadena 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 Lunki 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 MuniIA 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
CloquetMN 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 MuniAwos NM USA TMY3 WMO#=722689	0.68	0.99	1.06	0.78	0.98	1.07	4B
Cody MuniWY 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 Heating Coefficient	Cooling Coefficient	Fans Coefficient	Warehouse Heating Coefficient	Cooling Coefficient	Fans Coefficient	Climate Zone
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 Lnrd 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
Rhinelander 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 FieldWA 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
ShishmarefAK 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 ApWA 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 WiIL 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
Worchester 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.

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	70	10
71	80	9.5
81	90	9
91	100	8.5
101	110	8
111	120	7.5
121	130	7
131	140	6.5
141	152	6
153	164	5.5
165	176	5
177	188	4.5
189	200	4
201	215	3.5
216	230	3
231	245	2.5
246	260	2
261	275	1.5
276	99999	1

D.2 Building Type: Library

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	105	10
106	120	9.5
121	135	9
136	150	8.5
151	165	8
166	183	7.5
184	201	7

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
202	219	6.5
220	237	6
238	255	5.5
256	275	5
276	295	4.5
296	315	4
316	335	3.5
336	355	3
356	375	2.5
376	395	2
396	415	1.5
416	9999	1

D.3 Building Type: School

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	115	10
116	125	9.5
126	135	9
136	145	8.5
146	155	8
156	165	7.5
166	177	7
178	189	6.5
190	201	6
202	213	5.5
214	225	5
226	240	4.5
241	255	4
256	270	3.5
271	285	3
286	300	2.5
301	315	2
316	330	1.5
331	9999	1

D.4 Building Type: Retail

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	85	10
86	97	9.5
98	109	9
110	121	8.5
122	133	8
134	145	7.5
146	157	7
158	169	6.5
170	181	6
182	196	5.5
197	211	5
212	226	4.5
227	241	4
242	256	3.5
257	271	3
272	286	2.5
287	301	2
302	316	1.5
317	9999	1

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

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	30	10
31	38	9.5
39	46	9
47	54	8.5
55	62	8
63	70	7.5
71	78	7
79	86	6.5
87	96	6
97	106	5.5
107	116	5

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
117	126	4.5
127	136	4
137	146	3.5
147	156	3
157	166	2.5
167	176	2
177	186	1.5
187	9999	1

D.6 Building Type: Apartment

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	75	10
76	83	9.5
84	91	9
92	99	8.5
100	107	8
108	115	7.5
116	123	7
124	131	6.5
132	139	6
140	149	5.5
150	159	5
160	169	4.5
170	179	4
180	189	3.5
190	199	3
200	209	2.5
210	219	2
220	229	1.5
230	9999	1

D.7 Building Type: Courthouse

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	120	10
121	132	9.5
133	144	9
145	156	8.5
157	168	8
169	180	7.5
181	192	7
193	207	6.5
208	222	6
223	237	5.5
238	252	5
253	267	4.5
268	282	4
283	297	3.5
298	312	3
313	327	2.5
328	342	2
343	357	1.5
358	9999	1

D.8 Building Type: Lodging

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

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	95	10
96	107	9.5
108	119	9
120	131	8.5
132	143	8
144	155	7.5
156	167	7
168	179	6.5
180	191	6
192	206	5.5
207	221	5

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
222	236	4.5
237	251	4
252	266	3.5
267	281	3
282	296	2.5
297	311	2
312	326	1.5
327	9999	1

D.9 Building Type: Medical office

Table D.9. Energy Asset Score table for medical office.

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	190	10
191	205	9.5
206	220	9
221	235	8.5
236	250	8
251	265	7.5
266	280	7
281	298	6.5
299	316	6
317	334	5.5
335	352	5
353	370	4.5
371	388	4
389	406	3.5
407	424	3
425	442	2.5
443	460	2
461	478	1.5
479	9999	1

D.10 Building Type: City Hall

Table D.10. Energy Asset Score table for city hall.

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	80	10
91	100	9.5
101	110	9
111	120	8.5
121	130	8
131	140	7.5
141	150	7
151	160	6.5
161	172	6
173	184	5.5
185	196	5
197	208	4.5
209	220	4
221	232	3.5
233	244	3
245	256	2.5
257	268	2
269	280	1.5
281	9999	1

D.11 Building Type: Parking Garage (Ventilation Only)

Table D.9. Energy Asset Score table for parking garage (ventilation only).

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	10	10
11	13	9.5
14	15	9
16	17	8.5
18	19	8
20	21	7.5
22	24	7
25	27	6.5
28	30	6
31	33	5.5
34	36	5

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
37	39	4.5
40	42	4
43	45	3.5
46	48	3
49	51	2.5
52	54	2
55	57	1.5
58	9999	1

D.12 Building Type: Police Station

Table D.10. Energy Asset Score table for police station.

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	180	10
181	195	9.5
196	210	9
211	225	8.5
226	240	8
241	255	7.5
256	270	7
271	285	6.5
286	303	6
304	321	5.5
322	339	5
340	357	4.5
358	375	4
376	393	3.5
394	411	3
412	429	2.5
430	447	2
448	465	1.5
466	9999	1

D.13 Building Type: Post Office

Table D.11. Energy Asset Score table for post office.

Minimum EUI (kBtu/sq.ft)	Maximum EUI (kBtu/sq.ft)	Asset Score
0	100	10
101	108	9.5
109	116	9
117	124	8.5
125	134	8
135	144	7.5
145	154	7
155	164	6.5
165	174	6
175	184	5.5
185	196	5
197	208	4.5
209	220	4
221	232	3.5
233	244	3
245	256	2.5
257	268	2
269	280	1.5
281	9999	1

Appendix E

Energy Asset Score Data Collection Form

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Building Energy Asset Score: Data Collection Form - *Preview Input Mode*

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

This form contains all of the minimum required data fields necessary to generate an estimated score range and an Asset Score report preview for single-use rectangular buildings. Fields shaded in green are required inputs for using the Asset Score Preview Input Mode of the tool. Fields shaded in yellow will be inferred and may be edited or verified before scoring. Use the Data Collection Form - Full Input Mode Long Version for additional shaped buildings, mixed-use types, complex HVAC systems, and/or available optional fields in the Asset Score Full Input Mode.

Building location	STREET				
	CITY		STATE		POSTAL CODE
Orientation of longest facade (N,S,E,W)			Gross floor area - ft2		
Year completed			Number of floors		

Building Use Type

- ☐ Assisted Living
- ☐ City Hall
- ☐ Community Center
- ☐ Courthouse
- ☐ Education
- ☐ Library
- ☐ Lodging
- ☐ Medical Office
- ☐ Multi-family(4 stories +)
- ☐ Multi-family(less than 4 stories)
- ☐ Office
- ☐ Parking Garage ☐ Ventilation only
- ☐ Post Office
- ☐ Police Station
- ☐ Religious Building
- ☐ Retail
- ☐ Senior Center
- ☐ Warehouse non-refrigerated

Construction Properties

Roof type
- ☐ Built-up with Concrete Deck
- ☐ Built-up with Metal Deck
- ☐ Built-up with Wood Deck
- ☐ Metal Surfacing
- ☐ Shingles/Shakes

Floor type
- ☐ Concrete Slab
- ☐ Slab on Grade
- ☐ Steel Joist
- ☐ Wood Frame

Wall type
- ☐ Brick/stone on Masonry
- ☐ Brick/stone on Steel Frame
- ☐ Brick/stone on Wood Frame
- ☐ Metal Panel/Curtain Wall
- ☐ Siding on Steel Frame
- ☐ Siding on Wood Frame

Window framing type
- ☐ Metal
- ☐ Metal with Thermal Breaks
- ☐ Wood/Vinyl/Fiberglass

Window glass type
- ☐ Single-pane
- ☐ Double-pane
- ☐ Double-pane w/ Low-E
- ☐ Triple-pane
- ☐ Triple-pane w/ Low-E

Window-to-Wall Ratio

Lighting

Major retrofits since construction?	☐ Yes ☐ No	Year of manufacture for major retrofit	

Fixture	Lighting type *(CFL, Fluorescent T5/High Output T5; Fluorescent T8/Super T8; Fluorescent T12/ High Output T12; High-Pressure Sodium; Incandescent/ Halogen; LED, Mercury Vapor; Metal Halide)*	Mounting type *(Recessed, Surface, Pendant)*	Lighting fixture details: *% Served*
a.			
b.			

Heating/Cooling

Major retrofits since construction?	☐ Yes ☐ No	Year of manufacture for major retrofit	

HVAC System *(Equipment Type; Cooling Source; Heating Source; Fuel Type)*	☐ Packaged Terminal Air Conditioner *(Zone Equipment; Terminal DX; Furnace; Gas)* ☐ Four Pipe Fan Coil Unit *(Zone Equipment; Plant Chiller; Plant Boiler; Gas)* ☐ Packaged Terminal Heat Pump *(Zone Equipment; Terminal DX; Heat Pump; Electricity)* ☐ Packaged Rooftop Air Conditioner *(AHU; Central DX; Central Furnace; Gas)* ☐ Packaged Rooftop Heat Pump *(AHU; Central DX; Heat Pump; Electricity)* ☐ Packaged Rooftop VAV with Hot-Water Reheat *(AHU; Central DX; Plant Boiler; VAV-Reheat)* ☐ Packaged Rooftop VAV with Electric Reheat *(AHU; Central DX; Central Furnace; VAV-Reheat)* ☐ VAV with Hot-Water Reheat *(AHU; Plant Chiller; Plant Boiler; VAV-Reheat)* ☐ VAV with Electric Reheat *(AHU; Plant Chiller; Central Furnace; VAV-Reheat)* ☐ Warm Air Furnace *(AHU; No Cooling; Central Furnace; Gas)* ☐ Ventilation Only *(AHU; No Cooling; No Heating)*
Heating Fuel type	☐ Gas ☐ Electricity

Service Hot Water

Major retrofits since construction?	☐ Yes ☐ No	Year of manufacture for major retrofit	
Fuel type	☐ Electric ☐ Gas		

Data Collection Form version 9/30/15

FIELDS SHADED GREEN ARE REQUIRED

FIELDS SHADED YELLOW ARE ONLY REQUIRED IF APPLICABLE

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

Data Collection Form - Full Version

FIELDS SHADED GREEN 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 and tracks closely with the user interface of the Energy Asset Scoring Tool. The Scoring Tool requires the user to --

1) Enter basic building information including data regarding the building's construction assembly (roofs, skylights, windows, walls, floors) and its major energy systems (HVAC, lighting, hot water systems);
2) Create one or more "blocks" to represent the building's geometry and configuration; and
3) Assign assembly components and energy systems to building block(s).

Required vs Optional Data Inputs:

- In order to generate a score for a building, all fields shaded in green are required.
- Fields shaded in yellow are only required if applicable (e.g., if skylights, plant chillers, or plant boilers have been entered).
- Users are encouraged to provide information for the optional data fields where available in order to generate a more accurate score. When optional items are left blank, the Asset Scoring Tool queries a database of energy-system configurations and performance data to infer building parameters based on year of construction and location.

General Building Information

FIELDS SHADED GREEN ARE REQUIRED

Year completed	YEAR IN WHICH THE BUILDING WAS COMPLETED		
Gross floor area*	ft^2		
* Gross floor area (GFA) 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.			
Building location	STREET		
	CITY	STATE	POSTAL CODE

Building use type For mixed-use buildings, choose up to 5 use types. Each use type must be >2500 sq ft and >5% of the total building GFA. Choose "Office" for a college/university building containing mostly offices. If this building includes use types not listed here, exclude that portion of the building when entering data, or contact asset.score@ee.doe.gov for assistance.	☐ Assisted Living ☐ City Hall ☐ Community Center ☐ Courthouse ☐ Education (K-12 School, College/University Training Facilities) ☐ Library ☐ Lodging ☐ Medical Office	☐ Multi-family (4 stories +) ☐ Multi-family (less than 4 stories) ☐ Office ☐ Parking Garage ☐ Post Office ☐ Police Station ☐ Religious Building ☐ Retail ☐ Senior Center ☐ Warehouse non-refrigerated

Construction Properties

FIELDS SHADED GREEN ARE REQUIRED

Make additional copies of this page if your building has more or different roof or floor types.

Roof type Choose applicable roof type.	☐ Built-up with Concrete Deck ☐ Built-up with Metal Deck ☐ Built-up with Wood Deck ☐ Metal Surfacing ☐ Shingles/Shakes
Roof thermal properties Fill in ONLY ONE of the following three data fields. If the building has multiple roof types, record each type separately.	ROOF INSULATION R-VALUE °F•ft2•h/Btu ROOF INSULATION THICKNESS in ROOF ASSEMBLY U-VALUE Btu/°F•ft^2•h

Floor type Choose applicable floor type.	☐ Concrete (over Unconditioned Space) ☐ Slab on Grade ☐ Steel Joist ☐ Wood Frame
Floor thermal properties Fill in ONLY ONE of the following three data fields. If the building has multiple floor types, record each type separately.	FLOOR INSULATION R-VALUE °F•ft^2•h/Btu FLOOR INSULATION THICKNESS in FLOOR ASSEMBLY U-VALUE Btu/°F•ft^2•h
Slab on grade insulation Applicable for Slab-on-Grade Floor Type only.	☐ No insulation ☐ Vertical (Perimeter) insulation Depth (ft)

The scoring tool allows you to edit window properties for each exterior wall surface. Make additional copies of the following section for multiple wall surfaces with different, window types, or properties.

Wall type Choose applicable wall type.	☐ Brick/stone on Masonry ☐ Brick/stone on Steel Frame ☐ Brick/stone on Wood Frame ☐ Metal Panel/Curtain Wall ☐ Siding on Steel Frame ☐ Siding on Wood Frame
Wall thermal properties Fill in ONLY ONE of the following three data fields. If the building has multiple wall types, record each type separately.	WALL INSULATION R-VALUE °F•ft²•h/Btu WALL INSULATION THICKNESS in WALL ASSEMBLY U-VALUE Btu/°F•ft²•h

Window framing type If a wall surface has windows with multiple framing types, choose predominant type in that wall.	☐ Metal ☐ Metal with Thermal Breaks ☐ Wood/Vinyl/Fiberglass
Window glass type If a wall surface has windows with multiple glass types, choose predominant type in that wall.	☐ Single-pane ☐ Double-pane ☐ Double-pane w/ Low-E ☐ Triple-pane ☐ Triple-pane w/ Low-E
Window gas fill type	☐ Air (default) ☐ Other
Window U-value	Btu/°F•ft²•h
Window solar heat gain coefficient (SHGC)	(range 0-1)
Window visible transmittance (VT)	(range 0-1)

Skylight type Choose applicable skylight glazing material.	☐ Glass ☐ Plastic (default)
Skylight U-value	Btu/°F•ft²•h
Skylight solar heat gain coefficient (SHGC)	(range 0-1)
Skylight visible transmittance (VT)	(range 0-1)
Skylight layout	☐ All Zones ☐ Core Only (default)
Percent of roof area Estimate the percent of the roof area covered in skylights.	%

Lighting

FIELDS SHADED GREEN ARE REQUIRED

Make additional copies of this page if the same lighting type has different fixture configurations

Fixture	Lighting type	Mounting type Recessed Surface Pendant	Watts per Lamp	Number of Lamps in Fixture (up to 12)
a.	Compact fluorescent			
b.	Fluorescent T5			
c.	Fluorescent T5 - High Output			
d.	Fluorescent T8			
e.	Fluorescent T8 - High Efficiency			
f.	Fluorescent T12			
g.	High-pressure sodium			
h.	Incandescent/Halogen			
i.	LED			
j.	Mercury vapor			
k.	Metal halide			

HVAC System

If the HVAC system of your building includes a Central Plant (e.g. District chilled water; District hot water, chiller, or boiler), as the heating and/or cooling source, then complete the relevant “Plant Equipment” section(s), then proceed to the ‘HVAC Distribution Equipment’ section(s). Otherwise, go directly to the ‘HVAC Equipment’ section(s)

See Appendix C—Typical HVAC Systems as Configured in Asset Score for examples of how common HVAC systems may be entered into the Asset Score Tool.

Central Plant Equipment: Cooling

FIELDS SHADED GREEN ARE REQUIRED

This section is ONLY for buildings with a cooling plant.

Cooling plant type	☐ Chiller ☐ District Chilled Water
Chilled Water Reset	☐ Yes ☐ No (default)
Chiller Pump Control	☐ Constant Primary (default) ☐ Constant Primary; Variable Secondary
Chiller compressor type	☐ Reciprocating ☐ Screw/scroll (default) ☐ Centrifugal
Chiller condenser type	☐ Air (default) ☐ Water
Condenser Pump Control *Applicable ONLY if condenser type is water*	☐ Constant Speed (default) ☐ Variable Speed
Cooling Tower Fan Control *Applicable ONLY if condenser type is water*	☐ Single Speed (default) ☐ Variable Speed

If Chiller was selected as the Cooling plant type, complete the items below

Year of manufacture 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.	YEAR
Number of pieces of cooling equipment Enter the total number regardless of size	#
Cooling equipment efficiency For multiple pieces of equipment with various efficiencies, enter the weighted average efficiency of the predominant equipment. To convert from different heating/cooling units, see Appendix B—HVAC Unit Conversion table. Note: If you specify the equipment's efficiency, the year of manufacture will not be used.	COP
Average output capacity For multiple pieces of equipment, enter the average capacity for all pieces of equipment.	tons

Central Plant Equipment: Heating

FIELDS SHADED GREEN ARE REQUIRED

This section is ONLY for buildings with a heating plant.

Heating plant type	☐ Boiler ☐ District Hot Water
Boiler fuel type	☐ Gas (default) ☐ Electricity
Boiler draft type	☐ Mechanical (default) ☐ Other draft

If Boiler was selected as the Heating plant type, complete the items below

Year of manufacture 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.	YEAR
Number of pieces of heating equipment Enter the total number regardless of size	#
Heating equipment efficiency For multiple pieces of equipment with various efficiencies, enter the weighted average efficiency of the predominant equipment. To convert from different heating/cooling units, see Appendix B—HVAC Unit Conversion table. Note: If you specify the equipment's efficiency, the year of manufacture will not be used.	%
Average output capacity For multiple pieces of equipment, enter the average capacity for all pieces of equipment.	KBtu/hr

HVAC Equipment

FIELDS SHADED GREEN ARE REQUIRED

Distribution equipment	☐ Air Handler Unit (AHU) ☐ Zone Equipment (e.g. fan coil, forced air, or packaged terminal units
Cooling source	☐ No cooling ☐ DX Coil ☐ Central Plant
Heating source	☐ No heating ☐ Central Furnace ☐ Heat Pump (electric) ☐ Central Plant
Furnace/Heat Pump fuel type	☐ Electricity ☐ Gas (default)

Complete the items below if DX coils were selected as the Cooling source

Year of manufacture 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.	YEAR
Number of pieces of cooling equipment Enter the total number regardless of size	#
Cooling equipment efficiency For multiple pieces of equipment with various efficiencies, enter the weighted average efficiency of the predominant equipment. To convert from different heating/cooling units, see Appendix B—HVAC Unit Conversion table. Note: If you specify the equipment's efficiency, the year of manufacture will not be used.	COP
Average output capacity For multiple pieces of equipment, enter the average capacity for all pieces of equipment.	tons

Complete the items below if Central Furnace or Heat Pump were selected as the Heating source

Year of manufacture 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.	YEAR
Number of pieces of heating equipment Enter the total number regardless of size	#
Heating equipment efficiency For multiple pieces of equipment with various efficiencies, enter the weighted average efficiency of the predominant equipment. To convert from different heating/cooling units, see Appendix B—HVAC Unit Conversion table. Note: If you specify the equipment's efficiency, the year of manufacture will not be used.	☐ % (Central Furnace) ☐ COP (Heat Pump)
Average output capacity For multiple pieces of equipment, enter the average capacity for all pieces of equipment.	KBtu/hr

Air Handler Unit

FIELDS SHADED GREEN ARE REQUIRED

Complete the items below if AHU was selected as the HVAC Distribution equipment type

Distribution

Distribution Type	☐ Single Zone AHU (default) ☐ Multi Zone AHU
Terminal Unit *Applicable ONLY for systems with Multi-zone AHU*	☐ Reheat ☐ Powered Induction Unit

Fan Systems

Fan motor efficiency	%
Fan efficiency	%
Economizer	☐ Yes ☐ No (default)
Demand Control Ventilation	☐ Yes ☐ No (default)
Fan control	☐ Constant Air Volume (default) ☐ Variable Air Volume
Supply Air Temperature (SAT) Reset *Applicable ONLY if fan control is variable*	☐ Yes ☐ No (default)
Fan Static Pressure Reset *Applicable ONLY if fan control is variable*	☐ Yes ☐ No (default)

Service Hot Water

FIELDS SHADED GREEN ARE REQUIRED

Fuel type	☐ Electric ☐ Gas
Use of heat pump equipment	☐ Yes ☐ No (default)
Distribution type	☐ Looped ☐ Distributed
Water heater efficiency	%
Tank volume	gallons
Tank insulation thickness	in
Tank insulation R-value	°F•ft^2•h/Btu
Use of Low Flow Faucets	☐ Yes ☐ No (default)

Building Operations

FIELDS SHADED GREEN ARE REQUIRED

Information about your building's operations 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
Total occupants	
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	
Setpoint, heating	°F
Setpoint, cooling	°F

Operating Hours

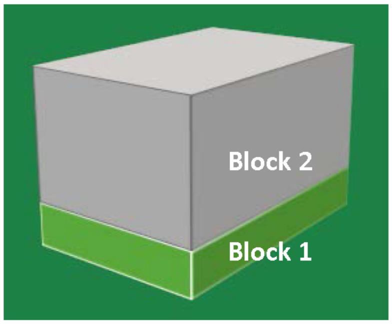
Opening time - closing time (weekdays)		to	
Opening time - closing time (Saturday)		to	
Opening time - closing time (Sunday)		to	

Elevators

Elevator Type Buildings with fewer than 6 floors typically have hydraulic elevators. Buildings with 6 or more floors typically have traction elevators.	☐ Hydraulic ☐ Traction
Number of Elevators	
Year of Manufacture	

Block Geometry and Component Configuration

The energy asset score tool is designed to permit modeling a building with one or more 'blocks' that represent building sections with distinctly different energy assets or physical configurations. Most buildings may be scored as one block unless at least one of the follow situations applies:



a. The building has sections with different numbers of floors
b. The building footprint cannot be simplified by using only one of the available basic footprint shapes—rectangle, L-, T-, H-, or U-shape
c. Different parts of the building are served by different types of HVAC systems. (e.g., Block 1 is served by a local chiller; Block 2 is served by packaged DX units. Note that this does NOT refer to multiple pieces or sizes of equipment of the same type.)
d. The building is mixed-use. (e.g., Block 1 is retail; Block 2 is office.)
e. The building has sections with different operating schedules and/or internal loads. (e.g., Block 1 is occupied 16 hour per day; Block 2 is occupied 8 hours per day. Note that different operating conditions do NOT affect a building's asset score, but are considered in the economics of upgrade opportunities.)

Instructions:
1) Choose applicable block footprint shape and indicate dimensions for each surface (exterior wall)
2) Record window-to-wall ratios or the number and dimensions of the windows for each surface of the shape
3) Enter lighting power density options for the block
4) Enter HVAC system thermal zone layout for the block.

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

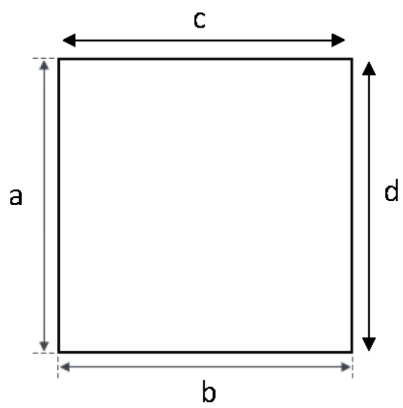
Block footprint shape	☐ Rectangular ☐ L-Shape ☐ T-Shape ☐ H-Shape ☐ U-Shape
Block name	
Number of floors	ABOVE GROUND
	BELOW GROUND
Average floor-to-floor height (default is 12 ft)	Ft
Average floor-to-ceiling height (default is 9 ft)	Ft
Orientation (default is 0.0 ○)	CLOCKWISE DEGREES FROM NORTH
Orientation 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.	

Block dimensions
Enter the external dimensions (ft) of the block. The tool will automatically calculate the Total Block Floor Area (square feet).

Window to wall ratio
Every surface with a window must have a valid window-to-wall ratio. Select either a 'Continuous' (manually calculated) or 'Discrete' (calculated by the Tool) Window Layout approach for the window-to-wall ratio of your building. Refer to the Appendix B: Window Layout diagrams for assistance in recording data. If window-to-wall ratios are equivalent on all sides, you only need to record this information once.

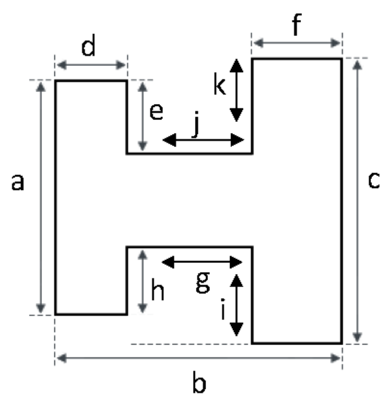
Footprint Shapes

Rectangular



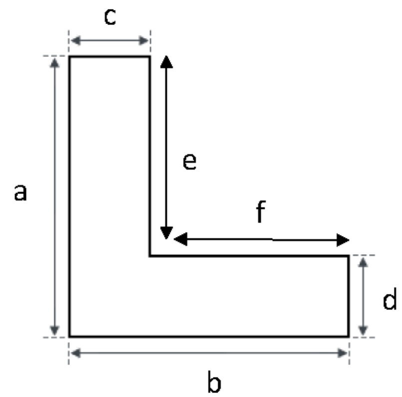
Blocksurface (wall)		Window Layout				Daylight Controls (yes/no)
		Continuous	Discrete			
		Window-to-Wall Ratio	Window Width	Window Height	# of Windows	
a =	ft	%	ft	ft		☐
b =	ft	%	ft	ft		☐
c =	ft	%	ft	ft		☐
d =	ft	%	ft	ft		☐

H-Shape



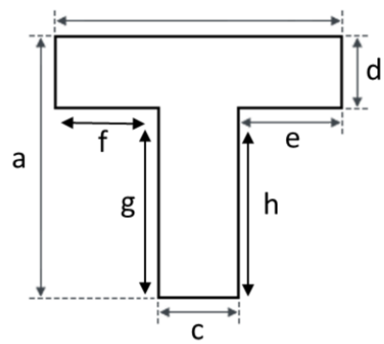
Blocksurface (wall)		Window Layout				Daylight Controls (yes/no)
		Continuous	Discrete			
		Window-to-Wall Ratio	Window Width	Window Height	# of Windows	
a =	ft	%	ft	ft		☐
b =	ft	%	ft	ft		☐
c =	ft	%	ft	ft		☐
d =	ft	%	ft	ft		☐
e =	ft	%	ft	ft		☐
f =	ft	%	ft	ft		☐
g =	ft	%	ft	ft		☐
h =	ft	%	ft	ft		☐
i =	ft	%	ft	ft		☐
j =	ft	%	ft	ft		☐
k =	ft	%	ft	ft		☐
l =	ft	%	ft	ft		☐

L-Shape



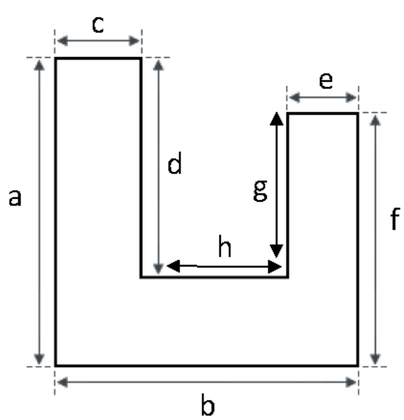
Blocksurface (wall)		Window Layout				Daylight Controls (yes/no)
		Continuous	Discrete			
		Window-to-Wall Ratio	Window Width	Window Height	# of Windows	
a =	ft	%	ft	ft		☐
b =	ft	%	ft	ft		☐
c =	ft	%	ft	ft		☐
d =	ft	%	ft	ft		☐
e =	ft	%	ft	ft		☐
f =	ft	%	ft	ft		☐

T-Shape



Blocksurface (wall)		Window Layout				Daylight Controls (yes/no)
		Continuous	Discrete			
		Window-to-Wall Ratio	Window Width	Window Height	# of Windows	
a =	ft	%	ft	ft		☐
b =	ft	%	ft	ft		☐
c =	ft	%	ft	ft		☐
d =	ft	%	ft	ft		☐
e =	ft	%	ft	ft		☐
f =	ft	%	ft	ft		☐
g =	ft	%	ft	ft		☐
h =	ft	%	ft	ft		☐

U-Shape



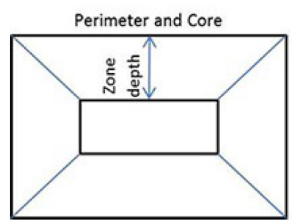
Blocksurface (wall)		Window Layout				Daylight Controls (yes/no)
		Continuous	Discrete			
		Window-to-Wall Ratio	Window Width	Window Height	# of Windows	
a =	ft	%	ft	ft		☐
b =	ft	%	ft	ft		☐
c =	ft	%	ft	ft		☐
d =	ft	%	ft	ft		☐
e =	ft	%	ft	ft		☐
f =	ft	%	ft	ft		☐
g =	ft	%	ft	ft		☐
h =	ft	%	ft	ft		☐

Lighting Fixture Details

Every fixture in a block must have either a percentage served value OR the total number of fixtures entered for the calculation of lighting power density (watts per square foot). Refer to the Lighting types selected in the Lighting section to complete the table below.

Fixture	Lighting type	Total Number of Fixtures	% Area Served	Occupancy Controls (yes/no)
a.	Compact fluorescent			
b.	Fluorescent T5			
c.	Fluorescent T5 - High Output			
d.	Fluorescent T8			
e.	Fluorescent T8 - High Efficiency			
f.	Fluorescent T12			
g.	High-pressure sodium			
h.	Incandescent/Halogen			
i.	LED			
j.	Mercury vapor			
k.	Metal halide			

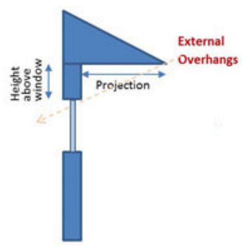
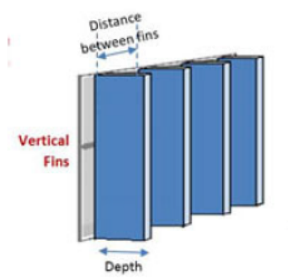
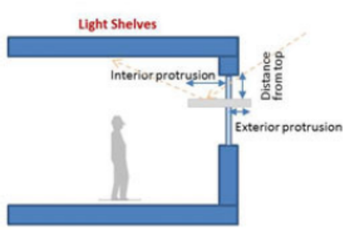
HVAC Thermal Zones



A building may be divided into thermal zones to reflect sections of the building that may have similar thermal loads, share a common thermostat, or are served by the same HVAC system. Your building may include either a single thermal zone or may be divided into four perimeters zones and one core zone (perimeter and core). If you don't know the thermal zone layout of your building, choose 'Single zone' for small buildings and 'Perimeter and core' for large buildings.

Thermal Zone Layout	☐ Single zone (default) ☐ Perimeter and core PERIMETER ZONE DEPTH (FT)
Carbon Monoxide (CO) Sensors *Applicable ONLY if the building use type is Parking Garage*	☐ Yes ☐ No (default)

Optional Window Block Entries

<table>
<tr><td colspan="2">Window Exterior Shading Type</td><td>☐ No shading
☐ External overhangs
☐ Vertical fins
☐ Light shelves</td></tr>
<tr><td rowspan="2">
</td><td>Overhang: Height above window</td><td>ft</td></tr>
<tr><td>Overhang: Projection</td><td>ft</td></tr>
<tr><td rowspan="3">
</td><td>Vertical fins: Fin depth</td><td>ft</td></tr>
<tr><td>Vertical fins: Distance between fins</td><td>ft</td></tr>
<tr><td>Vertical fins:
Edge fin only</td><td>☐ Yes
☐ No</td></tr>
<tr><td rowspan="3">
</td><td>Light shelves: Distance from top</td><td>ft</td></tr>
<tr><td>Light shelves: Exterior protrusion</td><td>ft</td></tr>
<tr><td>Light shelves: Interior protrusion</td><td>ft</td></tr>
</table>

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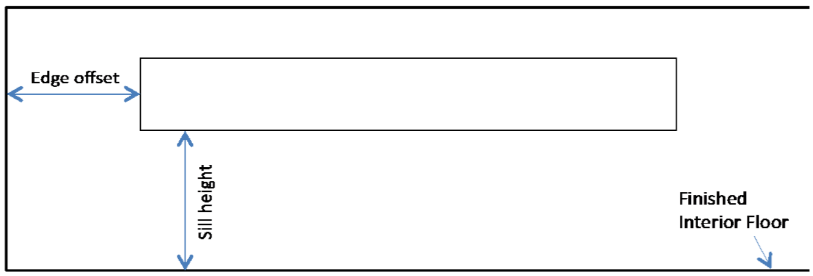
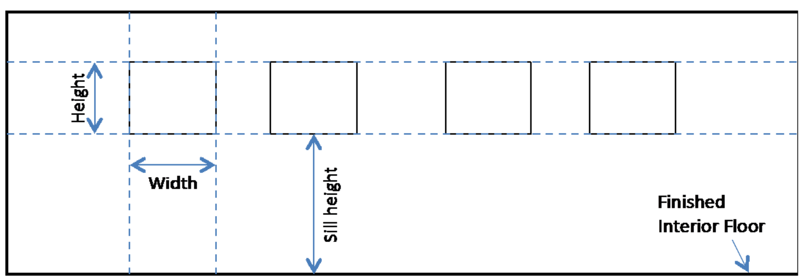
Appendix A: Window layout

Continuous window layout—Manually calculate and enter the *Window-to-Wall Ratio*. The *Edge offset* and *Sill height* of the windows may be added per the following diagram (optional):



Discrete window layout—Enter the *number of windows* and the *width* and *height* of the windows per the following diagram, and the Tool will calculate the window-to-wall ratio:



Appendix B:

HVAC Unit Conversion table

Cooling			
1	**SEER to COP Conversion**		
	Step 1	EER	$(-0.0182 \times (SEER)^2) + (1.1088 \times SEER)$
	Step 2	COP	EER/3.413
2	**EER to COP Conversion**		
		COP	EER/3.412
3	**kW/ton to COP Conversion**		
		COP	(12/(kw/ton))/3.412

Heating			
1	**HSPF to COP Conversion**		
		COP	(-0.0255 x (HSPF)2) +(0.6239 * HSPF)
2	**AFUE to Thermal Efficiency for gas Furnaces**		
	All Single Packaged Equipment		
		E_t	0.005163 X AFUE + 0.4033
	All Split Systems (With AFUE <= 83.5)		
		E_t	0.002907 x AFUE +0.5787
	All Split Systems (With AFUE > 83.5)		
		E_t	0.011116 X AFUE - 0.098185
3	**AFUE to Thermal Efficiency for Boilers**		
	For 75% <= AFUE <80%		
		E_t	0.1 X AFUE + 72.5%
	For 80% <= AFUE <= 100%		
		E_t	0.875 X AFUE + 10.5%
4	**Combustion Effiiency to Thermal Efficiency**		
		E_t	E_c - 2%

Appendix C:

Typical HVAC Systems as Configured in Asset Score

Common Term	Asset Score Fields				
	Distribution Equipment (AHU or Zone)	Cooling Source	Heating Source	Fan Control	Distribution
Packaged Roof Top Unit (RTU)	AHU	DX Coil (Central)	Central Furnace (gas or electric)	Constant or Variable Volume (CAV/VAV)	Single Zone / Multi-Zone
Packaged Rooftop Heat Pump	AHU	DX Coil (Central)	Heat Pump (electric)	Constant or Variable Volume (CAV/VAV)	Single Zone / Multi-Zone
Central Plant Chiller/Boiler (AHU)	Central Plant - AHU	Chiller	Boiler	Constant or Variable Volume (CAV/VAV)	Single Zone / Multi-Zone
Packaged Terminal Air Conditioner (PTAC)	Zone	DX Coil (Terminal)	Central Furnace (gas or electric)	Constant Volume (Default)	N/A
Packaged Terminal Heat Pumps (PTHP)	Zone	DX Coil (Terminal)	Heat Pump (electric)	Constant Volume (Default)	N/A
Central Plant Chiller/Boiler (fan coil unit)	Central Plant - Zone	Central Plant - Chiller	Central Plant - Boiler	Constant Volume (Default)	N/A

Appendix F

Energy Asset Score Report

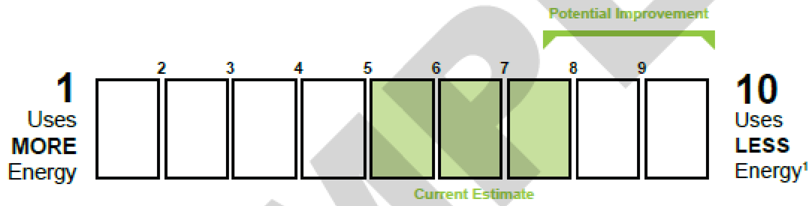
BUILDING ENERGY
ASSET SCORE Preview
OVERALL BUILDING SCORE

BUILDING INFORMATION

Example Building - Preview Input Mode
2000 A Street
Chicago, IL 60601

Building Type: **Office**
Gross Floor Area: **100,000 ft²**
Year Built: **2005**

Score Date: **09/23/2015**
Building ID #: **XXXXX**



Score range note:

Current score: Your building is likely to receive an Asset Score between 5.0 and 8.0 in Full Input Mode.
Potential score: On average, similar buildings may improve 2.5 point(s) with cost-effective upgrades.
Energy savings: On average, similar buildings may use 30% less energy with cost-effective upgrades.

Switch to Full Input Mode to add additional building data and generate an Asset Score report with cost effective upgrades

The **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 building based on the building's structure, heating, cooling, ventilation, and hot water systems. On Asset Score Full Version Reports, the building's **Structure and Systems** are individually evaluated and ranked. The **Upgrade Opportunities** page provides recommendations for how to improve the building's energy efficiency, increase the building's Asset Score, and save money.

[1] A score of 10 represents lowest expected energy usage using current energy efficiency technologies. A score of 8.5 represents a high-efficiency building that uses approximately 30% less energy than a building built to the AHSRAE 90.1-2004 energy code.

This report is based on self-reported building information. http://energy.gov/eere/buildings/building-energy-asset-score

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY

ASSET SCORE Preview

BUILDING ASSETS

Building Name: **Example Building - Preview Input Mode**

Gross Floor Area: **100,000 ft²**

BUILDING SYSTEM CHARACTERISTICS SUMMARY

Building Details

Building Shape	Rectangle*
Number of Floors	2
Orientation	North/South
Use Type	Office
Major retrofits since construction	No

Roof

Roof Type	Built-up w/ metal deck

Floor

Floor Type	Slab-on-Grade

Walls and Windows

Wall Type	Brick/Stone on masonry
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Layout	Continuous*
Window-to-Wall Ratio	0.4

Lighting

Lighting Type	Recessed Fluorescent T8
Percent of Total Floor area	100.0%

Service Water Heating

Fuel Type	Gas

Heating/Cooling

HVAC System Type	Packaged Rooftop Air Conditioner
Cooling Source	Central DX
Heating Source	Central Furnace
Fuel Type	Gas

Operations

Using Standard Operations**

Standard operating assumptions are used for scoring this building. These can be provided in the Full Input Mode and are only used to identify upgrade opportunities, which would be considered in generating the potential score.

Assumed Occupants	500
Hours of Operation	48.6 hrs/wk
Setpoint Cooling	75.0 F°
Setpoint Heating	70.0 F°
Misc. Energy Loads	0.75 W/ft²

* This value was not directly entered by the user. It was generated by the Asset Scoring Tool based on other building data provided. The user can re-score the building in Full Input Mode using actual information about this building characteristic if available.

** Standard operating assumptions are used for building optimization if no values are entered by the user.

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY

ASSET SCORE

OVERALL BUILDING SCORE

BUILDING INFORMATION

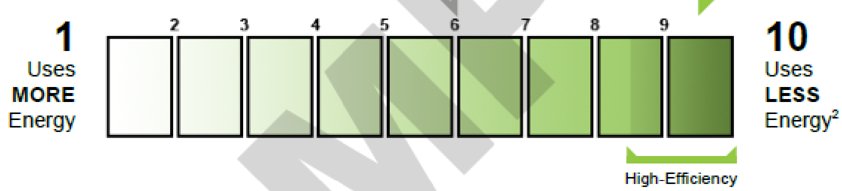
Example Building - Mixed Use
2000 A Street
Chicago, IL 60601

Building Type:	**Mixed Use**	Score Date:	**09/22/2015**
Gross Floor Area:	**140,000 ft²**	Building ID #:	**XXXXX**
Year Built:	**2005**		

Potential Score 9.5

Estimated Savings[1] 47%

Current Score 6



Building Use Types

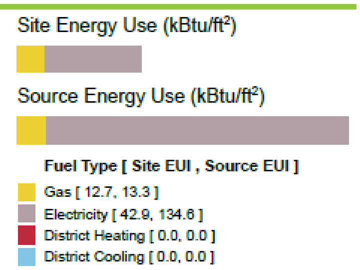
Office:	**100,000 ft²**
Retail:	**40,000 ft²**

This report includes a Score for the entire building as well as individual Scores for each of the separate use types.

Estimated Source Energy Use (kBtu/ft²)

Current Building	148
Upgraded Building	78

Energy Use Intensity by Fuel Type



The **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 building based on the building's structure, heating, cooling, ventilation, and hot water systems. The building's **Structure and Systems** are individually evaluated and ranked. The **Upgrade Opportunities** page provides recommendations for how to improve the building's energy efficiency, increase the building's Asset Score, and save money.

[1] Savings reflect the reduction in source energy that would result from undertaking all of the efficiency improvements identified on the Opportunities page. Actual savings will depend on a variety of factors including actual operating conditions.

[2] A score of 10 represents lowest expected energy usage using current energy efficiency technologies. A score of 8.5 represents a high-efficiency building that uses approximately 30% less energy than a building built to the AHSRAE 90.1-2004 energy code.

This report is based on self-reported building information. http://energy.gov/eere/buildings/building-energy-asset-score

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE

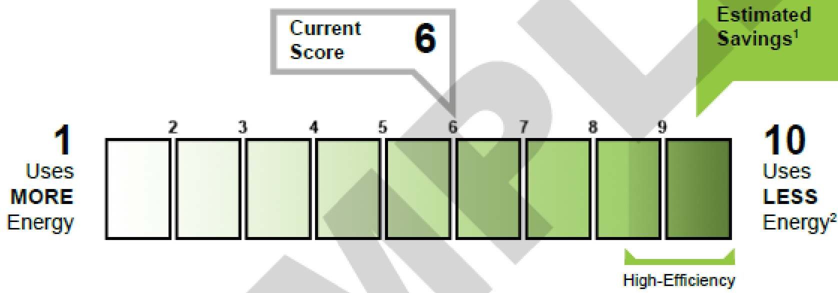
SCORE: OFFICE PORTION

Building Name: **Example Building - Mixed Use**

Gross Floor Area: **100,000 ft²**

Potential Score **9.5**

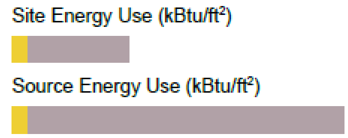
Estimated Savings[1] **47%**



Standard Occupancy and Operating Conditions	
Number of Assumed Occupants	499
Hours of Operation	48.6 hrs/wk
Cooling Set Point	75° F
Heating Set Point	70° F
Misc. Energy Loads	0.75 W/ft²

Estimated Source Energy Use (kBtu/ft²)	
Current Building	144
Upgraded Building	77

Energy Use Intensity by Fuel Type



Fuel Type [Site EUI , Source EUI]

- Gas [6.8, 7.1]
- Electricity [43.5, 136.6]
- District Heating [0.0, 0.0]
- District Cooling [0.0, 0.0]

[1] Savings reflect the reduction in source energy that would result from undertaking all of the efficiency improvements identified on the **Opportunities** page. Actual savings will depend on a variety of factors including actual operating conditions.

[2] A score of 10 represents lowest expected energy usage using current energy efficiency technologies. A score of 8.5 represents a high-efficiency building that uses approximately 30% less energy than a building built to the AHSRAE 90.1-2004 energy code.

This report is based on self-reported building information. http://energy.gov/eere/buildings/building-energy-asset-score

U.S. DEPARTMENT OF **ENERGY**

Example report version 9/30/15

BUILDING ENERGY

ASSET SCORE

SCORE: RETAIL PORTION

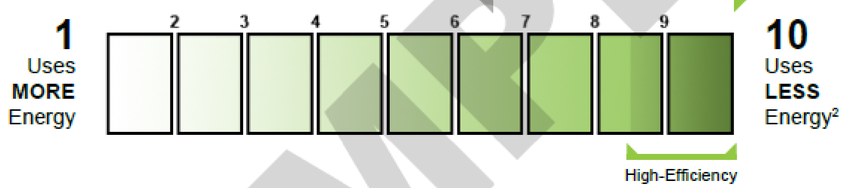
Building Name: **Example Building - Mixed Use**

Gross Floor Area: **40,000 ft²**

Potential Score 10

Estimated Savings[1] 48%

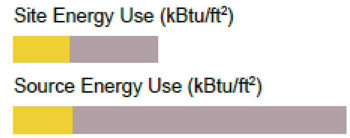
Current Score 6.5



Standard Occupancy and Operating Conditions	
Number of Assumed Occupants	597
Hours of Operation	46.3 hrs/wk
Cooling Set Point	75° F
Heating Set Point	70° F
Misc. Energy Loads	0.30 W/ft²

Estimated Source Energy Use (kBtu/ft²)	
Current Building	159
Upgraded Building	82

Energy Use Intensity by Fuel Type



Fuel Type [Site EUI , Source EUI]

- Gas [27.5, 28.8]
- Electricity [41.3, 129.8]
- District Heating [0.0, 0.0]
- District Cooling [0.0, 0.0]

[1] Savings reflect the reduction in source energy that would result from undertaking all of the efficiency improvements identified on the **Opportunities** page. Actual savings will depend on a variety of factors including actual operating conditions.

[2] A score of 10 represents lowest expected energy usage using current energy efficiency technologies. A score of 8.5 represents a high-efficiency building that uses approximately 30% less energy than a building built to the AHSRAE 90.1-2004 energy code.

This report is based on self-reported building information. http://energy.gov/eere/buildings/building-energy-asset-score

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE
UPGRADE OPPORTUNITIES

Building Name: **Example Building - Mixed Use** Gross Floor Area: **140,000 ft²**

Cost Effective Upgrade Opportunities	Energy Savings [3]	Cost [4]
Building Envelope		
• Add roof insulation in Office Block, Retail Block - *Learn More*	High	$ - $$
• Install high performance triple pane windows in Office Block, Retail Block - *Learn More*	High	$$ - $$$
Interior Lighting		
• Upgrade T8 fluorescent lighting in Office Block, Retail Block with LED lighting - *Learn More*	Medium	$$
• Add daylighting controls in Office Block, Retail Block - *Learn More*	Low	$$
HVAC Systems		
• Add air-side economizer in Office Block, Retail Block - *Learn More*	Medium	$-$$
• Implement demand controlled ventilation (DCV) in Office Block, Retail Block - *Learn More*	Medium	$$
• Add variable frequency drive to supply fans in Office Block, Retail Block - *Learn More*	Medium	$$
Hot Water Systems		
• Add low flow faucets in Retail Block, Office Block - *Learn More*	Low	$$

[3] The energy savings range reflects the expected incremental savings for the overall building associated with the specific efficiency upgrade opportunity assuming all other recommended upgrades have already been implemented. This assumption is made to avoid double counting of savings. The ranges reflect site energy savings and are based on standard operating assumptions, unless actual operating conditions are provided by the user.

[4] The costs are based on Advanced Energy Retrofit Guide and RS Means. The costs are replacement costs, not incremental costs. The costs do not include local incentives. Costs are shown as a range ($ = low cost, $$ = medium cost, $$$ = high cost).

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE
STRUCTURES AND SYSTEMS

5

Building Name: **Example Building - Mixed Use**

Gross Floor Area: **140,000 ft²**

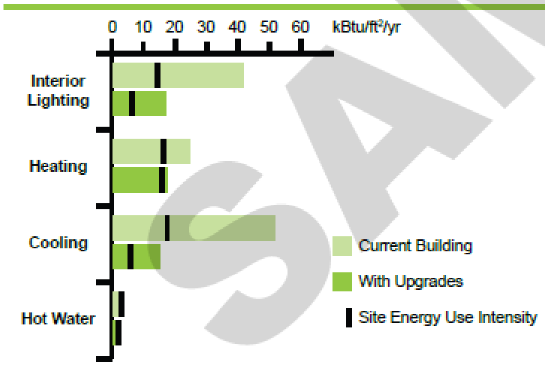
ABOUT THE BUILDING SYSTEMS

	Ranking[5]
Interior Lighting	Superior
Heating	Superior
Cooling	Good
Overall HVAC Systems	Superior

ABOUT THE BUILDING ENVELOPE

	Ranking[5]
Roof U-Value, Non-Attic (Btu/ft² h °F)	Good
Walls U-Value, Framed (Btu/ft² h °F)	Superior
Windows U-Value (Btu/ft² h °F)	Fair
Walls + Windows U-Value (Btu/ft² h °F)	Fair
Window Solar Heat Gain Coefficient	Good

SOURCE ENERGY USE INTENSITY BY END USE



[5] Ranking Range:
Fair: Building Envelope or Building Systems are less efficient than a typical building built to the AHSRAE 90.1-2004 energy code.
Superior: Building Envelope is more efficient than a typical building built to the AHSRAE 90.1-2013 energy code. Building Systems exceed the highest efficiency levels with market viable technologies.
Good: Building Envelope or Building Systems are between Fair and Superior.

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE 6
BUILDING ASSETS

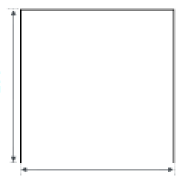
Building Name: **Example Building - Mixed Use** Gross Floor Area: **100,000 ft²**

Office Block CHARACTERISTICS SUMMARY

Geometry

Current Building

Above Ground:	2 floors
Below Ground:	0 floors
Floor-to-Floor Height	14.00 ft
Floor-to-Ceiling Height:	9.00 ft
Orientation:	0.0° from North
Use Type:	Office



Current Building

Roof

Roof Type	Built-up w/ metal deck
Roof U-value	0.056 Btu/F°-ft²-h

Skylights

No Skylights

Floor

Floor Type	Slab-on-Grade
Floor U-value	Estimated*

Walls and Windows

Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs
Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs
Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs
Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40

* This value was not directly entered by the user. It was generated by the Asset Scoring Tool based on other building data provided. The user can re-score the building using actual information about this building characteristic if available.

** Standard operating assumptions are used for building optimization if no values are entered by the user.

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE
BUILDING ASSETS

Building Name: **Example Building - Mixed Use** Gross Floor Area: **100,000 ft²**

	Current Building
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs

Lighting

Recessed Fluorescent T8	100.0% served

Heating/Cooling

Cooling	Central DX
Efficiency	Estimated*
Heating	Central Furnace
Efficiency	82.00%

Service Water Heating

Fuel Type	Gas
Distribution Type	Distributed
Water Heater Efficiency	80.0%

Operations

The information in this section is not required and does not affect the current Asset Score. If provided, it is only used to identify upgrade opportunities, which are considered in generating the potential score.

Miscellaneous Electric Load	4.00 W/ft²
Miscellaneous Gas Load	Standard**
Total Occupants	450 total occupants
Setpoint Heating	72.0 F°
Setpoint Cooling	76.0 F°
Weekdays	8:00am - 7:00pm

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U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE
BUILDING ASSETS

Building Name: **Example Building - Mixed Use**

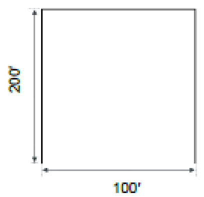
Gross Floor Area: **40,000 ft²**

Retail Block CHARACTERISTICS SUMMARY

Geometry

Current Building

Above Ground:	2 floors
Below Ground:	0 floors
Floor-to-Floor Height	14.00 ft
Floor-to-Ceiling Height:	9.00 ft
Orientation:	0.0° from North
Use Type:	Retail



Current Building

Roof

Roof Type	Built-up w/ metal deck
Roof U-value	0.056 Btu/F°-ft²-h

Skylights

No Skylights

Floor

Floor Type	Slab-on-Grade
Floor U-value	Estimated*

Walls and Windows

Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs

Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs

Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs

Surface	
Wall Type	Brick/Stone on masonry
Wall U-value	Estimated*
Window Framing Type	Metal
Window Glass Type	Single Pane
Window Gas Fill Type	None
Window Layout	Continuous
Window-to-Wall Ratio	0.40

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U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

BUILDING ENERGY
ASSET SCORE
BUILDING ASSETS

Building Name: **Example Building - Mixed Use**

Gross Floor Area: **40,000 ft²**

	Current Building
Window U-value	0.68 Btu/F°-ft²-h
Window SHGC	0.6
Window VT	Estimated*
Exterior Shading Type	External Overhangs

Lighting

Recessed Fluorescent T8	100.0% served

Heating/Cooling

Cooling	Central DX
Efficiency	Estimated*
Heating	Central Furnace
Efficiency	82.00%

Service Water Heating

Fuel Type	Gas
Distribution Type	Distributed
Water Heater Efficiency	80.0%

Operations

The information in this section is not required and does not affect the current Asset Score. If provided, it is only used to identify upgrade opportunities, which are considered in generating the potential score.

Miscellaneous Electric Load	1.00 W/ft²
Miscellaneous Gas Load	Standard**
Total Occupants	450 total occupants
Setpoint Heating	72.0 F°
Setpoint Cooling	76.0 F°
Weekdays	8:00am - 7:00pm

* This value was not directly entered by the user. It was generated by the Asset Scoring Tool based on other building data provided. The user can re-score the building using actual information about this building characteristic if available.

** Standard operating assumptions are used for building optimization if no values are entered by the user.

U.S. DEPARTMENT OF ENERGY

Example report version 9/30/15

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 ($/Unit)
	Chilled Water ($/ton-hr)	All Months	All	All	1-24	$0.10
2B	Electricity ($/kWh)	Summer (June-August)	Weekdays	Peak	9-21	$0.207
				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	$11.77
	Chilled Water ($/ton-hr)	All Months	All	All	1-24	$0.10
3A	Electricity ($/kWh)	Summer (June-August)	Weekdays	Peak	12-19	$0.292
				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

Upgrade Measures

Appendix H

Building Upgrade Measures

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.***

Control

- Add Air-Side Economizer
- Add Variable Frequency Drive to Cooling Tower Fan
- Add Variable Frequency Drive to Condenser Pumps
- Implement Chilled Water Temperature Reset
- Upgrade Cooling Plant Pumping System to Constant Primary-Variable Secondary Pumping System
- Implement Demand Controlled Ventilation
- Implement Fan Static Pressure Reset
- Implement Supply Air Temperature Reset
- Add Low Flow Faucets
- Add Daylighting Sensors for Perimeter Spaces

Appendix I

Data Validation List

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
Building Properties	New Building/Building Properties	Building Name	name	buildings	String	--	--	--	Yes	yes	Name can't be blank.	
	New Building/Building Properties	Year Completed	year_of_construction	buildings	Integer	>1900	years	--	Yes	yes	This field is required.	Please enter a value greater than or equal to 1900.
	New Building/Building Properties	Gross Floor Area	total_floor_area	buildings	Integer	--	ft2	--	Yes	yes	This field is required.	
	New Building/Building Properties	Street	address	buildings	String	--	--	--	Yes	yes	This field is required.	
	New Building/Building Properties	City	city	buildings	String	--	--	--	Yes	yes	This field is required.	
	New Building/Building Properties	n/a - pull down menu	state	buildings	String	--	--	Alabama	Yes	n/a	n/a	
	New Building/Building Properties	Postal Code	zip_code	buildings	Integer	--	--	--	Yes	yes	This field is required.	Please enter at least 5 characters; Please enter no more than 5 characters; Please enter only digits.
	New Building/Building Properties		notes	buildings	Memo	--	--	--	No	n/a	n/a	
Block	New/Edit Block	n/a	name	blocks	String	--	--	--	Yes	yes	Untitled block (red); Block name must be unique.	The building must have at least one block.
	New/Edit Block	n/a	is_above_ground	blocks	Boolean	Y/N	--	Yes (Above)	Yes	n/a		
	New/Edit Block	Number of Floors	number_of_floors	blocks	Integer	1-500	number	1	Yes	yes	Please enter a value less than or equal to 500.	Please enter only digits.

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Block	Avg. Floor-to-Floor Height	floor_to_floor_height	blocks	Integer	>9	ft	12	Yes	yes	Please enter a value greater than or equal to 9.	
	New/Edit Block	Avg. Floor-to-Ceiling Height	floor_to_ceiling_height	blocks	Integer	>0	ft	9	Yes	yes	Floor-to-ceiling height must be less than or equal to floor-to-floor height.	Please enter a valid number.
	New/Edit Block	Orientation	orientation	blocks	Integer	0-359	degrees	0.0	Yes	yes	Please enter a value less than or equal to 359.	Please enter a valid number.
	New Block	n/a	shape_id	blocks	Integer	--	--	1 (rectangle)	Yes	n/a		
	New/Edit Block	n/a	dimension_1	blocks	Integer	>10	ft	--	Yes	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_2	blocks	Integer	>10	ft	--	Yes	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_3	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_4	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_5	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Block	n/a	dimension_6	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_7	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.
	New/Edit Block	n/a	dimension_8	blocks	Integer	>10	ft	--	Depends on shape	yes	Please enter a value greater than or equal to 10.	This field is required.
Use Type	Add Use Type to Building	Use Type	use_type_id	building_use_types	Integer	--	--	--	Yes	Yes	Every block must have an assigned use type.	
Roof	New/Edit Roof	Roof Type	roof_type_id	roofs	Integer	--	--	--	Yes	n/a		
	New/Edit Roof	Thermal Properties (U-Value)	roof_u_factor	roofs	Integer	0.008 - 1.28	BTU/°F·ft^2·h	--	yes (if U-Value)	yes	Please enter a value less than or equal to 1.28; Please enter a value greater than or equal to 0.008.	This field is required and must be greater than zero.
	New/Edit Roof	Thermal Properties (R-Value)	roof_r_value	roofs	Integer	--	°F·ft^2·h/BTU	--	yes (if R-Value)	yes		This field is required and must be greater than zero.
	New/Edit Roof	Thermal Properties (Insulation Thickness)	roof_insulation_ thickness	roofs	Integer	--	inches	--	yes (if Insulation)	yes		This field is required and must be greater than zero.
Wall	New/Edit Wall	Wall Type	wall_type_id	walls	Integer	--	--	--	Yes	n/a		
	New/Edit Wall	Thermal Properties (U-Value)	wall_u_factor	walls	Integer	0.008 - 1.28	BTU/°F·ft^2·h	--	yes (if U-Value)	yes	Please enter a value less than or equal to 1.28; Please enter a value greater than or equal to 0.008.	

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Wall	Thermal Properties (R-Value)	wall_r_value	walls	Integer	--	°F·ft^2·h/BTU	--	yes (if R-Value)	yes		
	New/Edit Wall	Thermal Properties (Insulation Thickness)	wall_insulation_ thickness	walls	Integer	--	inches	--	yes (if Insulation)	yes		
Floor	New/Edit Floor	Floor Type	floor_type_id	floors	Integer	--	--	--	Yes	n/a		
	New/Edit Floor	Thermal Properties (U-Value)	floor_u_factor	floors	Integer	--	BTU/°F·ft^2·h	--	yes (if U-Value)	no		
	New/Edit Floor	Thermal Properties (R-Value)	floor_r_value	floors	Integer	<27	°F·ft^2·h/BTU	--	yes (if R-Value)	yes	Please enter a value less than or equal to 27.	
	New/Edit Floor	Thermal Properties (Insulation Thickness)	floor_insulation_ thickness	floors	Integer	--	inches	--	yes (if Insulation)	no		
	New/Edit Floor	Slab Insulation	slab_insulation_type _id	floors	Integer	--	--	1 (No Insulation)	yes (if Slab-on-Grade)	n/a		
	New/Edit Floor	Vertical Insulation Depth	vertical_insulation _depth	floors	Integer	--	ft	--	no	no		
Window	New/Edit Window	Framing Type	framing_type_id	windows	Integer	--	--	--	yes	n/a		
	New/Edit Window	Glass type	glass_type_id	windows	Integer	--	--	--	yes	n/a		
	New/Edit Window	Gas fill type	gas_fill_type_id	windows	Integer	--	--	1 (Air)	yes (if filled)	n/a		
	New/Edit Window	U-Value	ufactor	windows	Integer	0.12-1.22	BTU/°F·ft^2·h	--	no	yes	Please enter a value less than or equal to 1.22; Please enter a value greater than or equal to 0.12.	
	New/Edit Window	SHGC	shgc	windows	Integer	0.099-0.817	number	--	no	yes	Please enter a value less than or equal to 0.817; Please enter a value greater than or equal to 0.099.	
	New/Edit Window	VT	vt	windows	Integer	0.06-0.893	number	--	no	yes	Please enter a value less than or equal to 0.893; Please enter a value greater than or equal to 0.06.	

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	Construction	Window Layout	window_layout_id	surfaces	Integer	--	--	--	yes	yes	Every surface with a window must have a valid window-to-wall ratio or the total number of windows and window dimensions.	
	Construction	Window-to-Wall Ratio	window_wall_ratio	surfaces	Integer	<0.95	percent	--	yes (if Continuous)	yes	Please enter a value less than or equal to 0.95.	
	Construction	Edge offset	edge_offset	surfaces	Integer	--	ft	--	no	n/a		
	Construction	Sill height	sill_height	surfaces	Integer	<6	ft	--	no	yes	Please enter a value less than or equal to 6.	
	Construction	Exterior Shading Type	shading_type_id	surfaces	Integer	--	--	No Shading	yes (if Continuous)	n/a		
	Construction	Number of Windows	number_of_ windows	surfaces	Integer	>4	number	--	yes (if Discrete)	yes	Every surface with a window must have a valid window-to-wall ratio or the total number of windows and window dimensions.	Some blocks or surfaces have too many windows. Make sure total window to wall ratio per block and surface is less than 0.95.
	Construction	Width	width	surfaces	Integer	--	ft	--	yes (if Discrete)	yes	This field is required.	
	Construction	Height	height	surfaces	Integer	--	ft	--	yes (if Discrete)	yes	This field is required.	
	Construction	Height Above Window	overhang_height_above _window	surfaces	Integer	<2	ft	1	no	yes	Please enter a value less than or equal to 2.	
	Construction	Projection	overhang_depth	surfaces	Integer	--	ft	3	no	n/a		
	Construction	Fin Depth	fin_depth	surfaces	Integer	--	ft	3	no	n/a		
	Construction	Edge Fins Only	edge_fins_only	surfaces	Boolean	Y/N	--	Yes	no	n/a		
	Construction	Distance Between Fins	fin_distance_between	surfaces	Integer	--	ft	4	no	n/a		
	Construction	Distance From Top	light_shelf_distance_ from_top	surfaces	Integer	--	ft	2	no	n/a		

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	Construction	Exterior Protrusion	light_shelf_ext_ protrusion	surfaces	Integer	--	ft	3	no	n/a		
	Construction	Interior Protrusion	light_shelf_int_protrusion	surfaces	Integer	--	ft	1.5	no	n/a		
Skylight	New/Edit Skylight	Skylight Type	skylight_type_id	windows	Integer	--	--	--	yes (if Skylight)	n/a		
	New/Edit Skylight	U-Value	ufactor	windows	Integer	<5	BTU/°F·ft^2·h	1.17 (Glass) 1.1 (Plastic)	no	yes	Please enter a value less than or equal to 5.	
	New/Edit Skylight	SHGC	shgc	windows	Integer	<1	number	0.49 (Glass) 0.77 (Plastic)	no	yes	Please enter a value less than or equal to 1.	
	New/Edit Skylight	VT	vt	windows	Integer	<1	number	0.7	no	yes	Please enter a value less than or equal to 1.	
	Construction	Skylight Layout	skylight_layout_id	blocks	Integer	--	--	--	yes (if Skylight)	n/a		
	Construction	% of Roof Area	percent_footprint	blocks	Integer	<95	percent	--	yes (if Skylight)	yes	Please enter a value less than or equal to 100; Typical values range between 3% to 5% of roof area.	Every block with an assigned skylight must have a valid % of roof area.
Lighting	Add/Edit Fixture	Mounting Type	mounting_type_id	fixtures	Integer	--	--	--	yes	n/a		
	Add/Edit Fixture	Lighting Type	lamp_type_id	fixtures	Integer	--	--	--	yes	n/a		
	Add/Edit Fixture	Lamp Wattage	lamp_wattage	fixtures	Integer	--	number	--	yes	yes		This field is required.
	Add/Edit Fixture	Number of Lamps in Fixture	number_of_lamps	fixtures	Integer	1-12	number	--	yes	yes	Please enter a value less than or equal to 12; Please enter a value greater than or equal to 1.	This field is required.

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	Fixtures	Total Fixtures/% Serverd (drop down)	uses_percent_served	block_fixtures	Boolean	Y/N	--	No	yes	n/a		
	Fixtures	n/a	percent_served	block_fixtures	Integer	--	percent	--	yes (if percent served)	yes	Every fixture in a block must have either a percentage served or a number of fixtures.	
	Fixtures	n/a	number_of_fixtures	block_fixtures	Integer	--	number	--	yes (if total fixtures)	yes	Every fixture in a block must have either a percentage served or a number of fixtures.	
	Fixtures	Daylight Controls	has_daylight_controls	block_fixtures	Boolean	Y/N	--	No	no	n/a		
	Fixtures	Occupancy Controls	has_occupancy_controls	block_fixtures	Boolean	Y/N	--	No	no	n/a		
Water Heaters	Water Heaters	n/a	water_heater_id	block_water_heaters	Integer	--	--	--	no	n/a		
	New/Edit Water Heater	Fuel Type	fuel_type_id	water_heaters	Integer	--	--	1 (Gas)	yes (if Water Heater)	n/a		
	New/Edit Water Heater	Uses Heat Pump	uses_heat_pump	water_heaters	Boolean	Y/N	--	No	no	n/a		
	New/Edit Water Heater	Distribution Type	distribution_type_id	water_heaters	Integer	--	--	1 (Distributed)	yes	n/a		
	New/Edit Water Heater	Water Heater Efficiency	water_heater_ efficiency	water_heaters	Integer	60-100	percent	--	no	yes	Please enter a value less than or equal to 99; Please enter a value greater than or equal to 60.	
	New/Edit Water Heater	Tank Volume	tank_volume	water_heaters	Integer	--	gallons	--	no	n/a		
	New/Edit Water Heater	Tank Insulation Thickness	tank_insulation_ thickness	water_heaters	Integer	--	inches	--	no	n/a		
	New/Edit Water Heater	Tank Insulation R-Value	tank_insulation_r_ value	water_heaters	Integer	--	$°F \cdot ft^2 \cdot h/BTU$	--	no	n/a		
Opertions	Operations	n/a	operation_id	blocks	Integer	--	--	--	no	n/a		
	New/Edit Operations	Miscellaneous Electric Load	misc_electric_load	operations	Integer	<200	W/sq.ft.	--	no	yes	Please enter a value less than or equal to 200.	Typical values for Gas Equipment Loads will be less than 10 kBtu/ft^2.

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Operations	Miscellaneous Gas Load	misc_gas_load	operations	Integer	<0.68	kBtu/ft^2.	--	no	yes	Please enter a value less than or equal to 0.68	Typical values for Gas Equipment Loads will be less than 0.03 kBtu/ft^2.
	New/Edit Operations	Total Occupants	total_occupants	operations	Integer	--	number	--	no	n/a		
	New/Edit Operations	Setpoint Heating	setpoint_heating	operations	Integer	--	°F	--	no	n/a		
	New/Edit Operations	Setpoint Cooling	setpoint_cooling	operations	Integer	--	°F	--	no	n/a		
	New/Edit Operations	Weekdays	weekdays_open	operations	Boolean	Y/N	--	Yes	no	n/a		
	New/Edit Operations	Open	weekday_open_time	operations	Time	--	hours	--	no	n/a		
	New/Edit Operations	Close	weekday_open_time	operations	Time	--	hours	--	no	n/a		
	New/Edit Operations	Saturdays	saturdays_open	operations	Boolean	Y/N	--	No	no	n/a		
	New/Edit Operations	Open	saturday_open_time	operations	Time	--	hours	--	no	n/a		
	New/Edit Operations	Close	saturday_open_time	operations	Time	--	hours	--	no	n/a		
	New/Edit Operations	Sundays	sundays_open	operations	Boolean	Y/N	--	No	no	n/a		
	New/Edit Operations	Open	sunday_open_time	operations	Time	--	hours	--	no	n/a		
	New/Edit Operations	Close	sunday_open_time	operations	Time	--	hours	--	no	n/a		
Plants	New/Edit Plant	Heating/Cooling	is_heating	plants	Boolean	Y/N	--	Yes (Heating)	yes (if Plant)	n/a		
	New/Edit Plant	Plant Type	plant_type_id	plants	Integer	--	--	--	yes	n/a		
	New/Edit Plant	Fuel Type	fuel_type_id	plants	Integer	--	--	--	yes (if Heating)	n/a		
	New/Edit Plant	Draft Type	draft_type_id	plants	Integer	--	--	--	yes (if Heating)	n/a		
	New/Edit Plant	Year of Manufacture	vintage	plants	Integer	1900-2014	year	--	no	yes	Please enter a value less than or equal to 2014.	Please enter only digits.
	New/Edit Plant	# Pieces of Equipment	pieces_of_equipment	plants	Integer	--	number	--	no	no		Please enter only digits.

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Plant	Efficiency	efficiency	plants	Integer	1-100	percent (Heating)	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	
	New/Edit Plant	Efficiency	efficiency	plants	Integer	1-8	COP (Cooling	--	no	yes	Please enter a value less than or equal to 8; Please enter a value greater than or equal to 1.	
	New/Edit Plant	Average Output Capacity	capacity	plants	Integer	--	kBtu/hr-Heating; tons-Cooling	--	no	no		
	New/Edit Plant	Chilled Water Reset	chilled_water_reset	plants	Boolean	Y/N	--	No	no	n/a		
	New/Edit Plant	Chiller Pump Control	chiller_pump_control _type_id	plants	Integer	--	--	--	yes (if Cooling)	n/a		
	New/Edit Plant	Compressor Pump Control	condenser_pump_ control_type_id	plants	Integer	--	--	--	yes (if Water Condenser)	n/a		
	New/Edit Plant	Compressor Type	compressor_type_id	plants	Integer	--	--	--	yes (if Cooling)	n/a		
	New/Edit Plant	Condenser Type	condenser_type_id	plants	Integer	--	--	--	yes (if Cooling)	n/a		
Air Handler	New/Edit Air Handler	Cooling Source	cooling_air_handler_ type_id	air_handlers	Integer	--	--	--	yes	n/a		
	New/Edit Air Handler	Plant	cooling_plant_id	air_handlers	Integer	--	--	--	yes (if Plant)	n/a		
	New/Edit Air Handler	Year of Manufacture	cooling_vintage	air_handlers	Integer	1900-2014	year	--	no	yes	Please enter a value less than or equal to 2014.	Please enter only digits.
	New/Edit Air Handler	# Pieces of Equipment	cooling_pieces_of_ equipment	air_handlers	Integer	--	number	--	no	no		Please enter only digits.
	New/Edit Air Handler	Efficiency	cooling_efficiency	air_handlers	Integer	1-8	COP	--	no	yes	Please enter a value less than or equal to 8; Please enter a value greater than or equal to 1.	
	New/Edit Air Handler	Average Output Capacity	capacity	air_handlers	Integer	--	tons	--	no	no		
	New/Edit Air Handler	Heating Source	heating_air_handler_ type_id	air_handlers	Integer	--	--	--	yes	yes		

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Air Handler	Plant	heating_plant_id	air_handlers	Integer	--	--	--	yes (if Plant)	n/a		A heat pump is not a valid heating source when a plant is specified for cooling.
	New/Edit Air Handler	Year of Manufacture	heating_vintage	air_handlers	Integer	1900-2014	year	--	no	yes	Please enter a value less than or equal to 2014.	Please enter only digits.
	New/Edit Air Handler	# Pieces of Equipment	heating_pieces_of_equipment	air_handlers	Integer	--	number	--	no	no		Please enter only digits.
	New/Edit Air Handler	Efficiency	heating_efficiency	air_handlers	Integer	1.01-8	COP (for Heat Pump)	--	no	yes	Please enter a value less than or equal to 8; Please enter a value greater than or equal to 1.01.	
	New/Edit Air Handler	Efficiency	heating_efficiency	air_handlers	Integer	1-100	percent (for Furnace)	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	
	New/Edit Air Handler	Average Output Capacity	capacity	air_handlers	Integer	--	tons	--	no	no		
	New/Edit Air Handler	Fuel Type	fuel_type_id	air_handlers	Integer	--	--	--	yes (if Furnace or Heat Pump)	n/a		
	New/Edit Air Handler	Sink/Source Type	sink_source_type_id	air_handlers	Integer	--	--	--	yes (if Heat Pump)	n/a		
	New/Edit Air Handler	Distribution Type	distribution_type_id	air_handlers	Integer	--	--	--	yes (for all but Heat Pump)	n/a		
	New/Edit Air Handler	Terminal Unit	terminal_unit_id	air_handlers	Integer	--	--	--	yes (if Multiple Zone)	n/a		
	New/Edit Air Handler	Fan motor efficiency	fan_motor_efficiency	air_handlers	Integer	1-100	percent	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	
	New/Edit Air Handler	Fan efficiency	fan_efficiency	air_handlers	Integer	1-100	percent	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Air Handler	Economizer	has_economizer	air_handlers	Boolean	Y/N	--	No	no	n/a		
	New/Edit Air Handler	Fan Control	fan_control_id	air_handlers	Integer	--	--	--	no	n/a		
Zone Equipment	New/Edit Zone Equipment	Cooling Source	cooling_zone_ equipment_type_id	zone_equipments	Integer	--	--	--	yes	n/a		
	New/Edit Zone Equipment	Plant	cooling_plant_id	zone_equipments	Integer	--	--	--	yes (if Plant)	n/a		
	New/Edit Zone Equipment	Year of Manufacture	cooling_vintage	zone_equipments	Integer	1900-2014	year	--	no	yes	Please enter a value less than or equal to 2014.	Please enter only digits.
	New/Edit Zone Equipment	# Pieces of Equipment	cooling_pieces_of_ equipment	zone_equipments	Integer	--	number	--	no	no		Please enter only digits.
	New/Edit Zone Equipment	Efficiency	cooling_efficiency	zone_equipments	Integer	1-8	COP	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	
	New/Edit Zone Equipment	Average Output Capacity	cooling_capacity	zone_equipments	Integer	--	tons	--	no	no		
	New/Edit Zone Equipment	Heating Source	heating_zone_ equipment_type_id	zone_equipments	Integer	--	--	--	yes	yes		
	New/Edit Zone Equipment	Plant	heating_plant_id	zone_equipments	Integer	--	--	--	yes (if Plant)	n/a		A heat pump is not a valid heating source when a plant is specified for cooling.
	New/Edit Zone Equipment	Fuel Type	fuel_type_id	zone_equipments	Integer	--	--	--	yes (if Furnace)	n/a		
	New/Edit Zone Equipment	Year of Manufacture	heating_vintage	zone_equipments	Integer	>2014	year	--	no	yes	Please enter a value less than or equal to 2014.	Please enter only digits.
	New/Edit Zone Equipment	# Pieces of Equipment	heating_pieces_of_ equipment	zone_equipments	Integer	--	number	--	no	no		Please enter only digits.
	New/Edit Zone Equipment	Efficiency	heating_efficiency	zone_equipments	Integer	1.01-8	COP (for Heat Pump)	--	no	yes	Please enter a value less than or equal to 8; Please enter a value greater than or equal to 1.01	

Component	UI Window	UI Label	Input Name	Table (Source?)	Data Type	Range	Units	Default	Required?	Validation in UI	Validation text	Other Validation
	New/Edit Zone Equipment	Efficiency	heating_efficiency	zone_equipments	Integer	1-100	percent (for Furnace)	--	no	yes	Please enter a value less than or equal to 100; Please enter a value greater than or equal to 1.	
	New/Edit Zone Equipment	Average Output Capacity	heating_capacity	zone_equipments	Integer	--	tons	--	no	no		
HVAC Systems	HVAC Systems	Thermal Zone Layout	zone_layout_id	blocks	Integer	--	--	Single zone	yes	yes	Every block must have an assigned HVAC system.	
	HVAC Systems	Perimeter Zone Depth	perimeter_zone _depth	blocks	Integer	8-20	ft	15	yes (if Perimeter and Core)	yes	Please enter a value less than or equal to 8; Please enter a value greater than or equal to 1.01.	

Appendix J

Operational Assumptions and Equipment Sizing

DOE Commercial Building Energy Asset Score: Building Use Type Operational and Equipment Sizing Assumptions

To estimate a building's energy use intensity per year, the Asset Scoring Tool applies standard assumptions[1] concerning how the building is operated. To allow building owners and operators to understand how well these assumptions reflect their building's actual operations, the following tables provide a simplified list of assumptions used for each building type.

These tables reflect the full-time equivalent occupancy hours assumed for each building type, but a building's level of operations varies according to the day of the week, hour of the day, and even by season in cases such as schools. To accommodate the fact that operations fluctuate, the Asset Scoring Tool applies a specific set of operational assumptions to every hour of the year, depending on each building type. Precise schedules of these assumptions are presented in the appendix at the end of this document.

To get an overall idea of the assumptions used to estimate a building's energy use, consult the tables. For a more granular understanding of the assumptions, see the graphs in the appendix.

[1] Operational assumptions included in this document are based on ASHRAE Standard 90.1 2013 and ASHRAE Standard 90.1 Prototype Building Model. New operational assumptions will be developed as other building types are added to the Asset Scoring Tool.

Operational Assumptions

Schedules of Operation

	Occupancy Schedule[2] (hrs/wk)	Lighting Schedule (hrs/wk)	Equipment Schedule (hrs/wk)	Service Hot Water Schedule (hrs/wk)	Cooling Temperature Setpoints (°F)	Heating Temperature Setpoints (°F)
Assisted Living Facility	105.77	69.01	57.71	55.60	70	70
City Hall	48.60	56.50	86.15	27.70	75	70
Community Center	46.30	69.30	87.75	38.58	75	70
Courthouse	48.60	56.50	86.15	27.70	75	70
Education	41.75	80.38	85.80	29.05	75	70
Library	46.30	69.30	87.75	38.58	75	70
Lodging	105.77	69.01	57.71	55.60	70	70
Medical Office	90.40	104.60	99.90	34.93	75	70
Multi-family	114.75	55.14	110.58	88.06	75	70
Multi-family (less than 4 floors)	115.67	54.81	88.29	67.31	75	72
Office	48.60	56.50	86.15	27.70	75	70
Parking Garage	0.00	129.50	168.00	0.00	55[3]	NA
Police Station	90.40	104.60	99.90	27.70	75	70
Post Office	48.60	56.60	86.15	27.70	75	70
Religious Building	46.30	69.30	87.75	38.58	75	70
Retail	46.30	69.30	87.75	38.58	75	70
Senior Center	46.30	69.30	87.75	38.58	75	70
Warehouse non-refrigerated	0.00	54.55	60.00	0.00	80	60

[2] Closing times reflect those hours when occupant density is less than 20 percent and are only used for illustrative purposes.
[3] Parking garages can be ventilation only systems as well as heating only systems. In case of heating only systems, a setpoint of 55F is assumed.

Internal Loads

	Occupancy Density (sq ft/occupant)	Equipment Power Density (plug and process loads) (W/sq ft)
Assisted Living Facility	250	1.11
City Hall	200	1.00
Community Center	100	1.50
Courthouse	14	0.25
Education	40	1.39
Library	100	1.50
Lodging	250	1.11
Medical Office	200	2.00
Multi-family	380	0.62
Multi-family (less than 4 floors)	600	0.91
Office	200	0.75
Parking Garage	N/A	0.00
Police Station	33	1.50
Post Office	33	1.00
Religious Building	100	1.50
Retail	67	0.30
Senior Center	100	1.50
Warehouse non-refrigerated	N/A	0.24

Outdoor Ventilation Rates

	Outdoor Air Ventalation Rates
Assisted Living Facility	• 0.06 cfm/sq ft (for area - assisted living space) • 5.00 cfm/person (for people) • 0.085 cfm/sq ft (calculated for building)
City Hall	• 0.06 cfm/sq ft (for area - city hall space) • 5.00 cfm/person (for people) • 0.09 cfm/sq ft (calculated for building)
Community Center	• 0.06 cfm/sq ft (for area - community center space) • 5.00 cfm/person (for people) • 0.11 cfm/sq ft (calculated for building)
Courthouse	• 0.06 cfm/sq ft (for area - courthouse space) • 5.00 cfm/person (for people) • 0.41 cfm/sq ft (calculated for building)
Education	• 0.22 cfm/sq ft (for area - school space) • 10.00 cfm/person (for people) • 0.47 cfm/sq ft (calculated for building)
Library	• 0.06 cfm/sq ft (for area - library space) • 5.00 cfm/person (for people) • 0.11 cfm/sq ft (calculated for building)
Lodging	• 0.06 cfm/sq ft (for area - lodging space) • 5.00 cfm/person (for people) • 0.085 cfm/sq ft (calculated for building)
Medical Office	• 0.17 cfm/sq ft (for area - medical office space) • 5.00 cfm/person (for people) • 0.2048 cfm/sq ft (calculated for building)
Multi-family	• 0.06 cfm/sq ft (for area - apartment space) • 0.00 cfm/person (for people) • 0.06 cfm/sq ft (calculated for building)
Multi-family (less than 4 floors)	• 0.0375 cfm/sq ft (for area - low rise apartment space) • 0.00 cfm/person (for people) • 0.0375 cfm/sq ft (calculated for building)

Outdoor Ventilation Rates, continued

	Outdoor Air Ventalation Rates
Office	• 0.06 cfm/sq ft (for area - office space) • 5.00 cfm/person (for people) • 0.085 cfm/sq ft (calculated for building)
Parking Garage	• 0.75 cfm/sq ft (for area - parking garage space) • 0.00 cfm/person (for people) • 0.75 cfm/sq ft (calculated for building)
Police Station	• 0.06 cfm/sq ft (for area - police station space) • 5.00 cfm/person (for people) • 0.21 cfm/sq ft (calculated for building)
Post Office	• 0.06 cfm/sq ft (for area - post office space) • 5.00 cfm/person (for people) • 0.21 cfm/sq ft (calculated for building)
Religious Building	• 0.06 cfm/sq ft (for area - religious building space) • 5.00 cfm/person (for people) • 0.11 cfm/sq ft (calculated for building)
Retail	• 0.12 cfm/sq ft (for area - retail space) • 7.50 cfm/person (for people) • 0.23 cfm/sq ft (calculated for building)
Senior Center	• 0.06 cfm/sq ft (for area - senior center space) • 5.00 cfm31 /person (for people) • 0.11 cfm/sq ft (calculated for building)
Warehouse non-refrigerated	• 0.06 cfm/sq ft (for area - warehouse space) • 0.00 cfm/person (for people) • 0.06 cfm/sq ft (calculated for building)

Service Hot Water Use (for faucets/shower heads, etc.)

	Service Hot Water Use
Assisted Living Facility	14 gal/day/occupant
City Hall	0.26 gal/day/occupant
Community Center	0.18 gal/day/occupant
Courthouse	0.26 gal/day/occupant
Education	1.2 gal/day/occupant[4]
Library	0.18 gal/day/occupant
Lodging	14 gal/day/occupant[5]
Medical Office	3.01 gal/day/occupant
Multi-family	40 gal/day/occupant[6]
Multi-family (less than 4 floors)	30 gal/day/occupant
Office	1.0 gal/day/occupant
Parking Garage	0.0 gal/day/occupant
Police Station	1.0 gal/day/occupant
Post Office	1.0 gal/day/occupant
Religious Building	0.18 gal/day/occupant
Retail	0.61 gal/day/occupant
Senior Center	0.18 gal/day/occupant
Warehouse non-refrigerated	0.0 gal/day/occupant

[4] COMNET specifies this value as 0.61 gal/day/occupant for k-12 schools and 1.8 gal/day/occupant for high schools. An average of 1.2 gals/day/occupant is assumed for all schools.

[5] COMNET specifies this value in accordance with number of rooms. For hotels with less than 20 rooms, a value of 20 gal/day/occupant is prescribed, for 20-100 rooms, 14 gal/day/occupant, for greater than 100 rooms, 10 gal/day/occupant An average for 20-100 rooms is assumed.

[6] Assuming each dwelling unit to be 1,000 sq ft

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Equipment Sizing[7]

Heating and Cooling Equipment

- Cooling and Heating Capacity
- Sensible Heat Ratio
- Supply Air flow rate
- CHW and HW Loops: Maximum flow rate

Heating and cooling equipment is automatically sized based on the assumed internal loads specified above. The equipment capacity used in the energy model is based on the standard operation assumptions and does not reflect the actual equipment capacity. A building may have larger equipment to meet the specifically designed loads.

Ventilation Equipment

Maximum and minimum outdoor air flow rate are automatically calculated by the software based on the design outdoor air requirements specified.

Fans

Maximum air flow rate for fans is auto sized in the simulation software based on the system loads.

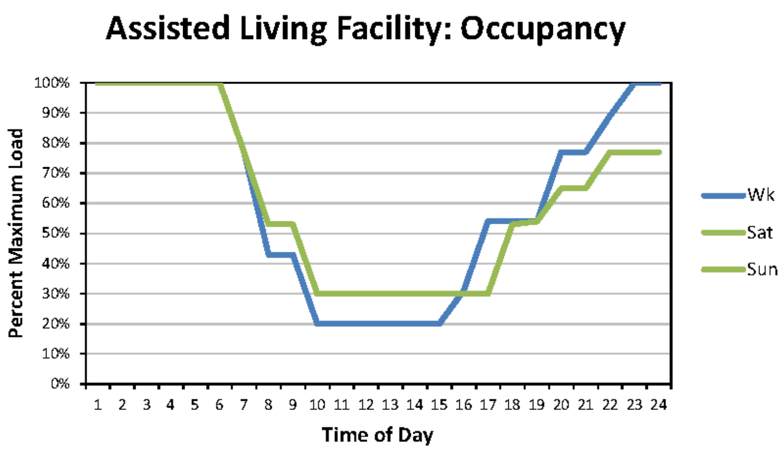
Pumps

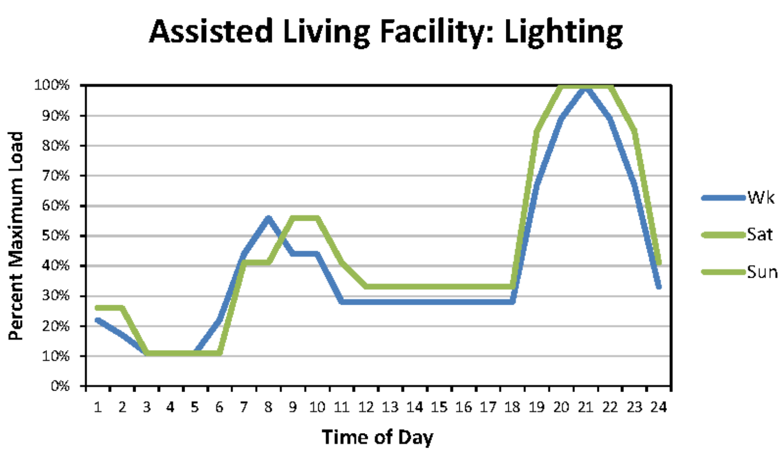
Rated flow rate is auto sized based on plant loads.

[7] The scoring tool assumes that the energy equipment listed here is sized specifically to meet the load requirements corresponding to the operational assumptions.

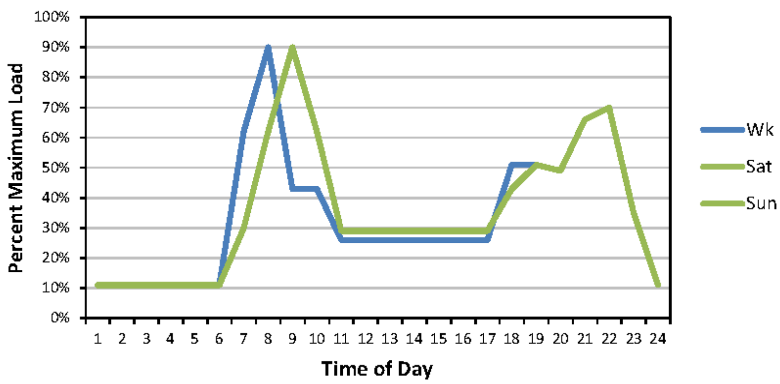
Appendix: Building Use Type Schedules

Assisted Living Facility

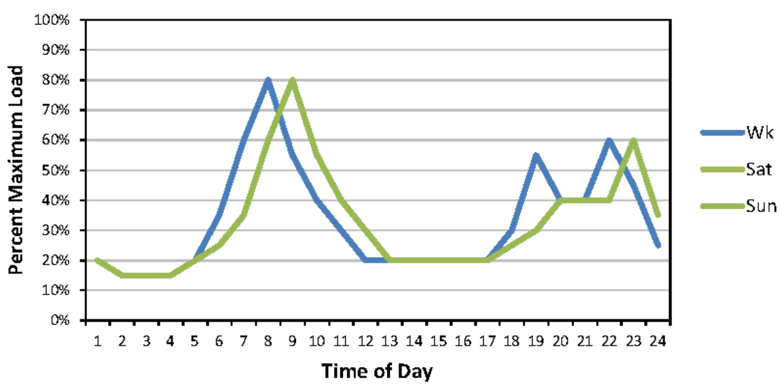




Assisted Living Facility: Equipment



Assisted Living Facility: Service Hot Water



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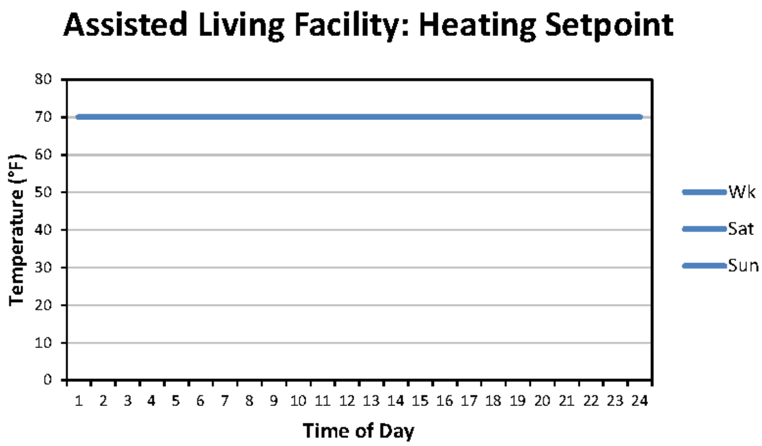

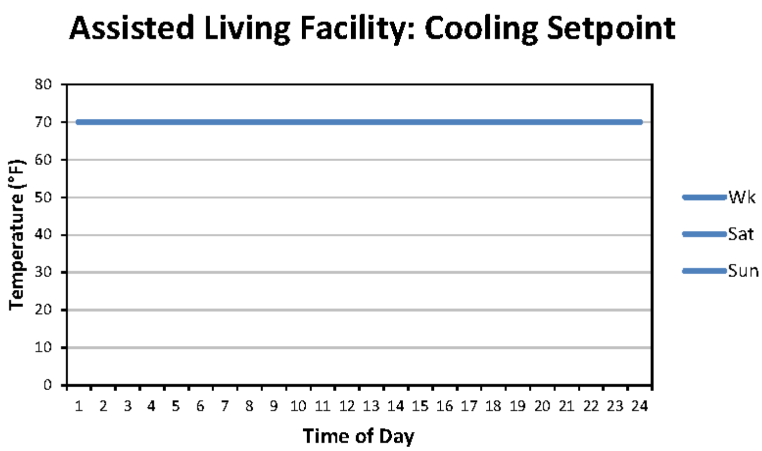

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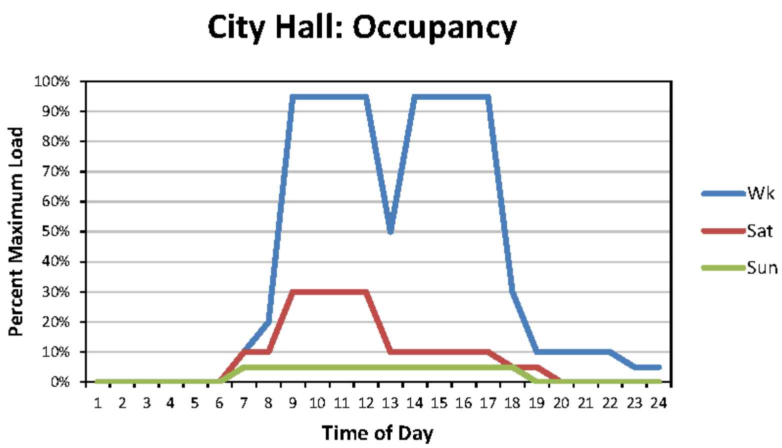
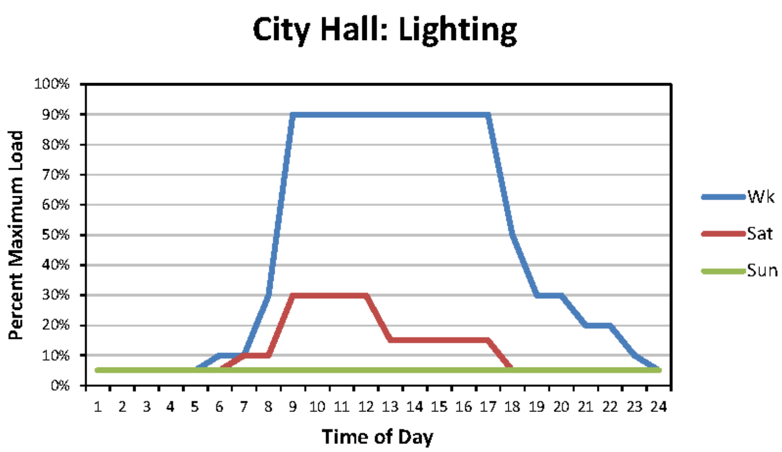
City Hall


City Hall: Occupancy
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


City Hall: Lighting
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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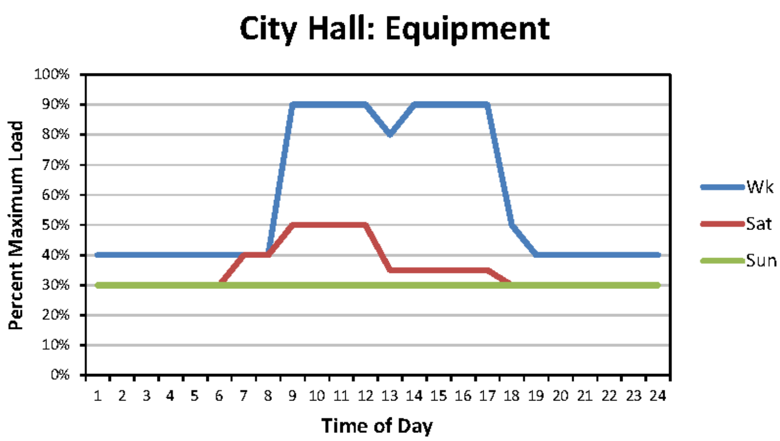

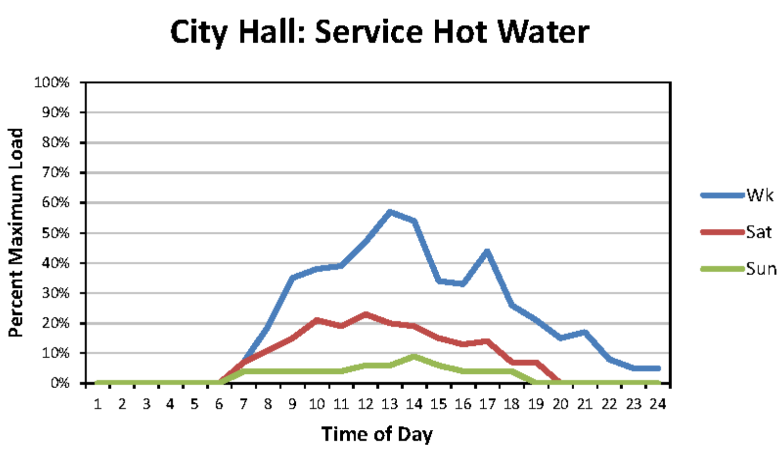

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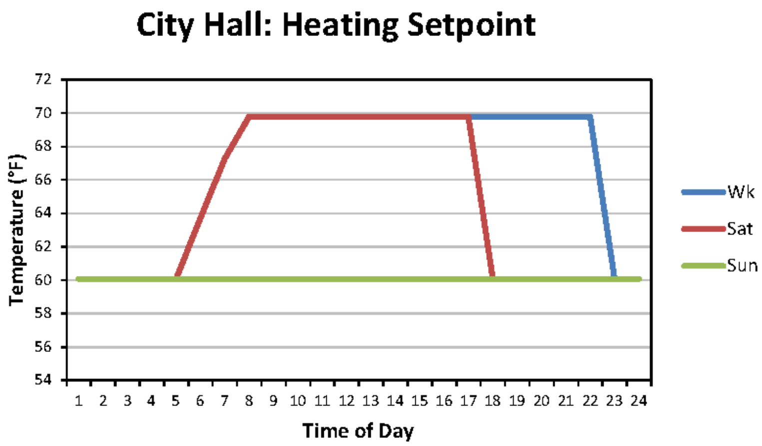
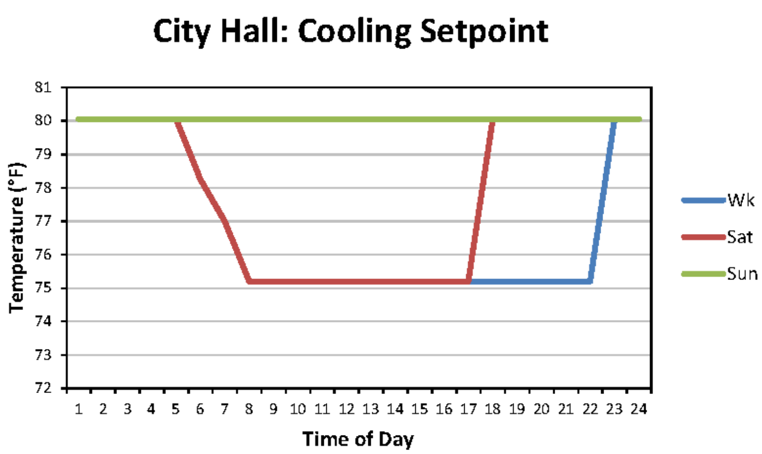
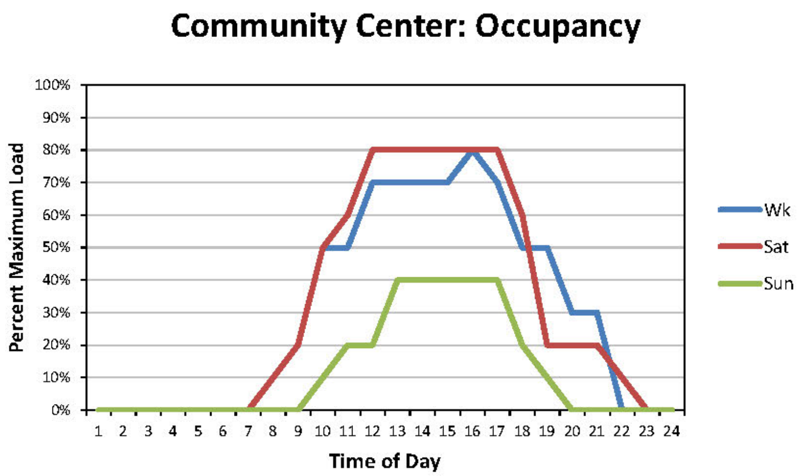
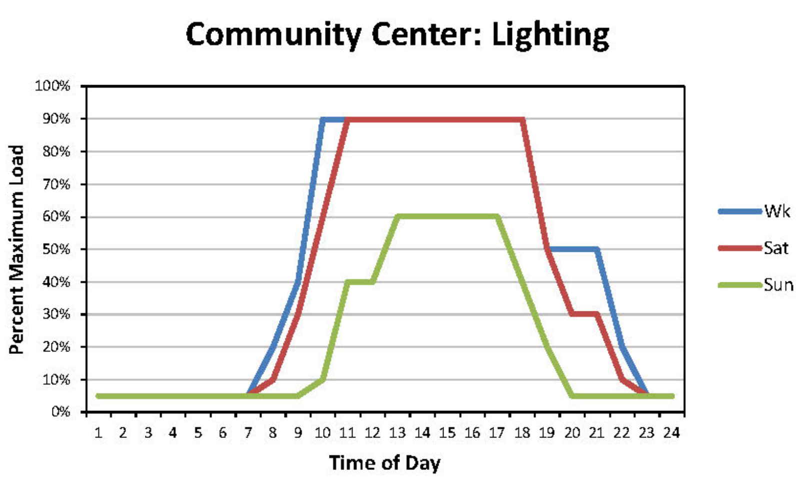
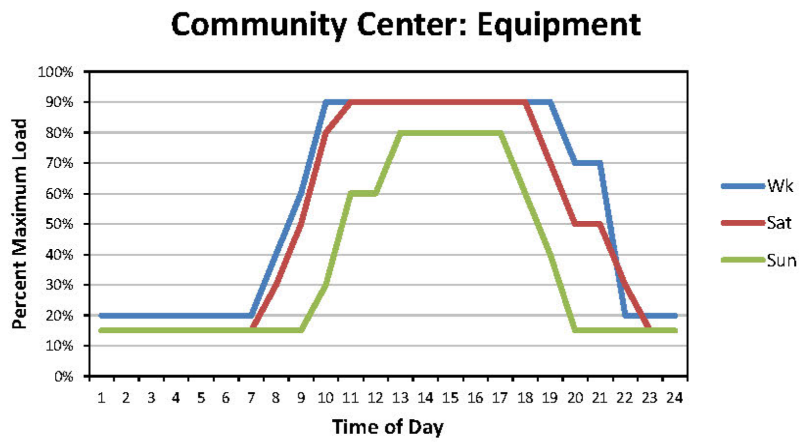


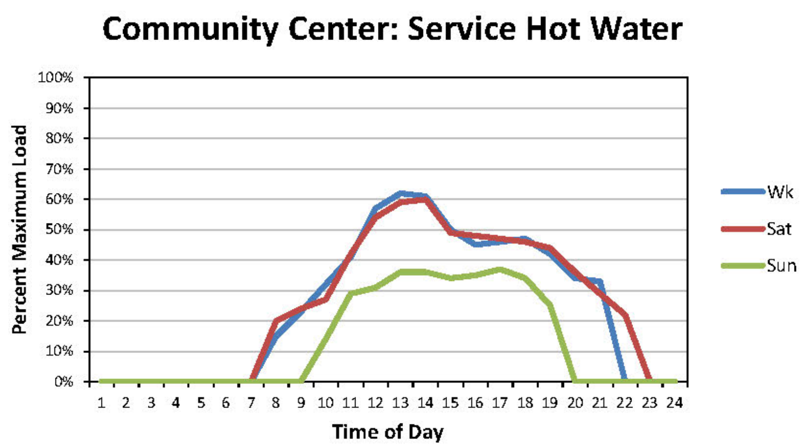


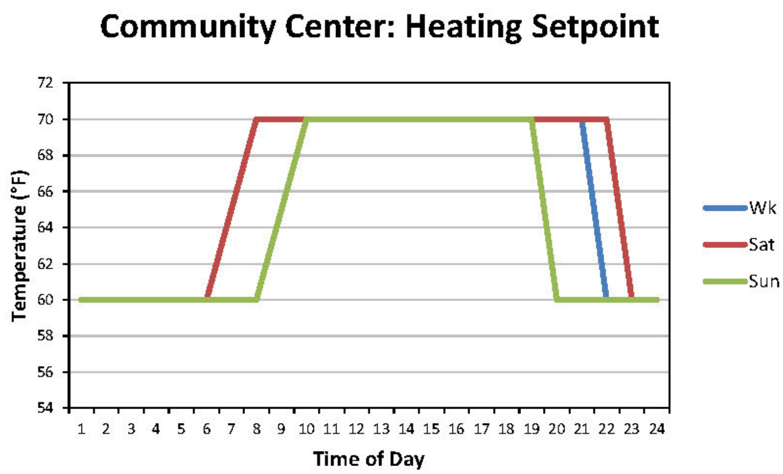
Community Center

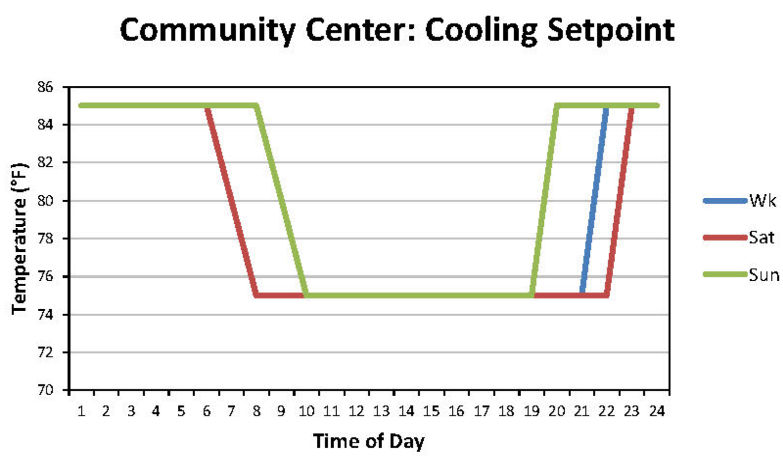




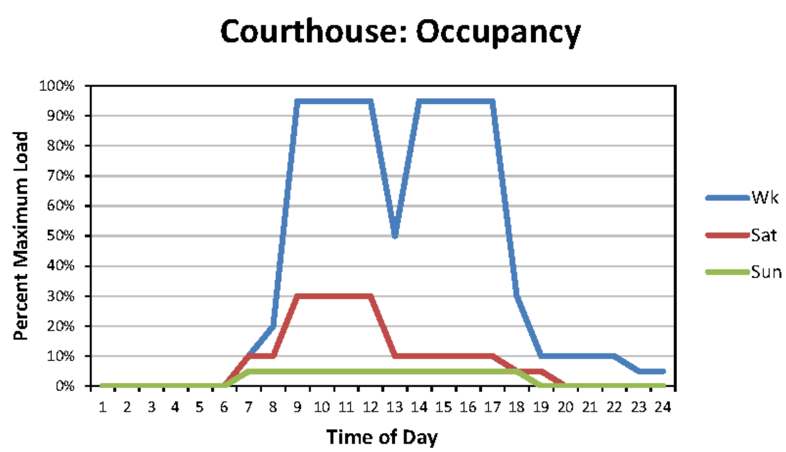

Community Center: Equipment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

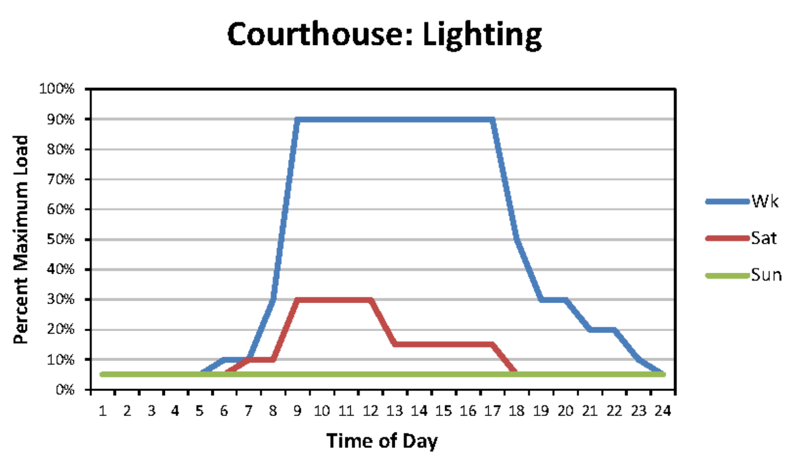

Community Center: Service Hot Water
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

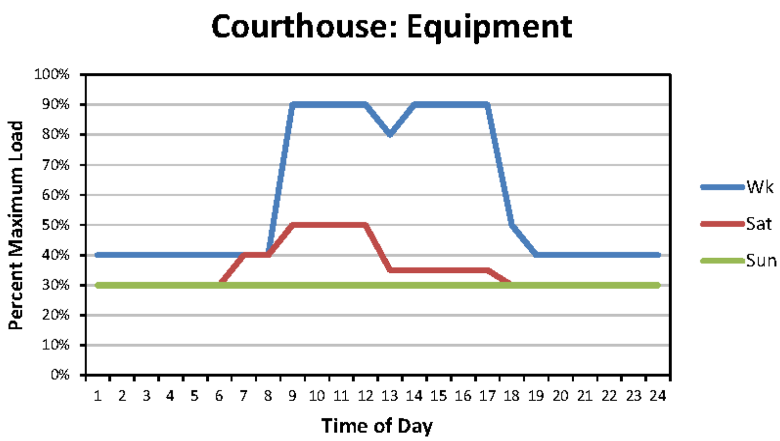

Community Center: Heating Setpoint
72
70
68
66
64
62
60
58
56
54
Temperature (°F)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Community Center: Cooling Setpoint
86
84
82
80
78
76
74
72
70
Temperature (°F)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

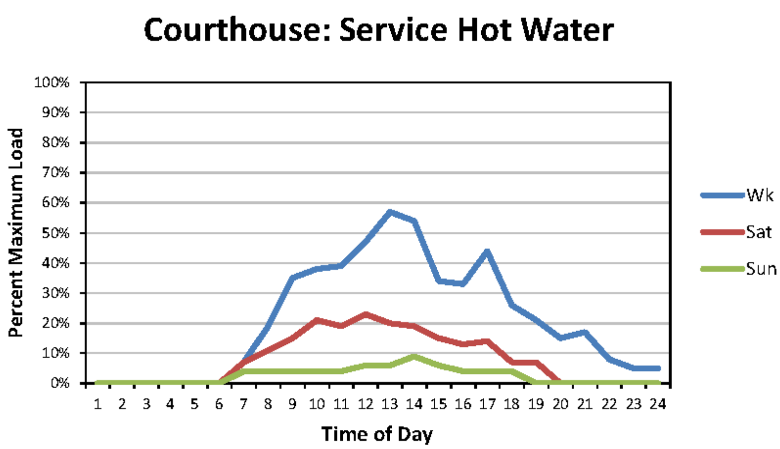
Courthouse


Courthouse: Occupancy
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Courthouse: Lighting
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

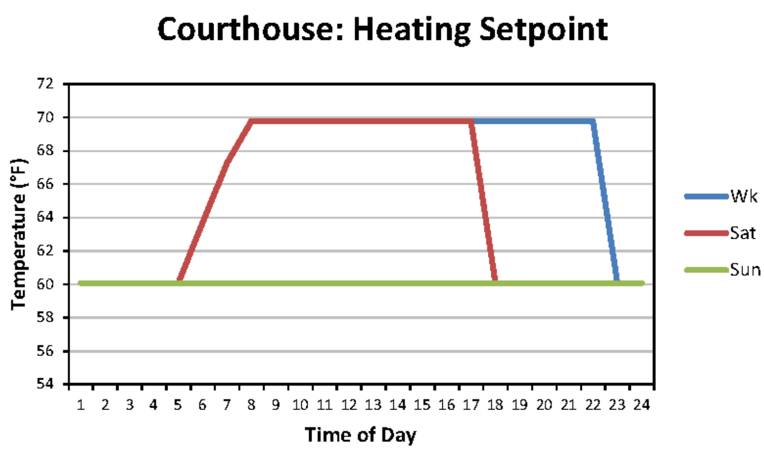


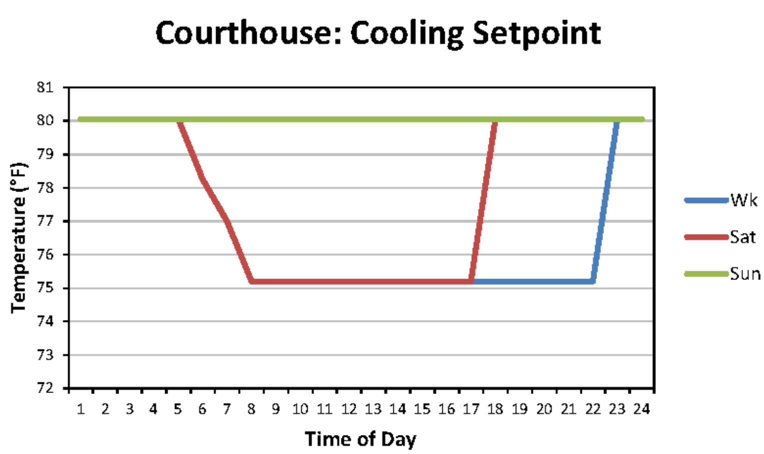
Courthouse: Equipment
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun



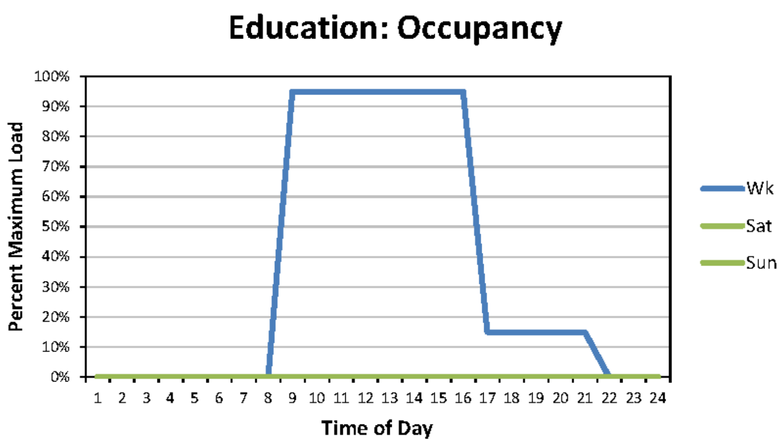
Courthouse: Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

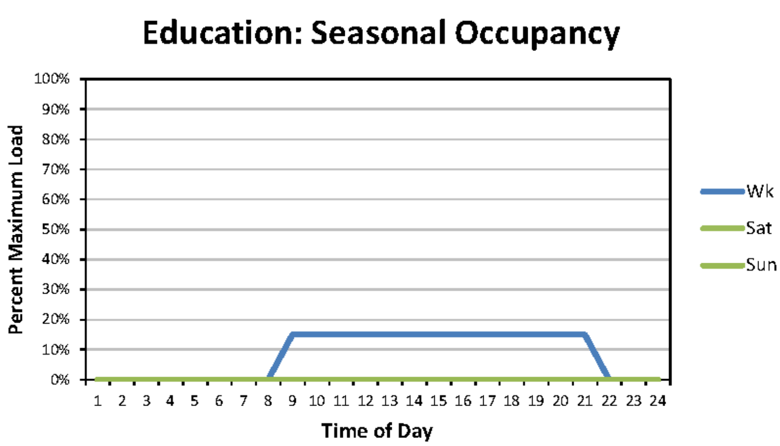
Energy Efficiency & Renewable Energy



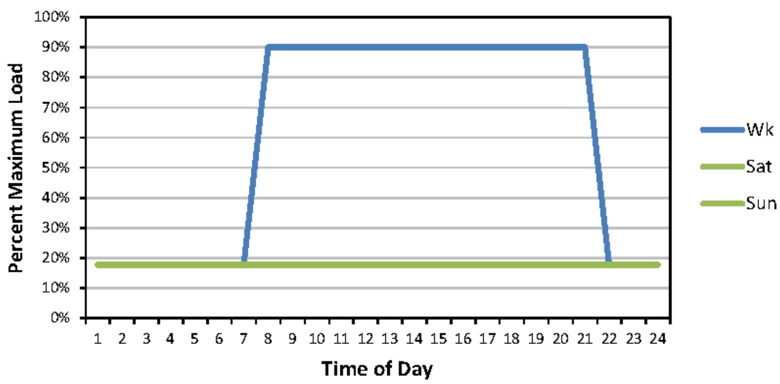


Education

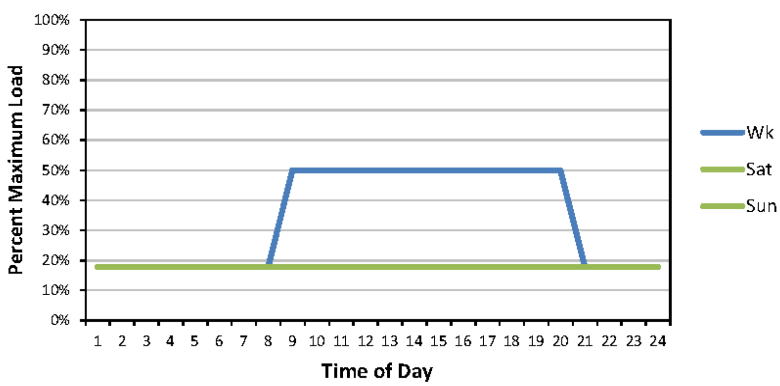

Education: Occupancy
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Education: Seasonal Occupancy
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

Education: Lighting



Education: Seasonal Lighting



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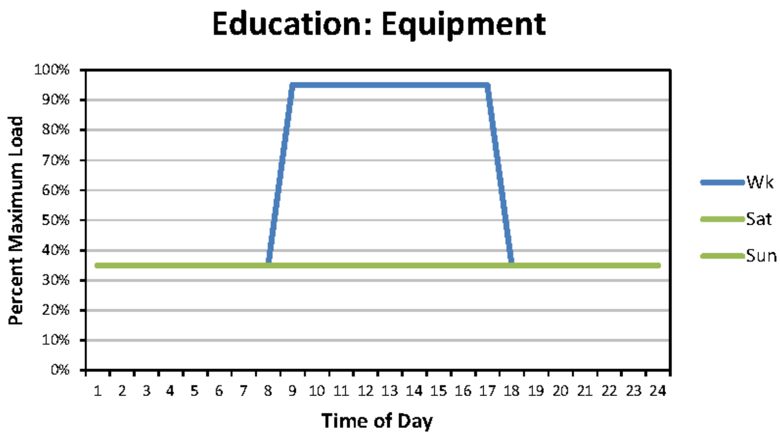
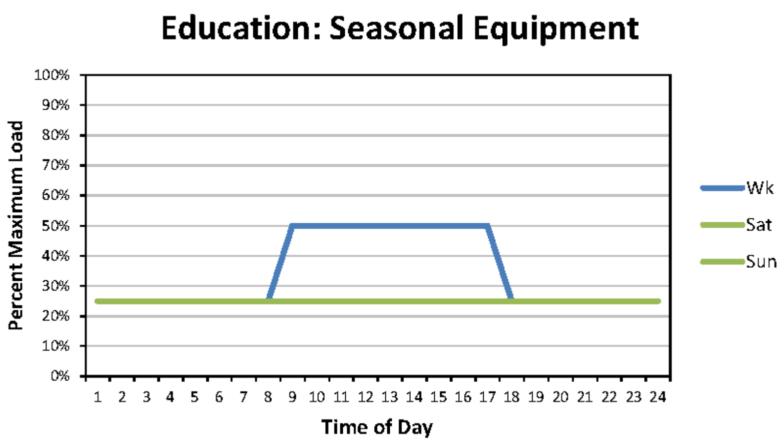
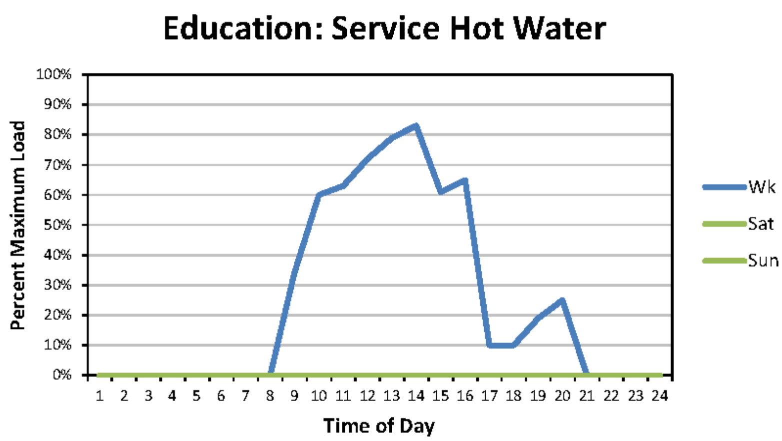
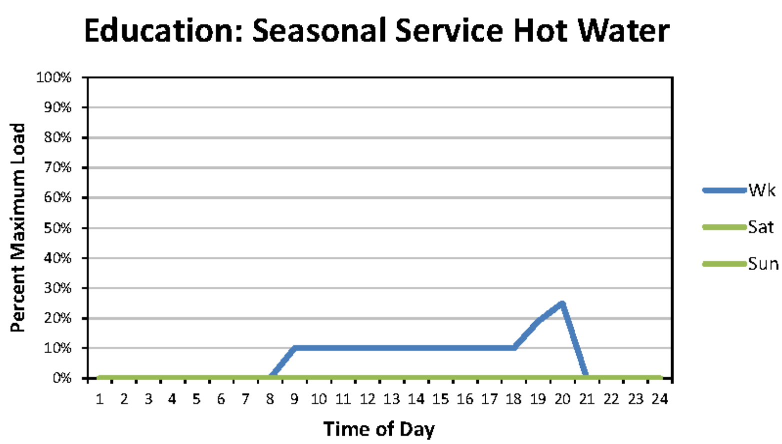





Education: Service Hot Water
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Education: Seasonal Service Hot Water
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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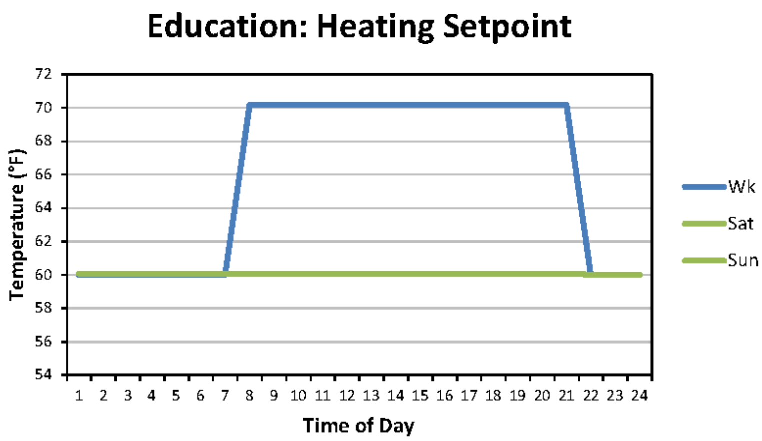
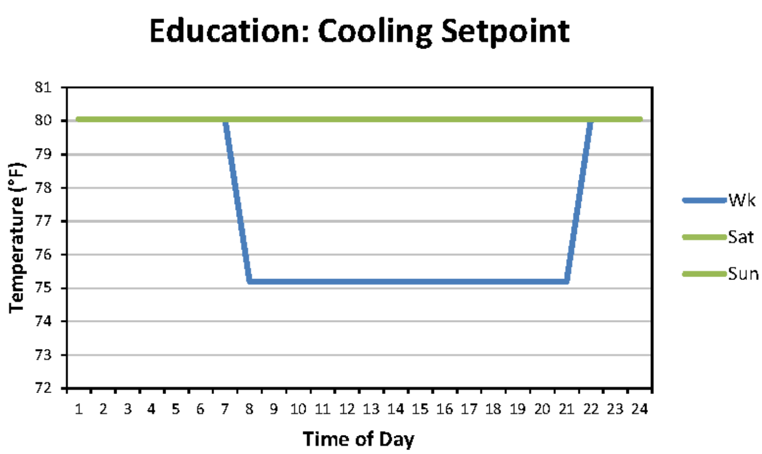
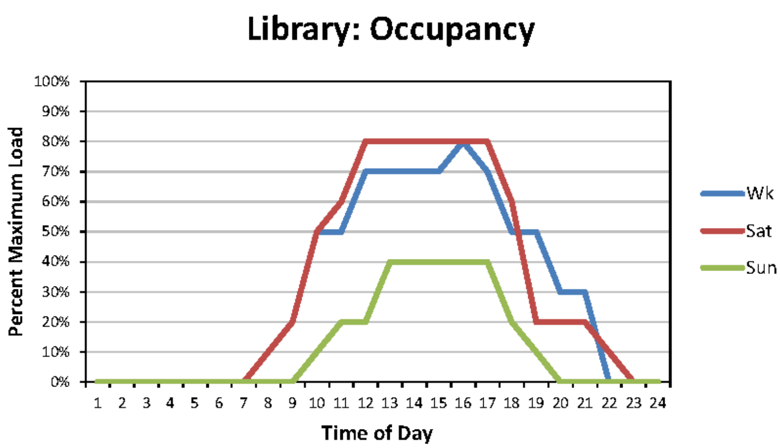
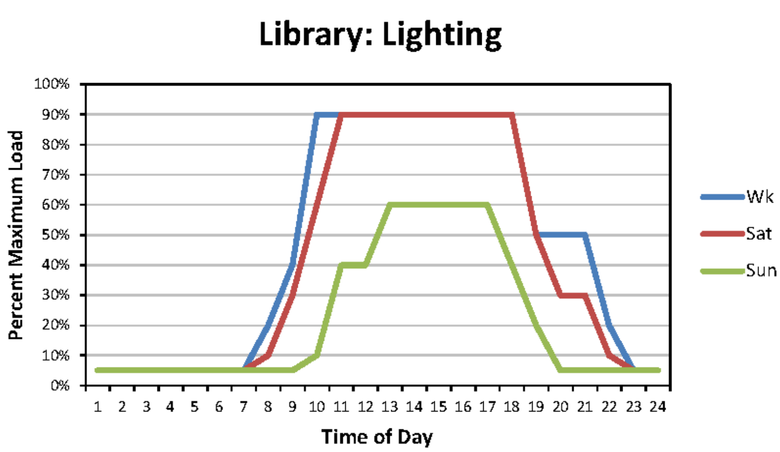


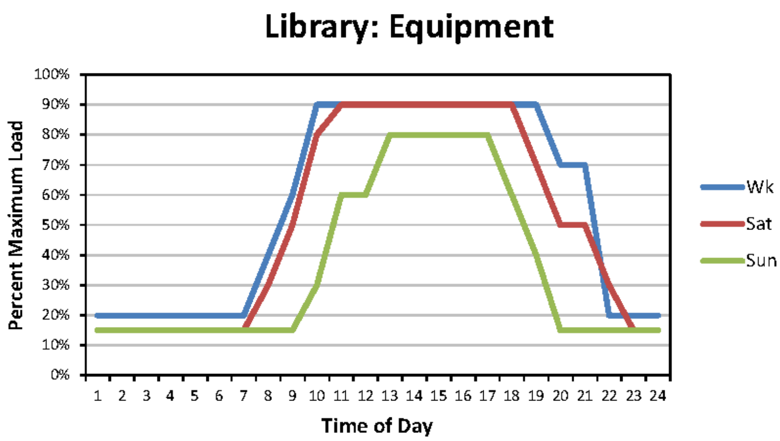


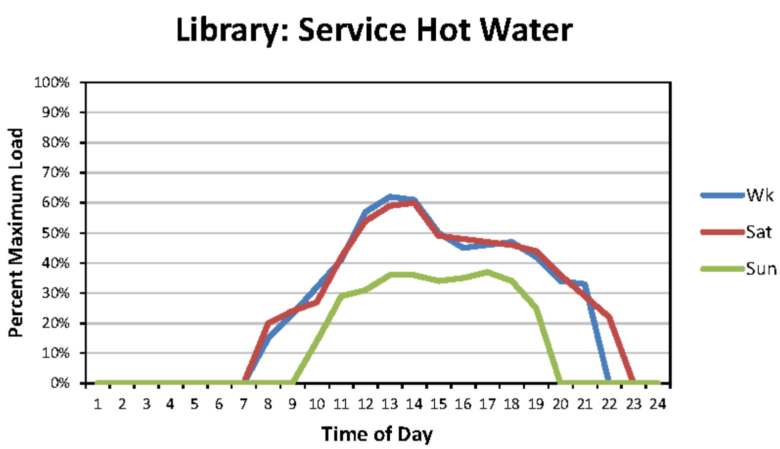
Energy Efficiency & Renewable Energy

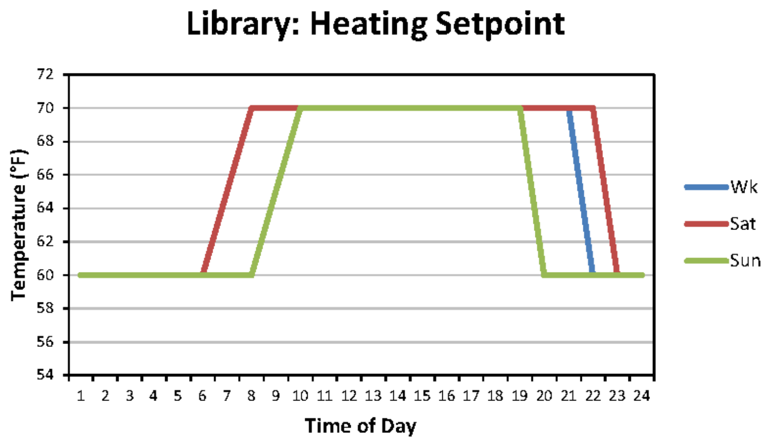
Library

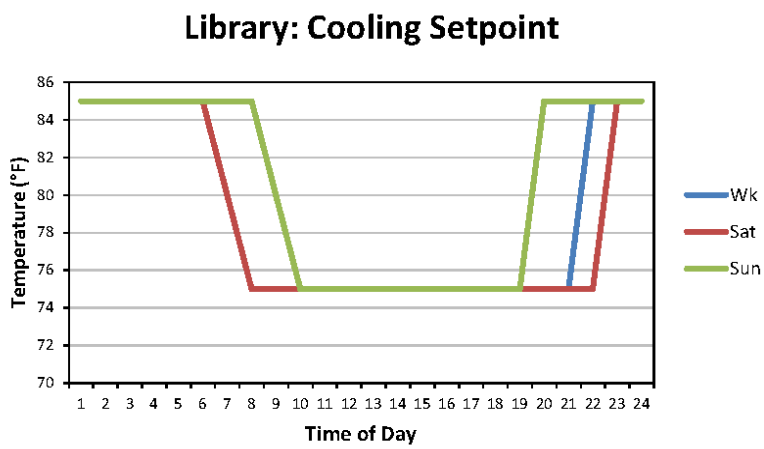




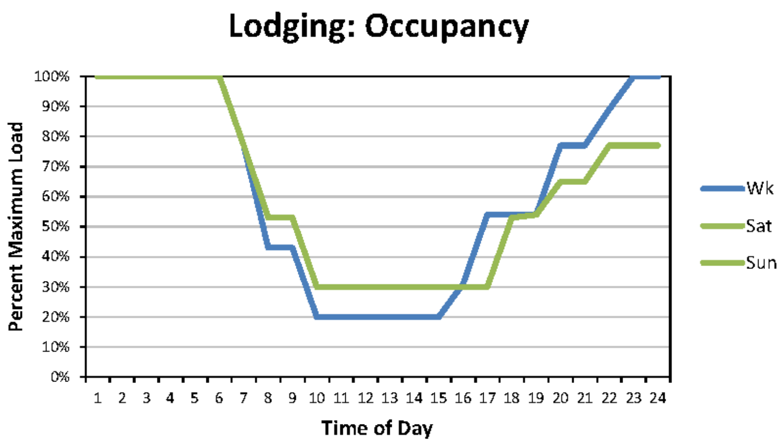

Library: Equipment
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

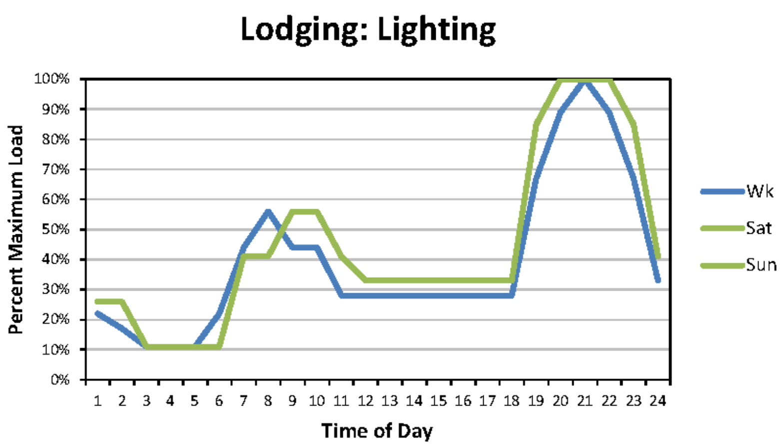

Library: Service Hot Water
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

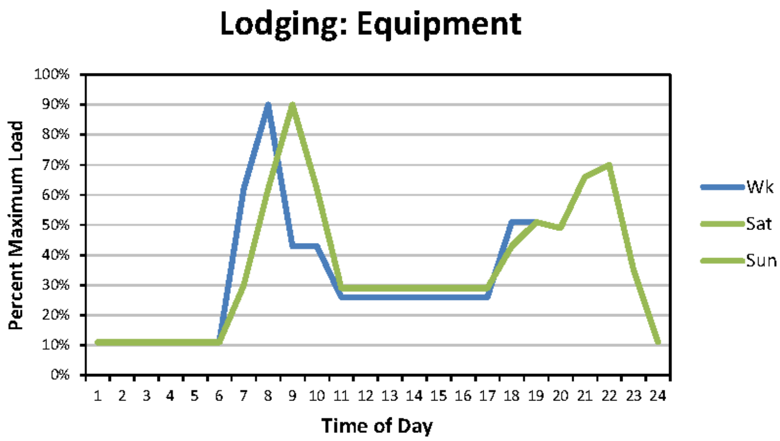

Library: Heating Setpoint
Temperature (°F)
72
70
68
66
64
62
60
58
56
54
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

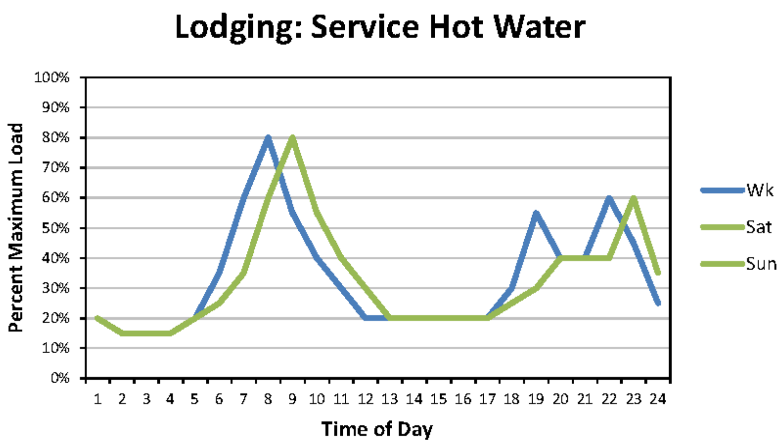

Library: Cooling Setpoint
Temperature (°F)
86
84
82
80
78
76
74
72
70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

Lodging


Lodging: Occupancy
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Lodging: Lighting
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Lodging: Equipment
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Lodging: Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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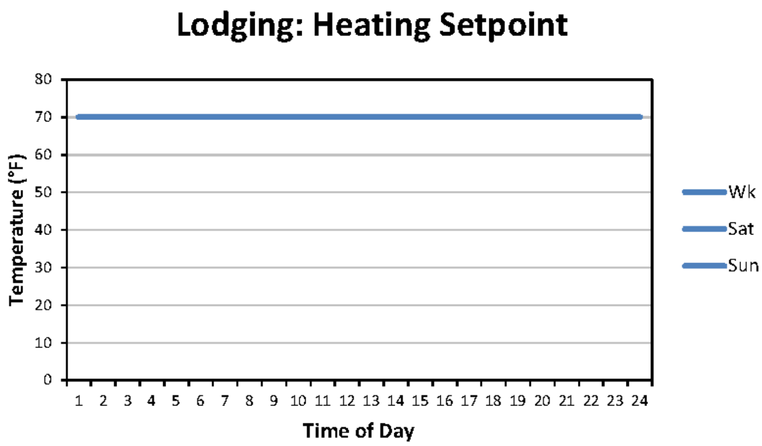
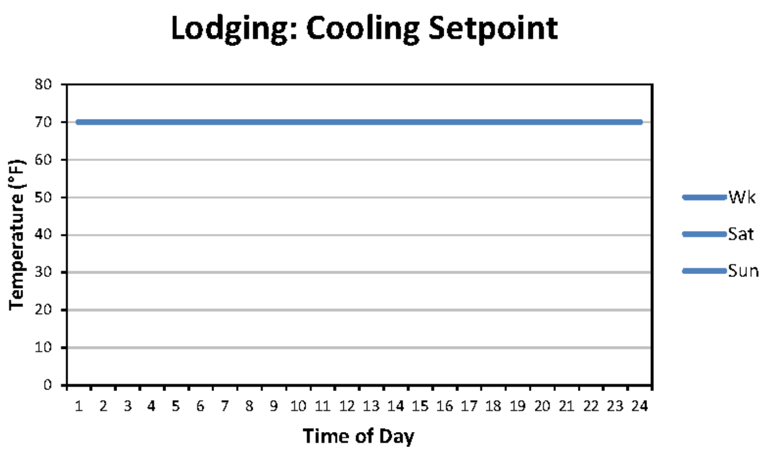
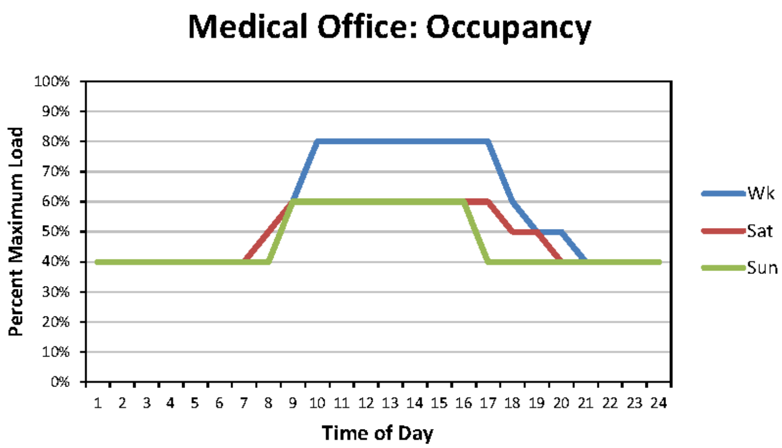
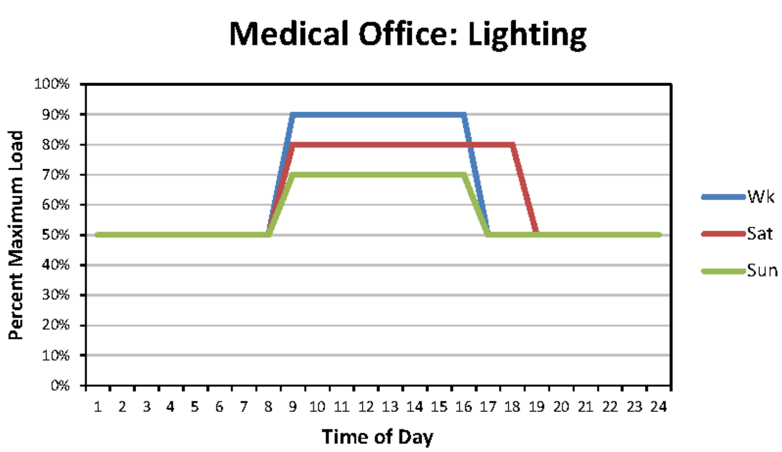
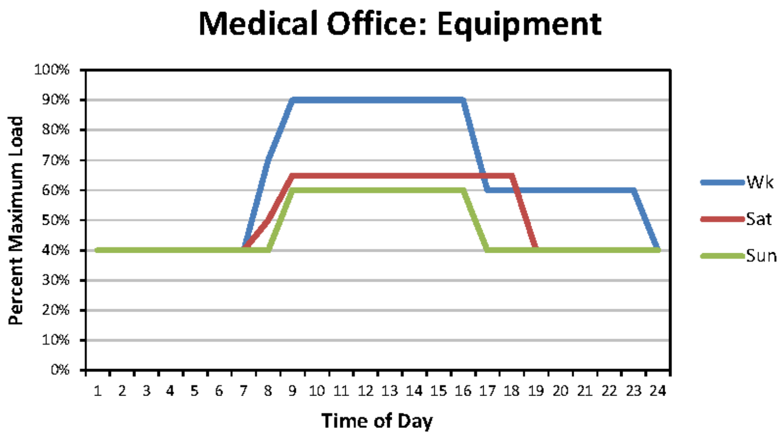


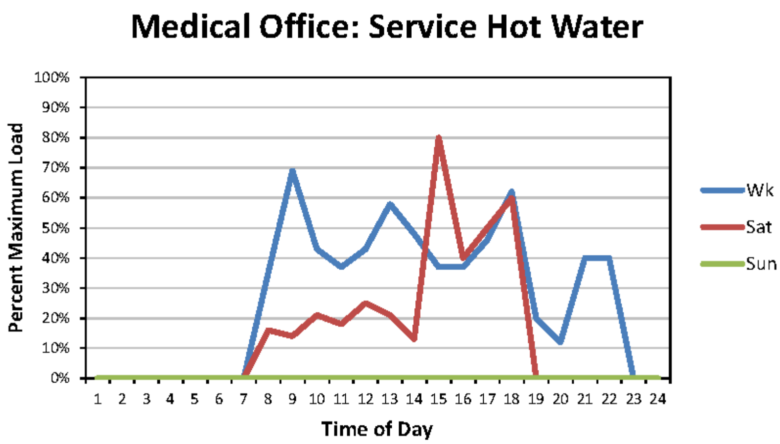


Medical Office

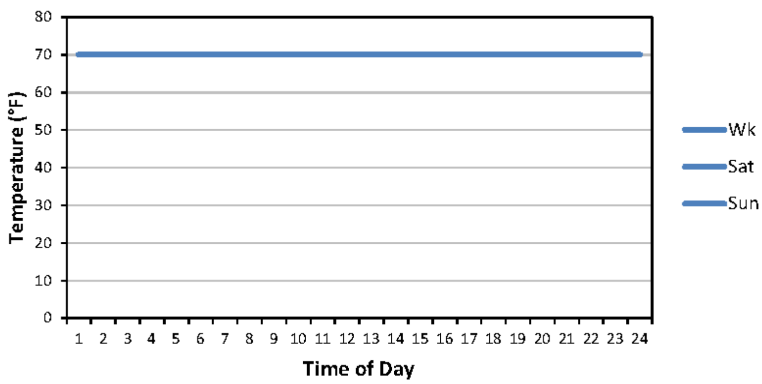




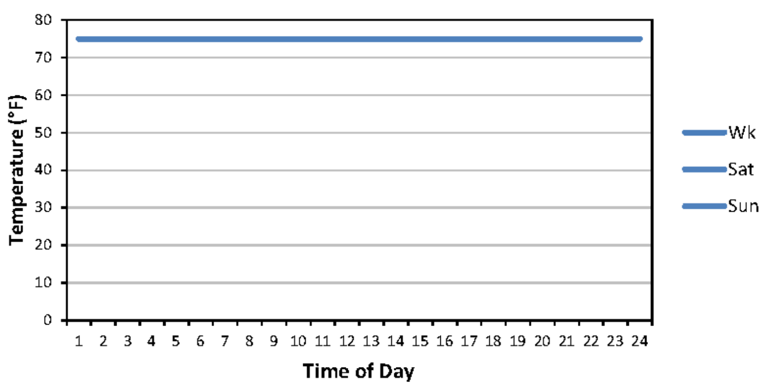

Medical Office: Equipment
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Medical Office: Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

Medical Office: Heating Setpoint



Medical Office: Cooling Setpoint



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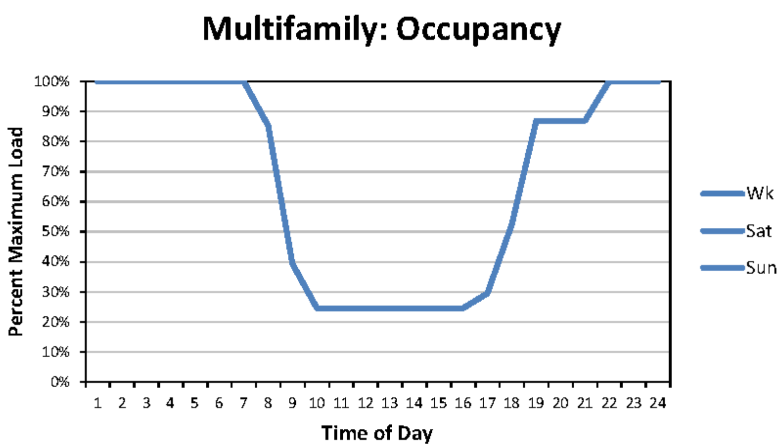
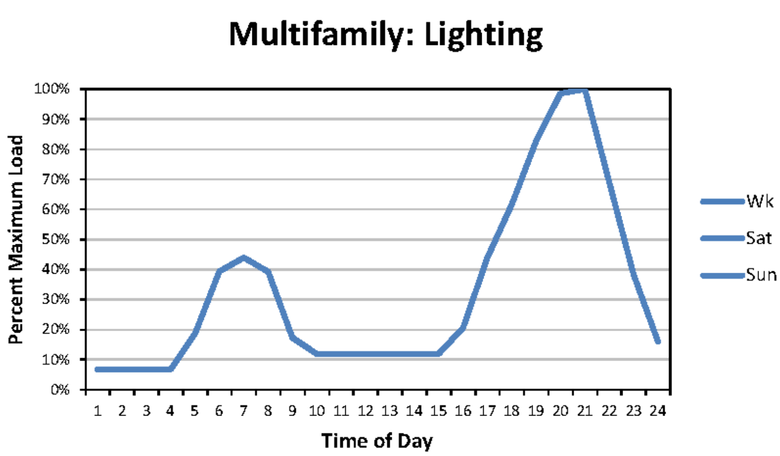
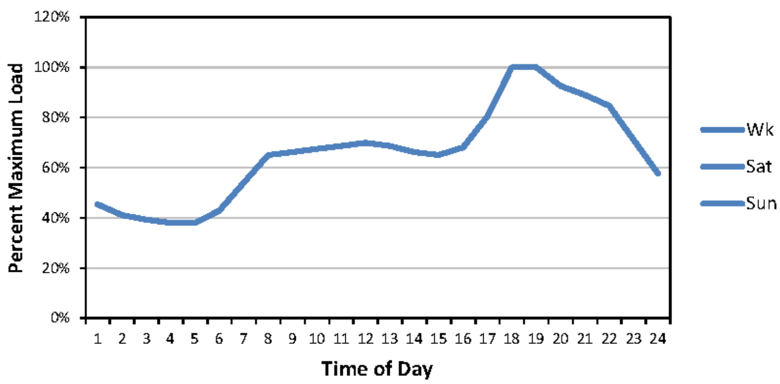
Multi-family

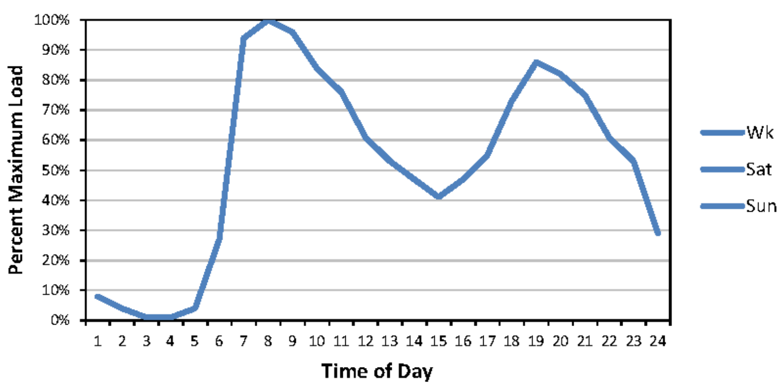




Multifamily: Equipment



Multifamily: Service Hot Water



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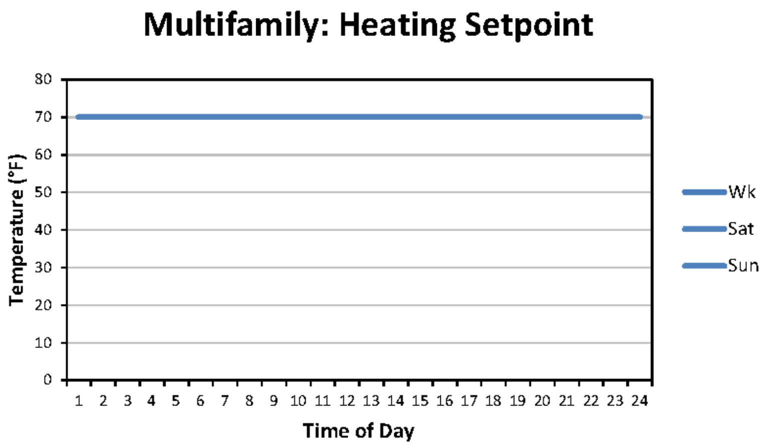

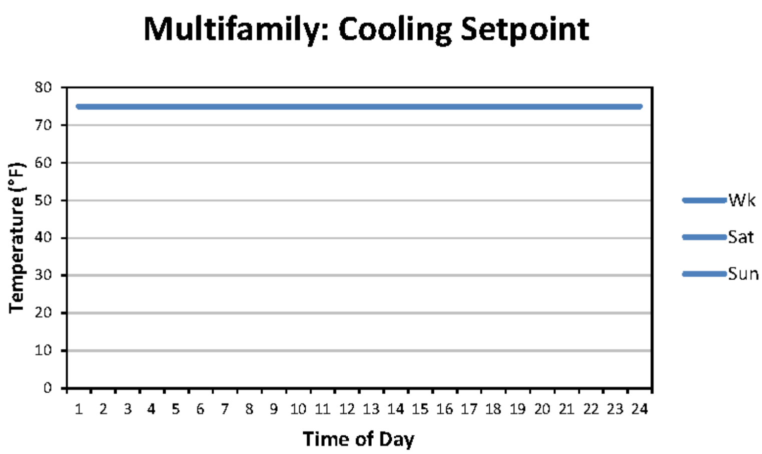

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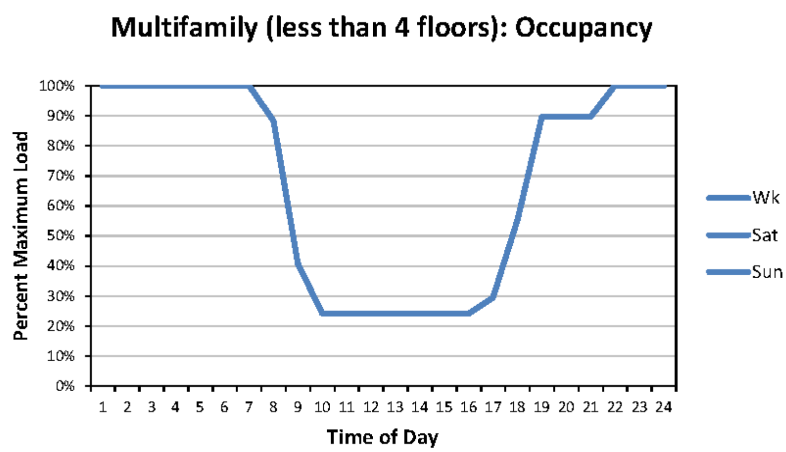
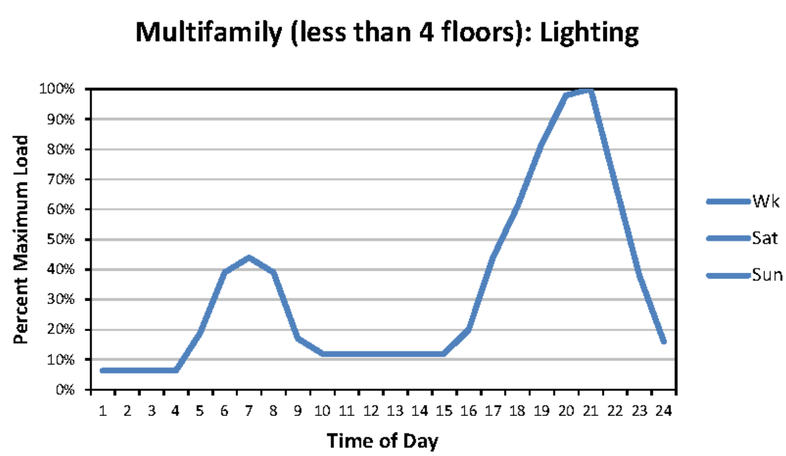
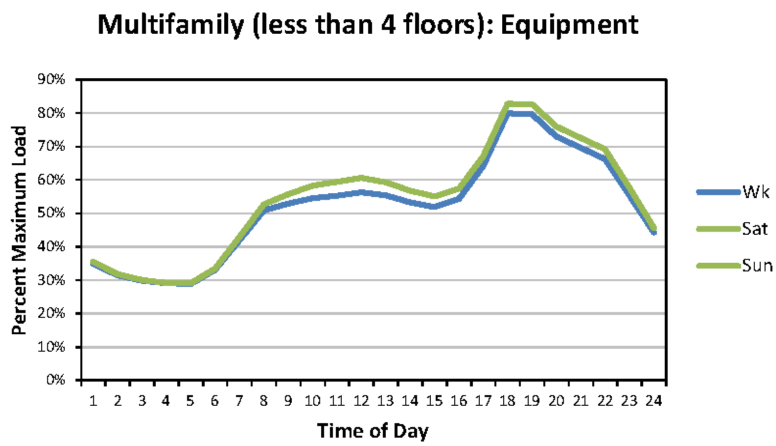
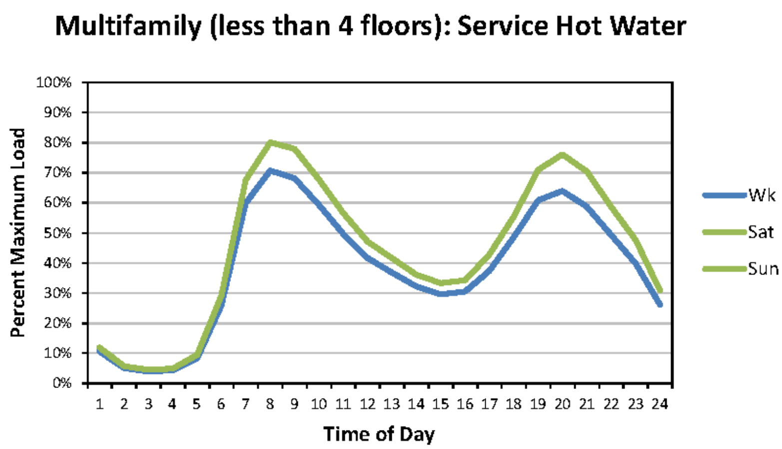
Multi family (less than 4 floors)






Multifamily (less than 4 floors): Equipment
Percent Maximum Load
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Multifamily (less than 4 floors): Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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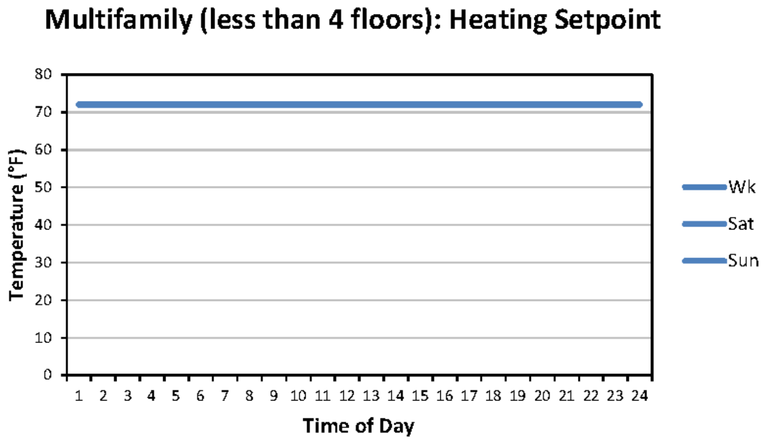

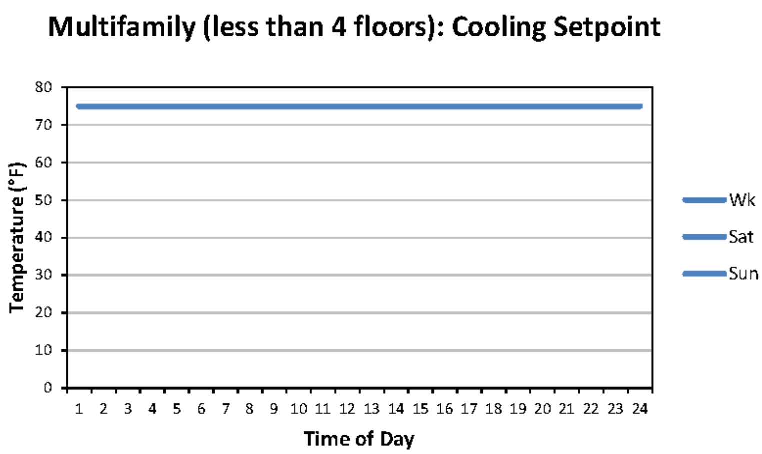

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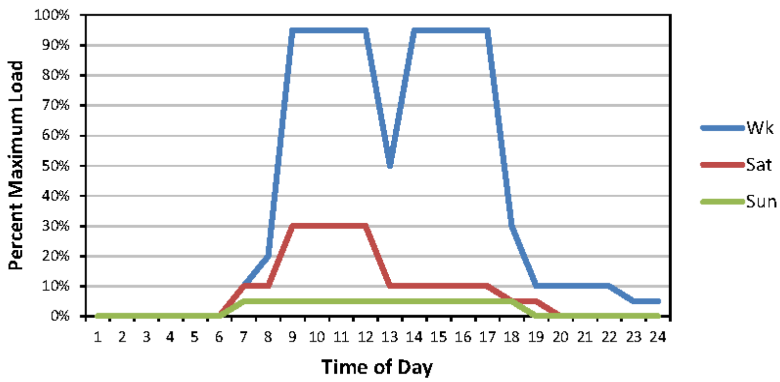
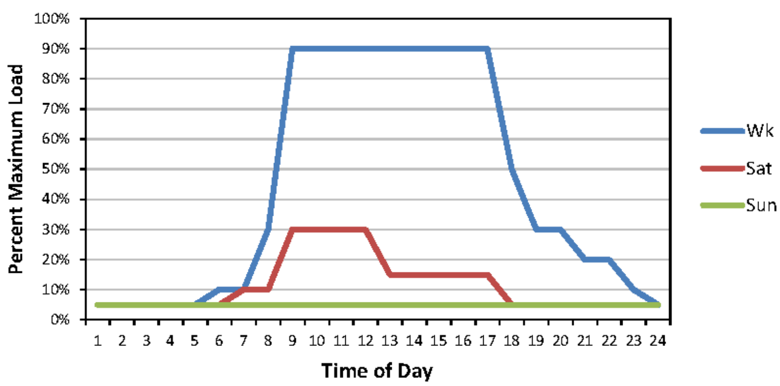
Office Building

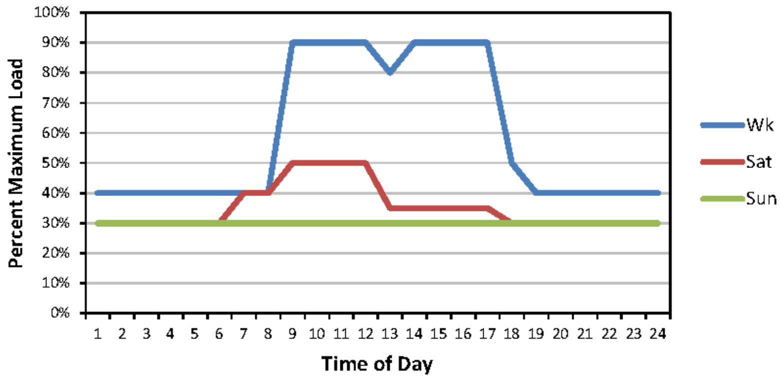
Office: Occupancy



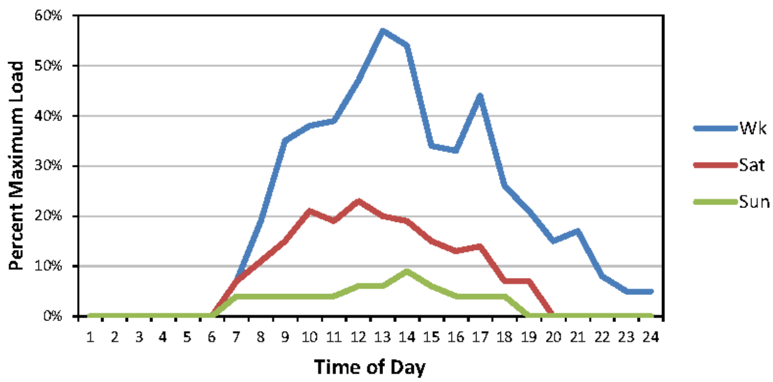
Office: Lighting



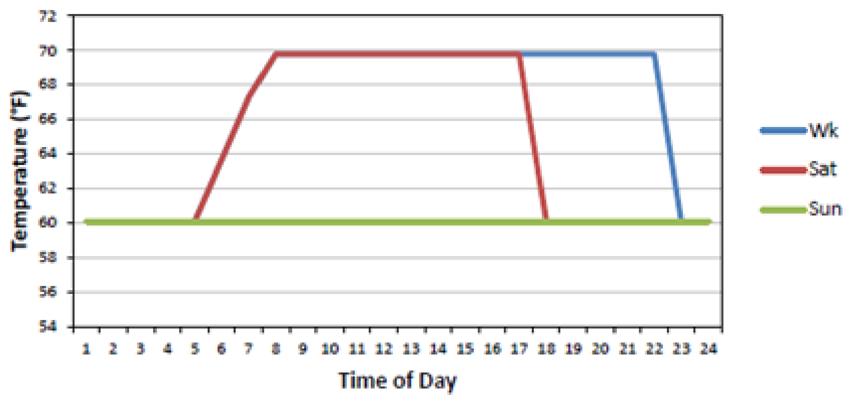
Office: Equipment



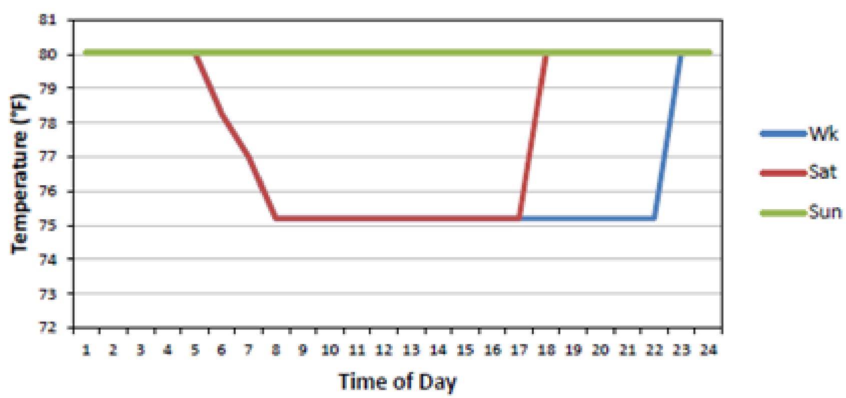
Office: Service Hot Water



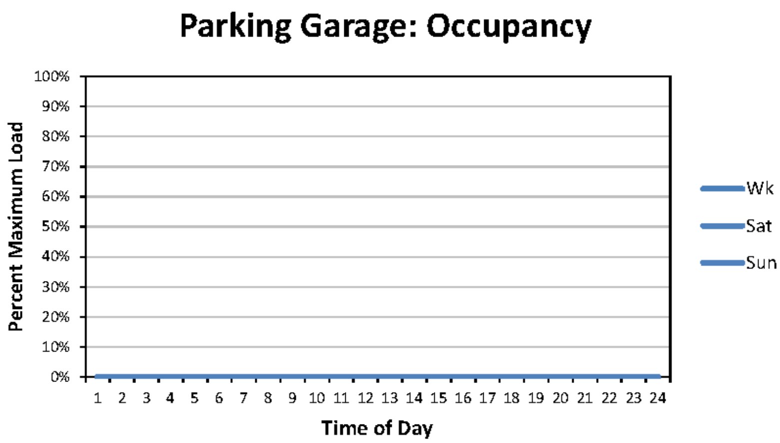
Office: Heating Setpoint

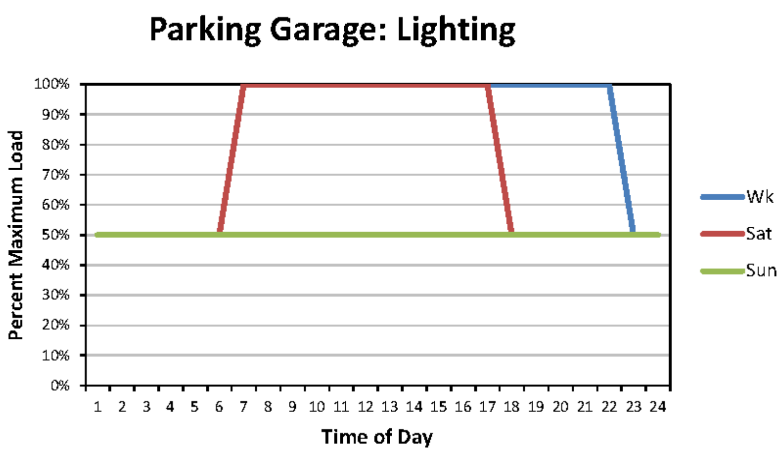


Office: Cooling Setpoint



Parking Garage





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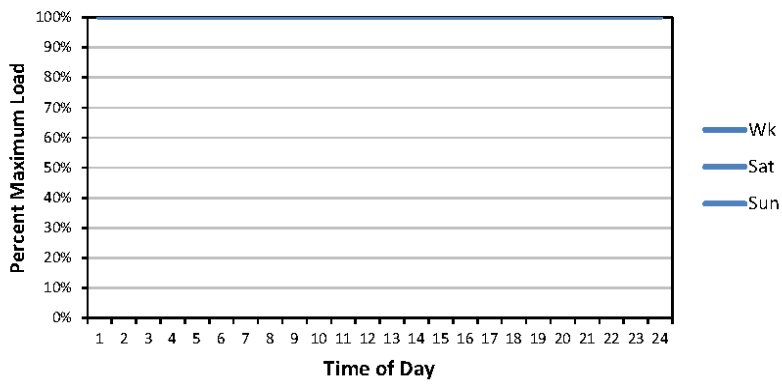
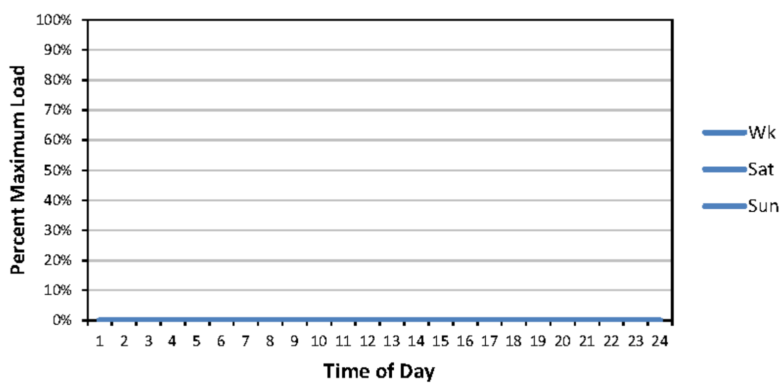
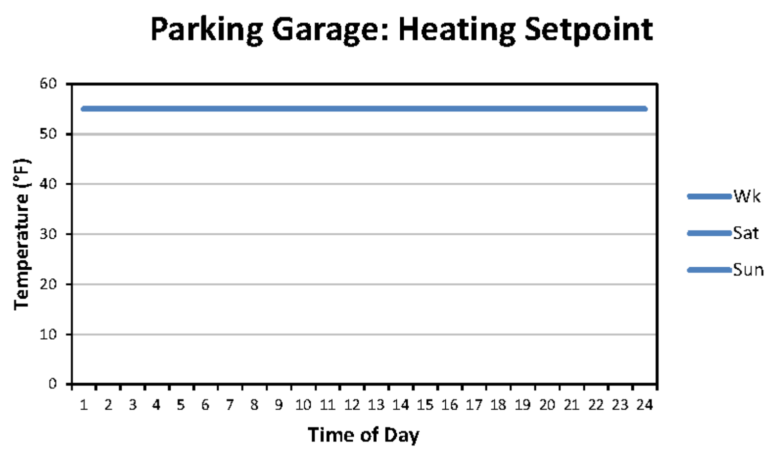
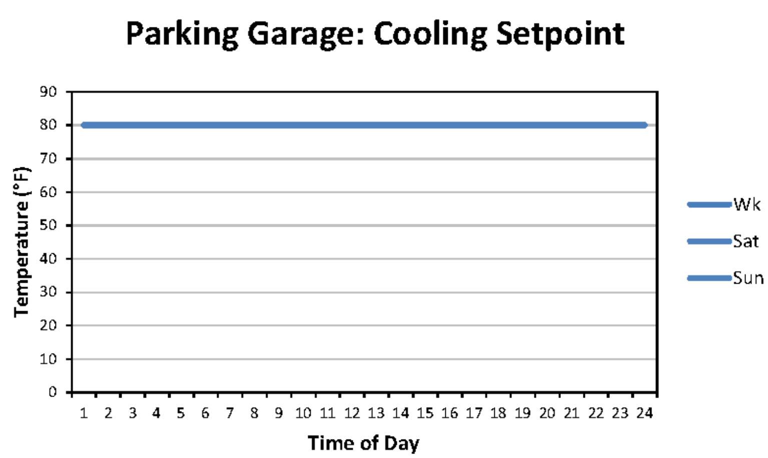
Parking Garage: Equipment



Parking Garage: Service Hot Water




Parking Garage: Heating Setpoint
Temperature (°F)
0
10
20
30
40
50
60
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Parking Garage: Cooling Setpoint
Temperature (°F)
0
10
20
30
40
50
60
70
80
90
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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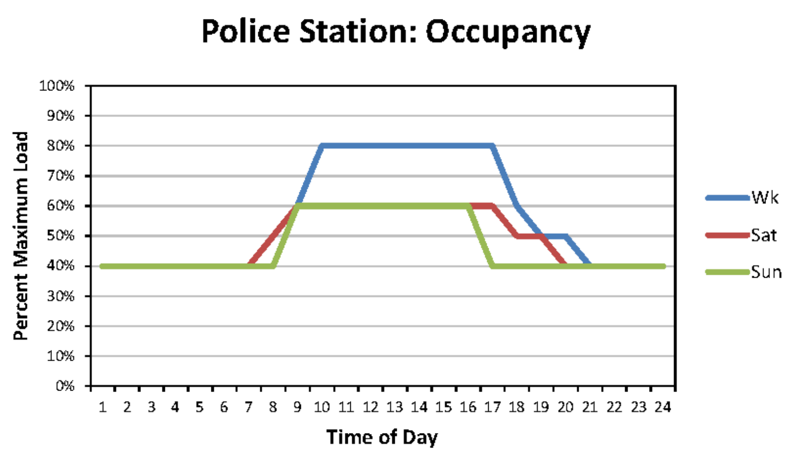
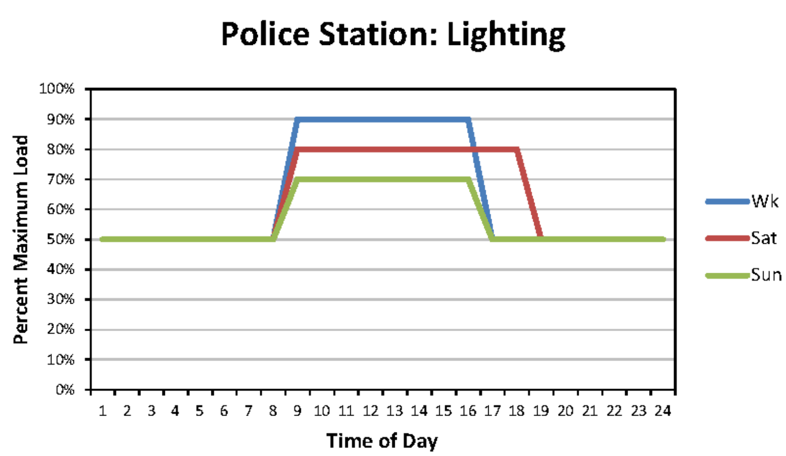
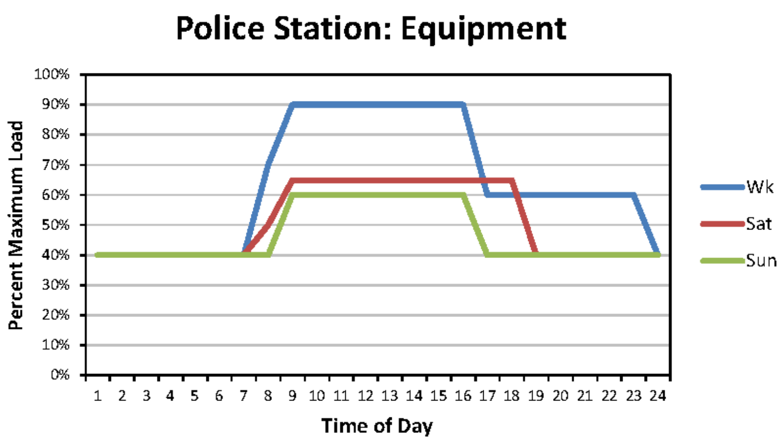
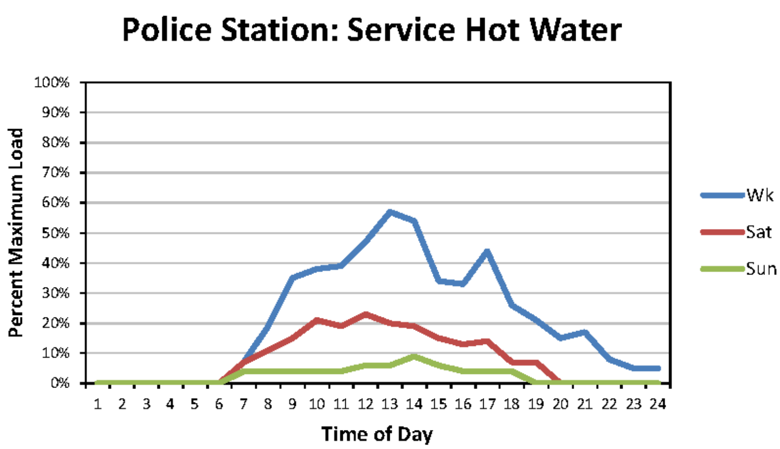
Police Station






Police Station: Equipment
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Police Station: Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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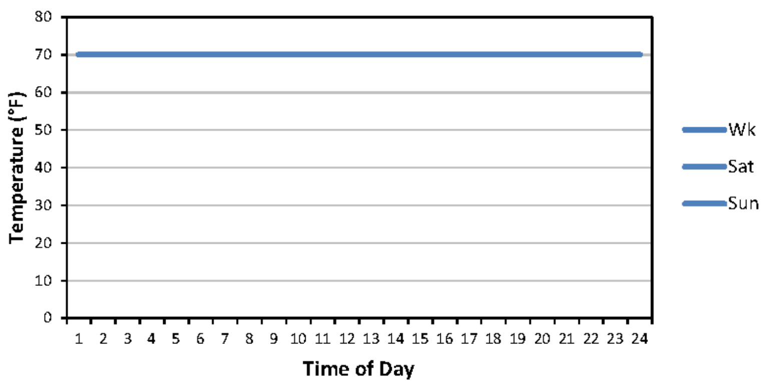
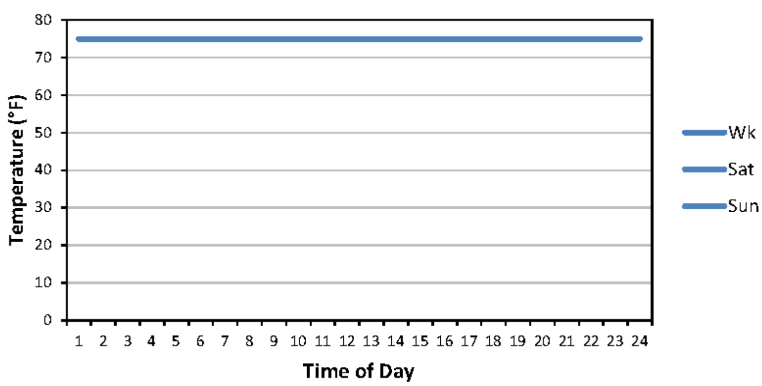
Police Station: Heating Setpoint



Police Station: Cooling Setpoint



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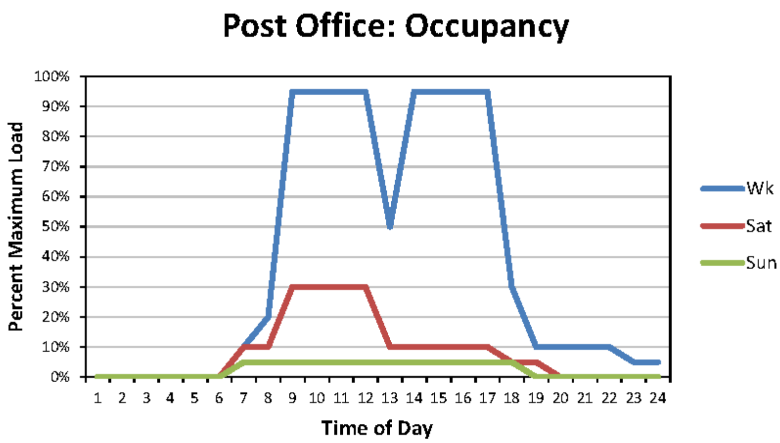
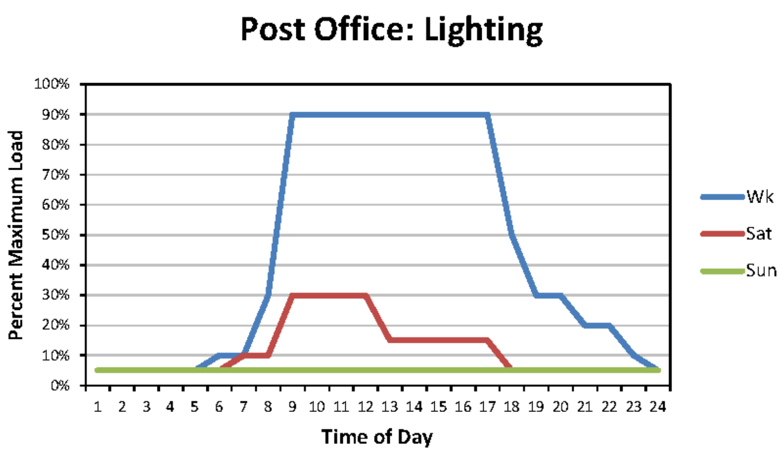
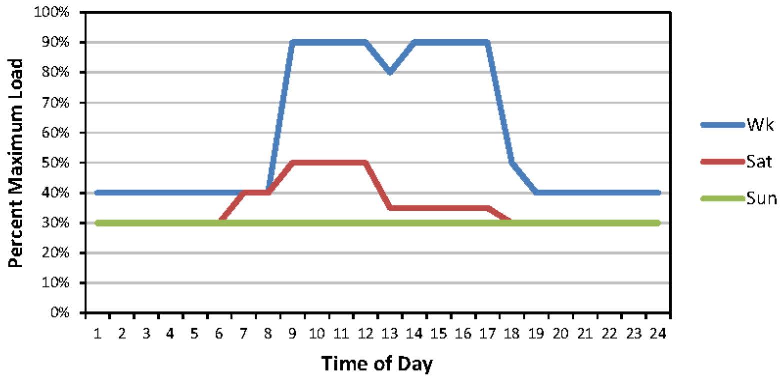
Post Office

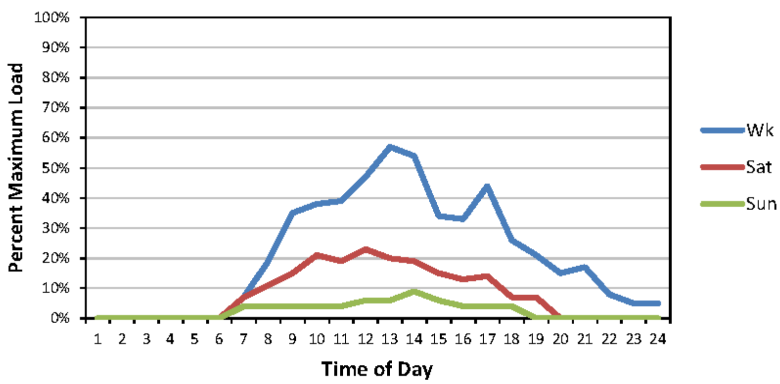


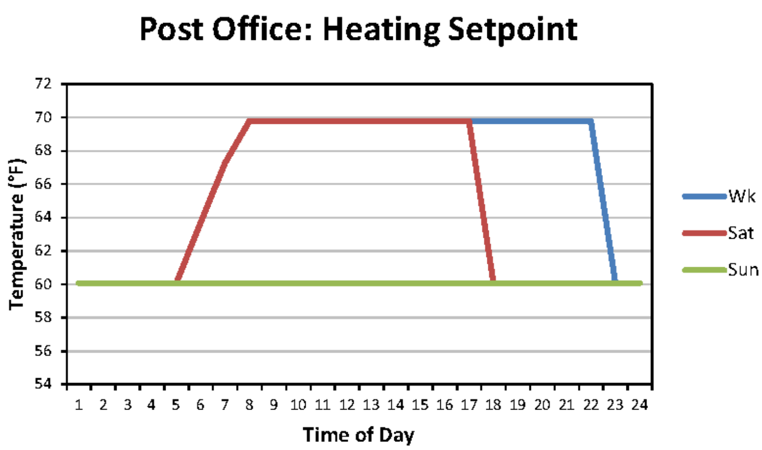


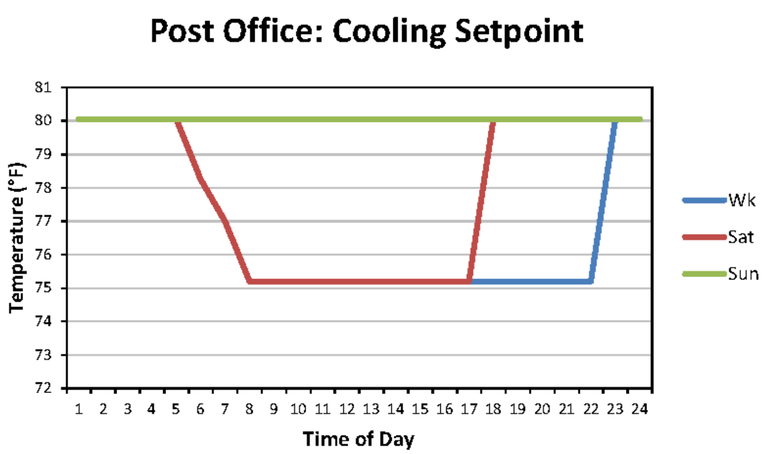
Post Office: Equipment



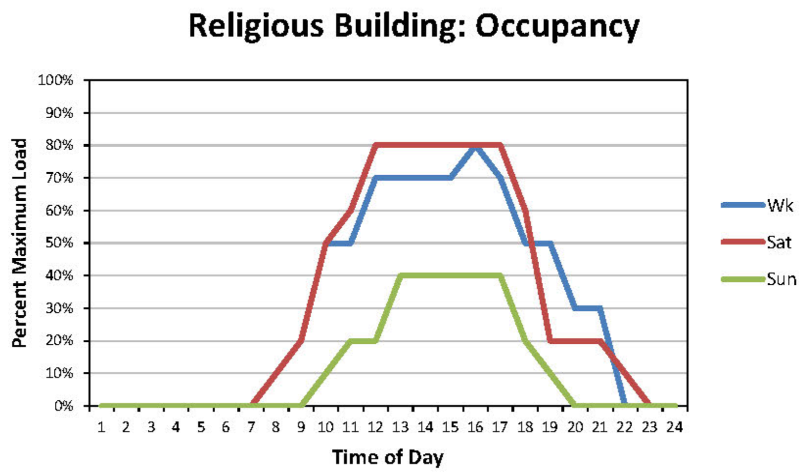
Post Office: Service Hot Water

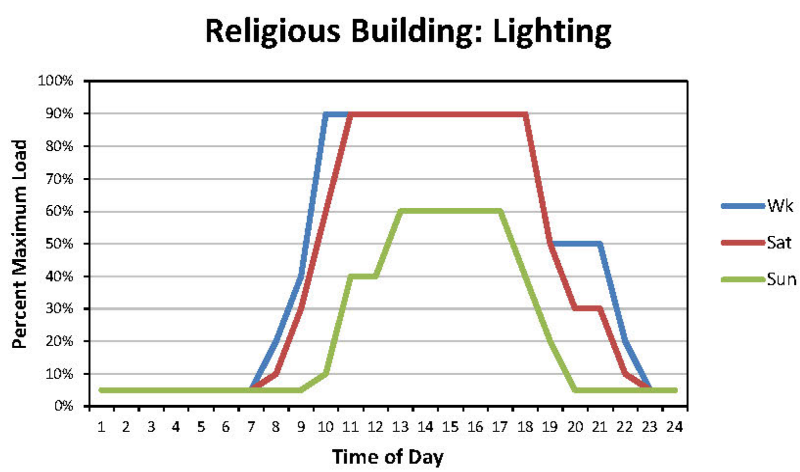



Post Office: Heating Setpoint
72
70
68
66
64
62
60
58
56
54
Temperature (°F)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

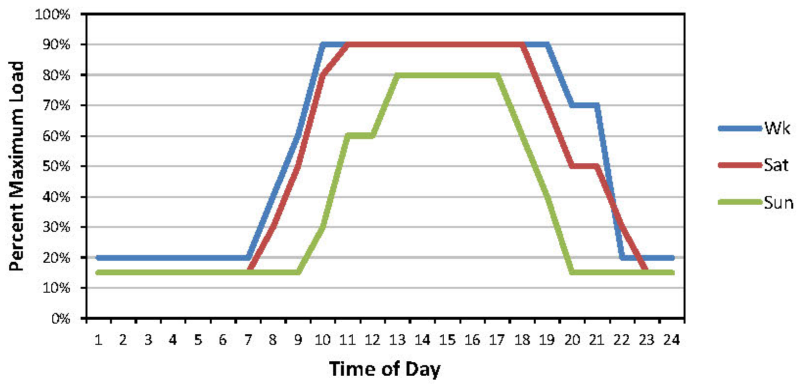

Post Office: Cooling Setpoint
81
80
79
78
77
76
75
74
73
72
Temperature (°F)
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

Religious Building

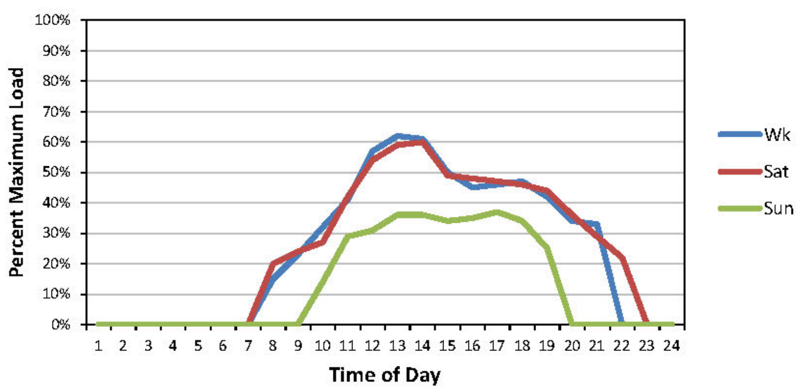


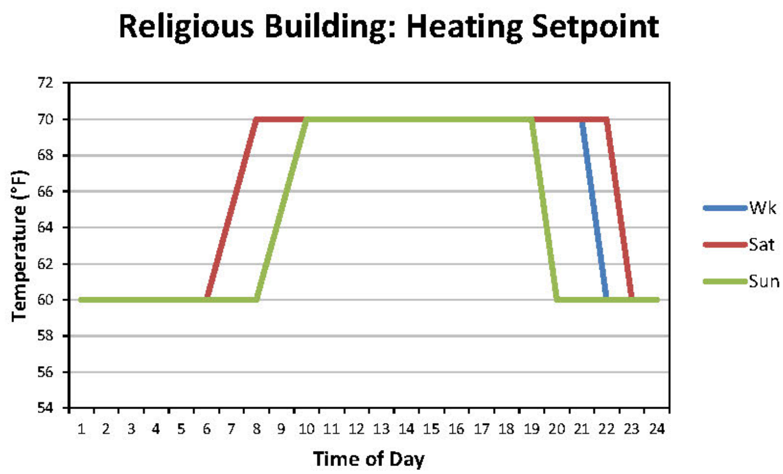


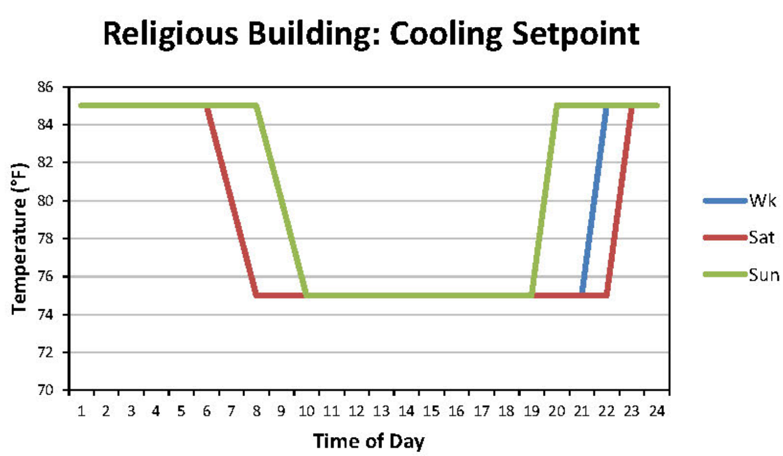
Religious Building: Equipment



Religious Building: Service Hot Water




Religious Building: Heating Setpoint
Temperature (°F)
72
70
68
66
64
62
60
58
56
54
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Religious Building: Cooling Setpoint
Temperature (°F)
86
84
82
80
78
76
74
72
70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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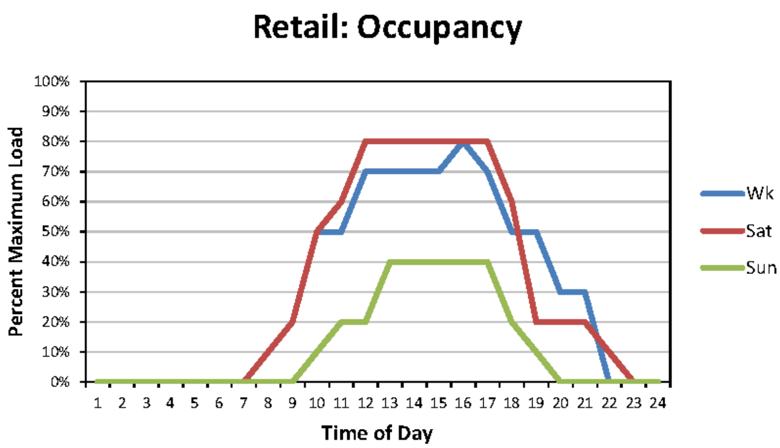
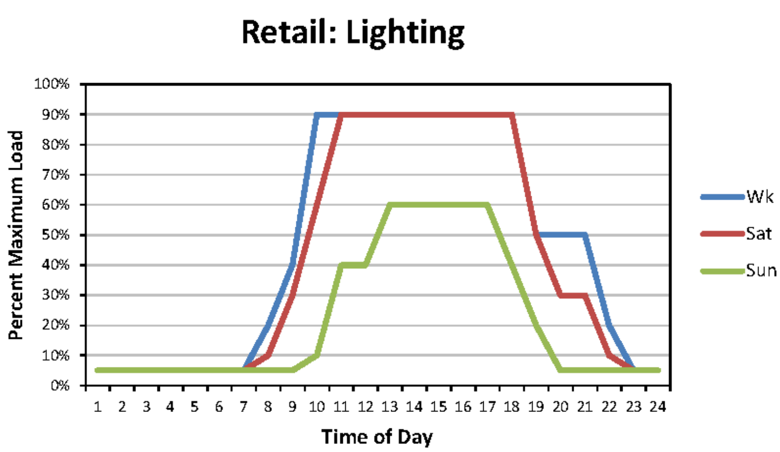
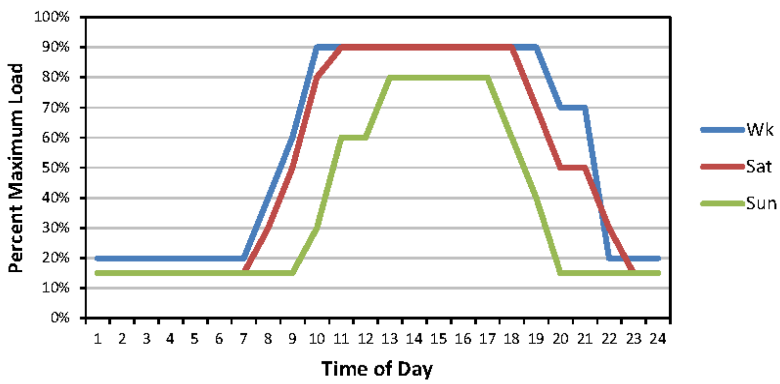
Retail

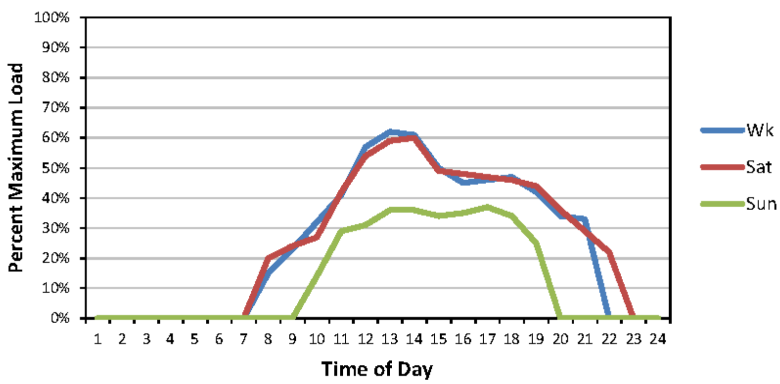




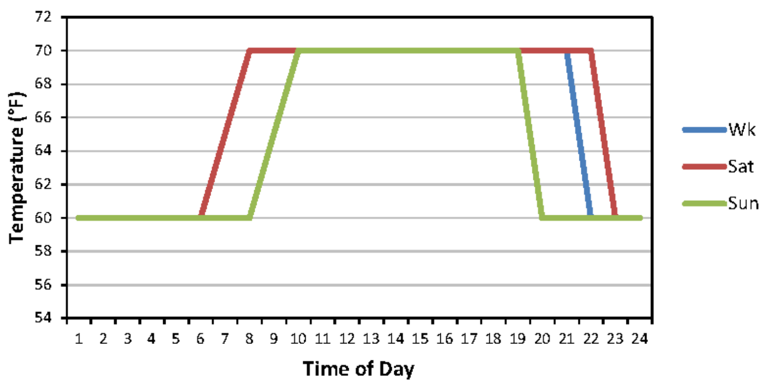
Retail: Equipment



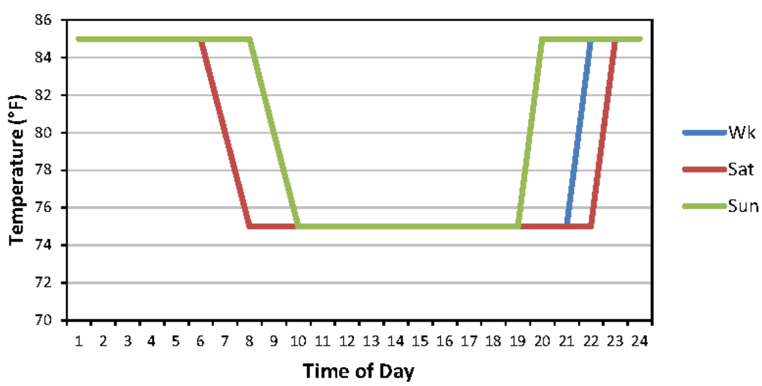
Retail: Service Hot Water



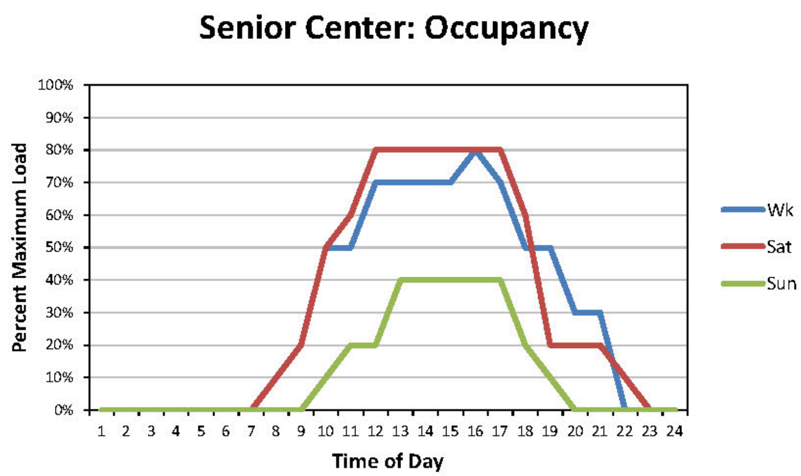
Retail: Heating Setpoint

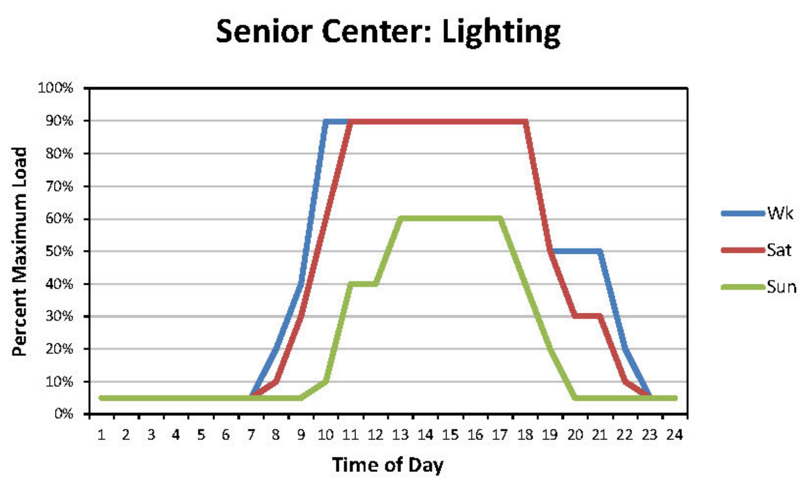


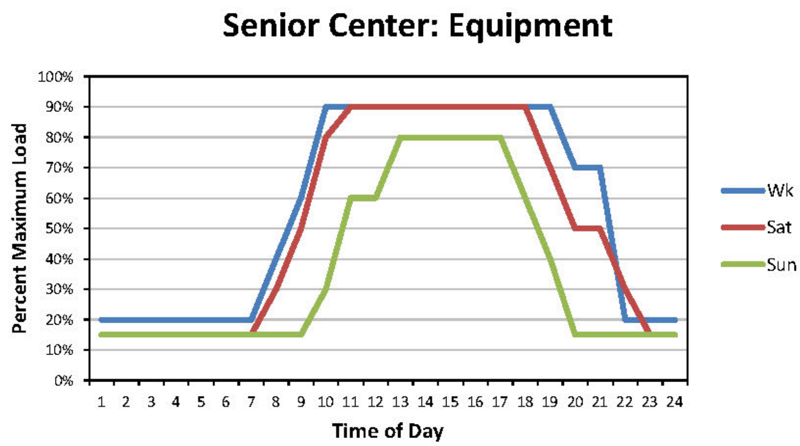
Retail: Cooling Setpoint

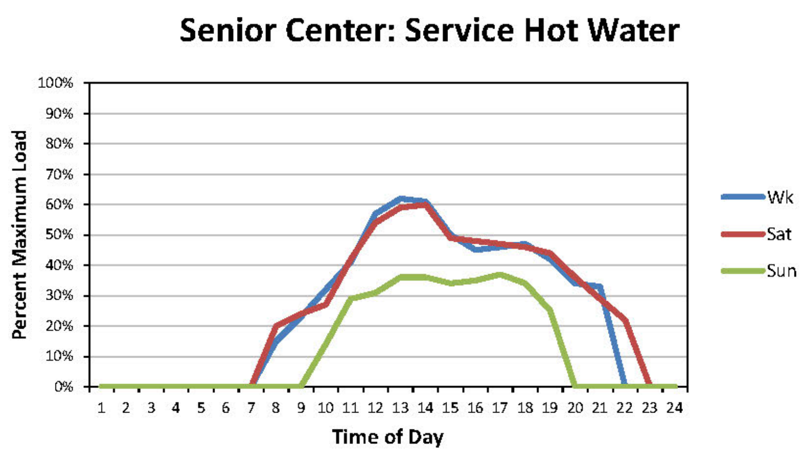


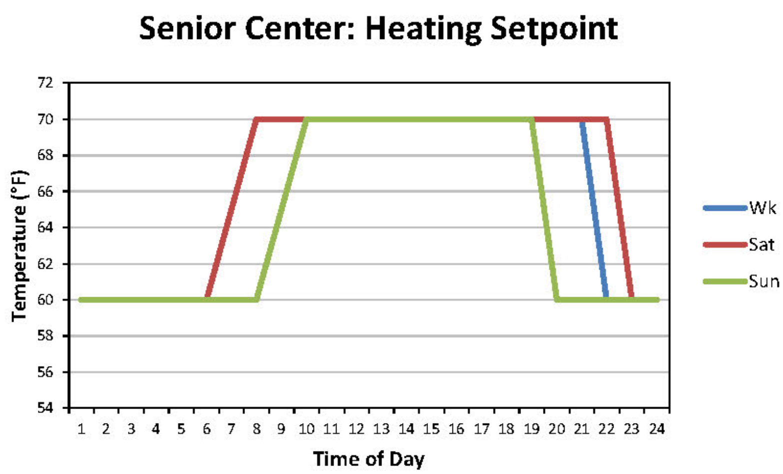
Senior Center

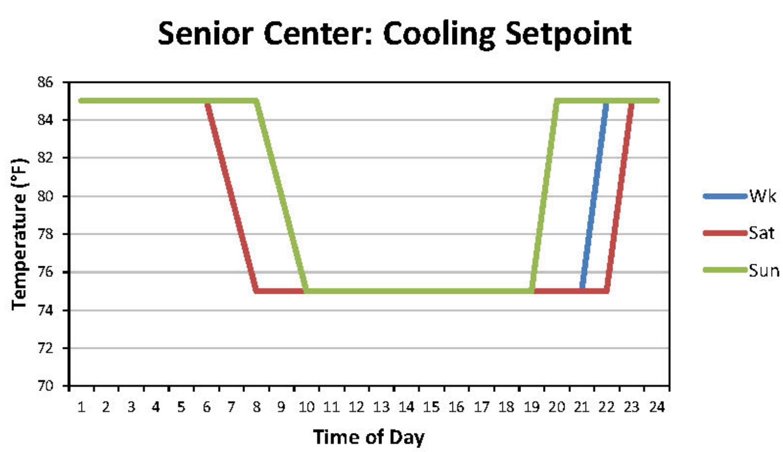




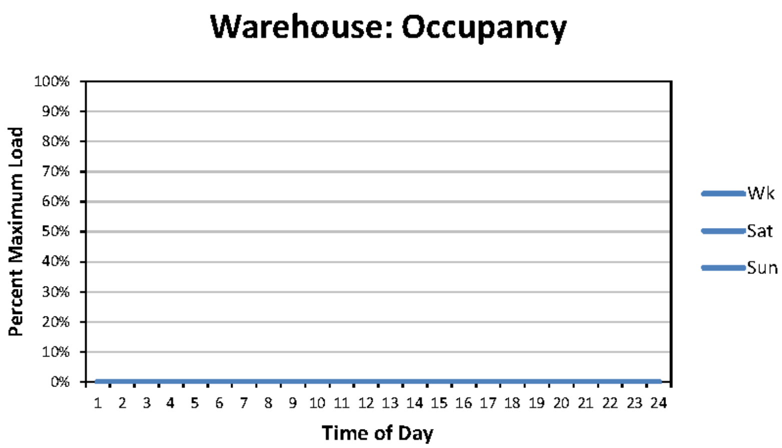

Senior Center: Equipment
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

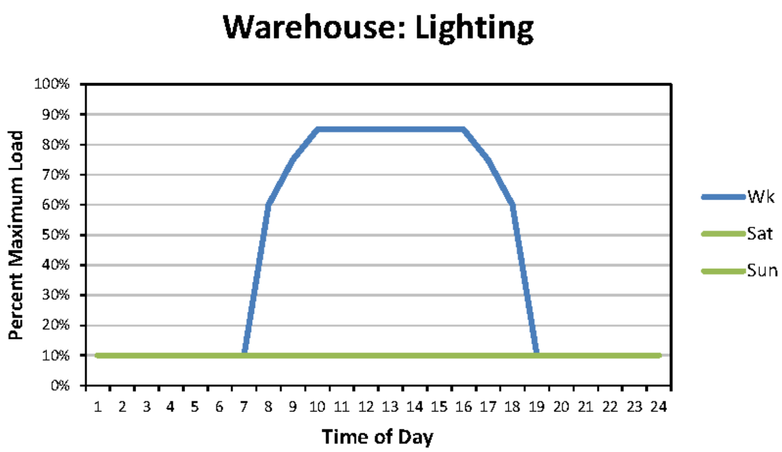

Senior Center: Service Hot Water
Percent Maximum Load
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

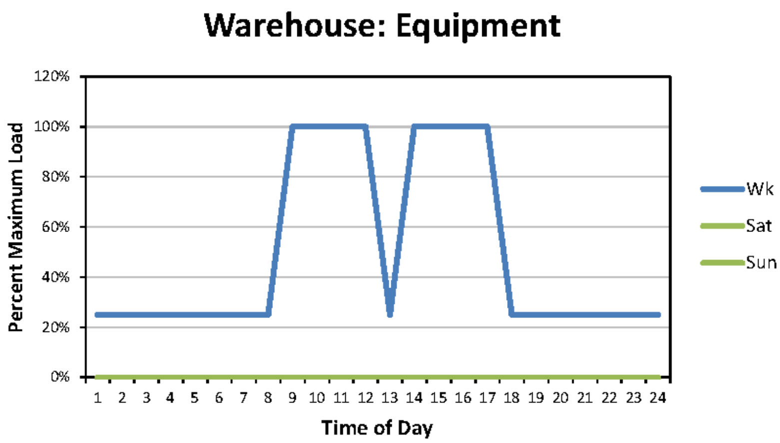

Senior Center: Heating Setpoint
Temperature (°F)
72
70
68
66
64
62
60
58
56
54
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

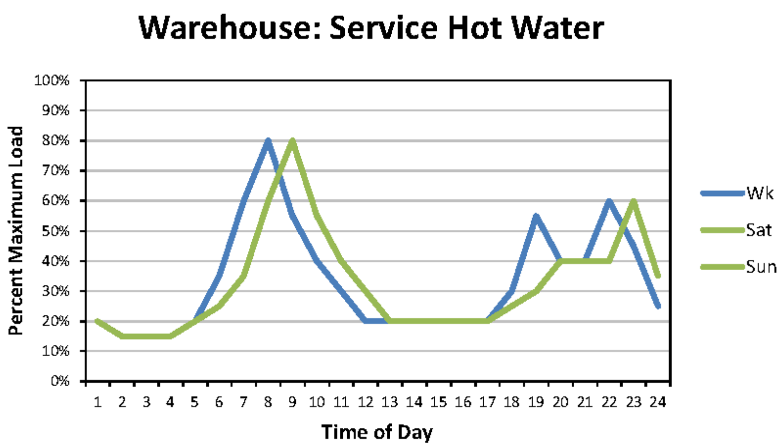

Senior Center: Cooling Setpoint
Temperature (°F)
86
84
82
80
78
76
74
72
70
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

Warehouse non-refrigerated






Warehouse: Equipment
120%
100%
80%
60%
40%
20%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun


Warehouse: Service Hot Water
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Percent Maximum Load
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24
Time of Day
Wk
Sat
Sun

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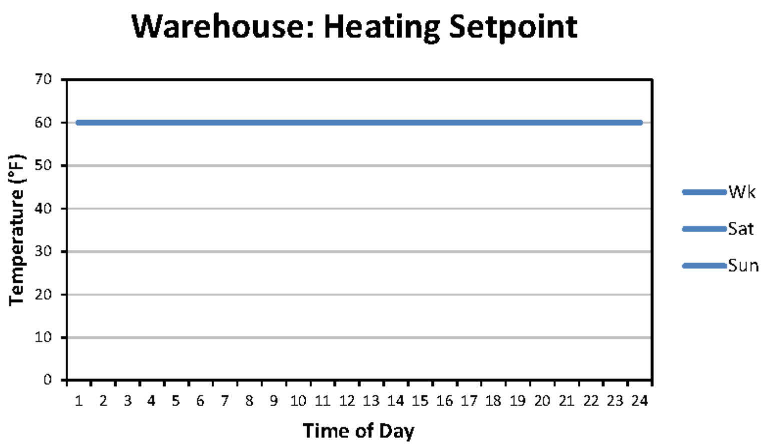
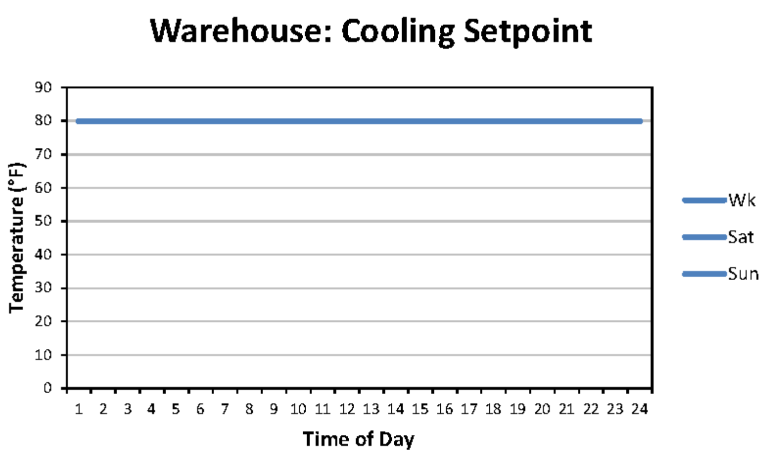




Appendix K

System Evaluation Comparison

Note: The evaluation ranges for System Performance and being revised. This appendix will be updated when the ranges have been developed.

Vintage	Location	Office Small SPR Heating	Office Small SPR Cooling	Office Small Total System	Police Station SPR Heating	Police Station SPR Cooling	Police Station Total System	Post Office SPR Heating	Post Office SPR Cooling	Post Office Total System	Library SPR Heating	Library SPR Cooling	Library Total System	Medical Office SPR Heating	Medical Office SPR Cooling	Medical Office Total System
2004	Albuquerque	0.433	0.361	0.380	0.481	0.389	0.407	0.564	0.597	0.588	0.721	0.294	0.322	0.324	0.444	0.374
2004	Baltimore	0.468	0.377	0.407	0.511	0.435	0.454	0.559	0.688	0.641	0.751	0.349	0.406	0.322	0.543	0.397
2004	Boise	0.440	0.338	0.378	0.488	0.354	0.396	0.563	0.569	0.567	0.769	0.282	0.342	0.322	0.430	0.348
2004	Burlington	0.412	0.356	0.390	0.456	0.404	0.431	0.476	0.614	0.526	0.669	0.277	0.393	0.321	0.483	0.342
2004	Chicago	0.422	0.382	0.403	0.463	0.450	0.455	0.494	0.663	0.571	0.672	0.317	0.403	0.321	0.560	0.369
2004	Duluth	0.389	0.264	0.348	0.424	0.336	0.392	0.420	0.533	0.450	0.587	0.227	0.380	0.320	0.396	0.327
2004	El_Paso	0.431	0.399	0.403	0.502	0.433	0.439	0.581	0.641	0.633	0.612	0.353	0.360	0.327	0.518	0.446
2004	Fairbanks	0.353	0.203	0.313	0.394	0.231	0.350	0.369	0.409	0.376	0.560	0.181	0.373	0.320	0.301	0.319
2004	Helena	0.406	0.286	0.346	0.454	0.308	0.373	0.468	0.519	0.491	0.720	0.230	0.325	0.322	0.360	0.327
2004	Houston	0.492	0.462	0.464	0.558	0.549	0.550	0.610	0.758	0.744	0.714	0.439	0.451	0.325	0.685	0.591
2004	Memphis	0.473	0.438	0.445	0.528	0.498	0.502	0.579	0.730	0.697	0.754	0.405	0.429	0.323	0.625	0.482
2004	Miami	0.509	0.518	0.517	0.760	0.617	0.617	0.608	0.809	0.807	0.441	0.512	0.512	0.352	0.737	0.729
2004	Phoenix	0.423	0.420	0.420	0.541	0.460	0.462	0.595	0.645	0.642	0.611	0.410	0.414	0.335	0.569	0.533
2004	Salem	0.447	0.338	0.378	0.503	0.372	0.410	0.596	0.589	0.592	0.845	0.255	0.326	0.324	0.399	0.340
2004	San_Francisco	0.418	0.349	0.369	0.555	0.366	0.393	0.591	0.574	0.578	0.581	0.265	0.280	0.337	0.261	0.314
2004	Vancouver	0.460	0.353	0.409	0.513	0.369	0.429	0.614	0.564	0.589	0.861	0.245	0.353	0.323	0.284	0.319
2010	Albuquerque	0.447	0.389	0.404	0.492	0.426	0.439	0.594	0.692	0.665	0.709	0.315	0.337	0.325	0.457	0.379
2010	Baltimore	0.465	0.469	0.468	0.508	0.550	0.538	0.586	0.809	0.720	0.767	0.371	0.421	0.323	0.611	0.413
2010	Boise	0.442	0.357	0.390	0.499	0.383	0.419	0.588	0.657	0.627	0.794	0.287	0.347	0.323	0.440	0.350
2010	Burlington	0.411	0.377	0.398	0.465	0.439	0.453	0.490	0.709	0.563	0.678	0.286	0.403	0.321	0.491	0.342
2010	Chicago	0.426	0.411	0.419	0.473	0.500	0.488	0.511	0.774	0.622	0.683	0.331	0.416	0.321	0.575	0.371
2010	Duluth	0.385	0.263	0.348	0.430	0.358	0.404	0.427	0.608	0.467	0.593	0.233	0.386	0.320	0.397	0.326
2010	El_Paso	0.444	0.438	0.439	0.514	0.482	0.485	0.614	0.751	0.729	0.656	0.356	0.365	0.327	0.536	0.454
2010	Fairbanks	0.347	0.198	0.311	0.395	0.236	0.354	0.371	0.444	0.382	0.547	0.181	0.375	0.320	0.295	0.319
2010	Helena	0.403	0.295	0.349	0.462	0.327	0.386	0.483	0.592	0.528	0.736	0.231	0.327	0.322	0.365	0.328
2010	Houston	0.462	0.557	0.547	0.529	0.673	0.663	0.640	0.903	0.875	0.726	0.464	0.472	0.325	0.740	0.625
2010	Memphis	0.465	0.535	0.518	0.520	0.620	0.604	0.612	0.868	0.805	0.775	0.421	0.448	0.323	0.689	0.504
2010	Miami	0.527	0.592	0.591	0.769	0.714	0.714	0.645	0.967	0.962	0.450	0.548	0.548	0.349	0.764	0.754
2010	Phoenix	0.436	0.481	0.478	0.556	0.525	0.526	0.622	0.768	0.758	0.583	0.430	0.432	0.335	0.593	0.552
2010	Salem	0.462	0.355	0.395	0.515	0.397	0.432	0.627	0.677	0.657	0.857	0.273	0.332	0.324	0.404	0.341
2010	San_Francisco	0.439	0.344	0.371	0.577	0.374	0.398	0.629	0.650	0.644	0.669	0.225	0.244	0.340	0.237	0.309
2010	Vancouver	0.463	0.352	0.409	0.524	0.382	0.438	0.646	0.637	0.641	0.895	0.246	0.353	0.324	0.280	0.319
2004 with Min Tech	Albuquerque	0.396	0.292	0.317	0.445	0.314	0.336	0.492	0.489	0.490	0.649	0.248	0.273	0.324	0.383	0.351
2004 with Min Tech	Baltimore	0.428	0.291	0.331	0.465	0.330	0.360	0.492	0.558	0.535	0.668	0.290	0.341	0.322	0.446	0.370
2004 with Min Tech	Boise	0.404	0.279	0.324	0.450	0.293	0.339	0.495	0.469	0.479	0.695	0.242	0.296	0.322	0.373	0.336
2004 with Min Tech	Burlington	0.386	0.297	0.349	0.426	0.332	0.378	0.436	0.507	0.464	0.612	0.239	0.346	0.321	0.416	0.335
2004 with Min Tech	Chicago	0.394	0.306	0.349	0.430	0.354	0.383	0.450	0.541	0.494	0.614	0.267	0.347	0.321	0.469	0.355
2004 with Min Tech	Duluth	0.374	0.234	0.326	0.407	0.291	0.362	0.399	0.449	0.413	0.557	0.202	0.348	0.320	0.352	0.323
2004 with Min Tech	El_Paso	0.396	0.312	0.323	0.468	0.337	0.347	0.507	0.521	0.519	0.563	0.289	0.296	0.327	0.435	0.399
2004 with Min Tech	Fairbanks	0.347	0.190	0.304	0.388	0.215	0.339	0.361	0.355	0.360	0.550	0.167	0.354	0.320	0.281	0.318
2004 with Min Tech	Helena	0.382	0.247	0.312	0.429	0.265	0.334	0.431	0.434	0.432	0.672	0.203	0.290	0.322	0.321	0.322
2004 with Min Tech	Houston	0.449	0.344	0.352	0.510	0.402	0.407	0.530	0.607	0.600	0.631	0.349	0.360	0.325	0.551	0.501
2004 with Min Tech	Memphis	0.432	0.329	0.347	0.480	0.369	0.381	0.506	0.585	0.570	0.674	0.328	0.350	0.323	0.506	0.429
2004 with Min Tech	Miami	0.470	0.378	0.379	0.715	0.443	0.443	0.535	0.644	0.643	0.410	0.399	0.399	0.352	0.587	0.583
2004 with Min Tech	Phoenix	0.393	0.315	0.319	0.511	0.343	0.347	0.522	0.517	0.518	0.564	0.325	0.329	0.335	0.463	0.446
2004 with Min Tech	Salem	0.411	0.283	0.327	0.465	0.313	0.355	0.520	0.486	0.498	0.759	0.221	0.284	0.324	0.350	0.330
2004 with Min Tech	San_Francisco	0.390	0.313	0.334	0.524	0.330	0.356	0.521	0.475	0.486	0.542	0.233	0.247	0.337	0.245	0.308
2004 with Min Tech	Vancouver	0.419	0.318	0.371	0.470	0.332	0.389	0.532	0.470	0.500	0.769	0.220	0.317	0.323	0.266	0.316
2010 with Max Tech	Albuquerque	0.484	0.399	0.421	0.527	0.437	0.454	0.677	0.779	0.751	0.739	0.340	0.363	0.325	0.522	0.400
2010 with Max Tech	Baltimore	0.503	0.483	0.491	0.550	0.568	0.563	0.661	0.919	0.816	0.804	0.404	0.456	0.323	0.729	0.435
2010 with Max Tech	Boise	0.476	0.365	0.407	0.535	0.391	0.435	0.663	0.736	0.705	0.828	0.307	0.370	0.323	0.500	0.360
2010 with Max Tech	Burlington	0.435	0.385	0.415	0.493	0.450	0.472	0.529	0.793	0.615	0.704	0.305	0.427	0.321	0.562	0.348
2010 with Max Tech	Chicago	0.453	0.422	0.438	0.503	0.515	0.510	0.556	0.875	0.688	0.709	0.357	0.445	0.321	0.679	0.383
2010 with Max Tech	Duluth	0.398	0.267	0.357	0.445	0.364	0.416	0.445	0.671	0.494	0.605	0.245	0.400	0.320	0.440	0.329
2010 with Max Tech	El_Paso	0.478	0.452	0.456	0.546	0.497	0.502	0.699	0.853	0.828	0.681	0.390	0.400	0.327	0.632	0.500
2010 with Max Tech	Fairbanks	0.352	0.199	0.315	0.401	0.237	0.358	0.377	0.478	0.392	0.551	0.187	0.382	0.320	0.313	0.319
2010 with Max Tech	Helena	0.424	0.300	0.361	0.484	0.332	0.397	0.519	0.656	0.575	0.757	0.244	0.344	0.322	0.404	0.333
2010 with Max Tech	Houston	0.500	0.578	0.570	0.570	0.701	0.692	0.733	1.037	1.005	0.760	0.518	0.525	0.325	0.913	0.723
2010 with Max Tech	Memphis	0.505	0.554	0.542	0.566	0.644	0.632	0.696	0.996	0.921	0.815	0.465	0.493	0.323	0.842	0.554
2010 with Max Tech	Miami	0.566	0.617	0.617	0.811	0.747	0.747	0.728	1.116	1.111	0.464	0.620	0.620	0.349	0.958	0.940
2010 with Max Tech	Phoenix	0.464	0.499	0.497	0.582	0.546	0.547	0.703	0.881	0.869	0.600	0.480	0.482	0.335	0.725	0.652
2010 with Max Tech	Salem	0.497	0.363	0.411	0.551	0.405	0.446	0.713	0.758	0.741	0.894	0.291	0.353	0.324	0.454	0.349

Vintage	Location	Office Small SPR Heating	Office Small SPR Cooling	Office Small Total System	Police Station SPR Heating	Police Station SPR Cooling	Police Station Total System	Post Office SPR Heating	Post Office SPR Cooling	Post Office Total System	Library SPR Heating	Library SPR Cooling	Library Total System	Medical Office SPR Heating	Medical Office SPR Cooling	Medical Office Total System
2010 with Max Tech	San_Francisco	0.468	0.348	0.380	0.604	0.379	0.405	0.710	0.725	0.721	0.689	0.237	0.256	0.340	0.250	0.314
2010 with Max Tech	Vancouver	0.502	0.356	0.429	0.565	0.386	0.454	0.740	0.707	0.724	0.938	0.257	0.369	0.324	0.295	0.320

Vintage	Location	Hotel Small SPR Heating	Hotel Small SPR Cooling	Hotel Small Total System	Apartment Mid Rise SPR Heating	Apartment Mid Rise SPR Cooling	Apartment Mid Rise Total System	Court House SPR Heating	Court House SPR Cooling	Court House Total System	Retail Stand Alone SPR Heating	Retail Stand Alone SPR Cooling	Retail Stand Alone Total System	Warehouse SPR Heating	Warehouse SPR Cooling	Warehouse Total System
2004	Albuquerque	0.333	0.375	0.357	0.564	0.397	0.448	0.430	0.436	0.435	0.549	0.439	0.479	0.520	0.146	0.301
2004	Baltimore	0.326	0.460	0.388	0.643	0.508	0.567	0.515	0.460	0.476	0.608	0.587	0.598	0.594	0.197	0.406
2004	Boise	0.328	0.368	0.344	0.590	0.365	0.471	0.479	0.419	0.443	0.583	0.417	0.507	0.553	0.106	0.362
2004	Burlington	0.322	0.420	0.346	0.666	0.390	0.578	0.554	0.497	0.529	0.652	0.503	0.612	0.623	0.061	0.489
2004	Chicago	0.323	0.450	0.364	0.664	0.482	0.591	0.547	0.525	0.536	0.641	0.593	0.624	0.606	0.119	0.444
2004	Duluth	0.321	0.395	0.333	0.672	0.300	0.588	0.575	0.490	0.548	0.673	0.394	0.625	0.616	0.009	0.503
2004	El_Paso	0.342	0.403	0.387	0.468	0.463	0.464	0.386	0.473	0.460	0.480	0.515	0.509	0.463	0.211	0.256
2004	Fairbanks	0.319	0.367	0.324	0.702	0.257	0.614	0.604	0.450	0.575	0.680	0.309	0.640	0.667	0.000	0.601
2004	Helena	0.323	0.347	0.330	0.613	0.305	0.489	0.508	0.399	0.456	0.603	0.358	0.524	0.591	0.048	0.448
2004	Houston	0.343	0.506	0.478	0.478	0.568	0.557	0.432	0.560	0.548	0.485	0.713	0.676	0.455	0.324	0.338
2004	Memphis	0.330	0.484	0.430	0.596	0.555	0.566	0.489	0.522	0.516	0.564	0.656	0.629	0.560	0.293	0.371
2004	Miami	0.387	0.569	0.565	0.326	0.629	0.626	0.240	0.614	0.608	0.113	0.809	0.780	-	0.391	0.388
2004	Phoenix	0.367	0.435	0.428	0.346	0.475	0.468	0.358	0.496	0.486	0.404	0.593	0.576	0.381	0.312	0.314
2004	Salem	0.326	0.375	0.345	0.595	0.305	0.443	0.458	0.460	0.459	0.590	0.400	0.509	0.571	0.045	0.371
2004	San_Francisco	0.334	0.331	0.332	0.456	0.164	0.256	0.370	0.516	0.465	0.522	0.232	0.346	0.497	0.000	0.181
2004	Vancouver	0.322	0.395	0.341	0.609	0.229	0.459	0.489	0.449	0.471	0.609	0.310	0.528	0.617	0.001	0.476
2010	Albuquerque	0.333	0.390	0.366	0.587	0.441	0.489	0.426	0.448	0.442	0.536	0.456	0.485	0.551	0.140	0.326
2010	Baltimore	0.327	0.482	0.398	0.660	0.571	0.613	0.512	0.554	0.540	0.600	0.664	0.632	0.617	0.187	0.432
2010	Boise	0.328	0.383	0.350	0.610	0.402	0.504	0.477	0.429	0.449	0.578	0.426	0.508	0.582	0.096	0.394
2010	Burlington	0.322	0.439	0.351	0.680	0.431	0.606	0.553	0.508	0.534	0.651	0.540	0.623	0.637	0.036	0.507
2010	Chicago	0.323	0.471	0.370	0.678	0.540	0.627	0.546	0.541	0.543	0.637	0.644	0.640	0.615	0.094	0.453
2010	Duluth	0.321	0.412	0.335	0.720	0.322	0.639	0.579	0.498	0.554	0.669	0.403	0.624	0.623	0.003	0.514
2010	El_Paso	0.338	0.419	0.395	0.536	0.534	0.534	0.389	0.486	0.470	0.478	0.550	0.534	0.505	0.212	0.271
2010	Fairbanks	0.319	0.382	0.325	0.744	0.265	0.659	0.610	0.449	0.581	0.678	0.309	0.639	0.677	-	0.617
2010	Helena	0.324	0.360	0.334	0.634	0.331	0.517	0.507	0.405	0.459	0.596	0.364	0.522	0.609	0.029	0.473
2010	Houston	0.337	0.550	0.507	0.567	0.681	0.667	0.423	0.628	0.608	0.469	0.816	0.763	0.505	0.329	0.349
2010	Memphis	0.327	0.523	0.445	0.644	0.645	0.645	0.493	0.603	0.580	0.570	0.750	0.690	0.588	0.296	0.390
2010	Miami	0.368	0.621	0.614	0.346	0.722	0.717	0.243	0.639	0.633	0.128	0.868	0.836	-	0.390	0.387
2010	Phoenix	0.359	0.455	0.443	0.433	0.583	0.575	0.350	0.516	0.505	0.363	0.647	0.621	0.462	0.317	0.322
2010	Salem	0.327	0.390	0.352	0.617	0.330	0.472	0.455	0.470	0.464	0.581	0.411	0.506	0.602	0.031	0.420
2010	San_Francisco	0.331	0.323	0.327	0.533	0.136	0.287	0.372	0.515	0.465	0.542	0.185	0.341	0.599	-	0.254
2010	Vancouver	0.322	0.413	0.346	0.628	0.242	0.482	0.486	0.452	0.471	0.602	0.300	0.519	0.634	-	0.499
2004 with Min Tech	Albuquerque	0.333	0.303	0.314	0.542	0.334	0.392	0.419	0.380	0.389	0.528	0.371	0.424	0.504	0.134	0.282
2004 with Min Tech	Baltimore	0.326	0.364	0.346	0.609	0.420	0.497	0.496	0.381	0.413	0.579	0.471	0.519	0.569	0.178	0.378
2004 with Min Tech	Boise	0.328	0.298	0.314	0.564	0.311	0.423	0.464	0.368	0.404	0.558	0.354	0.459	0.533	0.099	0.344
2004 with Min Tech	Burlington	0.322	0.336	0.326	0.628	0.331	0.526	0.530	0.433	0.487	0.617	0.430	0.563	0.594	0.058	0.467
2004 with Min Tech	Chicago	0.323	0.356	0.335	0.627	0.400	0.528	0.525	0.447	0.481	0.607	0.488	0.560	0.580	0.110	0.420
2004 with Min Tech	Duluth	0.321	0.318	0.320	0.633	0.259	0.543	0.549	0.438	0.512	0.634	0.351	0.583	0.588	0.009	0.482
2004 with Min Tech	El_Paso	0.342	0.322	0.326	0.453	0.385	0.393	0.378	0.401	0.398	0.466	0.424	0.431	0.455	0.188	0.233
2004 with Min Tech	Fairbanks	0.319	0.298	0.317	0.663	0.224	0.570	0.574	0.419	0.544	0.639	0.287	0.600	0.632	0.000	0.572
2004 with Min Tech	Helena	0.323	0.283	0.310	0.584	0.262	0.446	0.490	0.358	0.425	0.575	0.315	0.486	0.566	0.046	0.429
2004 with Min Tech	Houston	0.343	0.395	0.388	0.460	0.463	0.463	0.421	0.456	0.453	0.468	0.554	0.542	0.446	0.280	0.296
2004 with Min Tech	Memphis	0.330	0.380	0.365	0.567	0.454	0.479	0.473	0.427	0.434	0.540	0.514	0.521	0.540	0.255	0.333
2004 with Min Tech	Miami	0.387	0.438	0.437	0.319	0.506	0.504	0.238	0.496	0.493	0.112	0.618	0.602	-	0.330	0.327
2004 with Min Tech	Phoenix	0.367	0.341	0.343	0.338	0.388	0.386	0.352	0.408	0.405	0.395	0.464	0.459	0.379	0.267	0.270
2004 with Min Tech	Salem	0.326	0.302	0.316	0.569	0.262	0.400	0.445	0.406	0.420	0.565	0.349	0.467	0.549	0.043	0.358
2004 with Min Tech	San_Francisco	0.334	0.270	0.296	0.443	0.147	0.235	0.364	0.478	0.440	0.507	0.221	0.332	0.484	0.000	0.179
2004 with Min Tech	Vancouver	0.322	0.318	0.321	0.581	0.201	0.424	0.473	0.422	0.450	0.581	0.294	0.503	0.589	0.001	0.459
2010 with Max Tech	Albuquerque	0.333	0.431	0.388	0.644	0.482	0.535	0.450	0.507	0.491	0.583	0.492	0.524	0.605	0.150	0.354
2010 with Max Tech	Baltimore	0.327	0.539	0.419	0.749	0.632	0.685	0.557	0.647	0.615	0.673	0.733	0.703	0.701	0.205	0.483
2010 with Max Tech	Boise	0.328	0.422	0.365	0.677	0.436	0.553	0.512	0.482	0.494	0.640	0.458	0.555	0.651	0.101	0.430
2010 with Max Tech	Burlington	0.322	0.488	0.359	0.782	0.469	0.685	0.611	0.573	0.595	0.745	0.580	0.700	0.734	0.037	0.569
2010 with Max Tech	Chicago	0.323	0.526	0.383	0.779	0.596	0.708	0.601	0.627	0.614	0.725	0.707	0.719	0.701	0.100	0.504
2010 with Max Tech	Duluth	0.321	0.457	0.340	0.832	0.347	0.727	0.646	0.549	0.616	0.770	0.424	0.707	0.713	0.003	0.575

Vintage	Location	Hotel Small SPR Heating	Hotel Small SPR Cooling	Hotel Small Total System	Apartment Mid Rise SPR Heating	Apartment Mid Rise SPR Cooling	Apartment Mid Rise Total System	Court House SPR Heating	Court House SPR Cooling	Court House Total System	Retail Stand Alone SPR Heating	Retail Stand Alone SPR Cooling	Retail Stand Alone Total System	Warehouse SPR Heating	Warehouse SPR Cooling	Warehouse Total System
2010 with Max Tech	El_Paso	0.338	0.466	0.426	0.579	0.589	0.587	0.408	0.565	0.538	0.513	0.604	0.584	0.536	0.234	0.296
2010 with Max Tech	Fairbanks	0.319	0.421	0.328	0.855	0.284	0.748	0.690	0.477	0.650	0.786	0.319	0.732	0.794	-	0.713
2010 with Max Tech	Helena	0.324	0.396	0.343	0.710	0.356	0.570	0.549	0.444	0.500	0.666	0.385	0.572	0.691	0.030	0.524
2010 with Max Tech	Houston	0.337	0.622	0.558	0.621	0.762	0.744	0.448	0.759	0.725	0.506	0.924	0.857	0.542	0.376	0.396
2010 with Max Tech	Memphis	0.327	0.590	0.478	0.726	0.720	0.722	0.532	0.723	0.680	0.632	0.842	0.772	0.656	0.335	0.439
2010 with Max Tech	Miami	0.368	0.709	0.698	0.366	0.814	0.809	0.248	0.787	0.777	0.130	0.994	0.952	-	0.458	0.454
2010 with Max Tech	Phoenix	0.359	0.512	0.491	0.455	0.651	0.640	0.362	0.622	0.601	0.381	0.730	0.696	0.469	0.366	0.370
2010 with Max Tech	Salem	0.327	0.431	0.366	0.685	0.356	0.517	0.485	0.524	0.508	0.642	0.436	0.549	0.680	0.032	0.458
2010 with Max Tech	San_Francisco	0.331	0.354	0.342	0.570	0.142	0.303	0.387	0.549	0.491	0.583	0.188	0.355	0.661	-	0.264
2010 with Max Tech	Vancouver	0.322	0.458	0.355				0.524	0.476	0.502	0.672	0.306	0.564	0.726	-	0.554

Vintage	Location	City Hall SPR Heating	City Hall SPR Cooling	City Hall Total System	Office Medium SPR Heating	Office Medium SPR Cooling	Office Medium Total System	Religious Building SPR Heating	Religious Building SPR Cooling	Religious Building Total System	Senior Center SPR Heating	Senior Center SPR Cooling	Senior Center Total System	Office Large SPR Heating	Office Large SPR Cooling	Office Large Total System
2004	Albuquerque	0.133	0.792	0.437	0.155	0.797	0.422	0.488	0.557	0.524	0.481	0.632	0.548	0.216	0.866	0.669
2004	Baltimore	0.177	0.600	0.369	0.198	0.606	0.367	0.543	0.352	0.427	0.567	0.541	0.554	0.348	0.533	0.484
2004	Boise	0.155	0.816	0.357	0.176	0.812	0.348	0.541	0.519	0.532	0.547	0.639	0.576	0.287	0.757	0.556
2004	Burlington	0.231	0.763	0.344	0.248	0.751	0.341	0.611	0.429	0.551	0.626	0.545	0.606	0.463	0.623	0.541
2004	Chicago	0.219	0.756	0.370	0.235	0.752	0.364	0.583	0.404	0.503	0.606	0.572	0.595	0.425	0.579	0.514
2004	Duluth	0.241	0.777	0.318	0.252	0.748	0.312	0.621	0.463	0.584	0.637	0.578	0.627	0.470	0.590	0.514
2004	El_Paso	0.101	0.768	0.527	0.119	0.777	0.511	0.424	0.506	0.480	0.409	0.604	0.528	0.146	0.878	0.752
2004	Fairbanks	0.272	0.967	0.332	0.291	0.950	0.338	0.661	0.663	0.661	0.674	0.616	0.670	0.549	0.770	0.601
2004	Helena	0.193	0.818	0.329	0.213	0.811	0.324	0.589	0.583	0.587	0.593	0.645	0.604	0.359	0.726	0.530
2004	Houston	0.095	0.703	0.522	0.109	0.714	0.522	0.342	0.385	0.377	0.369	0.568	0.518	0.199	0.658	0.594
2004	Memphis	0.160	0.677	0.469	0.179	0.688	0.464	0.482	0.367	0.398	0.507	0.567	0.544	0.308	0.599	0.551
2004	Miami	0.023	0.810	0.743	0.030	0.828	0.757	0.104	0.428	0.397	0.112	0.594	0.536	0.039	0.754	0.734
2004	Phoenix	0.058	0.721	0.553	0.068	0.738	0.554	0.272	0.457	0.422	0.273	0.608	0.525	0.102	0.803	0.706
2004	Salem	0.128	0.751	0.310	0.146	0.735	0.296	0.526	0.548	0.534	0.551	0.612	0.570	0.245	0.808	0.553
2004	San_Francisco	0.069	0.709	0.287	0.083	0.662	0.256	0.420	0.496	0.452	0.435	0.522	0.468	0.102	0.704	0.478
2004	Vancouver	0.159	0.855	0.296	0.179	0.827	0.287	0.579	0.594	0.583	0.595	0.587	0.594	0.306	0.729	0.505
2010	Albuquerque	0.197	0.835	0.572	0.227	0.854	0.567	0.545	0.619	0.585	0.506	0.686	0.586	0.271	0.865	0.735
2010	Baltimore	0.253	0.842	0.538	0.274	0.854	0.530	0.581	0.466	0.517	0.578	0.635	0.603	0.413	0.696	0.623
2010	Boise	0.230	0.863	0.481	0.254	0.877	0.473	0.591	0.595	0.593	0.564	0.715	0.609	0.360	0.802	0.645
2010	Burlington	0.305	0.830	0.437	0.317	0.832	0.429	0.640	0.495	0.595	0.631	0.614	0.627	0.519	0.706	0.613
2010	Chicago	0.290	0.816	0.465	0.302	0.822	0.455	0.614	0.457	0.546	0.611	0.627	0.616	0.487	0.649	0.585
2010	Duluth	0.317	0.838	0.399	0.323	0.828	0.388	0.661	0.551	0.639	0.651	0.661	0.652	0.541	0.689	0.594
2010	El_Paso	0.160	0.805	0.630	0.186	0.824	0.628	0.482	0.550	0.529	0.447	0.644	0.565	0.203	0.886	0.797
2010	Fairbanks	0.353	1.015	0.411	0.360	1.023	0.407	0.691	0.780	0.698	0.678	0.715	0.680	0.598	0.863	0.654
2010	Helena	0.271	0.864	0.438	0.291	0.880	0.432	0.626	0.678	0.640	0.600	0.731	0.626	0.425	0.769	0.605
2010	Houston	0.093	0.803	0.579	0.107	0.818	0.579	0.344	0.430	0.413	0.380	0.610	0.551	0.156	0.733	0.666
2010	Memphis	0.169	0.815	0.530	0.187	0.829	0.525	0.498	0.424	0.445	0.516	0.611	0.573	0.319	0.682	0.617
2010	Miami	0.025	0.846	0.772	0.031	0.866	0.788	0.108	0.447	0.414	0.119	0.618	0.556	0.042	0.758	0.738
2010	Phoenix	0.077	0.766	0.632	0.093	0.787	0.643	0.313	0.495	0.462	0.315	0.650	0.571	0.096	0.863	0.795
2010	Salem	0.196	0.826	0.445	0.221	0.829	0.435	0.588	0.668	0.617	0.564	0.726	0.611	0.312	0.822	0.639
2010	San_Francisco	0.110	0.832	0.448	0.135	0.802	0.406	0.552	0.676	0.601	0.519	0.637	0.557	0.138	0.758	0.612
2010	Vancouver	0.238	0.955	0.423	0.262	0.965	0.414	0.622	0.788	0.658	0.597	0.745	0.623	0.386	0.732	0.581
2004 with Min Tech	Albuquerque	0.133	0.621	0.388	0.155	0.617	0.376	0.457	0.461	0.459	0.451	0.482	0.466	0.206	0.564	0.482
2004 with Min Tech	Baltimore	0.177	0.458	0.324	0.198	0.460	0.324	0.506	0.291	0.370	0.527	0.411	0.467	0.329	0.321	0.322
2004 with Min Tech	Boise	0.155	0.639	0.330	0.176	0.630	0.322	0.505	0.431	0.473	0.510	0.488	0.503	0.273	0.488	0.416
2004 with Min Tech	Burlington	0.231	0.592	0.324	0.248	0.577	0.323	0.569	0.355	0.493	0.581	0.418	0.535	0.437	0.395	0.412
2004 with Min Tech	Chicago	0.219	0.583	0.342	0.235	0.575	0.338	0.544	0.334	0.443	0.563	0.437	0.515	0.402	0.361	0.374
2004 with Min Tech	Duluth	0.241	0.606	0.305	0.252	0.577	0.301	0.578	0.384	0.529	0.590	0.446	0.562	0.443	0.380	0.414
2004 with Min Tech	El_Paso	0.101	0.597	0.446	0.119	0.599	0.434	0.397	0.417	0.411	0.385	0.459	0.434	0.140	0.549	0.500
2004 with Min Tech	Fairbanks	0.272	0.770	0.324	0.290	0.745	0.331	0.614	0.554	0.607	0.623	0.477	0.610	0.516	0.535	0.522
2004 with Min Tech	Helena	0.193	0.646	0.311	0.213	0.632	0.308	0.550	0.486	0.531	0.552	0.496	0.539	0.340	0.487	0.422
2004 with Min Tech	Houston	0.095	0.536	0.429	0.109	0.541	0.428	0.320	0.316	0.317	0.345	0.430	0.412	0.188	0.388	0.370
2004 with Min Tech	Memphis	0.160	0.517	0.396	0.179	0.523	0.394	0.450	0.302	0.338	0.472	0.430	0.444	0.292	0.359	0.351
2004 with Min Tech	Miami	0.023	0.619	0.579	0.030	0.628	0.587	0.097	0.350	0.329	0.105	0.449	0.415	0.038	0.446	0.439
2004 with Min Tech	Phoenix	0.058	0.556	0.452	0.068	0.565	0.453	0.254	0.375	0.355	0.257	0.461	0.418	0.097	0.478	0.443
2004 with Min Tech	Salem	0.128	0.584	0.286	0.146	0.566	0.275	0.491	0.454	0.476	0.513	0.467	0.497	0.232	0.523	0.418
2004 with Min Tech	San_Francisco	0.069	0.552	0.262	0.083	0.510	0.235	0.393	0.415	0.402	0.407	0.402	0.405	0.097	0.487	0.368
2004 with Min Tech	Vancouver	0.159	0.676	0.281	0.179	0.646	0.274	0.540	0.497	0.528	0.554	0.453	0.530	0.290	0.530	0.418

Vintage	Location	City Hall SPR Heating	City Hall SPR Cooling	City Hall Total System	Office Medium SPR Heating	Office Medium SPR Cooling	Office Medium Total System	Religious Building SPR Heating	Religious Building SPR Cooling	Religious Building Total System	Senior Center SPR Heating	Senior Center SPR Cooling	Senior Center Total System	Office Large SPR Heating	Office Large SPR Cooling	Office Large Total System
2010 with Max Tech	Albuquerque	0.197	1.056	0.653	0.228	1.099	0.646	0.618	0.791	0.705	0.572	0.908	0.708	0.291	0.911	0.777
2010 with Max Tech	Baltimore	0.255	1.095	0.608	0.276	1.126	0.595	0.662	0.604	0.631	0.665	0.843	0.737	0.452	0.739	0.667
2010 with Max Tech	Boise	0.231	1.090	0.526	0.255	1.128	0.514	0.671	0.759	0.704	0.643	0.944	0.723	0.390	0.843	0.685
2010 with Max Tech	Burlington	0.308	1.066	0.467	0.321	1.087	0.457	0.733	0.636	0.705	0.731	0.806	0.746	0.575	0.747	0.663
2010 with Max Tech	Chicago	0.292	1.061	0.506	0.305	1.084	0.493	0.702	0.589	0.656	0.705	0.831	0.741	0.537	0.689	0.630
2010 with Max Tech	Duluth	0.321	1.064	0.416	0.327	1.070	0.404	0.758	0.700	0.748	0.755	0.856	0.768	0.601	0.725	0.648
2010 with Max Tech	El_Paso	0.161	1.036	0.752	0.186	1.076	0.750	0.545	0.711	0.654	0.502	0.858	0.701	0.216	0.941	0.847
2010 with Max Tech	Fairbanks	0.360	1.248	0.426	0.369	1.283	0.422	0.798	0.975	0.811	0.792	0.920	0.799	0.672	0.959	0.734
2010 with Max Tech	Helena	0.273	1.077	0.467	0.293	1.119	0.459	0.713	0.857	0.747	0.688	0.956	0.734	0.463	0.803	0.644
2010 with Max Tech	Houston	0.093	1.064	0.696	0.107	1.095	0.696	0.389	0.563	0.524	0.432	0.820	0.707	0.171	0.786	0.716
2010 with Max Tech	Memphis	0.170	1.074	0.612	0.187	1.104	0.604	0.566	0.551	0.556	0.591	0.818	0.719	0.352	0.729	0.663
2010 with Max Tech	Miami	0.025	1.123	0.994	0.031	1.159	1.022	0.122	0.587	0.535	0.134	0.832	0.731	0.045	0.815	0.793
2010 with Max Tech	Phoenix	0.077	1.001	0.780	0.093	1.040	0.796	0.352	0.646	0.587	0.353	0.869	0.730	0.103	0.923	0.851
2010 with Max Tech	Salem	0.196	1.052	0.487	0.222	1.073	0.474	0.668	0.854	0.731	0.644	0.960	0.726	0.339	0.866	0.680
2010 with Max Tech	San_Francisco	0.110	1.039	0.494	0.135	1.020	0.445	0.624	0.842	0.704	0.587	0.820	0.655	0.148	0.852	0.680
2010 with Max Tech	Vancouver	0.239	1.175	0.446	0.263	1.212	0.434	0.709	0.979	0.764	0.685	0.962	0.728	0.422	0.810	0.639

Appendix L

Asset Score Sensitivity Analysis Results

Note: The following is an abbreviated version of Appendix L. The complete appendix is available at https://buildingenergyscore.energy.gov/assets/energy_asset_score_technical_protocol_appendix_L.pdf.

Appendix L

Asset Score Sensitivity Analysis Results

The results of sensitivity analysis are shown in a series of tornado diagrams, which indicate the potential impact (sensitivity) of the studied variables as a function of the output (energy use). Note that the variables were evaluated independently, meaning that the interaction of variables was not evaluated in this context. The x axis of the tornado diagrams is the examined variables and the y axis is the output of building energy use (Total Source Energy, Total Electricity, or Total Natural Gas). The plots are designed to be eye-charts and provide a quick visual on the importance of each variable. The further to the left a variable, the greater it's first-order sensitivity. Only the twenty most important variables are shown in the tornado diagram. In addition to each Total Source Energy tornado diagram, a table is supplied describing the input variable ranges simulated and the minimum and maximum Total Source Energy across the simulations associated with that input variable.

Variables

The 38 building input variables evaluated in the sensitivity simulations are listed below.

Variable	Units	Type
Aspect Ratio Multiplier	non-dim	double
Floor Plate Area Multiplier	ft2	double
Square Footage Multiplier	ft2	double
Floor-To-Floor Height Multiplier	ft	double
Perimeter Zone Depth	ft	double
Floor R-Value for 24 in	h ft2 F/Btu	double
Window-To-Wall Ratio	non-dim	double
Window Sill Height	ft	double
Window U-Value	Btu/h ft2 F	double
Window SHGC	non-dim	double
Window VLT	non-dim	double
Wall Construction Type		string
Wall U-Value	Btu/h ft2 F	double
Roof Construction Type		string
Roof U-Value	Btu/h ft2 F	double

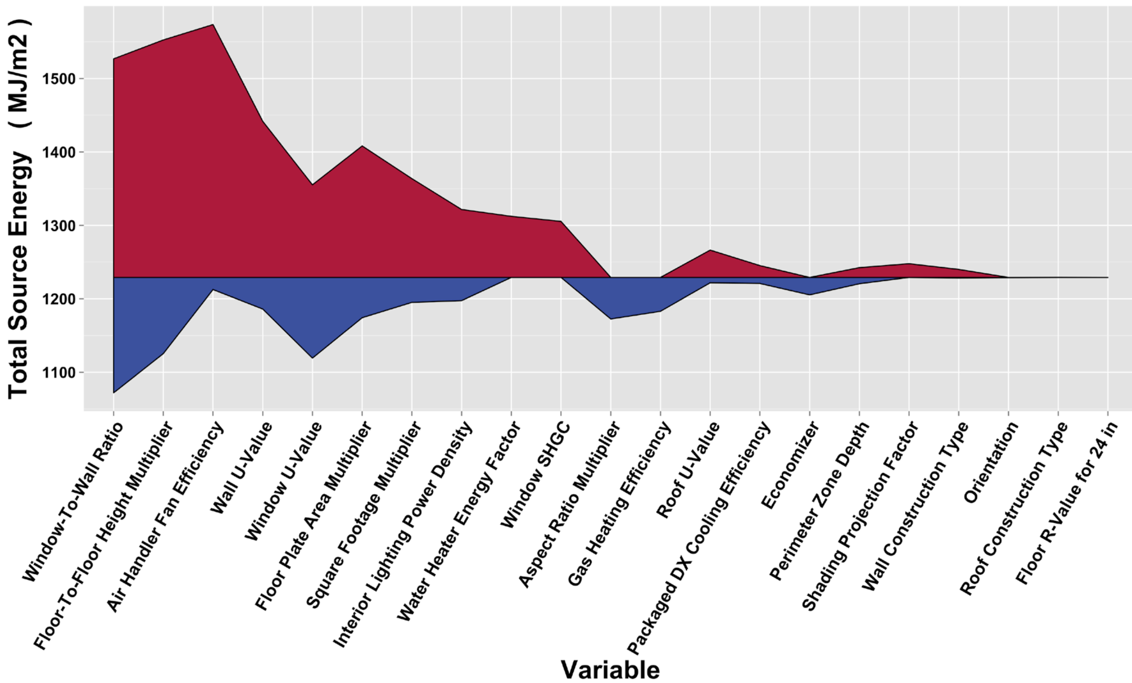
Daylighting Control Setpoint	ft-c	double
Interior Lighting Power Density	W/ft2	double
Shading Projection Factor	non-dim	double
Shading Height above Window	ft	double
Chiller Cooling Efficiency	COP	double
District Chiller Cooling Efficiency	COP	double
Boiler Heating Efficiency	percent	double
District Heating Efficiency	percent	double
Air Handler Fan Efficiency	percent	double
Air Source Heat Pump Cooling Efficiency	COP	double
Air Source Heat Pump Heating Efficiency	COP	double
Packaged DX Cooling Efficiency	COP	double
Gas Heating Efficiency	percent	double
Terminal DX Cooling Efficiency	percent	double
Terminal Furnace Heating Efficiency	percent	double
Terminal Furnace Heat Pump Heating Efficiency	percent	double
Water Heater Energy Factor	percent	double
Economizer		string
Fan Control		string
Condenser Pump Control		string
Fan Static Pressure Reset		string
Supply Air Temperature Reset		string
Orientation	degrees	double

Highrise Apartment

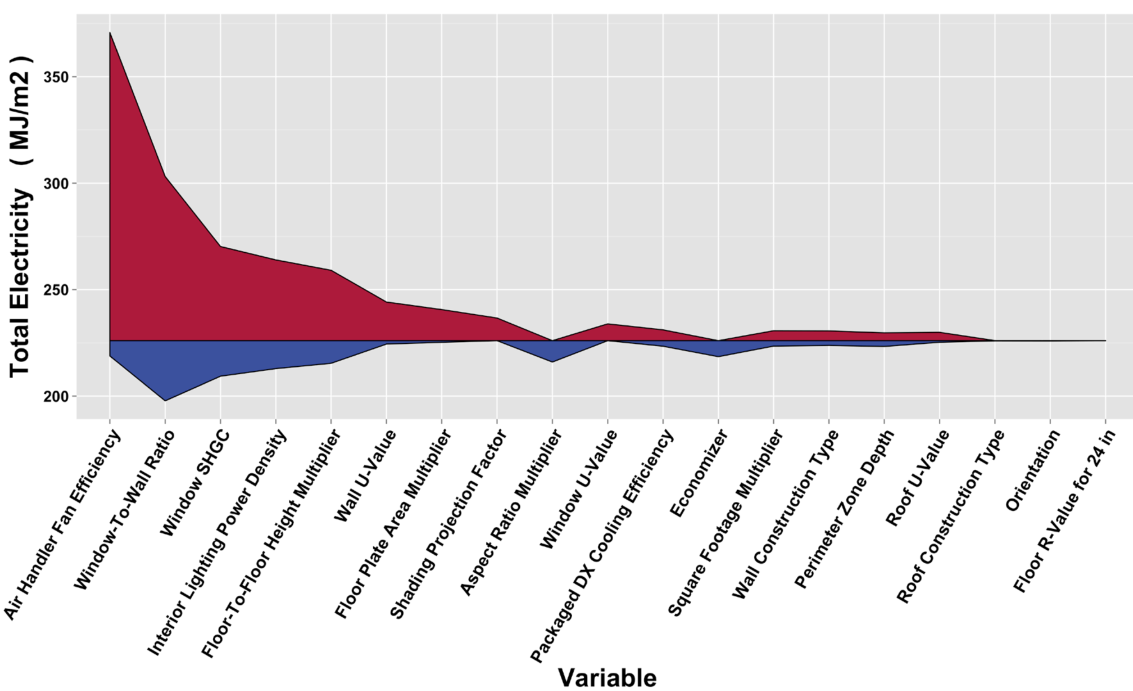
Location: Climate Zone 1A

Total Source Energy

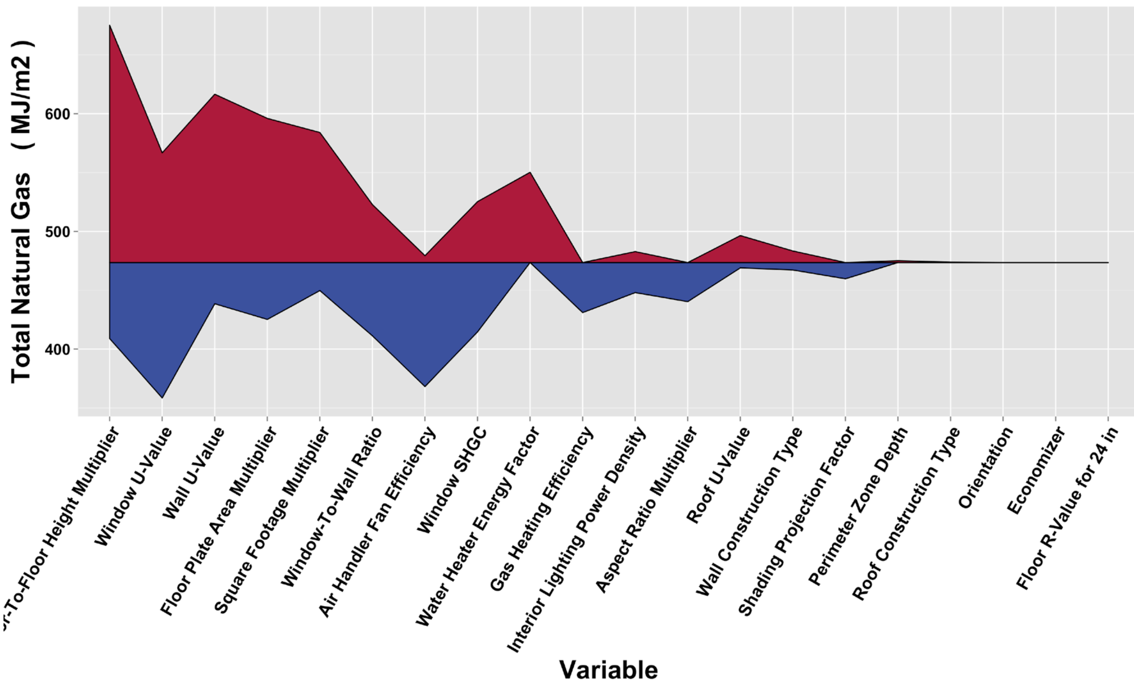
Variable Display Name	Minimum Input Value	Maximum Input Value	Minimum Total Source Energy	Maximum Total Source Energy
Aspect Ratio Multiplier	0.37	1.83	1172.61	1229.12
Floor Plate Area Multiplier	4218	28120	1174.32	1408.16
Square Footage Multiplier	25308	253080	1195.19	1363.62
Floor-To-Floor Height Multiplier	8	16	1125.41	1552.36
Perimeter Zone Depth	10	20	1220.50	1242.46
Floor R-Value for 24 in	0	0	1229.12	1229.12
Window-To-Wall Ratio	0	0.71	1072.05	1526.62
Window Sill Height	1	6	1229.12	1229.12
Window U-Value	0.12	1.22	1119.28	1355.19
Window SHGC	0.08	0.7	1229.12	1305.41
Window VLT	0.06	0.89	1229.12	1229.12
Wall Construction Type	masonry-on-masonry	wood-siding	1228.10	1240.04
Wall U-Value	0.03	0.58	1186.12	1441.57
Roof Construction Type	built-up concrete-deck	built-up wood-deck	1229.12	1229.33
Roof U-Value	0.01	0.2	1221.82	1266.36
Daylighting Control Setpoint	0	0	1229.12	1229.12
Interior Lighting Power Density	0.04	0.43	1197.55	1321.59
Shading Projection Factor	0	1	1229.12	1247.81
District Chiller Cooling Efficiency	0.52	1.48	1229.12	1229.12
Air Handler Fan Efficiency	22.66	81.56	1212.62	1573.33
Packaged DX Cooling Efficiency	2.18	4.26	1220.89	1245.23
Gas Heating Efficiency	1	1.13	1183.05	1229.12
Terminal DX Cooling Efficiency	0.68	1.32	1229.12	1229.12
Terminal Furnace Heating Efficiency	0.87	1.13	1229.12	1229.12
Terminal Furnace Heat Pump Heating Efficiency	0.73	1.27	1229.12	1229.12
Water Heater Energy Factor	1	99	1229.12	1312.26
Economizer	false	true	1205.36	1229.12
Fan Control	cav	false	1229.12	1229.12
Orientation	0	359	1228.80	1229.12



Total Electricity (High Rise Apartment; Climate Zone 1A)



Total Natural Gas (High Rise Apartment; Climate Zone 1A)



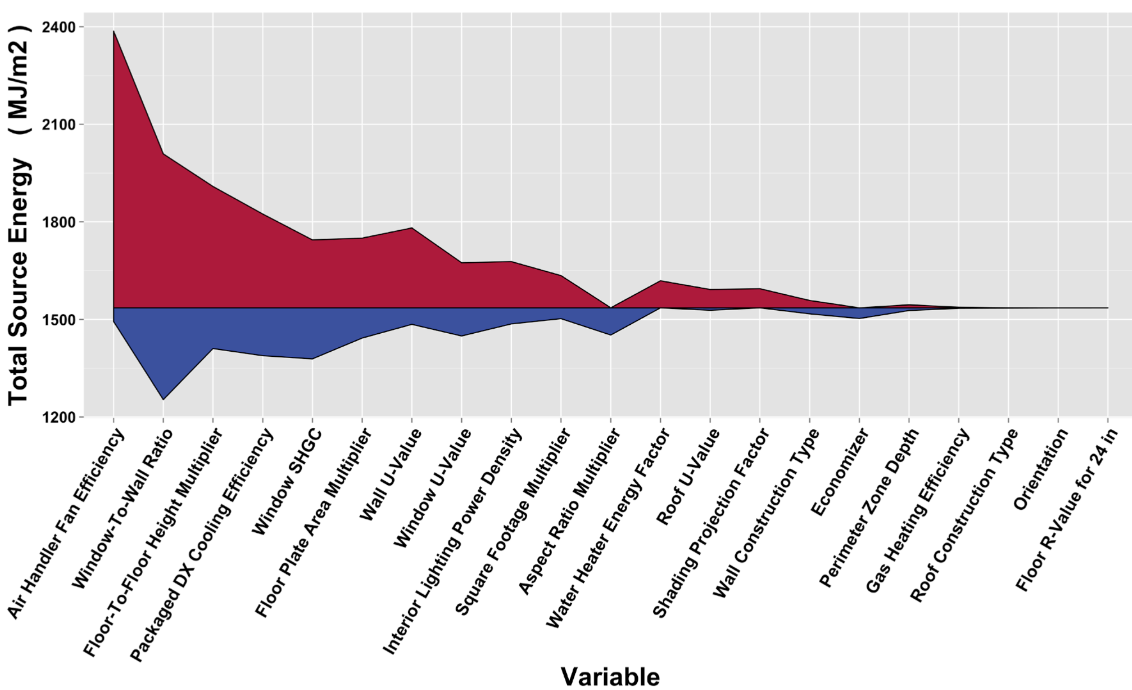
Highrise Apartment

Location: Climate Zone 1B

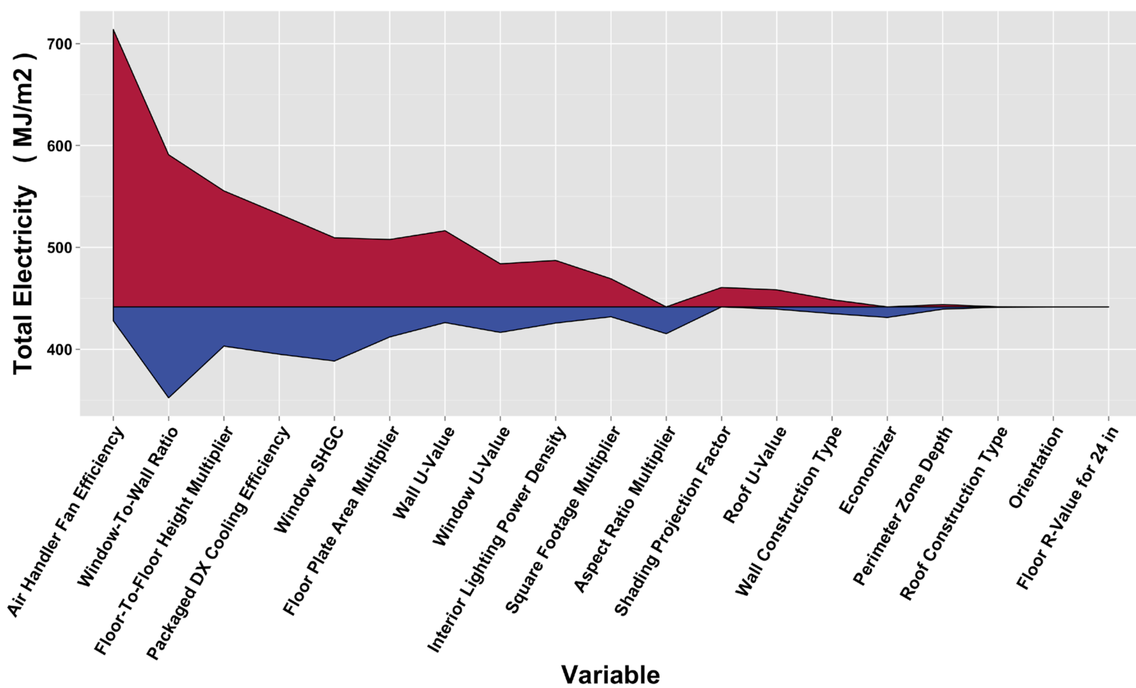
Total Source Energy

Variable Display Name	Minimum Input Value	Maximum Input Value	Minimum Total Source Energy	Maximum Total Source Energy
Aspect Ratio Multiplier	0.37	1.83	1451.99	1535.67
Floor Plate Area Multiplier	4218	28120	1442.69	1750.18
Square Footage Multiplier	25308	253080	1502.40	1634.74
Floor-To-Floor Height Multiplier	8	16	1410.44	1908.86
Perimeter Zone Depth	10	20	1527.45	1544.90
Floor R-Value for 24 in	0	0	1535.67	1535.67
Window-To-Wall Ratio	0	0.71	1253.34	2009.15
Window Sill Height	1	6	1535.67	1535.67
Window U-Value	0.12	1.22	1449.12	1674.44
Window SHGC	0.08	0.7	1378.61	1744.61
Window VLT	0.06	0.89	1535.67	1535.67
Wall Construction Type	masonry-on-masonry	wood-siding	1517.26	1558.26
Wall U-Value	0.03	0.58	1484.85	1781.41
Roof Construction Type	built-up concrete-deck	built-up wood-deck	1534.73	1536.12
Roof U-Value	0.01	0.2	1528.19	1592.06
Daylighting Control Setpoint	0	0	1535.67	1535.67
Interior Lighting Power Density	0.04	0.43	1486.21	1677.83

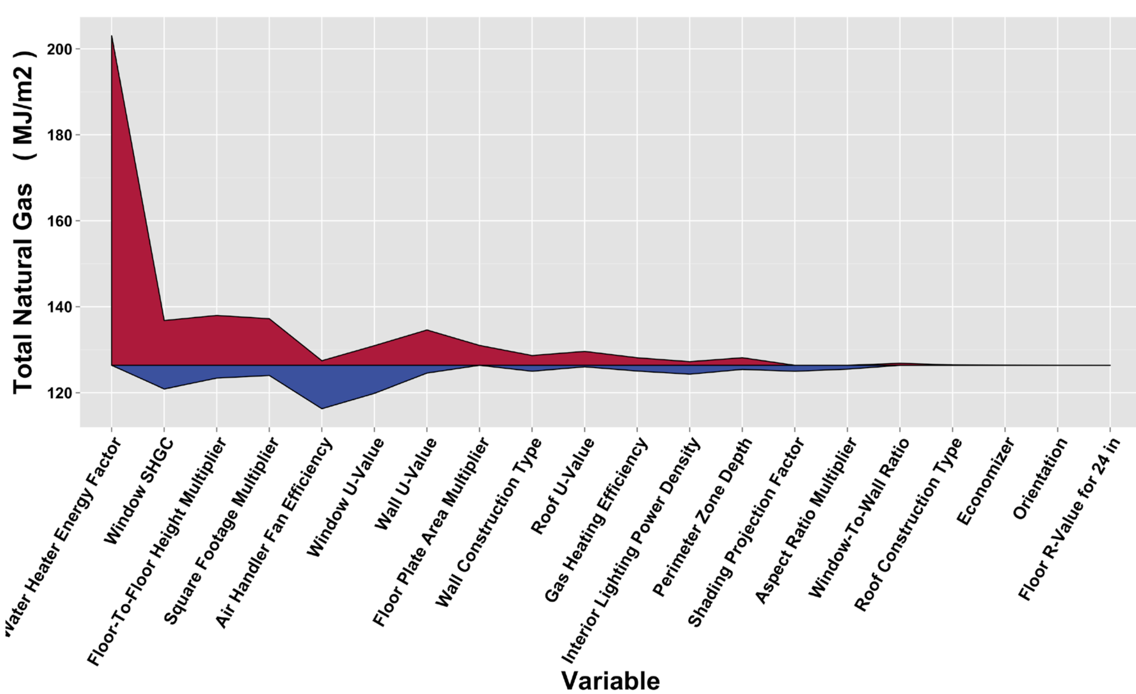
Shading Projection Factor	0	1	1535.67	1594.40
District Chiller Cooling Efficiency	0.52	1.48	1535.67	1535.67
Air Handler Fan Efficiency	22.66	81.56	1493.65	2386.69
Packaged DX Cooling Efficiency	2.18	4.26	1388.40	1824.08
Gas Heating Efficiency	0.87	1.13	1534.22	1537.57
Terminal DX Cooling Efficiency	0.68	1.32	1535.67	1535.67
Terminal Furnace Heating Efficiency	0.87	1.13	1535.67	1535.67
Terminal Furnace Heat Pump Heating Efficiency	0.73	1	1535.67	1535.67
Water Heater Energy Factor	1	99	1535.67	1618.78
Economizer	false	true	1502.84	1535.67
Fan Control	cav	false	1535.67	1535.67
Orientation	0	359	1535.46	1535.67



Total Electricity (High Rise Apartment; Climate Zone 1B)



Total Natural Gas (High Rise Apartment; Climate Zone 1B)



Appendix M

Model Documentation

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
Construction Assemblies					
Roof	Shingles/Shakes Construction	Attic roof with metal roofing.		Attics are not modeled in the current version of Asset Score Tool. Unconditioned attics will be added	
	Concrete Deck	Concrete deck, with insulation entirely above deck.			
	Metal Deck	Metal deck, with insulation entirely above deck.			
	Wood Deck	Wooden deck, with insulation entirely above deck.			
Skylights	Skylight Construction	Skylight construction of plastic or glass.	User input is used to populate the fields of U-Value, SHGC, and VT with default inputs. These can be overridden by the users if actual values are available.	Additional defaults will be added based on year of construction.	
	% of Roof Area	The skylight-roof-ratio or the percentage of roof area which is skylights.	User input of % Roof Area' is used to model a single large skylight at the center of the roof.	A more detailed approach to specifying layout of skylights will be considered as a future enhancement.	
	Top-lighting Control	Top-lighting sensors can be specified, if present.	Asset Score Tool follows ASHRAE Standard 90.1 2010 for calculation of total top-lit area and location of sensors. 100% of the lights under the top-lit area are controlled by top-lighting sensors. If not specified by the user, the Recommendation Engine recommends Top-lighting control based on the requirements specified in Standard 90.1-2010.	Simplification in the modeling of skylight layout might result in underestimation of savings due to top-lighting control. Potential future enhancement of improved skylight layout would increase savings from this control.	
Windows	Window Dimensions/ WWR	Continuous windows	Strip windows are modeled with user specified sill height or a default of 3'.		
		Discrete windows	Block level number of windows are split equally between the numbers of surfaces. User-entered window height is used and a single large window is modeled at the center of each vertical surface specified to have windows.	A more detailed approach to specifying layout of windows will be considered as a future enhancement.	
	Sidelighting Control	Daylighting sensors are modeled if specified to be present by the user.	Asset Score Tool follows ASHRAE Standard 90.1-2010 for calculation of total side-lit area and location of sensors. 100% of the lights within the side-lit area are controlled by sidelighting sensors. Sidelighting sensors are recommended by the Asset Score Tool if the total side-lit area qualifies for sidelighting control as specified by ASHRAE Standard 90.1-2010	Simplification in the modeling of discrete windows layout might result in underestimation of savings due to sidelighting control. Potential future enhancement of a more detailed approach to discrete window layout will increase savings from sidelighting control.	
	Interior Walls	Interior walls	For interior walls on adjacent surfaces of multiple blocks, the tool erroneously assigns windows if windows are specified at block level.	Automatically identify interior surfaces and not assign windows.	
Floors	Construction	User-specified floor insulation and construction isn't used in the AS model at present		Future enhancements to the tool will add the capability to use user input of floor construction assembly and thermal properties.	
Interior Surfaces	Construction	The Asset Score Tool's energy simulation capability can identify interior surfaces (ceilings and walls) based on adjacencies with other blocks and assigns standard interior	Interior surfaces are modeled with standard wall/ceiling construction.	Future enhancements will add a capability for the tool to automatically identify all interior surfaces and assign interior surface construction to the same. Windows assigned at block level will not be	

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
		wall/ceiling/floor construction to these surfaces. However, the user interface doesn't have the same capability at present and does not identify interior surfaces based on adjacencies. Due to this limitation, the UI expects construction assignments for interior walls and ceilings. Windows assigned at block level are also distributed to interior surfaces.		distributed to interior surfaces.	
Ground Heat Transfer	Modeling Approach	Default EnergyPlus Ground Temperature profiles are used to compute ground heat transfer.		Future enhancements to the tool will use user input of floor plate geometry, construction properties, and insulation levels to compute ground temperature profiles.	
Lighting					
Fixtures	Watts/Lamp, Number of Lamps/Fixture, % Area Server OR Number of Fixtures	Tool accepts lighting entry either through % area served or number of fixtures	When % area served option is used, the inference engine of the tool calculates the lighting power density based on the block use type and associated typical illumination levels. For 'Number of Fixtures' entry, the tool calculates the total lighting power density based on user input of Watts/Lamp and Number of Lamps/Fixture. Typical ballast factors are used based on fixture type.	None	
Lighting Controls	Occupancy Sensor Control	Occupancy sensors can be assigned to fixtures at block level.	Selection of this input reduces lighting power density of the associated fixture by 10%.	None	ASHRAE Standard 90.1-2010 Appendix G, Table G3.2
HVAC					
Equipment Sizing		A user can specify the average output capacity of HVAC equipment.	Asset Score auto sizes heating and cooling equipment, based on calculated loads and design day specification. Sizing factors used are 1.25 for heating equipment and 1.15 for cooling equipment.	None	ASHRAE Standard 90.1-2010 Appendix G, Section G3.1.2.2
Design Day Objects		The DDY files are determined based on the building's location. User-entered value of zip code is used to determine the most appropriate weather station and corresponding TMY3 weather file to be used for building energy simulation.	The cooling design day object is specified at 0.4% conditions, where Dry Bulb => Mean Wet Bulb. The heating design day is specified at 99.6% heating design temperatures.	None	ASHRAE 90.1 Prototypes
Plants					
Plants: Boiler	Draft Type, Year of Manufacture, , # pieces of equipment, average output capacity	The boiler can be natural or mechanical draft. Year of Manufacture should be specified if the building has undergone HVAC retrofits since its construction. This input should be used to specify the number of boilers and the average output capacity of the same.	These inputs are used by the inference engine to infer system efficiency. If 'Year of Manufacture' isn't entered, the 'Year of Construction' is used along with typical equipment life, to estimate the year of manufacture of the replaced equipment. These inputs are not used directly in the EnergyPlus model		
	Boiler Efficiency	The tool expects an input of Boiler Thermal efficiency.	This input is used in the EnergyPlus models. If the value isn't provided, the inference engine can infer the same based on user input of 'Draft Type, 'Year of Manufacture', '# pieces of Equipment' and 'Average Output Capacity'.		
	Boiler Flow Mode		This is a default modeling assumption in Asset Score models. Constant flow boilers. Boiler pumping arrangement is defaulted to constant speed.		

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
	Hot Water (HW) Pump		This is a default modeling assumption in Asset Score models. Pumping system is Primary Only, where pump rides the pump curve. The pressure drop across the pump is pre-calculated and the pumping system is modeled with no differential pressure reset. .		ASHRAE 90.1 Prototypes (Large Office)
	HW Pump Coefficients		This is a default modeling assumption in Asset Score models A cubic curve is assumed with coefficients specified as: 0, 3.2485, -4.7443, 2.5294. This represents a constant speed pump, with continuous variable flow that rides the pump curve.		PNNL (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual. U.S. Department of Energy.
	Hot Water Pipes		This is a default modeling assumption in Asset Score models. Adiabatic pipes are assumed with no pipe losses.		
Plants: Chillers	Year of Manufacture,# pieces of equipment, average output capacity,	Year of Manufacture should be specified if the building has undergone HVAC retrofits since its construction. This input should be used to specify the number of chillers and the average output capacity of the same.	Used by the inference engine to infer system efficiency. Is not used directly in the EnergyPlus model. If 'Year of Manufacture' isn't entered, the 'Year of Construction' is used along with typical equipment life, to estimate the year of manufacture of the replaced equipment.		
	Chiller Compressor Type	Chiller compressor type can be specified as ‘Screw/Scroll’, ‘Centrifugal’ or ‘Reciprocating’	This input (along with other inputs) is used by the inference engine to infer chiller COP.	As a future enhancement to the tool, a different set of chiller performance curves will be used for user input of compressor type and condenser type.	
	Chiller Condenser Type	Chiller condenser can be ‘Air Cooled’ or ‘Water Cooled’	User input of ‘Water Cooled’ condenser requires the definition of a condenser plant and a link to the same.	Future enhancement to the tool will add evaporatively cooled condensers.	
	Chiller Efficiency	The user is expected to enter the chiller efficiency of Coefficient of Performance (COP).	If user input isn’t provided, the inference engine can infer this value based on user input of Year of Manufacture, # pieces of equipment, average output capacity, compressor type and condenser type.	Future enhancements to the tool will permit user input of kW/ton.	
	Control		Chiller flow mode is set to 'Constant Flow'.		
	Chilled Water (CHW) Pumps	Chiller pump control has 2 options, Constant Primary and Constant Primary, Variable Secondary. The user input of ' I don’t know' models 'Constant Primary' chiller pump controls.	Constant primary pump control models a primary only loop with continuous flow primary loop. Pump head is assumed to be 179352 Pa which corresponds to 60' of head at 60% total pump efficiency and 19 W/gpm power. Constant Primary, Variable Secondary models a primary/secondary loop, with continuous flow primary loop and variable flow secondary loop. The primary loops serve the plant side and secondary loop serves the demand side. Pump head is assumed to be 134,508 Pa for the secondary loop and 44,836 Pa for the primary loop.		PNNL. (2010). Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010. U.S. Department of Energy.
	CHW Pump Coefficients	Pump coefficients are not specified by the user. These are defaults values specified based on chiller pump control b	Constant speed pump is modeled with the pump riding the pump curve. Coefficients used are 0, 3.2485, -4.7443, 2.5294; The variable speed pumps are modeled without constant pressure setpoint with coefficients set to 0, 0.5726, -0.301, 0.7347.		PNNL (2010). Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010. U.S. Department of Energy.
	Pipe	This is not a user input in Asset Score.	All pipes are modeled as adiabatic pipes. No pipe heat losses are modeled for Asset Score Models.		PNNL (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual U.S. Department of Energy.

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
	Chilled Water Temperature Reset	Chilled water (CHW) supply temperature reset controls are modeled through this input.	CHW supply temperature is reset based on outdoor- dry-bulb temperature using the following schedule: CHW supply temperature of 44°F at 80°F outdoor air dry bulb and above, CHW supply temperature of 54°F at 60°F outdoor air dry bulb temperature and below, ramped linearly between 44°F and 54 F at temperatures between 80°F and 60°F.		PNNL (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual U.S. Department of Energy.
Plants: Condenser	Cooling Tower			Future enhancements would add fluid coolers for Asset Score.	
	Cooling Tower		The cooling tower is modeled with one cell. This is not a user input and a default modeling approach used in Asset Score.		
	Cooling Tower Fan Control	Cooling tower fan control has two options, Single Speed and Variable Speed, The user input of ' I don't know' models Single Speed' condenser fan controls. Single Speed or Variable Speed.	User input of 'Single Speed' models a cooling tower with a single speed fan. User input of 'Variable Speed' models a cooling tower with a variable speed fan.		
	Condenser Pump Control	Condenser pumps can be specified to be 'Constant' Speed or Variable Speed'. User input of 'I don't know' models a 'Constant Speed' pump for the condenser loop.	Constant speed pump is modeled with the pump riding the pump curve. Coefficients used are 0, 3.2485, -4.7443, 2.5294; The variable speed pumps are modeled without constant pressure setpoint with coefficients set to 0, 0.5726, -0.301, 0.7347. Pump head is assumed to be 179352 Pa which corresponds to 60' of head at 60% total pump efficiency and 19 W/gpm power.		
Air Handler					
Cooling Systems					
Cooling Source: DX Coil	Total Cooling Capacity Function of Temperature Curve Name	These are Asset Score defaults and not specified by the user.	Biquadratic Curve. Coefficients specified are - 0.42415, 0.04426, -0.00042, 0.00333, -8e-005, -0.00021,		OpenStudio Model Defaults
	Total Cooling Capacity Function of Flow Fraction Curve Name	These are Asset Score defaults and not specified by the user.	Quadratic Curve- Coefficients specified are - 0.77136, 0.34053, -0.11088, 0.75918, 1.13877		OpenStudio Model Defaults
	Energy Input Ratio Function of Temperature Curve Name	These are Asset Score defaults and not specified by the user.	Biquadratic Curve. Coefficients specified are - 1.23649,-0.02431, 0.00057, -0.01434, 0.00063, -0.00038,		OpenStudio Model Defaults
	Energy Input Ratio Function of Flow Fraction Curve Name	These are Asset Score defaults and not specified by the user.	Quadratic Curve- Coefficients specified are - 1.2055, -0.32953, 0.12308, 0.75918,1.13877;		OpenStudio Model Defaults
	Part Load Fraction Correlation Curve Name	These are Asset Score defaults and not specified by the user.	Quadratic Curve- Coefficients specified are 0.771, 0.229, 0, 0, 1;		OpenStudio Model Defaults
	Coil Stage Control	This is an Asset Score default, and not specified by the user.	For fan control specified as constant air volume, single speed coils are used. Two Speed coils are used for fan control specified as variable air volume. The minimum airflow ratio is set to 0.67 for two speed coils.		
	Cooling Supply Air Temperature	This is an Asset Score default, and not specified by the user.	Assumed to be 55°F, unless Supply Air Temperature Reset control is selected.		PNNL. (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual. U.S. Department of Energy.

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
	Equipment Efficiency	User input can be provided for DX cooling coil efficiency. This input should exclude supply fan power for packaged systems.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction is used with a typical equipment life.		
Cooling Source: Plants		Reference to a previously defined chiller plant or district chilled water plant.			
Cooling Source: No Cooling		No cooling system is modeled for the air handling unit.			
Heating Systems					
Heating Source: Central Furnace	Fuel Type	Can be Gas or Electric			
	Heating Supply Air Temperature	This is an Asset Score default, and not specified by the user.	For single zone systems, the supply air temperature is fixed at 105°F. For multi zone systems, supply air temperature is fixed at 55°F (unless supply air temperature reset control is used).		
	Equipment Efficiency	User input can be provided for furnace efficiency.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction used with a typical equipment life		
Heating Source: Heat Pump	Coil Type	This is an Asset Score default, and not specified by the user.	Single speed DX coils are used.		
	Supplementary heating	This is an Asset Score default, and not specified by the user.	Electric resistance coils		
	Maximum OA Temp for Supplementary Heater Operation	This is an Asset Score default, and not specified by the user.	40°F		
	Minimum OA Dry Bulb T for Compressor Operation	This is an Asset Score default, and not specified by the user.	17°F	Future Version of the tool with modifies this to 0°F. Studies indicate HP to perform at COP > 1 at temperatures till 0°F.	
	Heating Coil Defrost Strategy	This is an Asset Score default, and not specified by the user.	Resistive (electric resistance heater)		
	Defrost Heater Capacity	This is an Asset Score default, and not specified by the user.	2000 W		
	Heating Capacity Function of Temperature Curve Name	This is an Asset Score default, and not specified by the user.	Cubic Curve; 0.758746, 0.027626, 0.000148716, 3.4992e-006		OpenStudio Model Defaults
	Heating Capacity Function of Flow Fraction Curve Name	This is an Asset Score default, and not specified by the user.	Cubic Curve; Coefficients specified are 0.84, 0.16, 0, 0		OpenStudio Model Defaults
	Energy Input Ratio Function of Temperature Curve Name	This is an Asset Score default, and not specified by the user.	Cubic Curve; Coefficients specified are 1.19248, -0.0300438, 0.00103745, -2.3328e-005		OpenStudio Model Defaults
	Energy Input Ratio Function of Flow Fraction Curve Name	This is an Asset Score default, and not specified by the user.	Quadratic Curve; Coefficients specified are 1.3824, -0.4336, 0.0512		OpenStudio Model Defaults
	Part Load Fraction Correlation Curve Name	This is an Asset Score default, and not specified by the user.	Quadratic Curve; Coefficients specified are 0.75, 0.25, 0		OpenStudio Model Defaults
	Fan Control	This input isn't editable for Heat Pumps. Fan control is fixed to Constant Volume for Heat Pumps.		Add user input for fan control for heat pumps.	

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
	Equipment Efficiency	User input can be provided for heat pump efficiency.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction used with a typical equipment life		
Heating Source: Plants		Reference to a previously defined boiler plant or district hot water plant			
Heating Source: No Heating		No central heating system is modeled for the air handling unit.			
Distribution	Type	Single zone	Single zone distribution models one HVAC system per thermal zone.		
		Multiple zone	Models one system per block. Each zone has a reheat terminal which could be VAV with reheat or Parallel Fan Powered Induction Units.	Future versions of the tool will allow a user to specify multi-zone distribution systems in more detail. An additional input would be added which would allow a user to model one AHU per floor.	
Terminal Units	Terminal Unit	VAV with reheat	Models a reheat coil with a VAV damper. Reheat source can be specified by user (either electric resistance, hot water coils or gas-fired reheat coils) or defaults to hot water reheat if the primary heating source is hot water boiler. For all other systems, the default reheat is electric resistance coils.		
		Fan powered induction units	These reheat terminals are modeled with constant volume parallel fans, with minimum volume setpoint set to 30% of the peak design airflow rate. The default reheat coil is electric resistance or could be specified by the user to be hot water coils or gas fired coils.		
	Minimum Air Flow Fraction	User can specify this value as 0.3, 0.4. User input of 'I don't know' defaults to a value of 0.4 for the minimum airflow fraction.	Fixes the minimum damper position to a default of 0.4 or user specified input of 0.3. This is the minimum air flow fraction to a zone and a higher fraction indicates higher reheat energy use.	Future versions of the tool with add capability to specify dual maximum damper control as well as custom input for minimum damper position.	
Fan System	Fan Control	Fan control can be specified as 'Constant Volume' (CAV) or 'Variable Air Volume' (VAV). For user input of 'I don't know', CAV fans are modeled. There are a few exceptions to this rule: 1. For heat pumps, this input is not displayed and all heat pumps default to CAV fan control. 2. For 'Distribution Type' specified as 'Multi Zone', fan control is fixed as VAV.			
	Fan motor in Air Stream Fraction	This is an Asset Score default, and not specified by the user.	100% of the fan motor heat loss is added to the airstream in Asset Score models		
	Fan Static Pressure Drop	This is an Asset Score default, and not specified by the user.	Fan static pressure drops are calculated based on design airflow. The design supply airflow is inferred by the Asset Score inference engine and ASHRAE Standard 90.1-2010 Section 6.5.3.1 Fan Power Limitation rules are used to calculate static pressure drop.		PNNL. (2010).Achieving the 30% Goal: Energy and Cost Savings Analysis of ASHRAE Standard 90.1-2010. U.S. Department of Energy.

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
	Fan Part Load Coefficients	This is an Asset Score default, and not specified by the user.	Variable air volume fans are modeled with a cubic curve. Fan power coefficients are specified as (0.070428852, 0.385330201, -0.460864118, 1.00920344)		PNNL. (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual. U.S. Department of Energy.
HVAC System Controls	Airside Economizer	The input is available for MZ AHUs with VAV fan control. A user can specify if the AHU has an airside economizer.	If specified to be present by the user, the Asset Score tool models an airside economizer with fixed dry bulb control and economizer maximum limit specified as 73°F. For HVAC systems without economizer control, the Asset Score Recommendation Engine verifies the applicability of these controls based on climate zone and supply fan size.	Future enhancements will add additional control types for air-side economizers as well as user inputs for economizer high limits.	
	Demand Control Ventilation (DCV)	The input is available for MZ AHUs with VAV fan control. A user can specify if the AHU has demand control ventilation controls.	Minimum Ventilation rates are based on ASHRAE Standard 62.1 2004. If specified to be present by the user, DCV controls are modeled to the applicable AHU. For HVAC systems without DCV controls, the Asset Score Recommendation Engine verifies the applicability of these controls based on occupant density. DCV controls are added to spaces with occupant density less than or equal to 25 sq.ft/person, based on ASHRAE Standard 90.1-2013. For other use types, 10% of the area is assumed to have high occupancy and is modeled with DCV controls.		
	Supply Air Temperature Reset	The input is available for MZ AHUs with VAV fan control. A user can specify if the AHU has supply air temperature reset controls.	Equipment supply air temperature is reset based on outdoor air dry-bulb temperature. Supply air temperature is reset higher to 60°F (15.6°C) at outdoor low of 50°F (10°C). SAT is 55°F (12.8°C) at outdoor high of 70°F (21.1°C).		PNNL. (2015). ANSI/ASHRAE/IES Standard 90.1-2010 Performance Rating Method Reference Manual. U.S. Department of Energy.
	Fan Static Pressure Reset	The input is available for MZ AHUs with VAV fan control. A user can specify if the AHU has fan static present reset controls.	Fan static pressure reset is modeled through a different set of fan performance curves. The coefficients used to simulate fan static pressure reset are: (0.040759894, 0.08804497, -0.07292612, 0.943739823)		
Zone Equipment					
These are zonal systems, with airflow ranging from 800-1200 CFM, typically used in apartments, small offices, hotel guest rooms. These could be cooling only systems (window air conditioners) or heating and cooling systems (packaged terminal air conditioner or packaged terminal heat pumps) or split systems that provide cooling and/or heating.					
Cooling Source: Terminal DX	Coil Type		Single Speed DX Coil		
	Coil Performance Curves		Refer to DX coil above		
	Equipment Efficiency	User input can be provided for DX cooling coil efficiency. This input should exclude supply fan power for packaged systems.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction is used with a typical equipment life.		
Cooling Source: Plant		Reference to a previously define chiller plant or district chilled water plant.	This models a 4 pipe fan coil unit with a heating plant (if defined as the heating source) or dummy heating plant if heating source is defined as 'No Heating.'		
Heating Source: Single Zone Furnace	Fuel Type	Can be electricity of Gas			
	Equipment Efficiency	User input can be provided for furnace efficiency.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction is used with a typical equipment life.		
Heating	Fuel Type	Can only be electric.			

Asset Score Tool Modeling Strategy					
Input Category	**Input Selection/Field**	**User Input Provided**	**Tool Modeling Strategy (Inferences, Defaults, Optimization and Recommendations)**	**Future Enhancement**	**Reference**
Source: Heat Pump	Sink/Source	Can be air source		Future versions of the tool will add water source and ground source heat pumps.	
	Equipment Efficiency	User input can be provided for heat pump heating efficiency.	This input is directly used in the EnergyPlus simulation. If not provided, it can be inferred based on year of manufacture. If year of manufacture isn't provided, year of construction is used with a typical equipment life		
Heating Source: Plant		Reference to a previously define boiler plant or district hot water plant.	This models a 4 pipe fan coil unit with a cooling plant (if defined as a cooling source) or dummy cooling plant if cooling source is defined as 'No Cooling'		
Fan	Control	This is an Asset Score default, and not specified by the user	Assumed to be Constant Volume for all zonal systems		
	Pressure Drop	This is an Asset Score default, and not specified by the user	Assumed to be fixed at 0.3 inH2O		
	Fan Total Efficiency	This is an Asset Score default, and not specified by the user	Assumed to be fixed at 54%		

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