ENERGY STAR Portfolio Manager® Technical Reference

ENERGY STAR Score

OVERVIEW

EPA's 1 - 100 ENERGY STAR score is an external benchmark for assessing the performance of commercial buildings. The ENERGY STAR score, expressed as a number on a simple 1 - 100 scale, rates performance on a percentile basis: buildings with a score of 50 perform better than 50% of their peers; buildings earning a score of 75 or higher are in the top quartile of energy performance. First introduced in 1999, the score has been adopted by leading organizations across the United States because it offers a simple way to evaluate measured energy use, prioritize investments, and communicate relative performance across a portfolio of buildings. In July of 2013, the Environmental Protection Agency (EPA) and Natural Resources Canada (NRCan) together released the first 1 - 100 ENERGY STAR score for Canadian buildings, which applies the same methodology to assess measured performance relative to Canadian building stock. Within each section of this document, distinctions between the U.S. and Canadian methodologies are noted.

Recognizing the widespread adoption of the ENERGY STAR score in the commercial marketplace, EPA continually reviews and updates the technical approach to ensure accurate, equitable, and statistically robust scores. The overall objectives of the ENERGY STAR score are to:

- Evaluate energy performance for the whole building
- Reflect actual metered energy consumption
- Equitably account for different energy sources
- Normalize for building activity
- Provide a peer group comparison

Once developed, the ENERGY STAR score is programmed into EPA's online measurement and tracking tool, ENERGY STAR Portfolio Manager®. The following steps are used to compute the score for an individual property:

- Enter data into Portfolio Manager
- Compute actual source energy use intensity
- Compute the predicted source energy use intensity
- Compute an efficiency ratio comparing the actual use with the predicted use
- Assign a score based on how the ratio compares with the national distribution

The subsequent sections of this document offer specific details on the following aspects of the ENERGY STAR score:

OBJECTIVES

EPA has identified the following objectives for a successful energy performance metric:

1. **Evaluate energy performance for the whole building.** Rather than examining specific pieces of equipment within a building, a whole building metric accounts for the interactions among the various system components. For example, a particular HVAC system may be designed with efficient components, but if it is over-sized relative to the actual heating and cooling loads it will not perform efficiently. A robust analysis must account for energy use of the whole building.

2. **Reflect actual metered energy use.** The ENERGY STAR score must reflect the actual metered or billed energy consumption at a property. It cannot be based on predicted or simulated energy use, as simulations often fail to account for both the impact of building operation and maintenance patterns and the interactions among building systems.

3. **Equitably account for different energy sources.** Source energy accounts for both energy consumed at the site as well as energy used in generation and transmission. This approach is the most equitable for assessing properties with different fuel mixes and buildings with onsite power generation systems. In addition, source energy is more reflective of energy costs and GHG emissions.

4. **Normalize for building activity**. The intent of the ENERGY STAR score is to provide a fair assessment of energy performance, taking into account operational conditions required for the business activities within the building. Normalization requires adjustments to account for factors such as weather, operating hours, and the number of workers.

5. **Provide a peer group comparison**. A peer group comparison enables building owners and operators to track not only their improvement over time, but also how they stack up when compared to others with the same primary business function (e.g., retail store).

Given these objectives, *Figure 1* provides guidance on what the score does and does not offer.

The subsequent sections detail how each of these objectives is met through the selection of a robust data set and the application of a regression analysis to understand the effects of building activity. This document is focused on the general approach taken to develop the ENERGY STAR score. In addition, there are specific documents for each individual score that describe the analytical findings and procedures applied. These may be found at: www.energystar.gov/ScoreDetails.

Figure 1 – Purpose and Interpretation of the ENERGY STAR Score

✓ The Score Does	✗ The Score Does Not
✓ Evaluate actual metered energy use ✓ Normalize for business activity (hours, workers, climate) ✓ Compare buildings to the national population ✓ Indicate the level of energy performance	✗ Sum the energy use of each piece of equipment ✗ Credit specific technologies ✗ Compare buildings with others in Portfolio Manager ✗ Explain why a building performs well or poorly

COMPUTING YOUR SCORE

To receive an ENERGY STAR score in Portfolio Manager, you must enter 12 full calendar months of energy data for all energy types, in addition to complete data on property use details such as hours of operation and workers. To determine the score, Portfolio Manager will compute both the actual source energy use intensity (EUI) and the predicted source EUI based on these inputs. The ratio of actual source EUI to predicted source EUI is the efficiency ratio, which can be mapped through a lookup table to determine the 1 - 100 ENERGY STAR score. This process is detailed in *Figure 2*.

Figure 2 – Steps to Compute the ENERGY STAR Score

1	User enters building data into Portfolio Manager

- 12 months of complete energy use information for all energy types
- Specific physical building information (size, location, etc.)
- Specific use details describing building activity (hours, etc.)

2	Portfolio Manager computes the actual source EUI

- Total energy consumption for each fuel is converted from site energy into source energy
- Source energy values are added across all fuel types
- Source energy is divided by gross floor area to determine actual source EUI

3	Portfolio Manager computes the predicted source EUI

- A regression equation for each property type is used to determine predicted source EUI
- The equation begins with the average EUI for the property type and makes a series of adjustments based on the use details (hours, workers, etc.)

4	Portfolio Manager computes the energy efficiency ratio

- The ratio equals the actual source EUI (Step 2) divided by predicted source EUI (Step 3)
- Lower ratios indicate better performance

5	Portfolio Manager uses the efficiency ratio to assign a score via a lookup table

- For each score on the 1 - 100 scale, the lookup table provides a range of ratio values
- The ratio from Step 4 is used to identify the score
- A score of 75 indicates that the building performs better than 75% of its peers

Computing Your Score: How is it Different in Canada?

The steps to compute a score are identical in the U.S. and Canada. However, remember that Canadian buildings are being compared to other Canadian buildings, not to the U.S. building stock. Therefore, Step 2 will reference Canadian source energy factors, Step 3 will require scores based on Canadian reference data, and the lookup table in Step 5 will be based on the performance distribution of buildings in Canada.

IDENTIFYING YOUR PEER GROUP

The peer group for comparison is the national population of other buildings with the same primary business activity (e.g., office, K-12 school, etc.). Nationally representative data is the bedrock of the ENERGY STAR score. A nationally representative data set with actual (billed) whole building energy data enables EPA to adjust for business activity, to understand the full distribution (range) of energy performance, and to create a peer group comparison. It is important to note that EPA always uses a statistically robust national data set. The ENERGY STAR score *is not based* on information from other buildings entered into Portfolio Manager.

A nationally representative data set includes information on buildings in diverse locations and with diverse physical and operational characteristics. One of the most common surveys used by EPA is the Commercial Building Energy Consumption Survey (CBECS), which is conducted by the U.S. Department of Energy's Energy Information Administration. The survey samples more than 5,000 buildings across the U.S., collecting complete billing data and operational details for a variety of commercial building types. More information on this survey, including complete micro data files, is available at: https://www.eia.gov/consumption/commercial/index.php. EPA uses CBECS data as the basis for the majority of the ENERGY STAR scores. However, EPA also uses other data sources when CBECS data is insufficient. Refer to the specific property type documents to learn what data set was used to develop each score.

Once the nationally representative data set is identified, EPA applies a series of filters. These filters remove observations from the reference data in order to refine the peer group of comparison and overcome any technical limitations. Specifically, EPA applies some or all of the following four filters.

1. **Building Type Filters.** First, a filter is applied to select only buildings with the same basic operation (e.g., office) for the analysis.
2. **Program Filters.** Second, basic program filters are applied to define the peer group for evaluation. For example, EPA requires that most building types must operate at least 30 hours per week. This basic filter is a threshold for full-time operation and is a requirement for obtaining an ENERGY STAR score.
3. **Data Limitation Filters.** Third, it may be necessary to apply one or more filters to the data due to limitations in the way information is reported. For example, in the CBECS data, the amount of chilled water, wood, coal, and/or solar energy consumed is not reported. Therefore, buildings with these types of energy consumption are excluded, because the thermal requirement associated with these types of energy cannot be assessed.
4. **Analytical Filters.** Finally, once regression analysis begins, analytical filters may be used to eliminate outlier data points. Certain outlier points may have different behavior that cannot be assessed accurately with the rest of the data. For example, EPA found that hotels smaller than 5,000 ft² do not behave the same way as larger buildings, and therefore EPA excludes these buildings from the data set.

All data filters are selected according to these criteria. The specific filters associated with the regression analysis for each individual property type will depend on the available data and analytical results. Refer to the specific document for each individual property type for a full list of filters.

Identifying Your Peer Group: How is it Different in Canada?

A nationally representative data set is equally important when developing an ENERGY STAR score for commercial buildings in Canada. The source of data in Canada is the Survey on Commercial and Institutional Energy Use (SCIEU) which is commissioned by NRCan and executed by Statistics Canada. More information on this survey is available at http://www.statcan.gc.ca/. NRCan applies the same filtering strategy, including Building Type, Program, Data Limitation, and Analytical Filters.
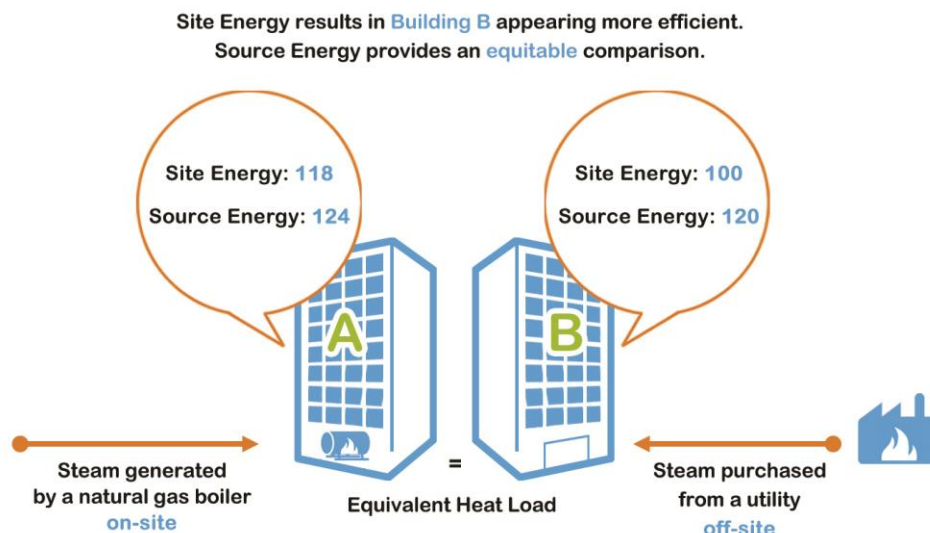
ACCOUNTING FOR FUEL MIX

Buildings use a variety of forms of energy, including electricity, natural gas, fuel oil, and district steam. In order to equitably combine all of these different forms of energy, EPA uses *source energy.* What you may be familiar with on your utility bills is called site energy, which is the quantity of energy you directly consume at the property. Source energy includes not only this energy, but also the energy required to generate and deliver this energy to your property.[1] EPA uses source energy because it provides the most equitable comparison of the thermodynamic efficiency of buildings using different fuel types.

To understand why source energy is the most equitable approach, it is instructive to consider how a building uses energy. Useful energy comes in the form of heat and electricity. Both heat and electricity may be generated at the building or by a utility. For example, a building may purchase electricity produced by a power plant or use natural gas to produce electricity onsite through a combined heat and power cycle. Similarly, a natural gas fired boiler can be used onsite to provide steam to a building, or a building can be heated using steam generated by a utility and distributed via a district system.

Heat and electricity are considered *secondary energy*, useful energy that is created from a raw source. The heat content of the original source is considered *primary energy*. Primary and secondary energy are not directly comparable because one represents a raw fuel while the other represents a converted fuel. ***Figure 3*** illustrates two buildings, which are identical in their construction and operation and require 100 MBtu of steam for heating. Building A purchases natural gas from a utility to produce steam onsite, whereas Building B purchases steam directly from a utility. That is, Building A is purchasing primary energy while Building B is purchasing secondary energy, and both buildings provide the same amount of heat to meet the demands of the occupants.

Figure 3 – Two Identical Buildings Heated by Steam

Site Energy results in Building B appearing more efficient.
Source Energy provides an equitable comparison.

Site Energy: 118
Source Energy: 124

Site Energy: 100
Source Energy: 120

Steam generated by a natural gas boiler on-site

Equivalent Heat Load

Steam purchased from a utility off-site

---

[1] Note that source energy does not include energy associated with mining or extraction of raw fuels such as coal or oil. For more on the scope of source energy, visit www.energystar.gov/SourceEnergy.

Because these buildings provide the same working environment, one would expect them to have the same EUI and ENERGY STAR score. As you can see in Figure 3, using Site EUI, Building B would appear to be more efficient, as its EUI is over 15% lower. On a source energy basis, the EUI values are within 3% of each other. Using source energy, these buildings appear more similar, which is the expected outcome given that they deliver the same amount of heat to the occupants. As this example illustrates, a building should not receive either a penalty or a credit for choosing a certain fuel. For this reason, it is necessary to express primary and secondary energy in equivalent units. EPA accomplishes this goal by converting to source (or primary) energy. This conversion accounts for the total thermodynamic requirement at the building. More information on these conversions is available at: www.energystar.gov/SourceEnergy.

Accounting for Fuel Mix: How is it Different in Canada?

Site and source factors are computed on a national basis. This means that buildings in the U.S. and Canada have different source energy factors, based on the infrastructure used to supply energy in each country. Specific details on the factors for Canada are also located at: www.energystar.gov/SourceEnergy.

NORMALIZING FOR OPERATION

To normalize for differences in business activity, EPA performs regression analysis to understand what aspects of building activity are statistically significant with respect to energy use. The result of this analysis is an equation that will predict the energy use of a building, based on its business activities. This section outlines the basic statistical techniques employed.

Regression Analysis Overview

The primary analysis is a weighted ordinary least squares regression, which evaluates source EUI relative to business activity (e.g., operating hours, number of workers, and climate). This linear regression yields an equation as described in *Figure 4*. This equation is used to compute Source EUI (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables). C_o represents a constant term and the other C values are regression coefficients. Each equation coefficient is a number that represents the correlation between the operating characteristic and the building's source EUI. For example, if *Characteristic$_1$* is gross floor area, then the value of C_1 is the statistical correlation between gross floor area and source EUI when simultaneously adjusting for all other characteristics in the equation. The *Independent Variables* section below discusses what characteristics are evaluated and included in the equation.

Figure 4 – Description of Regression Equation

Source EUI	=	C$_o$	+	C$_1$*Characteristic$_1$ + C$_2$*Characteristic$_2$ + …
• Predicted Source EUI • Mean source EUI for a theoretical sample of buildings with the same operational characteristics as yours		• Mean source EUI for the full national population in the reference data		• Series of adjustments for characteristics that describe your business activity • Adjustments are based on how your building differs from average • For example, if your building is open 75 hours per week and the national average is 50 hours per week, then the adjustment is based on the difference, 25 hours

Any given observation in the reference data set has an actual measured source EUI and also has a "predicted source EUI" – the source EUI that is computed using the regression equation and the values of each independent variable (characteristic) of the building. The predicted source EUI of an individual building can also be understood as the mean source EUI for a group of buildings have the exact same characteristics as your building. Buildings whose actual source EUI is lower than the predicted source EUI are comparatively better performers and vice versa.

The regression approach is different from an engineered model of building energy consumption. Engineered models will attempt to predict the exact kWh of specific activities (lighting, HVAC, etc.) and sum these together into a building total. In contrast, the regression approach looks at *measured* energy data and determines whether there are statistically significant correlations between key indicators of business activity and source EUI.

Dependent Variable

The dependent variable is the main unit of analysis; it is the term that appears on the left hand side of the regression equation. Typically, the dependent variable is source EUI, which is equal to total source energy divided by gross floor area. Generally speaking, larger commercial buildings use more total energy. By looking at EUI, it is possible to assess whether there is a difference on a *per square foot* basis. For example, in some cases there can be an economy of scale where larger buildings are actually able to use less energy on a per square foot basis. In other cases, the reverse is observed (diseconomy of scale). Therefore, the use of EUI, rather than total energy use, can enable a superior assessment of the effects of building size.[2]

Independent Variables (Building Characteristics)

Independent variables are the characteristics on the right hand side of the regression equation, which are used to normalize for business activity. In order for the ENERGY STAR score to be equitable, it is important to provide these adjustments for different levels of activity. Generally, the goal of normalization is to adjust for building characteristics that explain *how* a building operates, but not to provide adjustments for characteristics that explain *why* a building operates a certain way.

An example of a characteristic that explains *how* a building operates is hours. An emergency services building with 24-hour-a-day operation should not be penalized for using more energy than a building that is only open 9 hours per day. Characteristics that explain *how* a building operates are generally physical constraints and operational requirements of the business. These types of characteristics are always included if they show statistically significant results.

An example of a characteristic that explains *why* a building operates a certain way is lighting type. This type of characteristic is never included in the regression equation. Recall that the ENERGY STAR score is based on the comparison of a building's actual source EUI with its predicted source EUI from the regression equation. A change in technology affects the score only when it lowers the ***actual EUI***. EPA does not award specific points or assumptions based on technology. Including these variables in the prediction would effectively compare buildings only with others that had the same technology. Moreover, including these variables in the prediction could often be inaccurate if the technology is not properly installed and operated to obtain optimal savings. Therefore, the way that technology affects ENERGY STAR score is when it changes actual measured energy. ***Figure 5*** summarizes the criteria for including a characteristic in the regression analysis.

---

[2] For the data center property type, the dependent variable is Power Usage Effectiveness (PUE). Please refer to the technical description for additional information: www.energystar.gov/ScoreDetails. Similarly, for wastewater treatment plants, the dependent variable is source energy divided by the average flow through the plant in gallons per day (GPD).

Figure 5 – Summary of Criteria for Including Building Characteristics in the Regression

✓ **Characteristics Included**	× **Characteristics Excluded**
✓ Describe how a building operates ✓ Explain physical conditions and parameters ✓ Are determined by the business activity and needs	× Describe why a building performs a certain way × Specify technologies used × Reflect market conditions that may motivate behavior but are not related to thermodynamic performance
Examples: Hours, Workers, Floor Area, Computers, Weather	*Examples: Lighting Technology, Window Type, Energy Price*

Weather is listed among the characteristics included because it is a physical constraint on the building. Buildings will have certain heating and cooling requirements based on their location, and normalization is necessary to be equitable to all regions. Weather necessitates some additional discussion because there are numerous weather conditions that may influence energy use, including: average daily temperature, temperature maximum and minimum values, Heating Degree Days (HDD), Cooling Degree Days (CDD),[3] humidity, and cloud cover.

Many of these numerous weather characteristics are correlated with each other. For example, buildings with higher HDD tend to have lower CDD (e.g., colder climates). Similarly, buildings with higher CDD tend to have higher dew points (warmer, more humid climates). In general, a regression analysis will isolate the effect of one variable while simultaneously normalizing for the other variables. When two independent variables are highly correlated with each other, it is prudent to include only one of the two, because they end up capturing the same effect.

To explore the effects of humidity, EPA ran regression models that included HDD, CDD, and Dew Point. This analysis showed that a separate relationship for humidity was not statistically significant. Although removing moisture from the air requires energy, this energy requirement cannot necessarily be isolated as a statistically significant differentiator among buildings. The regression analysis simultaneously adjusts for each independent variable. It was observed that dew point is highly correlated with CDD. Therefore, in a regression analysis, independent statistically significant correlations for *both* CDD *and* dew point cannot be obtained. This indicates that the impact of dew point can be accounted for by the inclusion of CDD.

EPA has also performed analysis to look at Average Temperature as an alternative (or addition) to HDD and CDD. It was not found that Average Temperature offered a separate (or superior) correlation with source EUI than HDD and CDD on their own. Ultimately, EPA will typically use HDD and/or CDD as the primary indicators of weather conditions in the regression equations, depending on the weather relationships identified for a particular property type. Statistical correlations for these variables successfully account for weather differences across the country, and additional terms for factors such as humidity are not shown to be effective.

---

[3] HDD and CDD measure the deviation from a temperature of 65 degrees Fahrenheit over the course of the year. For each day with an average temperature lower than 65 degrees, HDD is the difference between the average temperature and 65 degrees. The annual HDD is the sum of this difference across all days with an average temperature below 65 degrees. CDD is calculated in a similar manner, to measure deviations above 65 degrees. Note that 65°F is equivalent to 18°C.

> ### Normalizing for Operation: How is it Different in Canada?
>
> There are no substantive differences in the regression methodology applied by NRCan in development of the 1 - 100 score for Canadian buildings.
>
> - **Regression Approach.** Ordinary least squares regression is also employed.
> - **Dependent Variable.** The dependent variable is also Source EUI, though in Canada the units will be GJ/m^2.
> - **Independent Variables.** Independent variables are evaluated according to the same criteria, but in some cases, units will differ. For example, Canada uses $°C$ for HDD and CDD and m^2 for gross floor area.
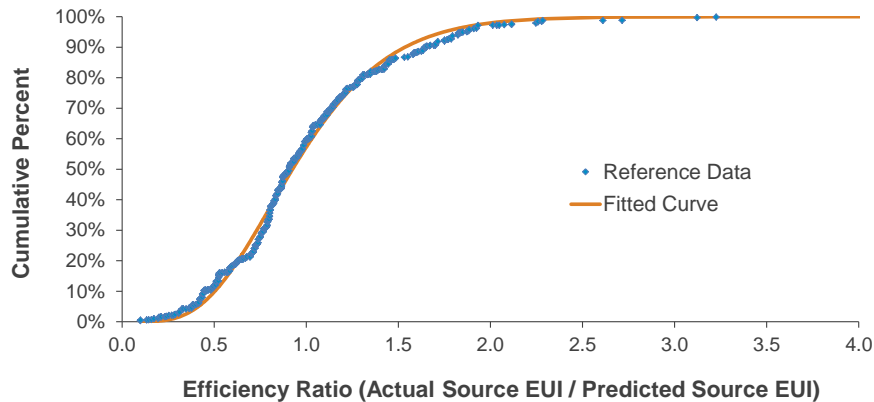
TRANSLATING PERFORMANCE INTO A 100-POINT SCALE

The statistical regression equation answers the question: *how much energy do buildings use relative to their operation?* A second piece of analysis is required to answer the question: *how much energy do buildings use relative to each other?* Ultimately, the goal of the ENERGY STAR score is to provide a 1 - 100 percentile ranking of performance, relative to the national population. The regression equation yields a prediction of source EUI based on the building's business activity. Some buildings in the reference data sample will use more energy than predicted by the regression equation, while others will use less. The *actual* source EUI of each observation is divided by its *predicted* source EUI to calculate an energy efficiency ratio. Lower efficiency ratios indicate that the building uses less energy than predicted, and consequently is more efficient. Higher efficiency ratios indicate the opposite. The best buildings may have ratios as low as 0.25, indicating that their actual source EUI is only 25% of the predicted source EUI from the regression equation. The worst buildings can use over 3 times as much energy as predicted, corresponding to ratios of 3.0.

The cumulative distribution of these energy efficiency ratios is plotted from smallest to largest, as show in **Figure 6**. Once this distribution is plotted, a best-fit curve through the data is determined. Typically, EPA will use a gamma distribution and find the best gamma curve through the data by minimizing the sum of squared differences. Because the smooth curve is mathematically defined by a specific equation, it is possible to use the curve to calculate the energy efficiency ratio at a given percent. That is, the orange line can be translated into a "Lookup Table" that shows the energy efficiency ratio at each percent, from 1 to 100. For example, the ratio on the fitted curve at 1% corresponds to a score of 99; only 1% of the population has a ratio this small or smaller. The ratio on the gamma curve at the value of 25% will correspond to the ratio for a score of 75; only 25% of the population has ratios this small or smaller. This ratio defines the threshold for the top quartile. Buildings located in the U.S. or its territories may be eligible to apply for the ENERGY STAR if they achieve a score of 75 or higher. More information on ENERGY STAR certification and the application process is available at: www.energystar.gov/BuildingCertification.

Figure 6 – Sample Cumulative Distribution with Fitted Curve

Translating Performance into a 100 Point Scale: How is it Different in Canada?

In Canada, the peer group of comparison is Canadian buildings, based on the SCIEU reference data. Using this data, the process for determining the cumulative distribution and the best-fit curve is the same as in the U.S.

UNDERSTANDING BUILDINGS AND CAMPUSES

The main unit for benchmarking in Portfolio Manager is the property, which may be used to describe either a single building or a campus of buildings. The applicability of the ENERGY STAR score depends on the type of property. For some properties, the ENERGY STAR score will apply to the entire property, regardless of the number of buildings. For other properties, the ENERGY STAR score can only apply to individual buildings on the property. Each ENERGY STAR score is available either for a campus or for an individual building, but never for both.

- **Campus Score.** A campus score applies to properties where it is common to find a campus setting, and where each building on the campus is necessary to make the complete function of the property. For example, the school gym may be in a separate building, but it is inherently part of the school. When there is a campus property of this type, the entire campus will receive a 1 - 100 score; the score is not designed for individual buildings on the campus. When there is a single building property of this type (e.g., entire school in one building), it is also eligible for a score. The property types that earn a campus score are:

  - K-12 School
  - Hospital
  - Hotel
  - Multifamily Housing
  - Senior Living Community

- **Building Score.** A building score is intended for use at individual buildings only and will never apply to an entire campus. The building score is more common than the campus score because in most cases the primary function is contained within a single building. For example, offices and warehouses are typically single buildings. In cases where multiple buildings are situated together (e.g., an office park), the score is

designed to apply to each individual building and not to the campus. The majority of property types earn building scores – this approach applies to all types except those listed above under campus score.

Understanding Buildings and Campuses: How is it Different in Canada?

The treatment of buildings and properties is identical in the U.S. and Canada.

ADJUSTING FOR MULTIPLE USES

Generally, EPA recommends that you enter your buildings according to the primary use (e.g., office, K-12 school, hotel, retail, etc.) and that you enter as few additional use types as possible. Entering a single use type will most closely approximate how the building would have been recorded in the reference data survey and will therefore yield the most accurate score. However, in some cases, buildings may have multiple distinctly different uses. The following procedures are applied to compute the score across multiple uses.

Multiple Uses of the Same Type

Some buildings have multiple property uses of the exact same type (e.g., two different office uses in one building). This situation is most common for multitenant office buildings, where different parts of the building may have different operating schedules or worker densities, and therefore are entered as distinct uses. In this case, all uses of the same type are *combined together into one aggregate use. That is, the building is treated as if it had only one use.*

For example, if a building has ten office uses (one for each tenant), then the uses are combined into one aggregate office use, and then the regression equation is applied to the combined office use to generate the predicted energy and the ENERGY STAR score. *Figure 7* describes how different use details (building characteristics) are combined. Because all uses are combined together, a user may choose to enter only a single use. In this case, the building with a single use will earn the same score as a building with multiple uses, as long as the correct method of combination is applied.

Figure 7 – Procedures for Combining Use Details

Type of Detail	Method of Combination	Examples
Physical Quantity	Sum together value for all uses	Gross Floor Area, Number of Computers, Number of Workers
Operational Condition	Average the values across all uses – weight by floor area	Hours of Operation, Percent Heated, Percent Cooled
Yes/No Questions	Mark aggregate as Yes if *any* individual uses are yes	Presence of Cooking, School Weekend Operation

Multiple Uses of Different Types

Some buildings have multiple uses of different types. For example, in an urban setting there may be a building that is part hotel and part office. In this situation, Portfolio Manager will apply separate regression equations for each use *type* and combine the resulting predictions into a prediction for the whole building. *Figure 8* illustrates this process for the office and hotel example.

In order to predict the energy EUI for the mixed-use building, the regression equation for each use type is applied. First, the regression is used to produce a predicted EUI for each use type. Second, the predicted EUI for each use is multiplied by its floor area to yield a predicted source energy. Third, the predicted source energy is added across all use types to obtain a prediction for the whole building. Finally, once the whole building prediction is obtained, it is compared with the measured whole building energy to determine the efficiency. Note that it is *not necessary to sub-meter* the actual energy use of each use type. Rather, the whole building energy is compared with a whole building prediction.

Figure 8 – Computing Predicted Source EUI in a Mixed-Use Building
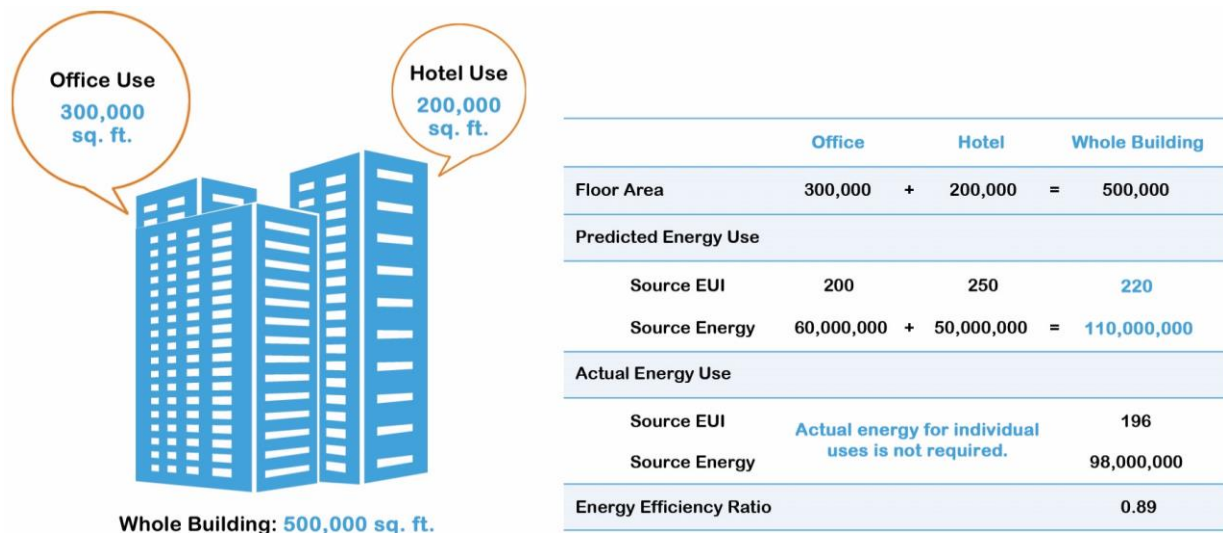
Once the energy efficiency ratio is obtained, a lookup table is required to translate this to a score. The lookup tables from each use type (in this example, hotel and office) are combined by averaging the ratio at each score, and weighting that average ratio by the percent of predicted source energy of the space. In the example above, the hotel contributes 45.45% of the predicted energy (50,000,000/110,000,000), while the office contributes 54.55%. Therefore, the hotel and office lookup tables are averaged together weighted by these percents.

In this example, there are only two use types (office and hotel), but the same approach could be applied for any number of uses. EPA requires that one use type account for more than 50% of the entire floor area in a mixed-use building. This use type is the primary peer group of comparison.

Adjusting for Multiple Uses: How is it Different in Canada?

The procedures to combine multiple uses within a single building are identical in the U.S. and Canada.

ADJUSTING FOR PROPERTY USES WITHOUT ENERGY STAR SCORES

The ENERGY STAR score is dependent on a nationally representative data set and robust analysis, as discussed throughout this document. Because of this technical foundation, it is not possible to provide a 1 - 100 score for every building type. A full listing of those types for which there is an ENERGY STAR score is available at: www.energystar.gov/EligiblePropertyTypes.

For those types of buildings that cannot earn an ENERGY STAR score, a variety of other metrics such as greenhouse gas emissions, weather normalized energy use, and comparison to national median energy use are available. In addition, there are algorithms provided that enable multi-use buildings to earn an ENERGY STAR score even if one or more of the use types is not able to do so on its own. That is, a standalone library cannot earn an ENERGY STAR score, but a mixed-use building with a public library and an office building is able to earn a score as long as the library is less than 25% of the floor area. These procedures are described below.

Parking Lots, Parking Garages, Pools, and Data Centers with Energy Estimates

On their own, these use types are not eligible to earn an ENERGY STAR score. However, when these uses are part of other properties with a primary function that does have an ENERGY STAR score (e.g., office, K-12 school), then there are special adjustments to enable a score. The goal of the ENERGY STAR score is to rate the primary use of the building, not supplemental parking or pool areas.

To compute the score, Portfolio Manager calculates a predicted source energy consumption for the applicable uses (parking, pool, or data centers with energy estimates) using engineered assumptions about the required energy needs.[4] Then, after computing the actual source energy of the building, the prediction for the applicable uses is subtracted from the actual energy use. The resulting value is used in the numerator of the energy efficiency ratio. That is, the prediction of applicable uses is subtracted from the actual energy rather than added to the regression prediction. For example, if an office building has a parking garage, then the energy efficiency ratio is computed like this:

$$Energy\ Efficiency\ Ratio = \frac{Actual\ Source\ Energy - Prediction\ of\ Parking}{Predicted\ Source\ Energy\ for\ the\ Office}$$

Once this ratio is computed, the standard lookup table (in this case, office) is used to return the score.

All Other Uses with no ENERGY STAR Score

On their own, these use types are not able to earn an ENERGY STAR score. However, buildings that have a primary function that does have a score (e.g., office, K-12 school) can earn a score when these other, non-score-able uses are present, provided that the combined floor area of these other uses and spaces using data center estimates accounts for less than 25% of the total floor area. In these situations, Portfolio Manager will assume that the predicted source EUI of the "other" space is identical to the predicted EUI of the main primary function (e.g., office, K-12 school).

---

[4] For details on these predictive equations, visit: www.energystar.gov/ScoreDetails.

To calculate the score, the predicted source EUI for primary function (e.g., office) is computed according to its regression equation. Because it is assumed that the "other" use will have the same predicted EUI as the main use, the predicted EUI of the whole building is the same as the predicted EUI for the primary function. Thus, the energy efficiency ratio can be computed as the actual source EUI for the whole building divided by the predicted source EUI of the main portion of the building. Portfolio Manager then looks up the efficiency ratio in the lookup table for the main space type.

It may seem odd to assume that the "other" type of use will have the same predicted EUI as the primary use. However, because there is no valid means of predicting the energy use for the "other" use, it is reasonable to assume that it could be *either* greater than *or* less than the main use. EPA does not make an assumption either way, but rather assumes a constant EUI. This limitation is the reason why the other use types are limited to 25% of total floor area. The limit reduces the amount of error introduced by the energy intensity assumptions. If this 25% limit is exceeded, the property will not receive a score.

> ### Adjusting for Uses without ENERGY STAR Scores: How is it Different in Canada?
> The procedures for property types that do not have a 1 - 100 ENERGY STAR score are identical in the U.S. and Canada.