ENERGY STAR® PortfolioManager®

Technical Reference

ENERGY STAR Score for Hospitals in the United States

OVERVIEW

The ENERGY STAR Score for Hospitals applies to general medical and surgical hospitals, including critical access hospitals and children's hospitals. The objective of the ENERGY STAR score is to provide a fair assessment of the energy performance of a property relative to its peers, taking into account the climate, weather, and business activities at the property. To identify the aspects of building activity that are significant drivers of energy use and then normalize for those factors, a statistical analysis of the peer building population is performed. The result of this analysis is an equation that will predict the energy use of a property, based on its experienced business activities. The energy use prediction for a building is compared to its actual energy use to yield a 1 to 100 percentile ranking of performance, relative to the national population.

- **Property Types.** The ENERGY STAR score for hospitals applies to general and medical hospitals, including critical access hospitals and children's hospitals. The score applies to an entire hospital whether it is a single building or a campus of buildings.
- **Reference Data.** The analysis for hospitals is based on data from an industry survey conducted by the America Society for Healthcare Engineering (ASHE), a personal membership society of the American Hospital Association (AHA).
- **Adjustments for Weather and Business Activity.** The analysis includes adjustments for:
    - Building Size
    - Number of Full-Time Equivalent Workers
    - Number of Staffed Beds
    - Number of MRI Machines
    - Weather and Climate (using Cooling Degree Days, retrieved based on Zip code)
- **Release Date.** The ENERGY STAR score for hospitals is updated periodically as more recent data becomes available:
    - Most Recent Update: November 2011
    - Original Release: November 2001

This document presents details on the development of the 1 - 100 ENERGY STAR score for hospitals. More information on the overall approach to develop ENERGY STAR scores is covered in our Technical Reference for the ENERGY STAR Score, available at www.energystar.gov/ENERGYSTARScore. The subsequent sections of this document offer specific details on the development of the ENERGY STAR score for hospitals:

REFERENCE DATA & FILTERS

For the ENERGY STAR score for hospitals, the reference data used to establish the peer building population in the United States is based on data from an industry survey conducted by the American Society for Healthcare Engineering (ASHE), a personal membership society of the American Hospital Association (AHA). EPA relies on publicly available external data sets to develop ENERGY STAR scores where feasible, but a sufficiently robust set of hospital energy consumption information was not available. The industry-based survey was designed to account for the variation in service found in hospital facilities and to take into consideration energy use in multi-building campus settings. Efforts were made to provide as large, diverse, and representative of a sample as possible. AHA includes nearly all of the hospitals in the U.S., and ASHE members work in approximately 80% of the hospitals in the country. The survey was open to all interested participants, including non-members, and efforts were made by EPA, ASHE, and AHA to provide as large, diverse, and representative of a sample as possible.

To analyze the building energy and operating characteristics in this survey data, four types of filters are applied to define the peer group for comparison and to overcome any technical limitations in the data: Building Type Filters, Program Filters, Data Limitation Filters, and Analytical Filters. A complete description of each of these categories is provided in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore. ***Figure 1*** presents a summary of each filter applied in the development of the ENERGY STAR score for hospitals, the rationale behind the filter, and the resulting number of properties in the data set after the filter is applied. After all filters are applied, the remaining data set has 191 properties.

Figure 1 – Summary of Filters for the ENERGY STAR Score for Hospitals

Condition for Including an Observation in the Analysis	Rationale	Number Remaining
Must have complete data for energy use and operating characteristics	EPA Program Filter – Complete data is necessary for analysis	232
Hospital type must be General Medical and Surgical (including Critical Access Hospitals and Children's Hospitals).	Building Type Filter – In order to be defined as Hospital, the Hospital type must be General Medical and Surgical (including Critical Access Hospitals and Children's Hospitals).[1]	208
If Parking Energy is reported with metered data, the size of all parking structures (completely enclosed and partially enclosed parking) cannot exceed building size.	EPA Program Filter – If the combined square foot of parking structures exceeds the size of the hospital building then the overall structure is classified as parking, not Hospital. This is a standard policy in Portfolio Manager	205

[1] Hospital type is defined as the space type that represents more than 50% of the floor area, or the space type that represents the largest floor area, if no one space type is more than 50%.

Condition for Including an Observation in the Analysis	Rationale	Number Remaining
If Parking Energy is reported with metered data, EPA's Estimated Parking Adjustment must be less than 50% of the actual source energy.	Analytical Filter – In order to perform an analysis of the building (not the parking), EPA estimates the energy use of the parking area[2]. If this estimation is 50% or more the actual source energy, it is determined that there is too much variability/error in the energy use.	205
Must have greater than 0.5 and less than 10 workers per 1,000 square foot	Analytical Filter – Values determined to be data entry errors or statistical outliers.	201
Must have less than 0.02 MRI Machines per 1,000 square foot	Analytical Filter – Values determined to be data entry errors or statistical outliers.	200
Must have less than 1.8 Staffed Beds[3] per 1,000 square foot	Analytical Filter – Values determined to be data entry errors or statistical outliers.	198
Must have floor area less than 2 million square feet	Analytical Filter – Values determined to be data entry errors or statistical outliers.	194
Must have Source EUI[4] greater than 100 kBtu/ft^2 and less than 1000 kBtu/ft^2	Analytical Filter – Values determined to be data entry errors or statistical outliers.	**191**

Of the filters applied to the reference data, some result in constraints on calculating a score in Portfolio Manager and others do not. Building Type and Program Filters are used to limit the reference data to include only properties that are eligible to receive a score in Portfolio Manager, and are therefore related to eligibility requirements. In contrast, Data Limitation Filters account for limitations in the data availability, but do not apply in Portfolio Manager. Analytical Filters are used to eliminate outlier data points or different subsets of data, and may or may not affect eligibility. In some cases, a subset of the data will have different behavior from the rest of the properties (e.g., office buildings smaller than 5,000 ft^2 do not behave the same way as larger buildings), in which case an Analytical Filter will be used to determine eligibility in Portfolio Manager. In other cases, Analytical Filters exclude a small number of outliers with extreme values that skew the analysis, but do not affect eligibility requirements. A full description of the criteria you must meet to get a score in Portfolio Manager is available at www.energystar.gov/EligibilityCriteria.

Related to the filters and eligibility criteria described above, another consideration is how Portfolio Manager treats properties that are situated on a campus. 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 hospitals, the score is based on a campus of buildings, because each building on the campus is necessary to make the complete function of the property. For property types that earn a campus score, the entire campus will receive a 1 - 100 score and no individual buildings on the campus can earn a separate score. When there is a single building property of this type (e.g., entire hospital in one building), it is also eligible for a score.

[2] For more information on the methodology used for estimation, refer to the standard Portfolio Manager technical description for Parking, available at: www.energystar.gov/ScoreDetails

[3] Staffed Beds were defined as beds set up and staffed for use. This value may differ from licensed beds.

[4] Source EUI refers to the EUI after parking and pool energy estimates have been removed to isolate the EUI for the Hospital space.

Survey Weights

Analysis of the hospital survey data showed that one company contributed a large percentage (>30%) of the facilities in the data set. Additionally, the survey included a disproportionately large number of facilities from certain regions of the country, particularly from Texas and Florida. Therefore, rather than being a complete random sample of the population, the survey can be viewed as a stratified random sample, with multiple groups of respondents. In order to properly account for this stratification, survey sample weights were constructed to reflect the probability of being selected within each group. Observations were weighted by two categories. The first category was ownership by either the single large company or a company not affiliated with the large company. The second category was geographical region defined by the Census Regions and Divisions. Within each group, the weight of an individual observation was computed as:

Observation Weight = Total Size of Population in Group/Number of Responses in Group

The Total Size of Population in Group was obtained through regional market data supplied by AHA and market research on the company that contributed a large percentage of the observations. The Number of Responses in Group was counted from the complete set of 208 General and Medical Surgical hospitals in the survey.

VARIABLES ANALYZED

To normalize for differences in business activity, we perform a statistical analysis to understand what aspects of building activity are significant with respect to energy use. The filtered reference data set described in the previous section is analyzed using a weighted ordinary least squares regression, which evaluates energy use relative to business activity (e.g., number of workers, number of staffed hospital beds, climate). This linear regression yields an equation that is used to compute energy use (also called the dependent variable) based on a series of characteristics that describe the business activities (also called independent variables). This section details the variables used in the statistical analysis for hospitals.

Dependent Variable

The dependent variable is what we try to predict with the regression equation. For the hospital analysis, the dependent variable is energy consumption expressed in source energy use intensity (source EUI). This is equal to the total source energy use of the property divided by the gross floor area. The regressions analyze the key drivers of source EUI – those factors that explain the variation in source energy use per square foot in hospitals.

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for hospitals. Based on a review of the available variables in the data, in accordance with the criteria for inclusion in Portfolio Manager[5], the following variables were analyzed:

- Building Square Footage
- Number of Floors
- Total Number of Licensed Beds
- Total Number of Staffed Beds

[5] For a complete explanation of these criteria, refer to our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

- Number of Inpatient Days
- Number of Outpatient Visits
- Number of Full-time Equivalent (FTE) Workers
- Average Number of Hours per Week Occupied
- On-Site Laundry (Yes or No)
- Total Pounds of Laundry Processed Per Day
- On-Site Laboratory (Yes or No)
- On-Site Dietary Department (Yes or No)
- On-Site Tertiary Care Services (Yes or No)
- Number of MRI Machines
- Number of CAT or CT Scans
- Number of PET Scans
- Number of Fixed X-ray Machines
- Number of Fluoroscopy Machines
- Number of Linear Accelerators
- Percentage of Square Footage designated as Operating Rooms
- Percentage of Square Footage designated as Delivery Rooms
- Percentage of Square Footage designated as Trauma Rooms
- Percentage of Square Footage designated as Total Procedure Rooms
- Percentage of Square Footage designated as Catheterization and Surgical XRay Rooms
- Heating Degree Days (base 65)
- Cooling Degree Days (base 65)

We perform extensive review on all of these operational characteristics. In addition to reviewing each characteristic individually, characteristics are reviewed in combination with each other (e.g., Heating Degree Days times Percent Heated). As part of the analysis, some variables are reformatted to reflect the physical relationships of building components. For example, the number of workers is typically evaluated in a density format. The number of workers *per square foot* (not the gross number of workers) is expected to be correlated with the energy use per square foot. In addition, based on analytical results and residual plots, variables are examined using different transformations (such as the natural logarithm, abbreviated as Ln). The analysis consists of multiple regression formulations. These analyses are structured to find the combination of statistically significant operating characteristics that explain the greatest amount of variance in the dependent variable: source EUI.

The final regression equation includes the following variables:

- Number of full-time equivalent (FTE) workers per 1,000 square feet
- Number of staffed beds per 1,000 square feet
- Number of MRI Machines per 1,000 square feet
- Cooling degree days

These variables are used together to compute the predicted source EUI for hospitals. The predicted source EUI is the mean EUI for a hypothetical population of buildings that share the same values for each of these variables. That is, the mean energy use for a building that operates just like your building.

Climate Variables

Climate is one characteristic that was examined closely. EPA tested regression equations with Cooling Degree Days (CDD) and Heating Degree Days (HDD), CDD only, and HDD only. Cooling Degree Days showed a positive correlation with total energy usage, which was expected. Heating Degree Days showed a negative correlation with total energy usage, which was not expected. It is believed that both observed relationships are a result of large internal cooling loads associated with hospitals. That is, because of heat given off by equipment, cooling overall is more of a driving force for hospitals. The positive correlation with CDD is intuitive, but the negative relationship with HDD results from an inverse relationship between HDD and CDD. Due to the high correlation between HDD and CDD, it was not possible to develop a strong regression equation with statistically significant relationships for both weather variables. Equations with CDD only showed stronger statistical performance and provided a more intuitive explanation for the relationship between weather and energy intensity.

Testing

Finally, we test the regression equation using actual hospitals that have been entered in Portfolio Manager. This provides another set of buildings to examine in addition to the ASHE survey data, to see the average ENERGY STAR scores and distributions, and to assess the impacts and adjustments. This analysis provides a second level of confirmation that the final regression equation produces robust results that are unbiased with respect to the key operational characteristics such as worker density, number of staffed beds, number of MRI machines, and cooling degree days.

It is important to reiterate that the final regression equation is based on the nationally representative reference data, not data previously entered into Portfolio Manager.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 191 observations. The dependent variable is source EUI. Each independent variable is centered relative to the mean value, presented in ***Figure 2***. The final equation is presented in ***Figure 3***. All variables in the regression equation are significant at the 95% confidence level or better, as shown by the significance levels (a p-level of less than 0.02 indicates 98% confidence).

The regression equation has a coefficient of determination (R^2) value of 0.2398, indicating that this equation explains 23.98% of the variance in source EUI for hospitals. Because the final equation is structured with energy per square foot as the dependent variable, the explanatory power of square foot is not included in the R^2 value, thus this value appears artificially low. Re-computing the R^2 value in units of source energy[6], demonstrates that the equation actually explains 88.2% of the variation of source energy of hospitals. This is an excellent result for a statistically-based energy model.

Detailed information on the ordinary least squares regression approach is available in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore.

[6] The R^2 value in Source Energy is calculated as: 1 – (Residual Variation of Y) / (Total Variation of Y). The residual variation is sum of $(\text{Actual Source Energy}_i - \text{Predicted Source Energy}_i)^2$ across all observations. The Total variation of Y is the sum of $(\text{Actual Source Energy}_i - \text{Mean Source Energy})^2$ across all observations.

Figure 2 - Descriptive Statistics for Variables in Final Regression Equation

Variable	Mean	Minimum	Maximum
Source EUI (kBtu/ft^2)	484.8	109.9	976.0
Number of FTE Workers per 1000 ft^2	2.600	0.7646	6.498
Number of Staffed Beds per 1000 ft^2	0.4636	0.1106	1.426
Number of MRI Machines per 1000 ft^2	0.0031	0.0000	0.0136
Cooling Degree Days	1392	0.0	4810

Figure 3 - Final Regression Results

Summary				
Dependent Variable	Source Energy Intensity (kBtu/ft^2)			
Number of Observations in Analysis	191			
R^2 value	0.2398			
Adjusted R^2 value	0.2235			
F Statistic	14.67			
Significance (p-level)	0.0000			
	Unstandardized Coefficients	**Standard Error**	**T value**	**Significance (p-level)**
Constant	484.8	7.480	64.82	0.0000
C_Number of FTE Workers per 1000 ft^2	26.64	8.625	3.088	0.0023
C_Number of Staffed Beds per 1000 ft^2	120.3	48.72	2.470	0.0144
C_Number of MRI Machines per 1000 ft^2	8961	2989	2.998	0.0031
C_Cooling Degree Days	0.0227	0.0088	2.563	0.0112

Notes:
- *The regression is a weighted ordinary least squares regression, weighted by the Survey Weights (refer to Survey Weights Section)*
- *The prefix C_ on each variable indicates that it is centered. The centered variable is equal to difference between the actual value and the observed mean. The observed mean values are presented in **Figure 2**.*

ENERGY STAR SCORE LOOKUP TABLE

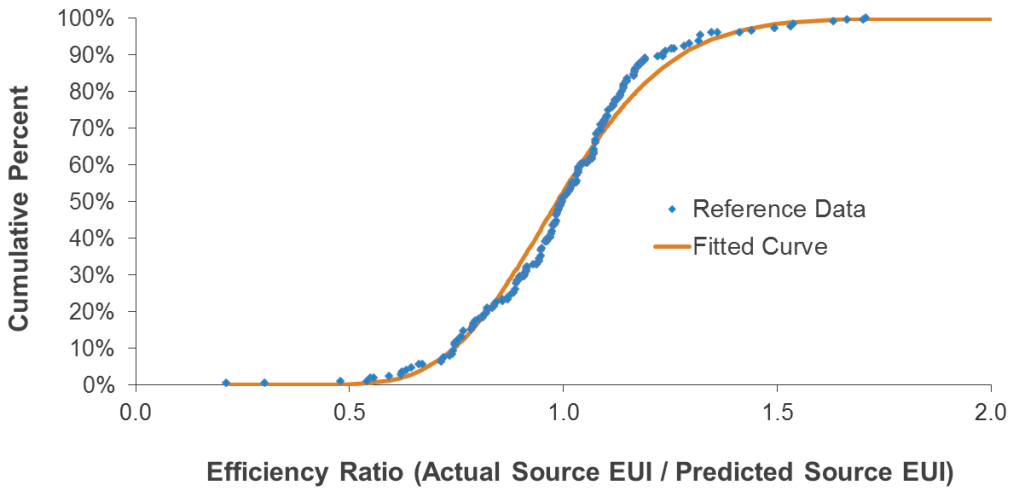
The final regression equation (presented in ***Figure 3***) yields a prediction of source EUI based on a building's operating characteristics. Some buildings in the reference data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference data observation is divided by its *predicted* source EUI to calculate an energy efficiency ratio:

$$Energy\ Efficiency\ Ratio = \frac{Actual\ Source\ EUI}{Predicted\ Source\ EUI}$$

A lower efficiency ratio indicates that a building uses less energy than predicted, and consequently is more efficient. A higher efficiency ratio indicates the opposite.

The efficiency ratios are sorted from smallest to largest and the cumulative percent of the population at each ratio is computed using the individual observation weights from the reference data set. ***Figure 4*** presents a plot of this cumulative distribution. A smooth curve (shown in orange) is fitted to the data using a two parameter gamma distribution. The fit is performed in order to minimize the sum of squared differences between each building's actual percent rank in the population and each building's percent rank with the gamma solution. The final fit for the gamma curve yielded a shape parameter (alpha) of 22.90 and a scale parameter (beta) of 0.04370. For this fit, the sum of the squared error is 0.2434.

Figure 4 – Distribution for Hospitals



The final gamma shape and scale parameters are used to calculate the efficiency ratio at each percentile (1 to 100) along the curve. For example, the ratio on the gamma 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. The complete score lookup table is presented in ***Figure 5***.

Figure 5 – ENERGY STAR Score Lookup Table for Hospitals

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio > =	Energy Efficiency Ratio <
100	0%	0.0000	0.5463
99	1%	0.5463	0.5843
98	2%	0.5843	0.6093
97	3%	0.6093	0.6286
96	4%	0.6286	0.6446
95	5%	0.6446	0.6584
94	6%	0.6584	0.6708
93	7%	0.6708	0.6819
92	8%	0.6819	0.6922
91	9%	0.6922	0.7017
90	10%	0.7017	0.7106
89	11%	0.7106	0.7190
88	12%	0.7190	0.7271
87	13%	0.7271	0.7347
86	14%	0.7347	0.7420
85	15%	0.7420	0.7491
84	16%	0.7491	0.7560
83	17%	0.7560	0.7626
82	18%	0.7626	0.7690
81	19%	0.7690	0.7752
80	20%	0.7752	0.7814
79	21%	0.7814	0.7873
78	22%	0.7873	0.7932
77	23%	0.7932	0.7989
76	24%	0.7989	0.8046
75	25%	0.8046	0.8101
74	26%	0.8101	0.8156
73	27%	0.8156	0.8210
72	28%	0.8210	0.8263
71	29%	0.8263	0.8315
70	30%	0.8315	0.8367
69	31%	0.8367	0.8418
68	32%	0.8418	0.8469
67	33%	0.8469	0.8520
66	34%	0.8520	0.8570
65	35%	0.8570	0.8620
64	36%	0.8620	0.8669
63	37%	0.8669	0.8719
62	38%	0.8719	0.8768
61	39%	0.8768	0.8816
60	40%	0.8816	0.8865
59	41%	0.8865	0.8914
58	42%	0.8914	0.8962
57	43%	0.8962	0.9011
56	44%	0.9011	0.9059
55	45%	0.9059	0.9108
54	46%	0.9108	0.9157
53	47%	0.9157	0.9206
52	48%	0.9206	0.9255
51	49%	0.9255	0.9304

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio >=	Energy Efficiency Ratio <
50	50%	0.9304	0.9353
49	51%	0.9353	0.9402
48	52%	0.9402	0.9452
47	53%	0.9452	0.9502
46	54%	0.9502	0.9552
45	55%	0.9552	0.9602
44	56%	0.9602	0.9653
43	57%	0.9653	0.9703
42	58%	0.9703	0.9755
41	59%	0.9755	0.9808
40	60%	0.9808	0.9861
39	61%	0.9861	0.9914
38	62%	0.9914	0.9968
37	63%	0.9968	1.0022
36	64%	1.0022	1.0078
35	65%	1.0078	1.0133
34	66%	1.0133	1.0191
33	67%	1.0191	1.0249
32	68%	1.0249	1.0307
31	69%	1.0307	1.0367
30	70%	1.0367	1.0429
29	71%	1.0429	1.0491
28	72%	1.0491	1.0554
27	73%	1.0554	1.0619
26	74%	1.0619	1.0686
25	75%	1.0686	1.0754
24	76%	1.0754	1.0825
23	77%	1.0825	1.0897
22	78%	1.0897	1.0972
21	79%	1.0972	1.1048
20	80%	1.1048	1.1128
19	81%	1.1128	1.1210
18	82%	1.1210	1.1297
17	83%	1.1297	1.1387
16	84%	1.1387	1.1481
15	85%	1.1481	1.1580
14	86%	1.1580	1.1685
13	87%	1.1685	1.1795
12	88%	1.1795	1.1914
11	89%	1.1914	1.2040
10	90%	1.2040	1.2179
9	91%	1.2179	1.2330
8	92%	1.2330	1.2497
7	93%	1.2497	1.2685
6	94%	1.2685	1.2903
5	95%	1.2903	1.3161
4	96%	1.3161	1.3483
3	97%	1.3483	1.3920
2	98%	1.3920	1.4626
1	99%	1.4626	>1.4626

EXAMPLE CALCULATION

As detailed in our Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore, there are five steps to compute a score. The following is a specific example for the score for hospitals:

1 User enters building data into Portfolio Manager

- 12 months of energy use information for all energy types (annual values, entered in monthly meter entries)
- Physical building information (size, location, etc.) and use details describing building activity (number of workers, etc.)

Energy Data	Value
Electricity	10,500,000 kWh
Natural gas	450,000 therms

Property Use Details	Value
Gross floor area (ft²)	400,000
Full Time Equivalent Workers	1,200
Number of Staffed Beds	220
Number of MRI Machines	1
CDD (provided by Portfolio Manager, based on Zip code)	1,300

2 Portfolio Manager computes the actual source EUI

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

Computing Actual Source EUI

Fuel	Billing Units	Site kBtu Multiplier	Site kBtu	Source kBtu Multiplier	Source kBtu
Electricity	10,500,000 kWh	3.412	35,826,000	3.14	112,493,640
Natural gas	450,000 therms	100	45,000,000	1.05	47,250,000
				Total Source Energy (kBtu)	159,743,640
				Actual Source EUI (kBtu/ft²)	**399.4**

3 Portfolio Manager computes the predicted source EUI

- Using the property use details from Step 1, Portfolio Manager computes each building variable value in the regression equation (determining the natural log or density as necessary).
- The centering values are subtracted to compute the centered variable for each operating parameter.
- The centered variables are multiplied by the coefficients from the regression equation to obtain a predicted source EUI.

Computing Predicted Source EUI

Variable	Actual Building Value	Reference Centering Value	Building Centered Variable	Coefficient	Coefficient * Centered Variable
Constant	--	--	--	484.8	484.8
Number of FTE Workers per 1000 ft²	3.000	2.600	0.400	26.64	10.66
Number of Staffed Beds per 1000 ft²	0.5500	0.4636	0.0864	120.3	10.39
Number of MRI Machines per 1000 ft²	0.0025	0.0031	-0.0006	8961	-5.377
Cooling Degree Days	1300	1392	-92	0.0227	-2.088
				Predicted Source EUI (kBtu/ft²)	**498.4**

4 Portfolio Manager computes the energy efficiency ratio

- The ratio equals the actual source EUI (Step 2) divided by predicted source EUI (Step 3)
- Ratio = 399.4 / 498.4 = 0.8014

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

- The ratio from Step 4 is used to identify the score from the lookup table
- A ratio of 0.8014 is greater than or equal to 0.7989 and less than 0.8046.
- ***The ENERGY STAR score is 76.***