ENERGY STAR® PortfolioManager®

Technical Reference

ENERGY STAR Score for Medical Offices in the United States

OVERVIEW

The ENERGY STAR Score for Medical Offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. 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 medical offices applies to facility space used to provide diagnosis and treatment for medical, dental, or psychiatric outpatient care. The score applies to individual buildings only and is not available for campuses.
- **Reference Data.** The analysis for medical offices is based on data from the Department of Energy, Energy Information Administration's 1999 Commercial Building Energy Consumption Survey (CBECS).
- **Adjustments for Weather and Business Activity.** The analysis includes adjustments for:
    - Square Footage
    - Number of Workers
    - Hours of Operation per Week
    - Weather and Climate (using Heating and Cooling Degree Days, retrieved based on Zip code)
    - Percent of the Building that is Heated and Cooled
- **Release Date.** The ENERGY STAR score for medical offices was released in February 2004.

This document presents details on the development of the 1 - 100 ENERGY STAR score for medical office properties. 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 medical offices:

REFERENCE DATA & FILTERS

For the ENERGY STAR score for medical offices properties, the reference data used to establish the peer building population in the United States is based on data from the Department of Energy, Energy Information Administration's (EIA) 1999 Commercial Building Energy Consumption Survey (CBECS). Detailed information on this survey, including complete data files, is available at: http://www.eia.doe.gov/emeu/cbecs/contents.html.

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 medical offices and the rationale behind the filter. After all filters are applied, the remaining data set has 82 properties.

Figure 1 – Summary of Filters for the ENERGY STAR Score for Medical Offices

Condition for Including an Observation in the Analysis	Rationale
PBAPLUS7= 8	Building Type Filter – CBECS defines building types according to the variable "PBAPLUS7." Medical Office Buildings are coded as PBAPLUS7= 8.
Must operate for at least 30 hours per week	Program Filter – Baseline condition for being a full time medical office building.
Must have at least 1 worker	Program Filter – Baseline condition for being a full time medical office building.
Source energy use intensity (kBtu/ft^2-yr) must be greater than 38 and less than 575 kBtu/ft^2-yr	Analytical Filter – Values determined to be statistical outliers.
Must have square foot of at least 5,000	Analytical Filter – Values determined to be statistical outliers.

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., hotels 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 medical office properties, the score is based on individual buildings, because the primary function of the medical office is contained within a single building and because the properties included in the reference data are single buildings. In cases where multiple medical offices are situated together (e.g., as part of a hospital campus), each individual building can receive its own ENERGY STAR score, but a group of buildings together cannot earn a score.

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, operating hours per week). 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 medical offices.

Dependent Variable

The dependent variable is what we try to predict with the regression equation. For the medical office analysis, the dependent variable is energy consumption expressed as the natural log of source energy use, or Ln (source energy). The regressions analyze the key drivers of Ln (source energy) – those factors that explain the variation in the natural log of source energy in medical offices.

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for medical offices. These include characteristics such as the total square foot, the weekly hours of operation, the number of workers, the percent of the building that is heated and cooled, and the number of heating and cooling degree days.

We perform extensive review on all operational characteristics available in the data, in accordance with the criteria for inclusion in Portfolio Manager.[1] 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 on the main shift 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). 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: Ln (source energy).

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

The final regression equation includes the following variables:

- Natural log of gross square foot
- Natural log of number of workers
- Natural log of weekly operating hours
- Heating degree days times Percent of the building that is heated
- Cooling degree days times Percent of the building that is cooled

These variables are used together to compute the predicted Ln (source energy) for medical offices. The predicted Ln (source energy) is the mean Ln (source energy) 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.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 82 observations. The dependent variable is Ln (source energy). Each independent variable is 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 0.05 indicates 95% confidence), with the exception of weekly operating hours and HDD times percent heated (88% and 84%, respectively). However, given the physical relationship between these variables and energy consumption, these results were considered acceptable, and therefore both weekly operating hours and HDD times percent heated were retained in the analysis.

The regression equation has a coefficient of determination (R^2) value of 0.9336, indicating that this equation explains 93.36% of the variance in Ln (source energy) for medical office buildings. 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.

Figure 2 - Descriptive Statistics for Variables in Final Regression Equation

Variable	Mean	Minimum	Maximum
Ln (Source Energy) (kBtu)	14.919	11.344	18.878
Ln (Square Foot)	9.856	6.908	13.122
Ln (Number of Workers)	3.840	0.693	7.718
Ln (Weekly Operating Hours)	3.937	3.555	4.820
Heating Degree Days x Percent Heated	3692	0.000	8176
Cooling Degree Days x Percent Cooled	1253	54	4143

Figure 3 - Final Regression Results

Summary				
Dependent Variable		Ln (Source Energy)		
Number of Observations in Analysis		82		
R^2 value		0.9336		
Adjusted R^2 value		0.9292		
F Statistic		213.6		
Significance (p-level)		<0.0001		
	Unstandardized Coefficients	**Standard Error**	**T value**	**Significance (p-level)**
Constant	2.78889	1.19393	2.34	0.0221
Ln (Square Foot)	0.91433	0.09998	9.14	0.0001
Ln (Number of Workers)	0.21568	0.09332	2.31	0.0235
Ln (Weekly Operating Hours)	0.46768	0.29816	1.57	0.1209
Heating Degree Days x Percent Heated	0.00005321	0.00003712	1.43	0.1558
Cooling Degree Days x Percent Cooled	0.00020111	0.00007429	2.71	0.0084

Notes:
- *The regression is a weighted ordinary least squares regression, weighted by the CBECS variable "ADJWT8".*

ENERGY STAR SCORE LOOKUP TABLE

The final regression equation (presented in ***Figure 3***) yields a prediction of Ln (source energy) 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* Ln (source energy) of each reference data observation is divided by its *predicted* Ln (source energy) to calculate an energy efficiency ratio:

$$Energy\ Efficiency\ Ratio = \frac{Actual\ Ln\ (Source\ energy)}{Predicted\ Ln\ (Source\ energy)}$$

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. For each building, the ratio is expressed in terms of a normalized Ln (source energy) to represent the value for Ln (source energy) that the building would have if it were average. This normalized energy use is obtained by multiplying the efficiency ratio by the mean value of Ln (source energy):[2]

$$Normalized\ Ln\ (Source\ Energy) = EnergyEfficiency\ Ratio \times 14.919$$

[2] The mean value of Ln (source energy) is determined by the dataset and is presented in ***Figure 2***. It is 14.919.

The normalized Ln (source energy) values are sorted from smallest to largest and the cumulative percent of the population at each energy value is computed. A smooth curve 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 fit is performed with the constraint that the gamma value of Ln (source energy) at an ENERGY STAR score of 75 must equal the actual value of Ln (source energy) at 75.

The final gamma shape and scale parameters are used to calculate the normalized Ln (source energy) value at each percentile (1 to 100) along the curve. For example, the normalized Ln (source energy) value on the gamma curve at 1% corresponds to a score of 99; only 1% of the population has a value this small or smaller. The normalized Ln (source energy) value on the gamma curve at the value of 25% will correspond to the normalized Ln (source energy) value for a score of 75; only 25% of the population has normalized Ln (source energy) values this small or smaller. The complete lookup table[3] is presented in ***Figure 4***.

[3] The lookup table was adjusted in 2018 to account for updated ratios used in Portfolio Manager to convert site energy to source energy.

Figure 4 – ENERGY STAR Score Lookup Table for Medical Offices

ENERGY STAR Score	Cumulative Percent	Normalized Ln (Source Energy) > =	<
100	0%	0.0000	13.7364
99	1%	13.7364	13.7944
98	2%	13.7944	13.8504
97	3%	13.8504	13.9024
96	4%	13.9024	13.9524
95	5%	13.9524	13.9994
94	6%	13.9994	14.0434
93	7%	14.0434	14.0854
92	8%	14.0854	14.1254
91	9%	14.1254	14.1624
90	10%	14.1624	14.1984
89	11%	14.1984	14.2324
88	12%	14.2324	14.2654
87	13%	14.2654	14.2964
86	14%	14.2964	14.3254
85	15%	14.3254	14.3544
84	16%	14.3544	14.3814
83	17%	14.3814	14.4074
82	18%	14.4074	14.4324
81	19%	14.4324	14.4564
80	20%	14.4564	14.4794
79	21%	14.4794	14.5024
78	22%	14.5024	14.5234
77	23%	14.5234	14.5454
76	24%	14.5454	14.5654
75	25%	14.5654	14.5854
74	26%	14.5854	14.6044
73	27%	14.6044	14.6234
72	28%	14.6234	14.6424
71	29%	14.6424	14.6604
70	30%	14.6604	14.6774
69	31%	14.6774	14.6954
68	32%	14.6954	14.7124
67	33%	14.7124	14.7284
66	34%	14.7284	14.7454
65	35%	14.7454	14.7614
64	36%	14.7614	14.7764
63	37%	14.7764	14.7924
62	38%	14.7924	14.8074
61	39%	14.8074	14.8224
60	40%	14.8224	14.8374
59	41%	14.8374	14.8514
58	42%	14.8514	14.8654
57	43%	14.8654	14.8794
56	44%	14.8794	14.8934
55	45%	14.8934	14.9064
54	46%	14.9064	14.9194
53	47%	14.9194	14.9324
52	48%	14.9324	14.9444
51	49%	14.9444	14.9564
50	50%	14.9564	14.9684
49	51%	14.9684	14.9804
48	52%	14.9804	14.9914
47	53%	14.9914	15.0024
46	54%	15.0024	15.0124
45	55%	15.0124	15.0234
44	56%	15.0234	15.0334
43	57%	15.0334	15.0424
42	58%	15.0424	15.0524
41	59%	15.0524	15.0614
40	60%	15.0614	15.0694
39	61%	15.0694	15.0784
38	62%	15.0784	15.0864
37	63%	15.0864	15.0944
36	64%	15.0944	15.1014
35	65%	15.1014	15.1094
34	66%	15.1094	15.1164
33	67%	15.1164	15.1234
32	68%	15.1234	15.1304
31	69%	15.1304	15.1374
30	70%	15.1374	15.1444
29	71%	15.1444	15.1514
28	72%	15.1514	15.1584
27	73%	15.1584	15.1654
26	74%	15.1654	15.1734
25	75%	15.1734	15.1804
24	76%	15.1804	15.1884
23	77%	15.1884	15.1964
22	78%	15.1964	15.2054
21	79%	15.2054	15.2154
20	80%	15.2154	15.2254
19	81%	15.2254	15.2364
18	82%	15.2364	15.2484
17	83%	15.2484	15.2604
16	84%	15.2604	15.2744
15	85%	15.2744	15.2904
14	86%	15.2904	15.3064
13	87%	15.3064	15.3254
12	88%	15.3254	15.3454
11	89%	15.3454	15.3664
10	90%	15.3664	15.3904
9	91%	15.3904	15.4174
8	92%	15.4174	15.4454
7	93%	15.4454	15.4764
6	94%	15.4764	15.5114
5	95%	15.5114	15.5484
4	96%	15.5484	15.5884
3	97%	15.5884	15.6324
2	98%	15.6324	15.6804
1	99%	15.6804	>15.6804

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 medical offices:

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 (hours, etc.)

Energy Data	Value
Electricity	123,400 kWh
Natural gas	2,000 therms

Property Use Details	Value
Gross floor area (ft²)	14,000
Weekly operating hours	50
Workers on the main shift[4]	25
Percent of the building that is heated	100%
Percent of the building that is cooled	100%
HDD (provided by Portfolio Manager, based on Zip code)	4200
CDD (provided by Portfolio Manager, based on Zip code)	1200

2 Portfolio Manager computes the actual Ln (source energy)

- 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
- The natural log of total source energy consumption is computed

Computing Actual Ln (Source Energy)

Fuel	Billing Units	Site kBtu Multiplier	Site kBtu	Source kBtu Multiplier	Source kBtu
Electricity	123,400 kWh	3.412	421,041	2.80	1,178,915
Natural gas	2,000 therms	100	200,000	1.05	210,000
				Total Source Energy (kBtu)	1,388,915
				Actual Ln (Source Energy) (kBtu)	**14.144**

[4] This represents typical peak staffing level during the main shift. For example, in a medical office if there are two daily 8 hour shifts of 100 workers each, the Workers on Main Shift value is 100.

3 Portfolio Manager computes the predicted source Ln (source energy)

- 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, or applying any minimum or maximum values used in the regression model, as necessary).
- The variables are multiplied by the coefficients from the regression equation to obtain a predicted Ln (source energy).

Computing Predicted Ln (Source Energy)

Variable	Actual Building Value	Coefficient	Coefficient * Variable
Constant	--	2.789	2.789
Ln (Square Foot)	9.547	0.9143	8.729
Ln (Number of Workers)	3.219	0.2157	0.694
Ln (Weekly Operating Hours)	3.912	0.4677	1.830
HDD x Percent Heated	4200	0.00005	0.223
CDD x Percent Cooled	1200	0.0002	0.241
	Predicted Ln (source energy) (kBtu)		**14.506**

4 Portfolio Manager computes the energy efficiency ratio

- The ratio equals the actual Ln (source energy) (Step 2) divided by predicted Ln (source energy) (Step 3)
- Ratio = 14.144 / 14.506 = 0.9750

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

- The ratio from Step 4 is converted into normalized Ln (source energy)
  - Normalized Ln (source energy) = energy efficiency ratio * mean Ln (source energy)
  - Mean Ln (source energy) is provided in ***Figure 2*** = 14.919
  - Normalized Ln (source energy) = 0.9750 * 14.919 = 14.546
- This value is then then used to identify the score from the lookup table
- A normalized value of 14.546 is greater than 14.5454 and less than 14.5654.
- ***The ENERGY STAR score is 76.***