ENERGY STAR® PortfolioManager® Technical Reference

ENERGY STAR Score for Retail Stores and Supermarkets in the United States

OVERVIEW

The ENERGY STAR Score for Retail Stores and Supermarkets applies to retail stores, supermarkets/grocery stores, and wholesale clubs/supercenters. 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 retail stores and supermarkets applies to retail stores, supermarkets/grocery stores, and wholesale clubs/supercenters. The score applies to individual establishments and is not available for entire strip malls or enclosed malls. To receive an ENERGY STAR score, a retail store must be a *single store* that is at least *5,000 square feet* and has an *exterior entrance* to the public.
- **Reference Data.** The analysis for retail stores and supermarkets is based on data from the Department of Energy, Energy Information Administration's 2012 Commercial Building Energy Consumption Survey (CBECS).
- **Adjustments for Weather and Business Activity.** The analysis includes adjustments for:
    - Number of Workers
    - Weekly Operating Hours
    - Number of Commercial Refrigeration/Freezer Units
    - Weather and Climate (using Heating and Cooling Degree Days, retrieved based on Zip code)
    - Percent of the Building that is Heated and Cooled
    - Whether or not the Building is a Supermarket
- **Release Date.** The ENERGY STAR score for retail stores and supermarkets is updated periodically as more recent data becomes available:
    - Most Recent Update: August 2018 (combined Retail/Supermarket model)
    - Prior Update: July 2008 (Supermarket)
    - Original Release: July 2001 (Supermarket); October 2007 (Retail)

This document presents details on the development of the 1 - 100 ENERGY STAR score for retail stores and supermarkets. 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 retail stores and supermarkets:

Independent Variables

The reference survey collects numerous property operating characteristics that were identified as potentially important for retail stores and supermarkets. Based on a review of the available variables in the data, in accordance with the criteria for inclusion in Portfolio Manager,[2] the following variables were analyzed:

- SQFT– Square footage
- NFLOOR – Number of floors
- NELVTR – Number of elevators
- NESLTR – Number of escalators
- COURT – Food court (yes/no)
- MONUSE – Months in use
- WKHRS – Weekly hours of operation
- NWKER – Number of employees during the main shift
- COOK – Energy used for cooking (yes/no)
- HEATP – Percent heated
- COOLP – Percent cooled
- SNACK – Snack bar or concession stand (yes/no)
- FASTFD – Fast food or small restaurant (yes/no)
- CAF – Cafeteria or large restaurant (yes/no)
- FDPREP – Commercial or large kitchen (yes/no)
- KITCHN – Small kitchen area (yes/no)
- BREAKRM – Employee lounge, breakroom, or pantry (yes/no)
- OTFDRM – Other food prep or serving areas (yes/no)
- RFGSTO – Large cold storage areas (yes/no)
- RFGWIN – Number of walk-in refrigeration units (also includes freezers)
- RFGOPN – Number of open refrigerated cases
- RFGCLN – Number of closed refrigerated cases
- RFGVNN – Number of refrigerated vending machines
- RFGICN – Number of ice makers
- RFGSTP – Percent cold storage
- PCTERMN – Number of computers
- LAPTPN – Number of laptops
- PRNTRN – Number of printers
- SERVERN – Number of servers
- TVVIDEON – Number of TV or video displays
- RGSTRN – Number of cash registers
- COPIERN – Number of photocopiers
- HDD65 – Heating degree days (base 65)
- CDD65 – Cooling degree days (base 65)

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

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 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, 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:

- Weekly Operating Hours
- Number of Workers per 1,000 Square Feet
- Number of Commercial Refrigeration/Freezer Units per 1,000 Square Feet
- Natural log of Heating Degree Days times Percent of the Building that is Heated
- Natural log of Cooling Degree Days times Percent of the Building that is Cooled
- Yes/No variable indicating whether the Building is a Supermarket (1 = yes, 0 = no)
- Adjustment for the Number of Workers per 1,000 Square Feet for a Supermarket

These variables are used together to compute the predicted source EUI for retail stores and supermarkets. 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.

Supermarkets/Grocery Stores

CBECS 2012 did not contain enough supermarket/grocery store observations to develop a supermarket-only model. Instead, it was determined that with the use of certain supermarket-specific terms, a combined retail store and supermarket model could be developed. Analysis reveals that supermarkets have different energy consumption and different responses to worker density. As a result, the final regression equation includes a Yes/No variable indicating whether the Building is a Supermarket, as well as an adjustment for the Number of Workers per 1,000 Square Feet for a Supermarket.

The determination of these adjustments was based on substantial analysis of the data and the differences among supermarkets and retail stores. EPA investigated a wide variety of regression formulations. These included regressions with an adjustment for all supermarkets, as well as those that accounted for different relationships with worker density, cooling degree days, and floor area. The regression model with the supermarket adjustment and additional workers per square footage adjustment best captured the differences between retail stores and supermarkets, and resulted in more equitable ENERGY STAR scores for both property types.

Testing

Finally, we test the regression equation using actual retail, supermarket/grocery store, and wholesale club/supercenter buildings that have been entered in Portfolio Manager. This provides another set of buildings to examine in addition to the CBECS 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, operating hours, and heating and cooling degree days.

Figure 3 - Final Regression Results

Summary				
Dependent Variable		Source Energy Intensity (kBtu/ft²)		
Number of Observations in Analysis		189		
R^2 value		0.7766		
Adjusted R^2 value		0.7679		
F Statistic		89.88		
Significance (p-level)		<0.0001		
	Unstandardized Coefficients	**Standard Error**	**T value**	**Significance (p-level)**
Constant	162.0	6.684	24.24	<0.0001
C_Weekly Operating Hours	1.222	0.2167	5.639	<0.0001
C_Number of Workers per 1,000 ft²	39.28	8.478	4.633	<0.0001
C_Number of Commercial Refrigeration/Freezer Units per 1,000 ft²	56.88	16.13	3.526	0.0005
C_Percent Heated x Ln (Heating Degree Days)	6.493	2.399	2.707	0.0074
C_Percent Cooled x Ln (Cooling Degree Days)	5.698	2.607	2.186	0.0301
Supermarket	252.6	25.12	10.05	<0.0001
Supermarket x C_Number of Workers per 1,000 ft²	81.23	32.36	2.510	0.013

Notes:

- *The regression is a weighted ordinary least squares regression, weighted by the CBECS variable "FINALWT".*
- *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**.*
- *Number of Commercial Refrigeration/Freezer Units per 1,000 ft² includes open, closed, and walk-in refrigeration/freezer units.*
- *Supermarket is a yes/no variable (1 for yes, 0 for no) indicating whether the property is a supermarket.*

ENERGY STAR SCORE LOOKUP TABLE

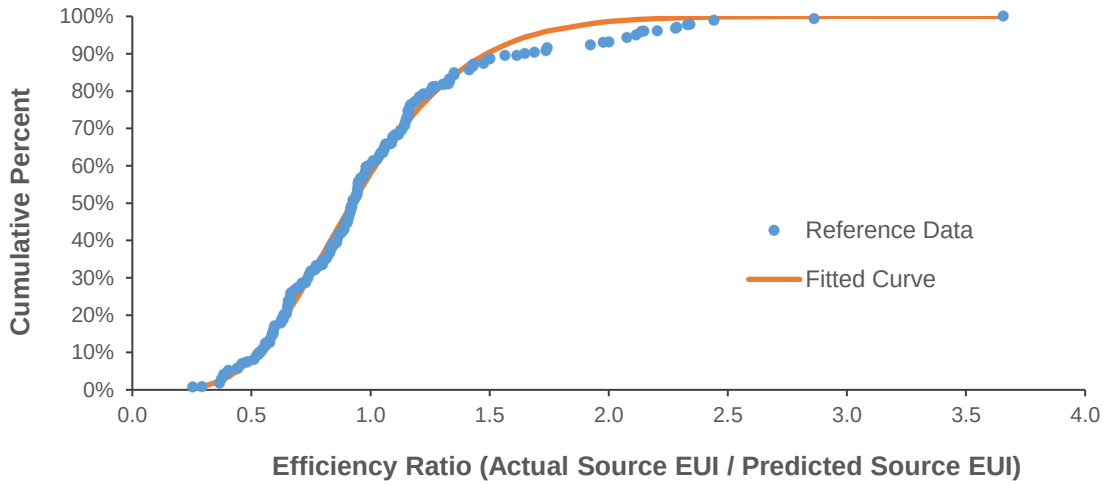
The final regression equation (presented in ***Figure 3***) yields a prediction of source EUI based on a building's operating characteristics. Some buildings in the reference data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each 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 6.433 and a scale parameter (beta) of 0.1514. For this fit, the sum of the squared error is 0.08526.

Figure 4 – Distribution for Retail Stores and Supermarkets



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 Retail Stores and Supermarkets

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio > =	Energy Efficiency Ratio <
100	0%	0.0000	0.3054
99	1%	0.3054	0.3547
98	2%	0.3547	0.3889
97	3%	0.3889	0.4161
96	4%	0.4161	0.4392
95	5%	0.4392	0.4596
94	6%	0.4596	0.4780
93	7%	0.4780	0.4949
92	8%	0.4949	0.5107
91	9%	0.5107	0.5255
90	10%	0.5255	0.5396
89	11%	0.5396	0.5529
88	12%	0.5529	0.5658
87	13%	0.5658	0.5781
86	14%	0.5781	0.5901
85	15%	0.5901	0.6017
84	16%	0.6017	0.6129
83	17%	0.6129	0.6239
82	18%	0.6239	0.6346
81	19%	0.6346	0.6452
80	20%	0.6452	0.6555
79	21%	0.6555	0.6656
78	22%	0.6656	0.6756
77	23%	0.6756	0.6855
76	24%	0.6855	0.6952
75	25%	0.6952	0.7048
74	26%	0.7048	0.7143
73	27%	0.7143	0.7237
72	28%	0.7237	0.7330
71	29%	0.7330	0.7423
70	30%	0.7423	0.7515
69	31%	0.7515	0.7607
68	32%	0.7607	0.7698
67	33%	0.7698	0.7788
66	34%	0.7788	0.7879
65	35%	0.7879	0.7969
64	36%	0.7969	0.8059
63	37%	0.8059	0.8149
62	38%	0.8149	0.8239
61	39%	0.8239	0.8329
60	40%	0.8329	0.8418
59	41%	0.8418	0.8509
58	42%	0.8509	0.8599
57	43%	0.8599	0.8689
56	44%	0.8689	0.8780
55	45%	0.8780	0.8871
54	46%	0.8871	0.8962
53	47%	0.8962	0.9054
52	48%	0.9054	0.9147
51	49%	0.9147	0.9240
50	50%	0.9240	0.9333
49	51%	0.9333	0.9428
48	52%	0.9428	0.9523
47	53%	0.9523	0.9619
46	54%	0.9619	0.9716
45	55%	0.9716	0.9813
44	56%	0.9813	0.9912
43	57%	0.9912	1.0012
42	58%	1.0012	1.0113
41	59%	1.0113	1.0216
40	60%	1.0216	1.0319
39	61%	1.0319	1.0424
38	62%	1.0424	1.0531
37	63%	1.0531	1.0640
36	64%	1.0640	1.0750
35	65%	1.0750	1.0862
34	66%	1.0862	1.0976
33	67%	1.0976	1.1093
32	68%	1.1093	1.1211
31	69%	1.1211	1.1333
30	70%	1.1333	1.1457
29	71%	1.1457	1.1584
28	72%	1.1584	1.1714
27	73%	1.1714	1.1847
26	74%	1.1847	1.1985
25	75%	1.1985	1.2126
24	76%	1.2126	1.2271
23	77%	1.2271	1.2422
22	78%	1.2422	1.2577
21	79%	1.2577	1.2739
20	80%	1.2739	1.2907
19	81%	1.2907	1.3081
18	82%	1.3081	1.3264
17	83%	1.3264	1.3455
16	84%	1.3455	1.3656
15	85%	1.3656	1.3869
14	86%	1.3869	1.4094
13	87%	1.4094	1.4334
12	88%	1.4334	1.4592
11	89%	1.4592	1.4870
10	90%	1.4870	1.5173
9	91%	1.5173	1.5507
8	92%	1.5507	1.5880
7	93%	1.5880	1.6302
6	94%	1.6302	1.6793
5	95%	1.6793	1.7382
4	96%	1.7382	1.8123
3	97%	1.8123	1.9139
2	98%	1.9139	2.0812
1	99%	2.0812	> 2.0812

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 retail stores.

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	480,000 kWh
Natural gas	200 therms

Operational Use Data	Value
Gross floor area (ft²)	50,000
Supermarket	0 (No)
Weekly operating hours	70
Workers on the main shift[4]	7
Percent of the building that is heated	100%
Percent of the building that is cooled	100%
Number of commercial refrigeration/freezer units	7
HDD (provided by Portfolio Manager, based on Zip code)	3,850
CDD (provided by Portfolio Manager, based on Zip code)	2,300

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	480,000 kWh	3.412	1,637,760	2.80	4,585,728
Natural gas	200 therms	100	20,000	1.05	21,000
				Total Source Energy (kBtu)	4,606,728
				Actual Source EUI (kBtu/ft²)	**92.1**

[4] This represents typical peak staffing level during the main shift. For example, in a space where 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 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, or applying any minimum or maximum values used in the regression model, 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	--	--	--	162.0	162.0
Weekly Operating Hours	70.00	77.93	-7.930	1.222	-9.690
Number of Workers per 1,000 ft²	0.1400	0.8353	-0.6953	39.28	-27.31
Number of Commercial Refrigeration/Freezer Units per 1,000 ft²	0.1400	0.2631	-0.1231	56.88	-7.002
Percent Heated x Ln (Heating Degree Days)	8.256	6.911	1.345	6.493	8.733
Percent Cooled x Ln (Cooling Degree Days)	7.741	5.606	2.135	5.698	12.17
Supermarket	0.0000	--	0.0000	252.6	0.0000
Supermarket x Number of Workers per 1,000 ft²	0.0000	--	0.0000	81.23	0.0000
				Predicted Source EUI (kBtu/ft²)	**138.9**

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 = 92.1 / 138.9 = 0.6631

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 0.6631 is greater than or equal to 0.6555 and less than 0.6656
- ***The ENERGY STAR score is 79***