ENERGY STAR® PortfolioManager®

Technical Reference

ENERGY STAR Score for Retail Stores in Canada

OVERVIEW

The ENERGY STAR score for Retail Stores applies to both retail stores and wholesale club/supercenters. The objective of the ENERGY STAR score is meant to fairly assess how a property's energy use measures up against similar properties considering the climate and business activities. A statistical analysis of the peer population is performed to identify the aspects of property activity that are significant drivers of energy use and to normalize for those same factors. The result of this analysis is an equation that predicts the energy use of a property, based on its business activities. This prediction is compared to the property's actual energy use to yield a 1 to 100 percentile ranking in relation to the national population of properties.

- Property types. The ENERGY STAR score for retail stores applies to two property types: retail stores and wholesale club/supercenters. The score applies to individual stores and is not available for entire strip malls or enclosed malls. To be eligible for an ENERGY STAR score, a retail store must be a single store that is at least 464.5 m^2 (5,000 ft^2) and has an exterior entrance to the public.

- Reference data. The analysis for retail stores in Canada is based on data from the Survey on Commercial and Institutional Energy Use (SCIEU), which was commissioned by Natural Resources Canada (NRCan) and carried out by Statistics Canada, and represents the energy use for the year 2014.

- Adjustments for weather and business activity. The analysis includes adjustments for:
    - Worker density (the number of workers per 100 m^2)
    - Percentage of the building that is heated
    - Climate (using heating degree days, retrieved based on postal code)
    - Weekly operating hours
    - Total length of commercial refrigeration/freezer units
    - Whether or not the building is large
- Release date. This is the original release of the ENERGY STAR score for retail stores in Canada.

This document details the development of the 1 – 100 ENERGY STAR score for retail store properties. For more information on the methodology used to develop ENERGY STAR scores, go to the Technical Reference for the ENERGY STAR Score at http://www.energystar.gov/ENERGYSTARScore.

The following sections explains how the ENERGY STAR score for retail stores is developed.

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REFERENCE DATA & FILTERS

The reference data used to form the peer property population relies on the Survey on Commercial and Institutional Energy Use (SCIEU), which was commissioned by Natural Resources Canada and conducted by Statistics Canada in late 2015 and early 2016. The energy data for the survey was from the calendar year 2014. The raw collected data file for this survey is not publicly available, but a report providing summary results is available on Natural Resources Canada's website at: http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/menus/scieu/2014/tables.cfm.

Four types of filters are applied to analyze the building energy and operating characteristics in the survey. They are set to define the peer population for comparison and to overcome any technical limitations. Those filters are: Building Type Filters, Program Filters, Data Limitation Filters, and Analytical Filters.

A complete description of each category is given in the Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARScore. *Figure 1* summarizes each filter used to develop the ENERGY STAR score for retail stores model and the rationale that supports the filter. After all filters are applied, the remaining data set has 117 observations. Due to the confidentiality of the survey data, NRCan is not able to identify the number of cases after each filter.

Figure 1 – Summary of Filters for the ENERGY STAR Score for Retail Store

Condition for Including an Observation in the Analysis	Rationale
Defined as category 9 in SCIEU – Retail Store (non-food)	The SCIEU survey covered the commercial and institutional sector and included buildings of all types. For this model, only the observations identified as primarily retail store (non-food) are used.
Buildings must be more than 50% retail store (non-food) and less than 50% of another building type	Building Type Filter – To be considered part of the retail store peer population, the building must have a minimum retail store space.
Must have electricity consumption data	Program Filter – Retail stores that do not use electricity are rare or non-existent and may indicate an omission in energy data. Electricity can be grid-purchased or produced on site.
Must not use any "other" fuels for which the consumption is not reported	Data Limitation Filter – The survey asked whether fuels other than purchased electricity, on-site generated electricity from renewable sources, natural gas, light fuel oil, diesel, kerosene, propane, district steam, district hot water or district chilled water were consumed in the facility. Either the type of energy was not defined or in the case of wood, the energy was not easily convertible; therefore, the energy provided by these fuels could not be directly compared. In such cases, these observations were removed from the analysis.
Must be built in 2013 or earlier	Data Limitation Filter – The survey reported the energy for calendar year 2014. Therefore, if the building was being built in 2014, a full year of energy data would not be available.
Building must operate for a minimum of 40 hours per week	Program Filter – Retail stores must operate for at least 40 hours per week to be considered a full-time operating retail store.

Condition for Including an Observation in the Analysis	Rationale
The percent of the building that is heated must be greater than or equal to 50%	Program Filter – Retail stores must be at least 50% heated to be considered a retail store in Canada.
Must not include energy supplied to other buildings	Data Limitation Filter – The survey asked whether the energy reported at the facility included energy supplied to other buildings such as a multi-building complex or portables. Usage data may not have been included; therefore these buildings were removed.
The size of the indoor or partially enclosed parking structures must be less than 50% of the gross floor area including indoor and partially enclosed parking structures	Program Filter – If the combined square foot of parking structures exceeds the size of the retail store building, then the overall structure is classified as parking, not retail store. This is a standard policy in Portfolio Manager.
The size of the vacant space must be less than 50% of the gross floor area	Program Filter – Occupancy needs to be greater than 50% for retail stores to meet ENERGY STAR certification requirements.
Must operate at least 10 months per year	Program Filter – Basic requirement to be considered as full-time operation.
Must be a standalone retail store, anchor store, or strip mall	Program Filter – The score applies only to standalone stores, anchor stores (stores with an exterior entrance located in an enclosed mall) and strip mall stores (stores with an exterior entrance located in a strip mall setting).
Must have at least one cash register or computer	Program Filter – Retail stores that do not have at least 1 point of sale system are rare or non-existent and may indicate an omission in data.
Source EUI must be greater than 0.6 GJ/m^2 and less than 4.3 GJ/m^2	Analytical Filter – Values determined to be outliers based on analysis of the data. Outliers are typically clearly outside normal operating parameters for a building of this type.
Must have a worker density (workers per 100 m^2) that is greater than or equal to 0.5 and less than or equal to 4.5	Analytical Filter – Values determined to be outliers based on analysis of the data. Outliers are typically clearly outside normal operating parameters for a building of this type.
Must be at least 464.5 m^2	Analytical Filter – The analysis could not model trends for buildings smaller than 464.5 m^2 (5,000 ft^2).
Must be less than or equal to 20,000 m^2	Analytical Filter – Values determined to be outliers based on analysis of the data. In Canada, most single retail stores do not exceed 20,000 m^2.

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 available during the analysis, 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 has a different behaviour from the rest of the properties (e.g. retail stores smaller than 464.5 m^2 do not behave the same way as larger buildings), in which case an Analytical Filter is 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 obtain a score in Portfolio Manager is available at https://www.nrcan.gc.ca/energy/efficiency/buildings/energy-benchmarking/faq/3787#faq292.

Related to the filters and eligibility criteria described above, another consideration is how Portfolio Manager treats properties 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 campus of buildings. The applicability of the ENERGY STAR score depends on the type of property. For retail stores, the score is based on individual establishments and is not available for entire strip malls or enclosed malls.

Eligible store configurations include: free standing stores; stores located in open air or strip centers (a collection of attached stores with common areas that are not enclosed); and mall anchors (stores located in enclosed malls with exterior entrances).

Retail configurations not eligible to receive an ENERGY STAR score include: enclosed malls; individual stores located within enclosed malls without exterior entrances; lifestyle centers; strip malls; and individual stores that are part of a larger non-mall building (i.e. office or hotel). To receive an ENERGY STAR score, a retail store must be a single store that is at least 464.5 m^2 (5,000 ft^2) with an exterior entrance to the public.

VARIABLES ANALYZED

To normalize for differences in business activity, NRCan performed 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, was analyzed using a weighted ordinary least squares regression, which evaluated energy use relative to business activity (e.g. number of workers, operating hours per week, floor area, and climate). This linear regression gives an equation 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 retail stores in Canada.

Dependent Variables

The dependent variable is what NRCan tries to predict with the regression equation. For the retail store analysis, the dependent variable is energy use, 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 regression analyzes the key drivers of source EUI—those factors that explain the variation in source energy use per square metre in retail stores. The units for source EUI in the Canadian model are annual gigajoules per square metre (GJ/m^2).

Independent Variables

The reference survey contains numerous property operation questions that NRCan identified as likely to be important for retail stores. Based on a review of the variables found in the reference data, and following the criteria for inclusion in Portfolio Manager,[1] NRCan initially analyzed the following variables in the regression analysis:

- Gross floor area (m^2)
- Cooling degree days (CDD)
- Heating degree days (HDD)
- Percentage of floor space that is cooled

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

- Percentage of floor space that is heated
- Weekly hours of operation
- Number of workers during the main shift
- Length of all open/closed refrigeration/freezer units
- Area of walk-in refrigeration
- Number of vending machines
- Months in operation in 2014
- Number of commercial appliances
- Presence of a commercial kitchen
- Number of computers
- Number of cash registers
- Number of televisions/electronic displays/LCDs
- Year of construction

NRCan, with the advice of the Environmental Protection Agency (EPA), performed an extensive review on all of these operational characteristics individually and in combination with each other (e.g. heating degree days times percent heated). As part of the analysis, some variables were reformatted to reflect the physical relationships of building components. For example, the number of workers on the main shift can be evaluated in a density format: workers per 100 m^2. The worker density (as opposed to the gross number of workers) is more closely related to the energy use intensity. In addition, using analytical results and residual plots, variables were assessed using different transformations (such as the natural logarithm, abbreviated as Ln). Overall, the analysis consists of multiple regression formulations, structured to find the combination of statistically significant operating characteristics that explained the greatest amount of variance in the dependent variable: source EUI.

The final regression equation includes the following variables:

- Number of workers per 100 m^2 during main shift (worker density)
- Number of Heating Degree Days times the percentage of the building that is heated (PercHeat x HDD)
- Weekly operating hours (For large buildings)
- Length of Commercial Refrigeration/Freezer units per 100 m^2 (For large buildings)
- Larger than 750 m^2 Yes/No

These variables are used together to compute the predicted source EUI for retail stores. The predicted source EUI is the mean EUI for a hypothetical population of buildings that share the same values for each of these characteristics. It is the mean energy for buildings that operate like your building.

Worker Density Analysis

Worker density is an essential variable in the retail store model, as it was found to best represent levels of business activity. While cash register density and computer density can represent sales activities, worker density was found to best predict the EUI and explain variance in these variables.

Climate (HDD and CDD) Analysis

The analysis looked at the heating degree days, cooling degree days, percent of the building that is heated, and percent of the building that is cooled.

There was a strong positive correlation between the EUI and both the number of heating degree days (HDD), as well as the percentage of the building that is heated (PercHeat). The combination of these two terms (PercHeat x HDD) created a more robust variable that accounted for variations in percentage of the building heated and climate.

The climate analysis also included a review of two cooling terms: the percentage of the building that is cooled and cooling degree days (CDD). However, neither term nor any combination of terms containing percent cooled or CDD had a statistically significant relationship with EUI.

Large Yes/No

Through model analysis, it was observed that smaller retail stores did not behave in a similar predictable fashion as larger retail stores. The EUI of stores larger than 750 m^2 was also influenced by the number of weekly operating hours, as well as the length of refrigeration and freezers. Therefore, buildings larger than or equal to 750 m^2 receive an adjustment for hours, length of refrigeration/freezers, and size.

Testing

NRCan further analyzed the regression equation using actual data entered in Portfolio Manager. In addition to the SCIEU data, this analysis provided another set of buildings to examine the ENERGY STAR scores and distributions to assess the impacts and adjustments. It also confirmed that there are minimal biases when it comes to fundamental operational characteristics, such as worker density or percent heated, and that there was no regional bias or bias for the type of energy used for heating.

It is important to reiterate that the final regression equation is based on the nationally representative reference data from SCIEU 2014, not on 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 117 observations. The dependent variable is source EUI. Each independent variable is centred relative to the weighted mean value, presented in *Figure 2*. The final equation is presented in *Figure 3*. All variables in the regression equation are considered significant at a 90% confidence level or better, as shown by their respective significance levels.

The regression equation has a coefficient of determination (R^2) value of 0.326, indicating that this equation explains 32.6% of the variance in source EUI for retail stores. Because the final equation is structured with energy per unit area as the dependent variable, the explanatory power of the area is not included in the R^2 value, and thus this value appears artificially low. Recomputing the R^2 value in units of source energy[2] demonstrates that the equation actually explains 97.4% of the variation in total source energy of retail stores. It is an excellent result for a statistically based energy model.

For detailed information on the ordinary least squares regression approach, go to the Technical Reference for the ENERGY STAR Score, at www.energystar.gov/ENERGYSTARscore.

Figure 2 – Descriptive Statistics for Variables in Final Regression Equation

Variable	Minimum	Median	Maximum	Mean
Source energy per square metre (GJ/m^2)	0.6497	1.694	4.222	1.543
Worker Density	0.5069	1.569	4.347	1.624
PercHeat x HDD	2265	4711	6929	4408
Weekly Operating Hours*	0	0	168	28.76
Length of Refrigeration/Freezer per 100m^2*	0	0	8.147	0.1577
Large Yes/No*	0	0	1	0.4636

*Only applies to retail stores larger than 750 m^2

[2] 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 [Weight*(Actual Source Energy$_i$ – Predicted Source Energy$_i$)]^2 across all observations. The total variation of Y is the sum of [Weight*(Actual Source Energy$_i$ – Weighted Mean Source Energy)]^2 across all observations.

Figure 3 – Final Regression Results

Summary				
Dependent variable		Source energy use intensity (GJ/m^2)		
Number of observations in analysis		117		
R^2 value		0.326		
Adjusted R^2 value		0.295		
F statistic		10.72		
Significance (p-level)		< 0.0001		
	Unstandardized Coefficients	Standard Error	T Value	Significance (p-level)
Constant	1.545	0.0452	34.16	<.0001
Worker Density	0.1951	7.181E-02	2.72	0.0076
PercHeat x HDD	2.059E-04	3.97E-05	5.18	<.0001
Weekly Operating Hours (Large)	1.065E-02	3.82E-03	2.79	0.0062
Length of Refrigeration/Freezer per 100 m^2 (Large)	0.1158	0.0518	2.24	0.0274
Large Yes/No	-0.5158	0.2670	-1.93	0.0559

- *Notes:*
- *The regression is a weighted ordinary least squares regression, weighted by the SCIEU variable "SWEIGHT."*
- *All model variables are centered. The centered variable is equal to the difference between the actual value and the observed mean. The observed mean values are presented in Figure 2.*
- *Heating and cooling degree days are sourced from Canadian weather stations included in the U.S. National Climatic Data Center system.*

ENERGY STAR SCORE LOOKUP TABLE

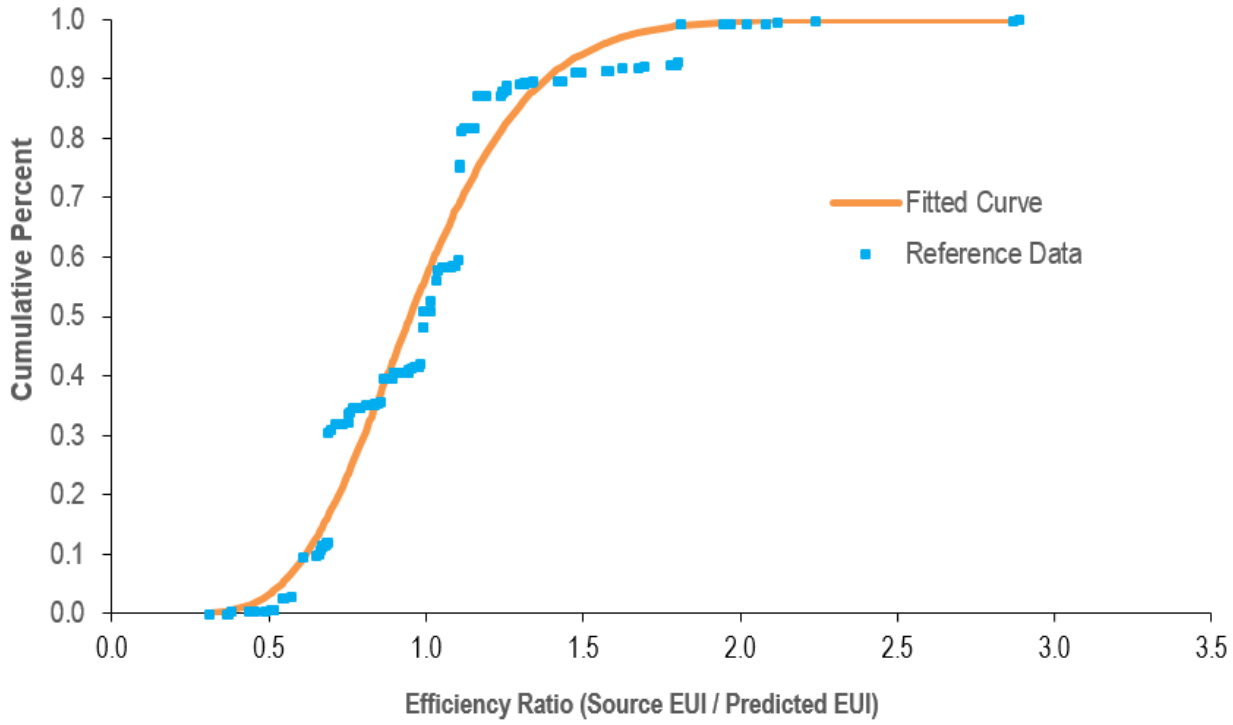
The final regression equation (presented in ***Figure 3***) gives a prediction of source EUI based on a building's operating characteristics. Some buildings in the SCIEU data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference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

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

An efficiency ratio lower than one 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 gives a shape parameter (alpha) of 10.48 and a scale parameter (beta) of 0.09350. The sum of the squared error for this fit is 0.4530.

Figure 4 – Distribution for Retail Store



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 registers such a small or even smaller ratio. The ratio on the gamma curve at the value of 25% corresponds to the ratio for a score of 75; only 25% of the population registers such a small or even smaller ratio. *Figure 5* shows the complete score lookup table.

Figure 5 – ENERGY STAR Score Lookup Table for Retail Store

ENERGY STAR Score	Cumulative Percent	Energy Efficiency Ratio > =	Energy Efficiency Ratio <
100	0%	0.0000	0.4149
99	1%	0.4149	0.4624
98	2%	0.4624	0.4944
97	3%	0.4944	0.5196
96	4%	0.5196	0.5407
95	5%	0.5407	0.5591
94	6%	0.5591	0.5756
93	7%	0.5756	0.5907
92	8%	0.5907	0.6046
91	9%	0.6046	0.6176
90	10%	0.6176	0.6299
89	11%	0.6299	0.6416
88	12%	0.6416	0.6527
87	13%	0.6527	0.6634
86	14%	0.6634	0.6737
85	15%	0.6737	0.6836
84	16%	0.6836	0.6932
83	17%	0.6932	0.7026
82	18%	0.7026	0.7117
81	19%	0.7117	0.7206
80	20%	0.7206	0.7293
79	21%	0.7293	0.7379
78	22%	0.7379	0.7462
77	23%	0.7462	0.7545
76	24%	0.7545	0.7626
75	25%	0.7626	0.7706
74	26%	0.7706	0.7785
73	27%	0.7785	0.7864
72	28%	0.7864	0.7941
71	29%	0.7941	0.8018
70	30%	0.8018	0.8093
69	31%	0.8093	0.8169
68	32%	0.8169	0.8244
67	33%	0.8244	0.8318
66	34%	0.8318	0.8392
65	35%	0.8392	0.8466
64	36%	0.8466	0.8539
63	37%	0.8539	0.8612
62	38%	0.8612	0.8685
61	39%	0.8685	0.8758
60	40%	0.8758	0.8831
59	41%	0.8831	0.8904
58	42%	0.8904	0.8977
57	43%	0.8977	0.9050
56	44%	0.9050	0.9123
55	45%	0.9123	0.9196
54	46%	0.9196	0.9269
53	47%	0.9269	0.9343
52	48%	0.9343	0.9417
51	49%	0.9417	0.9491
50	50%	0.9491	0.9566
49	51%	0.9566	0.9641
48	52%	0.9641	0.9716
47	53%	0.9716	0.9793
46	54%	0.9793	0.9869
45	55%	0.9869	0.9947
44	56%	0.9947	1.0025
43	57%	1.0025	1.0104
42	58%	1.0104	1.0183
41	59%	1.0183	1.0264
40	60%	1.0264	1.0345
39	61%	1.0345	1.0428
38	62%	1.0428	1.0511
37	63%	1.0511	1.0596
36	64%	1.0596	1.0682
35	65%	1.0682	1.0770
34	66%	1.0770	1.0859
33	67%	1.0859	1.0949
32	68%	1.0949	1.1042
31	69%	1.1042	1.1136
30	70%	1.1136	1.1232
29	71%	1.1232	1.1330
28	72%	1.1330	1.1430
27	73%	1.1430	1.1533
26	74%	1.1533	1.1639
25	75%	1.1639	1.1747
24	76%	1.1747	1.1859
23	77%	1.1859	1.1974
22	78%	1.1974	1.2093
21	79%	1.2093	1.2216
20	80%	1.2216	1.2344
19	81%	1.2344	1.2477
18	82%	1.2477	1.2616
17	83%	1.2616	1.2761
16	84%	1.2761	1.2913
15	85%	1.2913	1.3073
14	86%	1.3073	1.3243
13	87%	1.3243	1.3423
12	88%	1.3423	1.3617
11	89%	1.3617	1.3825
10	90%	1.3825	1.4052
9	91%	1.4052	1.4300
8	92%	1.4300	1.4577
7	93%	1.4577	1.4890
6	94%	1.4890	1.5253
5	95%	1.5253	1.5686
4	96%	1.5686	1.6229
3	97%	1.6229	1.6969
2	98%	1.6969	1.8178
1	99%	1.8178	>1.8178

EXAMPLE CALCULATION

According to the Technical Reference for the ENERGY STAR Score at www.energystar.gov/ENERGYSTARScore, there are five steps to compute a score for retail stores. The following is an example:

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	1,200,000 kWh
Natural gas	120,000 m^3

Property Use Details	Value
Gross floor area (m^2)	10,000
Number of Workers on Main Shift	25
Percent That Can Be Heated	100
HDD (provided by Portfolio Manager, based on postal code)	5584
Weekly Operating Hours	70
Length of All Open or Closed Refrigeration/Freezer Units	40

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 GJ Multiplier	Site GJ	Source Multiplier	Source GJ
Electricity	1,200,000 kWh	0.0036	4,320	1.96	8,467
Natural gas	120,000 m^3	0.03843	4,612	1.01	4,658
				Total Source Energy (GJ)	13,125
				Source EUI (GJ/m^2)	1.313

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 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 retail stores regression equation to obtain a predicted source EUI.

Computing Predicted Source EUI

Variable	Actual Building Value	Reference Centering Value	Building Centered Variable	Coefficient	Coefficient x Centered Variable
Constant	-	-	-	1.545	1.545
Worker Density*	0.25	1.624	-1.374	0.1951	-0.2681
PercHeat x HDD	5584	4409	1175	2.059E-04	0.2419
Weekly Operating Hours (Large)	70	28.76	41.24	1.065E-02	0.4392
Length of Refrigeration/Freezer per 100 m^2 (Large)	0.4	0.1577	0.2423	0.1158	2.806E-02
Large Yes/No	1	0.4636	0.5364	-0.5158	-0.2767
				Predicted Source EUI (GJ/m^2)	1.710

**Workers per 100 m^2*

4 Portfolio Manager computes the energy efficiency ratio

- The ratio equals the actual source EUI (Step 2) divided by the predicted source EUI (Step 3).
- Ratio = 1.313 / 1.710 = 0.7678

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 0.7678 is greater than 0.7626 and less than 0.7706.
- *The ENERGY STAR score is 75.*