ENERGY STAR® PortfolioManager® Technical Reference

ENERGY STAR Score for Hospitals in Canada

OVERVIEW

The ENERGY STAR Score for Hospitals in Canada applies to general medical hospitals, including critical access hospitals and children's hospitals. The objective of the ENERGY STAR score is to fairly assess how a property's energy use measures up against similar properties considering the climate, weather, and business activities. A statistical analysis of the peer building 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 – 100 percentile ranking in relation to the national population of properties.

- **Property types.** The ENERGY STAR score for hospitals in Canada applies to general medical hospitals, including critical access hospitals and children's hospitals. The ENERGY STAR score applies to an entire hospital, whether it is a single building or a campus of buildings. Individual buildings that are part of larger hospital campuses cannot receive their own score.

- **Reference data.** The analysis for hospitals in Canada relies 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. The SCIEU represents the energy use for the year 2014.

- **Adjustments for weather and business activity.** The analysis includes adjustments for:
  - Gross floor area used for food preparation
  - Number of sterilization units
  - Number of Magnetic Resonance Imaging (MRI) machines
  - Number of workers on the main shift
  - Weather and climate (using heating degree days, retrieved based on postal code)

- **Release date.** This is the second release of the ENERGY STAR score for hospitals in Canada. The ENERGY STAR score for hospitals is updated periodically as more recent data becomes available:
  - Most Recent Update: August 2020
  - Original Release: August 2015

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

ENERGY STAR Score for Hospitals in Canada

The following sections explain how the ENERGY STAR score for hospitals is developed:

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 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 group 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 hospitals model and the rationale that supports the filter. After all filters are applied, the remaining data set has 140 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 Hospitals

Condition for Including an Observation in the Analysis	Rationale
Defined as category 7 in SCIEU – Hospital	The SCIEU survey covered the commercial and institutional sector and included buildings of all types. For this model, only the observations identified as primarily Hospital are used.
Must be more than 50% hospital and less than 50% of any other building type	Building Type Filter – To be considered as a hospital, the building must have a minimum amount of hospital space.
Must have electricity consumption data	Program Filter – Hospitals 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 consumption data for calendar year 2014. Therefore, if the building was being built in 2014, a full year of energy data would not be available.
More than 50% of the building must be heated	Program Filter – Hospitals must be greater than 50% heated to be considered a hospital in Canada.
More than 50% of the building must be cooled	Program Filter – Hospitals must be greater than 50% cooled to be considered a hospital 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 buildings were removed.

Condition for Including an Observation in the Analysis	Rationale
The area 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 area of parking structures is more than 50% the area of the hospital building, the overall structure is classified as a parking structure, not as a hospital.
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 hospital to meet ENERGY STAR certification requirements.
Building must operate for a 168 hours per week	Analytical Filter – Hospitals must operate for 168 hours per week to be considered a full-time operating hospital.
Must operate at least 10 months per year	Analytical Filter – Hospitals must operate for at least 10 months per year to be considered a full-time operating hospital.
Must have worker to bed ratio less than 50 workers per bed	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 at least one worker	Analytical Filter – Hospital that does not have any workers are rare or non-existent and may indicate an omission in data.
Must have bed density less than or equal to 2 per 100 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 food preparation percent less than 0.048 (i.e., 4.8%)	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.
Source EUI must be less than 5.5 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 be less than or equal to 300,000 m^2 in area	Analytical Filter – Values determined to be outliers based on analysis of the data. In Canada, most hospitals do not exceed 300,000 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 intended 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. 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/energy-star-canada/benchmarking-frequently-asked-questions/3787.

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 hospitals, the score is used for either a single building or campus of buildings

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 gave 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 hospitals in Canada.

Dependent Variables

The dependent variable is what NRCan tries to predict with the regression equation. For the hospitals 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 hospitals. 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 hospitals. Based on a review of the variables found in the reference data, following the criteria for inclusion in Portfolio Manager,[1] NRCan initially analyzed the variables below in the regression analysis:

- Gross floor area (m^2)
- Cooling degree days (CDD)
- Heating degree days (HDD)
- Percentage of floor space that is cooled
- Percentage of floor space that is heated
- Weekly hours of operation
- Number of workers during the main shift
- Number of computers
- Months in operation in 2014
- Number of commercial appliances
- Number of sterilization units
- Number of MRI units
- Number of beds
- Number of elevators
- Number of televisions/electronic displays/LCDs
- Year of construction
- Presence of onsite laundry

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

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

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:

- Percentage of floor space that is used for food preparation (food preparation percentage)
- Number of sterilization units per 100 m^2 (sterilization density)
- Number of MRI units per 100 m^2 (MRI density)
- Number of workers per 100 m^2 (worker density)
- Heating Degree Days (HDD)

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 characteristics. It is the mean energy for buildings that operate like your building.

Food Preparation Percentage

Food preparation percentage is defined as Gross Floor Area Used for Food Preparation divided by Gross Floor Area in Square Metres. Food preparation percentage showed a positive correlation with energy usage. It showed a strong statistical significance, and was therefore included in the model.

Medical Diagnosis or Treatment Machines

The SCIEU 2014 survey collected data on the presence of various types of medical equipment, including x-ray and MRI machines. As MRI machines are potentially high energy consumers, it was important to investigate their impact on energy and energy use intensity. The results of the analysis indicated that the number of MRIs was a statistically significant predictor of energy use intensity in hospitals.

Sterilization Density Analysis

The SCIEU 2014 survey collected data on the presence of sterilization units. A sterilization unit is defined as equipment dedicated to inactivate or remove all living organisms (including vegetative and spore forms) as well as viruses. Sterilization units include steam sterilizers such as autoclaves, cold sterilizers, gaseous autoclaves, and ultraviolet autoclaves and sterilizers. Special washing machines and dryers are not sterilization units. Sterilization density (number of sterilization units per 100 square metres) showed a positive correlation with energy usage. It showed a strong statistical significance, and was therefore included in the model.

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 percent cooled 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 relies on the nationally representative reference data from SCIEU 2014, and not on data previously stored in Portfolio Manager.

REGRESSION EQUATION RESULTS

The final regression is a weighted ordinary least squares regression across the filtered data set of 140 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 0.1992, indicating that this equation explains 19.92% of the variance in source EUI for hospitals. 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 explains 91.90% of the variation in total source energy of hospitals. It is an excellent result for a statistically based energy model.

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

[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 2 – Descriptive Statistics for Variables in Final Regression Equation

Variable	Minimum	Median	Maximum	Mean
Source energy per square metre (GJ/m^2)	0.3174	3.649	5.157	3.584
Food Preparation Percent	0	1.177E-02	4.619E-02	1.371E-02
Sterilization Density	0	0	0.1207	1.194E-02
MRI Density	0	0	6.670E-03	6.100E-04
Worker Density	7.404E-02	1.284	6.524	1.460

Figure 3 – Final Regression Results

Summary				
Dependent variable		Source energy use intensity (GJ/m^2)		
Number of observations in analysis		140		
R^2 value		0.1992		
Adjusted R^2 value		0.1694		
F statistic		6.67		
Significance (p-level)		< 0.0001		
	Unstandardized Coefficients	**Standard Error**	**T Value**	**Significance (p-level)**
Constant	3.584	7.645E-02	46.87	<.0001
Food Preparation Percent*	25.96	7.123	3.64	0.0004
Sterilization Density	10.01	4.240	2.36	0.0197
MRI Density	131.0	63.11	2.08	0.0399
Worker Density	0.1398	7.500E-02	1.86	0.0646

Notes:
- ** The adjustment for the percentage of space dedicated to food preparation is capped at a value of 0.05 or 5%.*
- *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

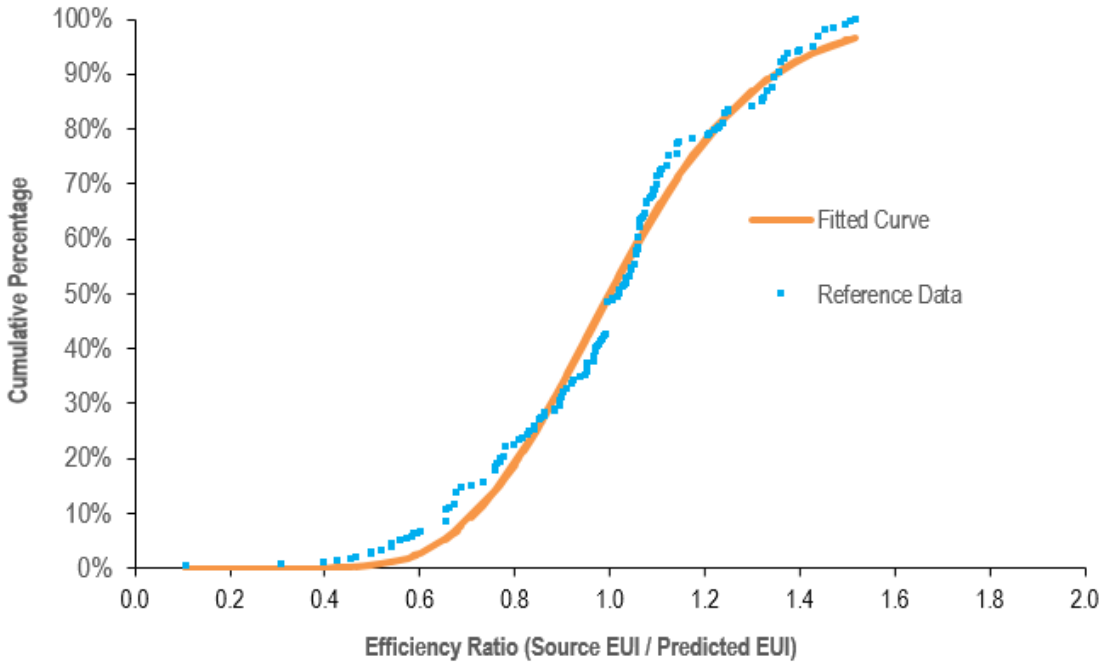
The final regression equation (presented in ***Figure 3***) gives a prediction of source EUI based on a building's operating characteristics. Some buildings in the SCIEU data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference 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 group and each building's percent rank with the gamma solution. The final fit for the gamma curve gave a shape parameter (alpha) of 16.92 and a scale parameter (beta) of 6.021E-02. The sum of the squared error for this fit is 1.451.

Figure 4 – Distribution for Hospital



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% corresponds to the ratio for a score of 75; only 25% of the population has a ratio this small or smaller. Figure 5 shows the complete score lookup table.

Figure 5 – ENERGY STAR Score Lookup Table for Hospital

ENERG STAR Score	Cumulative Percentage	Energy Efficiency Ratio > =	Energy Efficiency Ratio <	ENERGY STAR Score	Cumulative Percentage	Energy Efficiency Ratio >=	Energy Efficiency Ratio <
100	0%	0.0000	0.5189	50	50%	0.9993	1.0057
99	1%	0.5189	0.5644	49	51%	1.0057	1.0121
98	2%	0.5644	0.5946	48	52%	1.0121	1.0186
97	3%	0.5946	0.6181	47	53%	1.0186	1.0251
96	4%	0.6181	0.6377	46	54%	1.0251	1.0316
95	5%	0.6377	0.6547	45	55%	1.0316	1.0382
94	6%	0.6547	0.6699	44	56%	1.0382	1.0448
93	7%	0.6699	0.6837	43	57%	1.0448	1.0515
92	8%	0.6837	0.6964	42	58%	1.0515	1.0583
91	9%	0.6964	0.7082	41	59%	1.0583	1.0651
90	10%	0.7082	0.7194	40	60%	1.0651	1.0720
89	11%	0.7194	0.7299	39	61%	1.0720	1.0790
88	12%	0.7299	0.7399	38	62%	1.0790	1.0860
87	13%	0.7399	0.7495	37	63%	1.0860	1.0932
86	14%	0.7495	0.7587	36	64%	1.0932	1.1004
85	15%	0.7587	0.7676	35	65%	1.1004	1.1078
84	16%	0.7676	0.7762	34	66%	1.1078	1.1153
83	17%	0.7762	0.7845	33	67%	1.1153	1.1229
82	18%	0.7845	0.7927	32	68%	1.1229	1.1306
81	19%	0.7927	0.8006	31	69%	1.1306	1.1385
80	20%	0.8006	0.8083	30	70%	1.1385	1.1466
79	21%	0.8083	0.8158	29	71%	1.1466	1.1548
78	22%	0.8158	0.8233	28	72%	1.1548	1.1632
77	23%	0.8233	0.8305	27	73%	1.1632	1.1718
76	24%	0.8305	0.8377	26	74%	1.1718	1.1806
75	25%	0.8377	0.8447	25	75%	1.1806	1.1897
74	26%	0.8447	0.8517	24	76%	1.1897	1.1990
73	27%	0.8517	0.8585	23	77%	1.1990	1.2085
72	28%	0.8585	0.8653	22	78%	1.2085	1.2184
71	29%	0.8653	0.8720	21	79%	1.2184	1.2287
70	30%	0.8720	0.8786	20	80%	1.2287	1.2393
69	31%	0.8786	0.8852	19	81%	1.2393	1.2503
68	32%	0.8852	0.8917	18	82%	1.2503	1.2617
67	33%	0.8917	0.8982	17	83%	1.2617	1.2737
66	34%	0.8982	0.9046	16	84%	1.2737	1.2863
65	35%	0.9046	0.9110	15	85%	1.2863	1.2995
64	36%	0.9110	0.9174	14	86%	1.2995	1.3134
63	37%	0.9174	0.9238	13	87%	1.3134	1.3283
62	38%	0.9238	0.9301	12	88%	1.3283	1.3441
61	39%	0.9301	0.9364	11	89%	1.3441	1.3612
60	40%	0.9364	0.9427	10	90%	1.3612	1.3797
59	41%	0.9427	0.9489	9	91%	1.3797	1.4000
58	42%	0.9489	0.9552	8	92%	1.4000	1.4226
57	43%	0.9552	0.9615	7	93%	1.4226	1.4480
56	44%	0.9615	0.9678	6	94%	1.4480	1.4774
55	45%	0.9678	0.9741	5	95%	1.4774	1.5124
54	46%	0.9741	0.9803	4	96%	1.5124	1.5562
53	47%	0.9803	0.9867	3	97%	1.5562	1.6157
52	48%	0.9867	0.9930	2	98%	1.6157	1.7123
51	49%	0.9930	0.9993	1	99%	1.7123	>1.7123

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 hospitals. Below is a specific 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	13,400,000 kWh
Natural gas	800,000 m^3

Property Use Details	Value
Gross floor area (m^2)	50,000
Gross Floor Area Used for Food Preparation (m^2)	10
Number of Workers	400
Number of MRI Units	1
Number of Sterilization Units	2
HDD (provided by Portfolio Manager, based on postal code)	3,400

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	13,400,000 kWh	3.600E-03	48,238	1.960	94,546
Natural gas	800,000 m^3	3.843E-02	30,744	1.010	31,051
				Total Source Energy (GJ)	125,597
				Source EUI (GJ/m^2)	**2.512**

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 hospital 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	-	-	-	3.584	3.584
Food Preparation Percent*	2.000E-04	1.371E-02	-1.351E-02	25.96	-0.3507
Worker Density**	0.8000	1.460	-0.6600	0.1398	-9.227E-02
MRI Density**	2.000E-03	6.063E-04	1.394E-03	131.0	0.1826
Sterilization Density**	4.000E-03	1.194E-02	7.940E-03	10.01	-7.948E-02
HDD	3,400	5,080	-1,680	1.493E-04	-0.2508
			Predicted Source EUI (GJ/m^2)		**2.993**

**The adjustment for the percentage of space dedicated to food preparation is capped at a value of 0.05 or 5%.*
***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 = 2.512/2.993 = 0.8392

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 0.8392 is greater than 0.8377 and less than 0.8447
- ***The ENERGY STAR score is 75.***