ENERGY STAR® PortfolioManager® Technical Reference

ENERGY STAR Score for Worship Facilities in Canada

OVERVIEW

The ENERGY STAR Score for Worship Facilities in Canada applies to buildings that primarily function as places of worship, such as churches, temples, mosques, synagogues, and meetinghouses. 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 Worship Facilities in Canada applies to buildings that are used as religious worship facilities. This includes churches, temples, mosques, synagogues, meetinghouses, or any other buildings that primarily function as religious worship facilities. The ENERGY STAR score applies to individual worship facility buildings only and is not available for campuses.

- **Reference data.** The analysis for worship facilities in Canada is based on data from the *Survey of Commercial and Institutional Energy Use* (SCIEU), which was commissioned by Natural Resources Canada (NRCan) and carried out by Statistics Canada and represents the energy consumption year 2019.

- **Adjustments for weather and business activity.** The analysis includes adjustments for:
  - Weekly Operating Hours
  - Worship Seats
  - Ceiling Height
  - Weather and Climate (using Heating and Cooling Degree Days, retrieved based on postal code)
  - Percent of the Building that is Heated and Cooled

- **Release date.** August 2023 is the original release date of the ENERGY STAR score for Worship Facilities in Canada.

This document details the calculation of the 1 – 100 ENERGY STAR score for Worship Facilities. 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.

Canada

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ENERGY STAR® PortfolioManager®

Technical Reference

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The following sections explain how the ENERGY STAR score for worship facilities 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. The energy data for the survey was from the calendar year 2019. The raw data file for this survey is not publicly available, but a report providing summary results will be available on Natural Resources Canada's website at: https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/data_e/databases.cfm?attr=0.

Four types of filters are applied to analyse 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 Worship Facility model and the rationale that supports the filter. After all filters are applied, the remaining data set has 380 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 Worship Facilities

Condition for Including an Observation in the Analysis	Rationale
Defined as Worship Facility in SCIEU2019	The SCIEU survey covered the commercial and institutional sector and included buildings of all types. For this model, only the observations identified as primarily Worship Facility are used.
Must be more than 50% Worship Facility and less than 50% of any other building type	Building Type Filter – To be considered as a worship facility, the building must have a minimum amount of Worship Facility space.
Must have electricity consumption data	Program Filter – worship facilities 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 be built in 2018 or earlier	Data Limitation Filter – The survey reported the energy consumption data for calendar year 2019. Therefore, if the building was being built in 2019, a full year of energy data would not be available.
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.
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 Worship Facility building, the overall structure is classified as a parking structure, not as a worship facility.
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 Worship Facility to meet ENERGY STAR certification requirements.
More than 50% of the building must be heated	Program Filter – More than 50% of a worship facility must be heated for it to be considered a worship facility.
Must be at least 92.9 m^2	Program Filter – To be considered as a worship facility, buildings must be at least 92.9 m^2 (1,000 sq. ft.) in Canada.

Condition for Including an Observation in the Analysis	Rationale
Must operate for at least one hour per week	Program Filter – To be considered as a worship facility, buildings must operate for at least one hour per year
Must operate for at least 10 months per year	Program Filter – To be considered as a worship facility, buildings must operate for at least 10 months per year
Must have at least one worker	Program Filter – To be considered as a worship facility, buildings must have at least one worker
Ceiling height must be at least 2.0 m	Program Filter – To be considered as a worship facility, buildings must have a ceiling height of at least 2.0m.
Must have Food Preparation Percentage less than or equal to 10	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 higher than 0 and lower or equal to 3.0G J/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.

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#es17.

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

VARIABLES ANALYSED

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 analysed 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 Worship Facilities in Canada.

Dependent Variables

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

- Gross floor area (m²)
- Gross floor area for food preparation (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 worship seats
- Number of computers
- Months in operation in 2019
- Number of domestic appliances
- Number of commercial appliances
- Number of electronic displays
- Ceiling height (m)
- Year of construction
- Indoor gymnasiums and racquet sport courts

NRCan, with the advice of the Environmental Protection Agency (EPA) and its contractor, 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 worship religious seats can be evaluated in a density format: seats per 100 m^2. 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:

- Weekly Operating Hours (Hours)
- Number of Worship Seats per 100 m^2 (Seating Density)
- Ceiling Height
- Percent Cooled x Cooling Degree Days (Percent Cooled x CDD)
- Percent Heated x Heating Degree Days (Percent Heated x HDD)

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

These variables are used together to compute the predicted source EUI for Worship Facilities. 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.

Testing

NRCan further analysed 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 2019, 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 380 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 0.2867 indicating that this equation explains 28.67% of the variance in source EUI for Worship Facilities. 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 66.82% of the variation in total source energy of Worship Facilities. It is a reasonable 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 $[\text{Weight}*(\text{Actual Source Energy}_i - \text{Predicted Source Energy}_i)]^2$ across all observations. The total variation of Y is the sum of $[\text{Weight}*(\text{Actual Source Energy}_i - \text{Weighted Mean Source Energy})]^2$ 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)	0.0111	0.6324	2.964	0.7843
Weekly Operating Hours	1.000	18.00	168.0	22.06
Seating Density	0.4019	29.90	85.87	29.81
Ceiling Height	2.438	7.000	35.00	8.230
Percent Cooled x CDD	0.000	6.500	408.0	79.47
Percent Heated x HDD	1767	4560	8352	4560

Figure 3 – Final Regression Results

Summary				
Dependent variable			Source energy use intensity (GJ/m^2)	
Number of observations in analysis			380	
R^2 value			0.2867	
Adjusted R^2 value			0.2771	
F statistic			30.06	
Significance (p-level)			<0.0001	
	Unstandardized Coefficients	**Standard Error**	**T Value**	**Significance**
Constant	0.7843	2.235E-02	35.1	<.0001
Weekly Operating Hours	5.580E-03	1.17E-03	4.78	<.0001
Seating Density	1.651E-02	1.67E-03	9.9	<.0001
Ceiling Height	2.046E-04	5.09E-03	4.02	<.0001
Percent Cooled x CDD	5.196E-04	2.176E-04	2.39	0.0174
Percent Heated x HDD	6.670E-05	2.687E-04	2.48	0.0135

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

ENERGY STAR SCORE LOOKUP TABLE

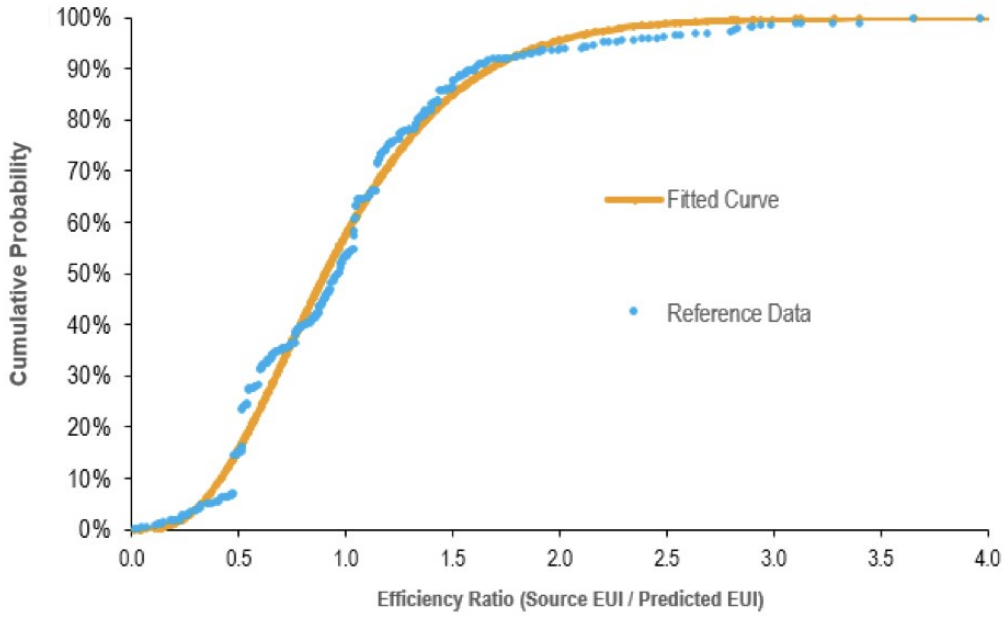
The final regression equation (presented in ***Figure 3***) gives a prediction of source EUI based on a building's operating characteristics. Some buildings in the SCIEU data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference 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 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 3.753 and a scale parameter (beta) of 0.2633. The sum of the squared error for this fit is 0.8713.

Figure 4 – Distribution for Worship Facilities



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 Worship Facilities

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	0.1896	50	50%	0.9019	0.9141
99	1%	0.1896	0.2365	49	51%	0.9141	0.9263
98	2%	0.2365	0.2705	48	52%	0.9263	0.9388
97	3%	0.2705	0.2983	47	53%	0.9388	0.9513
96	4%	0.2983	0.3225	46	54%	0.9513	0.9640
95	5%	0.3225	0.3441	45	55%	0.9640	0.9768
94	6%	0.3441	0.3640	44	56%	0.9768	0.9899
93	7%	0.3640	0.3824	43	57%	0.9899	1.0030
92	8%	0.3824	0.3998	42	58%	1.0030	1.0164
91	9%	0.3998	0.4163	41	59%	1.0164	1.0300
90	10%	0.4163	0.4320	40	60%	1.0300	1.0438
89	11%	0.4320	0.4472	39	61%	1.0438	1.0578
88	12%	0.4472	0.4618	38	62%	1.0578	1.0720
87	13%	0.4618	0.4759	37	63%	1.0720	1.0865
86	14%	0.4759	0.4897	36	64%	1.0865	1.1013
85	15%	0.4897	0.5032	35	65%	1.1013	1.1163
84	16%	0.5032	0.5163	34	66%	1.1163	1.1317
83	17%	0.5163	0.5292	33	67%	1.1317	1.1474
82	18%	0.5292	0.5418	32	68%	1.1474	1.1634
81	19%	0.5418	0.5543	31	69%	1.1634	1.1798
80	20%	0.5543	0.5666	30	70%	1.1798	1.1967
79	21%	0.5666	0.5787	29	71%	1.1967	1.2139
78	22%	0.5787	0.5906	28	72%	1.2139	1.2316
77	23%	0.5906	0.6025	27	73%	1.2316	1.2499
76	24%	0.6025	0.6142	26	74%	1.2499	1.2686
75	25%	0.6142	0.6259	25	75%	1.2686	1.2880
74	26%	0.6259	0.6375	24	76%	1.2880	1.3080
73	27%	0.6375	0.6490	23	77%	1.3080	1.3288
72	28%	0.6490	0.6604	22	78%	1.3288	1.3502
71	29%	0.6604	0.6718	21	79%	1.3502	1.3726
70	30%	0.6718	0.6832	20	80%	1.3726	1.3958
69	31%	0.6832	0.6945	19	81%	1.3958	1.4201
68	32%	0.6945	0.7058	18	82%	1.4201	1.4456
67	33%	0.7058	0.7171	17	83%	1.4456	1.4723
66	34%	0.7171	0.7284	16	84%	1.4723	1.5005
65	35%	0.7284	0.7397	15	85%	1.5005	1.5303
64	36%	0.7397	0.7510	14	86%	1.5303	1.5620
63	37%	0.7510	0.7623	13	87%	1.5620	1.5960
62	38%	0.7623	0.7736	12	88%	1.5960	1.6325
61	39%	0.7736	0.7850	11	89%	1.6325	1.6720
60	40%	0.7850	0.7964	10	90%	1.6720	1.7152
59	41%	0.7964	0.8078	9	91%	1.7152	1.7630
58	42%	0.8078	0.8193	8	92%	1.7630	1.8164
57	43%	0.8193	0.8309	7	93%	1.8164	1.8773
56	44%	0.8309	0.8425	6	94%	1.8773	1.9484
55	45%	0.8425	0.8542	5	95%	1.9484	2.0340
54	46%	0.8542	0.8660	4	96%	2.0340	2.1424
53	47%	0.8660	0.8779	3	97%	2.1424	2.2919
52	48%	0.8779	0.8898	2	98%	2.2919	2.5406
51	49%	0.8898	0.9019	1	99%	2.5406	>2.5406

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 Worship Facilities. 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	31,300 kWh
Natural gas	9,200 m^3

Property Use Details	Value
Gross floor area (m^2)	1,115
Weekly Operating Hours	30
Seating Capacity	5 300
Ceiling Height (m)	9
Percent Cooled	100%
Percent Heated	100%
CDD (provided by Portfolio Manager, based on postal code)	13
HDD (provided by Portfolio Manager, based on postal code)	5,832

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	31,300 kWh	3.600E-03	112.7	1.830	206.2
Natural gas	9,200 m^3	3.843E-02	353.6	1.060	374.8
				Total Source Energy (GJ)	581.0
				Source EUI (GJ/m^2)	**0.5210**

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 centring values are subtracted to compute the centred variable for each operating parameter (e.g., actual building value minus reference centring value).
- The centred variables are multiplied by the coefficients from the Worship Facility regression equation to obtain a predicted source EUI.

Computing Predicted Source EUI

Variable	Actual Building Value	Reference Centring Value	Building Centred Variable	Coefficient	Coefficient x Centred Variable
Constant	-	-	-	0.7843	0.7843
Weekly Operating Hours	30	22.06	7.940	5.580E-03	0.04431
Seating Density	26.9	29.81	-2.094	1.651E-02	-0.04795
Ceiling Height (m)	9	8.230	0.7000	2.046E-04	0.01575
Percent Cooled x CDD	5832	79.49	-76.22	5.196E-04	-0.03960
Percent Heated x HDD	3	4,560	1272	6.670E-05	0.08484
			Predicted Source EUI (GJ/m²)		**0.8417**

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 = 0.5210 / 0.8479= 0.6179

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 0.6179 is greater than 0.6142 and less than 0.6259.
- ***The ENERGY STAR score is 75.***