ENERGY STAR® Portfolio Manager® Technical Reference

ENERGY STAR Score for Senior Living Communities and Residential Care Facilities in Canada

OVERVIEW

The ENERGY STAR Score for Senior Living Communities and Residential Care Facilities in Canada applies to facilities that provide permanent rehabilitative, restorative and/or ongoing skilled nursing care to patients or residents in need of assistance with activities of daily living. Residential care facilities include nursing homes and residential developmental handicap, mental health and substance abuse facilities. 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 senior living communities and residential care facilities in Canada applies to properties that provide permanent rehabilitative, restorative and/or ongoing skilled nursing care to patients or residents in need of assistance with activities of daily living. The ENERGY STAR score applies to entire senior living communities or residential care facilities, whether they are single buildings or campuses of buildings.

- **Reference data.** The analysis for senior living communities and residential care 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 2014.

- **Adjustments for weather and business activity.** The analysis includes adjustments for:
  - Gross floor area
  - Licensed bed capacity
  - Number of workers on the main shift
  - Weather and climate (using heating and cooling degree days, retrieved based on postal code)
  - Percent of the building that is cooled
  - Percent of the building that is heated

- **Release date.** This is the second release of the ENERGY STAR score for Senior Living Communities and Residential Care Facilities in Canada. The ENERGY STAR score for Senior Living Communities and Residential Care Facilities is updated periodically as more recent data becomes available:
  - Most Recent Update: August 2021
  - Original Release: February 2016

This document details the calculation of the 1 – 100 ENERGY STAR score for senior living communities and residential care 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.

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Technical Reference

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The following sections explain how the ENERGY STAR score for senior living communities and residential care facilities is developed:

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 Senior Living Communities in Canada.

Dependent Variables

The dependent variable is what NRCan tries to predict with the regression equation. For the Senior Living Communities 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 Senior Living Communities. 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 Senior Living Communities. 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 (m^2)
- 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 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

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

NRCan, with the advice of the Environmental Protection Agency (EPA) and it's 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 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:

- Natural log of Gross Floor Area (natural log of Area)
- Number of workers per 100 m^2 (worker density)
- Number of beds per 100 m^2 (bed density)
- Percent Heated x Heating Degree Days (Percent Heated x HDD)
- Percent Cooled x Cooling Degree Days (Percent Cooled x CDD)

These variables are used together to compute the predicted source EUI for Senior Living Communities. 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.

Climate Variables

Climate is one characteristic that was examined closely. NRCan analysed the relationship between EUI and both Cooling Degree Days (CDD) and Heating Degree Days (HDD). While HDD was found to be consistently significant in the models, analysis showed that CDD also contributed to increased energy use, although to a lesser extent compared to HDD. Due to the limited variance of CDD within a single sample year, and the complex relationship between HDD and CDD in different climate regions in Canada, NRCan had concerns that the impact of cooling was not being fully represented in the model. To adjust, NRCan used a combination of analysis techniques, including linear regression of EUI and Percent Cooled x CDD in the SCIEU 2014 senior living community data, review of engineering models, and comparisons to Portfolio Manager data, to determine an appropriate factor to account for cooling energy. From the analysis, the rate of increase of source energy to Percent Cooled x CDD was determined. Applying this adjustment resulted in a more comprehensive model with both cooling and heating terms that is better adapted to changing climate trends.

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 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 191 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 0.2295, indicating that this equation explains 22.95% of the variance in source EUI for Senior Living Communities. 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 89.52% of the variation in total source energy of Senior Living Communities. 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.

ENERGY STAR SCORE LOOKUP TABLE

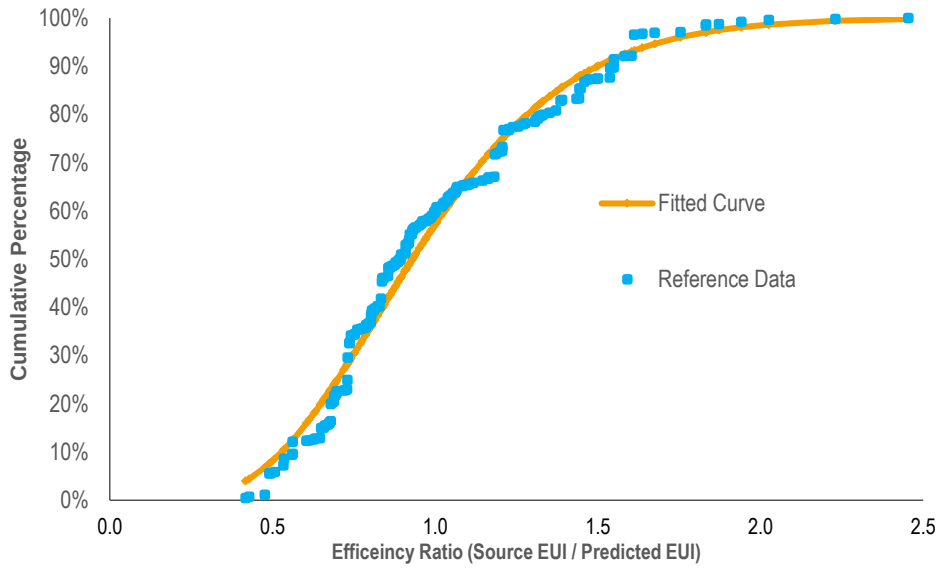
The final regression equation (presented in ***Figure 3***) gives a prediction of source EUI based on a building's operating characteristics. Some buildings in the SCIEU data sample use more energy than predicted by the regression equation, while others use less. The *actual* source EUI of each reference 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 6.407 and a scale parameter (beta) of.0.1531. The sum of the squared error for this fit is 0.2487.

Figure 4 – Distribution for Senior Living Community



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.

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 Senior Living Communities. 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	900,000 kWh
Natural gas	200,000 m^3

Property Use Details	Value
Gross floor area (m^2)	11,000
Number of Beds	200
Number of Workers	60
Percent Cooled	100%
Percent Heated	100%
CDD (provided by Portfolio Manager, based on postal code)	165
HDD (provided by Portfolio Manager, based on postal code)	2,900

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	900,000 kWh	3.600E-03	3,240	1.960	6350
Natural gas	200,000 m^3	3.843E-02	7,686	1.010	7763
				Total Source Energy (GJ)	14,113
				Source EUI (GJ/m^2)	**1.283**

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 Senior Living Community 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	-	-	-	2.177	2.177
Natural Log of Area	9.306	7.953	1.353	0.1517	0.2053
Worker Density	0.5455	1.056	-0.5105	0.2208	-0.1127
Bed Density*	1.400	1.309	0.0910	1.067	9.710E-02
Percent Cooled x CDD	165.0	97.54	67.46	3.000E-04	2.024E-02
Percent Heated x HDD**	3500	4579	-1079	5.019 E-04	-0.5416
			Predicted Source EUI (GJ/m²)		**1.845**

**The adjustment for the Bed Density is capped at a value of 1.4 beds per 100 m².*
*** The adjustment for HDD in Percent Heated x HDD has a minimum of 3,500,meaning that any property with a value below 3,500 will be assigned a value of 3,500.*

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 = 1.283 / 1.845 = 0.6954

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 0.6954 is greater than 0.6898 and less than 0.6996
- ***The ENERGY STAR score is 76.***