Approved VCS Methodology VM0008

Version 1.0

Methodology for Weatherization of Single Family and Multi-family Buildings
Sectoral Scope 3

Part A. GENERAL INFORMATION

1. Technologies/Measures

1.1 This methodology covers Weatherization of Dwellings, that is, energy efficiency measures directed at reducing the consumption of energy within a Dwelling. Examples include, but are not limited to, adding/improving insulation, air sealing, and replacing Appliances and central heating/cooling components.

1.2 Definitions

Appliance means a major or minor household Appliance, which includes, but is not necessarily limited to, a refrigerator, microwave, dishwasher, clothes washer or dryer, space heater, and water heater. It does not include heating/cooling systems. An Appliance runs on electricity or another fuel source and is a discreet unit. It must be contained within the Building Envelope to be included in the Project activity.

Building Envelope means the exterior thermal boundary of the physical structure of an individual building. Thermal boundary typically includes the ceiling/roof, wall, floor, attic floor, window, or door that separates the habitable, occupiable, and conditioned spaces from the outdoor weather.

Cooling Degree Days (CDD) measure the cumulative degree difference between the warmer outside temperature and the base temperature of the conditioned space on a daily basis during the cooling season. CDD are determined by summing the daily degree days, which are calculated as the average daily temperature minus the base temperature. The average daily temperature is calculated by summing the daily high temperature and the daily low temperature and dividing by two. The average daily temperature can also be calculated by averaging the daily temperature over shorter time intervals, rather than just the high and low temperature. CDD reported by weather stations are often reported in sixty or thirty minute time intervals. In the US, the cooling base temperature is 78° F.

Dwelling means a single family house, including a mobile home[1], or an apartment within a multi-family building. The following are eligible under the methodology as long as the eligibility requirements in 1.3 are met: single family residential homes, including mobile homes; and multi-family residential homes.[2]

[1] In the United States, mobile homes built later than 1976 are referred to as “manufactured homes” as defined in section 603 of the National Manufactured Housing Construction and Safety Standards Act of 1974. In this methodology, the term “mobile home” also refers to and includes a “manufactured home” when the replacement home is a manufactured home that can be transported and is permanently affixed to a steel chassis.

[2] In the United States, multi-family buildings that are over three stories above grade are considered commercial under the ASHRAE building standard 90.1-2004. These are also covered by the methodology.

Energy Load means the sum of the heat load, cooling load and the electricity demand per Dwelling. Heat load means the total fuel consumed, including electricity (in BTUs, GJ or kWh) to provide comfort in a conditioned space in a given year. Cooling load means the total electricity, or other fuel type in the case of central cooling systems, consumed (in BTUs, GJ or kWh) necessary to remove heat from the conditioned space to provide comfort in a given year.

Heating Degree Days (HDD) measure the cumulative degree difference between the colder outside temperature and the base temperature of the conditioned space on a daily basis during the heating season. HDD are determined by summing the daily degree days, which are calculated as the base temperature minus the average daily temperature.[3] The average daily temperature is calculated by summing the daily high temperature and the daily low temperature and dividing by two. The average daily temperature can also be calculated by averaging the daily temperature over shorter time intervals, rather than just the high and low temperature. HDD reported by weather stations are often reported in sixty or thirty minute time intervals. In the US, the base temperature is 65° F. In the UK, the base temperature is 15° C.

R-value means a measurement of thermal resistance as expressed by a recognized authority, such as the U.S. Department of Energy, or the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE). The R-value of insulation in the floor, walls, ceiling, skirting or any other element will depend on the thickness and specific material of the installed insulation.

Same Building Stock means Dwellings 1) in the same state, province, or region, 2) in the same category (single family or multi-family), and 3) inhabited by the same income group (low-income, middle-income or high-income) as defined by a recognized authority.[4]

U-value means the thermal conductance of a material or, in other words, the total heat transmission in GJ per square meter per hour with a 1°C temperature difference between the inside and the outside. The U-value of the window is the inverse of the R-value or 1/R. The U-value for the make and model of a window can often be found on a window manufacturer's specification sheet included with the window.

Weatherization means energy efficiency measures in Dwellings. Weatherizing shall refer to the act of installing energy efficiency measures in Dwellings.

1.3 Applicability.

1.3.1 Any Dwelling or measures included in a Project shall meet the following conditions:

[3] For example, a winter day (24 hours) has a low daily temperature of 20°F and a high daily temperature of 35°F. The total HDD for that day are calculated as: 65°F (base temperature) –((35°F+20°F)/2). The HDD for that day are 37.5. If, the next day is slightly warmer and the daily low is 30°F and the daily high is 38°F, then the HDD for that day are 31. The cumulative HDD for the two days are 68.5. HDD for the heating season are cumulative.

[4] In the US, The Department of Health and Human Services issues guidelines that define the term "low-income" as a multiple of the income level defined as poverty level on an annual basis. For example, the 2009 poverty level was $10,400 for a single person, and $21,200 for a family of four. Households are considered low income if their household income is no more than 200% of poverty level.

The condition of the Dwelling shall be and remain adequate for Project activities according to nationally recognized Weatherization best practice standards.[5] Project activities may not result in a violation of health and safety, environmental, or other relevant regulations.

The replacement Appliances and mobile homes must replace functioning Appliances, and/or occupied homes.

The Dwelling must be occupied. Vacancy is permitted on an intermittent basis for up to three months, or if the Dwelling is occupied seasonally on an annual basis.

The capacity of any replacement Appliance or replacement component of a central heating/cooling system shall satisfy the post-retrofit heat load, cooling load and electricity demand ("Energy Load") within the Dwelling.

In the case of heating/cooling systems that serve multiple Dwellings, all residential Dwellings connected to the system shall be included in the Project.

The Project activity must not be mandated, or required by local, state or federal law or regulation.

1.3.2 The methodology is applicable to Weatherizing whole buildings, replacing mobile homes or implementing individual energy efficiency measures within existing Dwellings. Applicable interventions fall into one of the following categories:

Category A--All energy retrofit: A combination of energy efficiency measures directed at the Building Envelope (i.e. air infiltration, insulation), improving the efficiency of the central heating and/or cooling system and reducing energy consumption of Appliances (i.e. replacement of refrigerators, air conditioning units, lamps, showerheads).

Category B--Efficiency enhancement of the Building Envelope and central heating and/or cooling system only.

Category C--Replacement of Appliances currently in service.

Category D--Replacement of a mobile home currently occupied.

1.3.3 The methodology does not cover fuel switching.

1.4 In the case of "replacement" of a mobile home, the word "retrofit" shall be read to mean replacement throughout the methodology.

1.5 When sampling, the minimum number of Dwellings or Appliances to be sampled shall be the square root of the total number of Dwellings i, or Appliances included in the Project. Statistically sound sampling approaches shall be used. When the control group approach (Approach 3 in Part C. Emission Reductions and Monitoring Parameters) is utilized, the size of the control group shall be the square root of the total number of Dwellings in the Project, but need not exceed 100 Dwellings

[5] For example, in the United States, the Department of Energy Weatherization Assistance Program and the Building Performance Institute provide training curricula, core competencies, and example best practice standards for Weatherization activities, which are available at: http://www.waptac.org/sp.asp?mc=training_resources and http://www.bpi.org/standards.aspx.

In any sampling approach, the following conditions must be met:

1) The sample shall be statistically valid, and may be one of the following:
    a. Simple random sample
    b. Systematic sampling
    c. Stratified sampling within the Same Building Stock
    d. Cluster sampling.
2) The sample must be representative of the population.
3) The data must come from an approved source, i.e. a certified energy auditor, or a nationally recognized data source.
4) Actions that may bias the sample shall be avoided. Sampling shall include Dwellings that are dispersed geographically. For each defined Building Stock included in the Project activity, sampling shall occur. Criteria include region, Dwelling type, and income.

2. Boundary

The Project boundary is the Building Envelope of the Dwelling(s) and its heating/cooling equipment.

3. Leakage

Appliances, heating/cooling equipment and/or mobile homes that are replaced shall be properly disposed of and their disposal shall be documented. The disposal documentation shall confirm that: 1) the Appliances have been disposed of in a manner that prevents operation of the Appliance, and 2) the disposal procedure complies with applicable law and regulations. If not documented, CO_2 emissions from continued operation of replaced Appliances, heating/cooling equipment and/or mobile homes and HFC emissions from refrigerators or air conditioners shall be accounted for as leakage.

Part B. ADDITIONALITY AND BASELINE

1. Additionality

1.1 A Project shall demonstrate additionality for project activities in category A, B, or C using either the Project Test set forth in section 1.2, or the Performance Test that incorporates the Performance Standard set forth in section 1.3 below. A Project shall demonstrate additionality for project activities in category D using the Project Test.

1.2 The Project Test:

For demonstration of additionality under project activities A, B, C and D the latest version of the CDM "Tool for the Demonstration and Assessment of Additionality" shall be applied, noting the following:

1) The project proponent may choose to complete an investment analysis or a barrier analysis or both.
2) Where the barrier analysis is used, sub-steps 3a and 3b of the above-referenced Tool shall be applied. The Project may rely on any of the barriers listed in the Tool as well as the barriers described below. When a barrier analysis is used, the following guidance applies:

    - Investment barrier: The Project may demonstrate it faces an investment barrier that the VCU revenue stream may help overcome. Such a barrier may be present when activities similar to those proposed in the Project: face a lack of available private capital due to real or perceived risks with the program or process or can only be

implemented with the aid of grants, tax incentives, subsidies or non-commercial finance terms. A lack of private capital is defined as a lack of investors or a lack of access to financing at the local, state, provincial or regional level for activities similar to those proposed in the Project.

- Technological barrier: The Project may demonstrate it faces a technological barrier that the VCU revenue stream may help overcome. Such a barrier may result from a less technologically advanced alternative to the technology proposed for the Project activity including an alternative that would lead to higher emissions. The barrier could be due to the performance uncertainty or low market share of the new technology adopted for the Project activity and/or the less technologically advanced alternative would have led to higher emissions: examples a Project may use to demonstrate a technological barrier include, but are not limited to, non-availability of human capacity to operate and maintain the new technology, lack of infrastructure to utilize the new technology, unavailability of the new technology or a high level of technology risk.

- Institutional barrier: The Project may demonstrate it faces financial, organizational, cultural or social barriers that the VCU revenue stream can help overcome. Such a barrier may be based on prevailing practices, institutional resistance to change, lack of adequate funds to offer effective incentives to engage in the Project activity or other factors that impede more effective Project implementation, monitoring or maintenance. Examples a Project may use to demonstrate an institutional barrier include, but are not limited to, absence of an existing trained and qualified workforce, absence of a strong central organization to manage the Project and/or perform the Project activities, absence of suitable tools for monitoring carbon emissions, absence of incentives that can be shown to help to stimulate the Project activity.

1.3. The Performance Standard provides as follows:

Category A--All energy retrofit: The percent savings in the pre- and post-retrofit Energy Load of each Dwelling in the Project shall be equal to or greater than the Performance Standard. The Performance Standard is a value above the benchmark that represents a percent savings in energy consumption that Dwellings are not likely to reach with 90% certainty in the absence of the Project. The benchmark is the annual average percent savings in weather normalized energy consumption in Dwellings from the Same Building Stock over the three most recent years for which data are available[6]. Dwellings weatherized as part of the Project may be excluded.

Category B--Efficiency enhancement of the Building Envelope and/or central heating/cooling system: The percent savings in the pre- and post-retrofit Energy Load of each Dwelling in the Project shall be equal to or greater than the Performance Standard. The Performance Standard is the same as defined in Category A. Although Category B comprises measures to the Building Envelope only, the same performance standard can be used if the percent savings is calculated for the entire energy consumption of the Dwelling and not just for the consumption of heating and cooling energy. This way, savings achieved under the Project are comparable to overall trends. By broadening the base, savings from the Project are diluted. They would be higher if calculated for the savings in heat and cooling energy alone.

The Performance Standard for Category A and Category B, x, shall be calculated as follows[7]:

[6] Energy Load shall be used to determine whether the dwelling is additional because the Energy load is established during the energy audit. Energy consumption is used to calculate the mean percent savings within the Same Building Stock (benchmark) because that is the data available. Energy Load and energy consumption may be used in conjunction because energy consumption may be projected based on Energy Load.

[7] Under a normal bell curve distribution, the mean plus or minus 2σ encompasses 95% of the statistical sample. Therefore 97.5% of the data falls below the value x, if x is calculated as the mean plus 2σ. A 90% likelihood of the data falling below the value x is calculated as the mean plus 1.85 σ.

For data following a normal distribution:

The Performance Standard is based on the standard deviation of the sample.

Equation 1

$$x = b + 1.85\sigma$$

Where:
x = Performance Standard
b = Benchmark[8]
σ = Standard deviation (sigma) of the percent savings in the Same Building Stock Energy Load

For data not following a normal distribution:

The Performance Standard is equal to the 90th percentile value within the numerically ordered sample. To calculate the 90th percentile the sample data point values ($v_1, v_2 \ldots v_N$) must be ordered from least to greatest. The 90th percentile value is equal to the value of the data point with the rank at which 90% of the data falls below.

Equation 2

a. $n = (NP_{90}/100) + 0.05$

b. x= the value of the data point at rank n calculated in equation 2a.

Where:
x = *Performance Standard*
n = *Rank of the ordered data point falling at the 90th percentile*
N = *Total number of data points included in the sample*
P_{90} = *90th percentile*

To be additional, Dwellings must satisfy the following condition:

Equation 3

$$\frac{EL_{Pre,\,i} - EL_{post,\,i}}{EL_{Pre,\,i}} * 100 \geq x$$

Where:
$EL_{pre,\,i}$= Pre-retrofit energy load of Dwelling *i*
$EL_{post,\,i}$= Post-retrofit energy load of Dwelling *i*

[8] To correct for any potential increase in electricity consumption due to an increase in electric appliances, the statewide percent increase in electricity consumption, as reported by the U.S. Department of Energy or other recognized authority, will be added to the value of the Benchmark to make the Performance Standard even more rigorous and conservative if such electricity data are reasonably available and it is feasible to do so. For example, in the US the value of the increase in regional electricity consumption may be obtained from the following website: http://apps1.eere.energy.gov/states/state_information.cfm

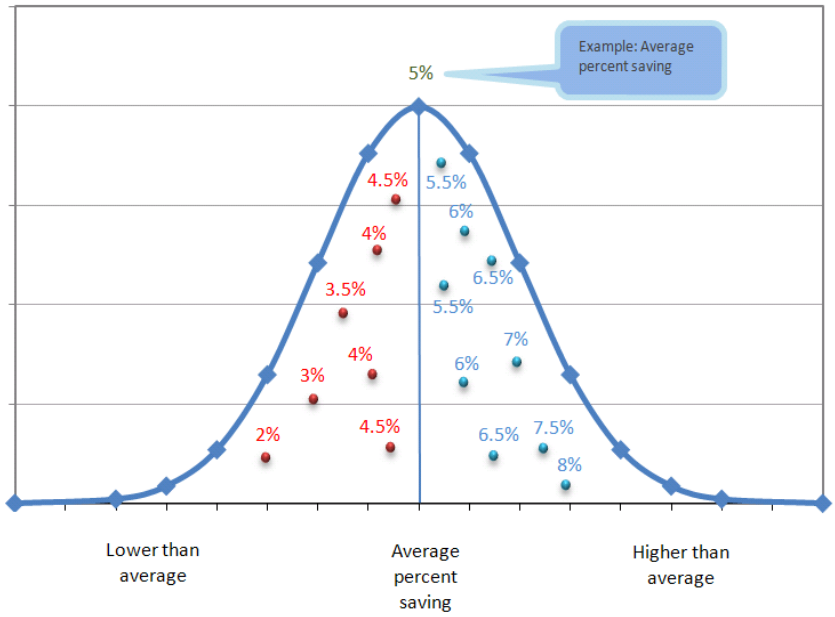


Figure 1. This graph shows the percent savings in energy consumption of buildings and Dwellings within the Same Building Stock. The percent savings is calculated from the change in weather normalized energy consumption in Dwellings from the Same Building Stock over at least the three most recent years for which data are available. The benchmark, on which the Performance Standard is based, is calculated from these data. Dwellings with a high percent savings in energy consumption will fall to the right of the average, and Dwellings with a low percent savings in energy consumption will fall to the left of the average.

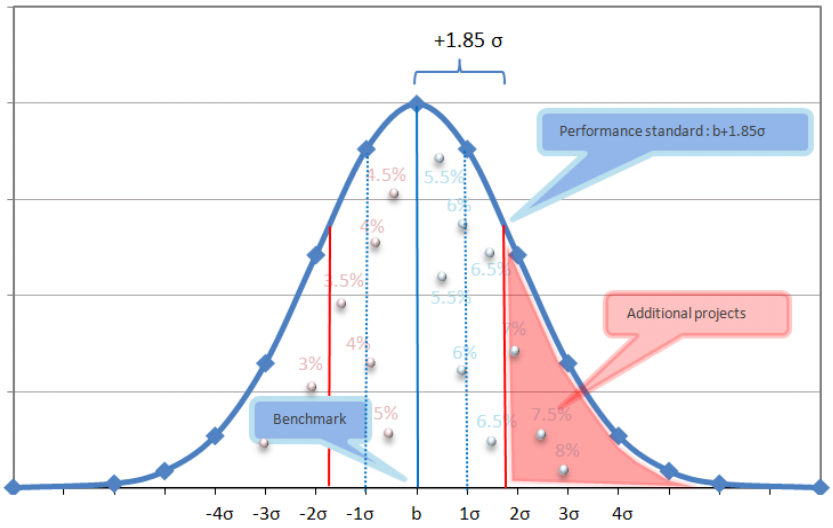


Figure 2. This graph shows how the Performance Standard (red line to the right) is calculated by determining the benchmark (solid blue line), defined as the annual average of the percent savings in weather normalized energy consumption in the Same Building Stock over the past three years, and adding 1.85σ . The standard deviation (σ) is calculated from the actual data obtained from the Same Building Stock within the past three years. The numbers along the horizontal axis represent the number of standard deviations from the average value (benchmark). For example, the data point 7% falls in line with 2σ, which means that 7% is 2 standard deviations away from the benchmark, meaning that 95% of all buildings do not reach a 7% savings in energy consumption or higher .

The parameters to be monitored for calculating the benchmark and standard deviation for Category A and Category B are listed in Table 1 below.

Table 1. Monitoring parameters for the Performance Standard for Category A and B

Parameter Description	Parameter	Unit	Source	Frequency
Pre-retrofit energy load of Dwelling i	$EL_{pre, i}$	BTU/m^2	Energy audit	Once
Post-retrofit energy load of Dwelling i	$EL_{post, i}$	BTU/m^2	Energy audit	Once
Benchmark, defined as the annual average percent savings in weather normalized energy consumption in Dwellings within the Same Building Stock.	*b*	Percent	Calculated from regional or national statistics for at least the three most recent 12 month periods for which data are available from Dwellings within the Same Building Stock. A sample of the Dwellings may be used. Percent savings are calculated by comparing year 1 to year 2 and year 2 to year 3[9].	Once
Standard Deviation of the annual percent savings.	σ	-	Calculated from regional or national statistics used to calculate the Benchmark.	Once

Category C--Replacement of Appliances: the energy consumption of the replacement Appliance shall meet or fall below the Performance Standard. The Performance Standard is a value below the benchmark that represents a level of energy consumption that Appliances are not likely to reach with 90% certainty in the absence of the Project. The benchmark is the annual average energy consumption by existing Appliances of the same Appliance type, as defined by the particular make and model of the Appliance. Appliances replaced as part of the Project may be excluded. National Appliance data may be used due to the uniformity of Appliances available in the market. Data may be further differentiated (i.e. by income class) as appropriate data are available.

The Performance Standard for Category C, *x*, shall be calculated as follows:

[9] Year 1, year 2 and year 3 may have gaps of time in between the years. For example: Year 1 data may cover 2001, year 2 data may cover 2005, and year 3 may cover 2009.

For data following a normal distribution:

The Performance Standard is based on the standard deviation of the sample.

Equation 4

$$x = b - 1.85\sigma$$

Where:
x = Performance Standard
b = Benchmark
σ = Standard deviation (sigma) of the annual energy consumption of existing Appliances in operation.

For data not following a normal distribution:

The Performance Standard is equal to the 90th percentile value within the numerically ordered sample. To calculate the 90th percentile the sample data point values ($v_1, v_2 ... v_N$) must be ordered from greatest to least. The 90th percentile value is equal to the value of the data point with the rank at which 90% of the data fall below.

Equation 5

a. $$n = (NP_{90}/100) + 0.05$$

b. x= the value of the data point at rank n calculated in equation 5a.

Where:
x = Performance Standard
n = Rank of the ordered data point falling at the 90th percentile
N = Total number of data points included in the sample
P90 = 90th percentile

To be additional, Dwellings must satisfy the following condition:

$$a_{rc,\,k} \leq x$$

Where:
x = *Performance Standard*
arc, k = Annual energy consumption of the replacement Appliance, type k

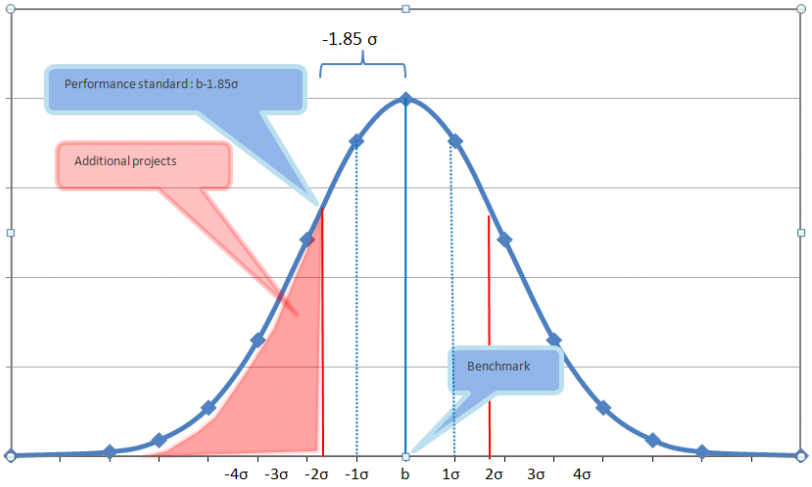


Figure 3. This graph shows how the Performance Standard (red line to the left) is calculated by determining the benchmark (solid blue line), defined as the annual average energy consumption by existing Appliances of the same Appliance type and subtracting 1.85σ. The standard deviation (σ) is calculated from the existing Appliance data obtained from the population. The numbers along the horizontal axis represent the number of standard deviations from the average value (benchmark). The shaded red section represents replacement Appliances with an annual energy consumption value that fall below the Performance Standard, and are considered additional.

The parameters to be monitored for calculating the benchmark and standard deviation for Category C are listed in Table 2 below.

Table 2. Monitoring parameters for the Performance Standard for Category C

Parameter Description	Parameter	Unit	Source	Frequency
Annual energy consumption of the replacement Appliance, type *k*	$a_{rc,\,k}$	kWh	Nameplate, or manufacturer's specification sheet.	Once
Benchmark, defined as the annual average electricity consumption by existing Appliances, of the same Appliance type.	*b*	kWh	Calculated from regional or national statistics for at least the recent 12 month period for which data are available. A sample of the Dwellings may be used.	Once
Standard Deviation of the annual energy consumption of existing Appliances.	σ	-	Calculated from regional or national statistics used to calculate the Benchmark.	Once

Category D--Replacement of a mobile home: No performance standard is defined.

2. Baseline Scenario

2.1 The baseline scenario represents the conditions most likely to occur in the absence of the Project.

Category A--All energy retrofit: the baseline scenario consists of fossil fuel and electricity consumed to satisfy the heat and cooling load and the Appliance plug load prior to Project implementation.

Category B--Efficiency enhancement of the Building Envelope and/or central heating/cooling system: the baseline scenario consists of fossil fuel consumed to satisfy the heat and cooling load prior to Project implementation. Electricity shall only be included when it is a heating or cooling source within the Dwelling. Appliances and their corresponding electricity consumption shall not be included.

Category C--Replacement of Appliances: the baseline scenario consists of electricity consumed by the Appliances to be replaced prior to Project implementation.

Category D--Replacement of a mobile home: the baseline scenario consists of fossil fuel and electricity consumed to satisfy the heat and cooling load and the Appliance plug load of the mobile home to be replaced prior to Project implementation.

Table 3: Greenhouse Gas Sources Included and Exclude in the Baseline and Project

Emissions	Source	Gas	Included/ Excluded	Description
Baseline (before retrofit)	Grid electricity consumption by cooling systems or other electric Appliances	CO_2	Included	Only CO_2 emissions from grid connected electricity generation shall be accounted for.
		CH_4	Excluded	
		N_2O	Excluded	
	Fossil fuel consumption by heating systems	CO_2	Included	Only CO_2 emissions from fossil fuel combustion shall be accounted for.
		CH_4	Excluded	
		N_2O	Excluded	
	Emissions from wood combustion for heat	CO_2	Excluded	Excluded for simplification and to be conservative.
		CH_4		
		N_2O		
Project Activity (after retrofit)	Grid electricity consumption by cooling systems or other electric Appliances	CO_2	Included	Only CO_2 emissions from grid connected electricity generation shall be accounted for.
		CH_4	Excluded	
		N_2O	Excluded	
	Fossil fuel consumption by heating systems	CO_2	Included	Only CO_2 emissions from fossil fuel combustion shall be accounted for.
		CH_4	Excluded	
		N_2O	Excluded	

	Emissions from wood combustion for heat	CO_2	Excluded	Excluded for simplification and to be conservative.
		CH_4		
		N_2O		
Leakage	Emissions from improper disposal of Appliances (e.g. refrigerators)	CO_2	Included	When the Appliance is not disposed of according to national laws and regulations there will be leakage from continued operation. The leakage emissions shall be calculated and excluded from emission reductions as described in the methodology.
		HFC	Included	
		CH_4	Excluded	
		N_2O	Excluded	

Part C. EMISSION REDUCTIONS AND MONITORING PARAMETERS

This section presents five approaches to calculating emission reductions and related monitoring parameters. They are: 1) the adjusted consumption approach, 2) the pre-and post retrofit audit approach, 3) the control group approach, 4) the deemed savings approach, and 5) the mobile homes approach. Equations required to calculate emission reductions under each approach and monitoring parameters applicable to each approach are listed in this section.

Category A--All energy retrofits: calculation of the emission reductions and monitoring shall be based on either:

1. The adjusted consumption approach;
2. The pre- and post-retrofit audit approach; or
3. The control group approach.

Category B--Efficiency enhancements of the Building Envelope and central heating/cooling: calculation of the emission reductions and monitoring shall be based on either:

1. The adjusted consumption approach;
2. The pre- and post-retrofit audit approach; or
3. The control group approach.

In Category B, electricity shall only be included in the calculation of emission reductions when it is a heating or cooling source within the building or Dwelling.

Category C--Appliance replacement: calculation of the emission reductions and monitoring shall be based on:

4. The deemed savings approach.

Category D--Replacement of a mobile home: calculation of the emission reductions and monitoring shall be based on either:

1. The adjusted consumption approach;
3. The control group approach; or
5. The mobile homes approach.

1. Adjusted consumption approach

In the adjusted consumption approach, measured energy consumption pre-retrofit, the baseline consumption, shall be corrected for changes in electricity demand over time and adjusted for Heating/Cooling Degree Days using an Electricity Correction Factor ("ECF") and Heating/Cooling Degree Day Correction Factors ("HDDCF" or "CDDCF" as applicable). A sample may be used to measure energy consumption pre-retrofit. Project consumption of fuel and electricity shall be subtracted from the adjusted baseline consumption. The result shall be multiplied by an emission factor for the fuel or electricity used in the baseline. A control group of non-weatherized, or non-retrofitted, Dwellings shall be monitored as a quality assurance measure.

1.1 Emission reductions in the adjusted consumption approach shall be calculated as follows:

Equation 6

$$ER_y = \sum_{i=1}^{I} (Elec_{b,i} * ECF_y * CDDCF_y - Elec_{p,y,i}) * Elec_{CO2} + \sum_{i,j=1}^{I,J} (F_{b,i,j} * HDDCF_y - F_{p,y,i,j}) * Cal_j * F_{CO2\,j} - L_y$$

Where:

ER_y	= Emission Reduction in year *y* in metric tons ("t") CO_2e/yr
i	= Dwelling
$Elec_{b,i}$	= Electricity consumed in the year prior to Project implementation for Dwelling *i* in kWh (baseline consumption)[10]
$Elec_{p,y,i}$	= Electricity consumed by the Project in year *y* for Dwelling *i* in kWh (Project consumption)
ECF_y	= Electricity correction factor for year *y* to be applied to the baseline
$CDDCF_y$	= Cooling degree days correction factor for year *y*
$HDDCF_y$	= Heating degree days correction factor[11] for year *y*
$F_{b,i,j}$	= Fuel type *j* consumed in the year prior to Project implementation for Dwelling *i* in the appropriate mass, or volume unit (baseline consumption)
$F_{p,y,i,j}$	= Fuel type *j* consumed by the Project in year *y* for Dwelling *i* in the appropriate mass, or volume unit (Project consumption)
Cal_j	= Calorific value of fuel type *j* in GJ/mass or volume
$Elec_{CO2}$	= Grid emission factor in tCO_2e/kWh
$F_{CO2,j}$	= The CO2 emission factor per unit of energy of fuel type *j* expressed in tCO_2e / GJ
L_y	= Leakage in year *y*
I	= Number of Dwellings
J	= Number of fuel types
j	= Fuel type
y	= Any consecutive twelve months during the Project's crediting period, and shall be defined with an integer from 1 on in a consecutive manner

[10] If multiple dwellings within a single building are served by a single meter, the electricity consumption unit shall change to kWh/m2 and the equation shall be multiplied by the area of each individual dwelling. Consequently, the area of each dwelling shall be recorded and included in the monitoring parameters.

[11] When fossil fuel is the cooling source the CDDCF shall replace the HDDCF in the equation. Conversely, when electricity is the heating source the HDDCF shall replace the CDDCF in the equation.

Leakage, L_y, shall be calculated as follows:

Equation 7

$$L_y = L_{CO2,y} + L_{HFC,y}$$

Leakage from continued operation of Appliances, $L_{CO2,y}$, shall be calculated as follows:

Equation 8

$$Lc_{O2,y,} = \sum_{k=1}^{K} (a_{np,k,y} * h_k * E_{dem,pre,k}) * Elec_{CO2} + \sum_{t=1}^{T-1} L_{(y-t),CO2}$$

Where:

$a_{np,k,y}$ = Appliance not properly disposed of Appliance type k in year y
K = Number of Appliance types
$E_{dem,pre,k}$ = Electricity demand of Appliance type k before replacement
h_k = Annual working hours of Appliance type k
$Elec_{CO2}$ = Grid emission factor in tCO2e/kWh
T = Years from beginning of crediting period

Leakage from improper disposal of refrigerators or air conditioners, $L_{HFC,y}$ shall be calculated as follows:

Equation 9

$$L_{HFC,y} = \sum_{k=1}^{K} a_{np,k,y} * RCC_a * GWP_R * \frac{1t}{1{,}000{,}000g}$$

Where:

RCC_a = Charge capacity of refrigerant gas of replaced cooling Appliance a in grams
GWP_R = Global Warming Potential of refrigerant gas R used in Appliance in tons CO_2equivalent per ton of R

Table 4: GWP for common refrigerant types

Refrigerant Type	**HFC-23**	**HFC-32**	**HFC-125**	**HFC-134a**	**HFC-143a**	**HFC-152a**
GWP 100yr (IPCC 1996)	11700	650	2800	1300	3800	140

Refrigeration equipment often uses blends of HFC refrigerant gases. The GWP of these blends should be calculated based on the proportion of different refrigerants used[12].

1.2 The grid emission factor ($Elec_{CO2}$) shall be calculated in a transparent and conservative manner based on one of the following approaches:

[12] Examples of the available compositions of refrigerant blends are available at the U.S. Environmental Protection Agency website: http://www.epa.gov/Ozone/snap/refrigerants/refblend.html

A combined margin, consisting of the combination of operating margin and build margin according to the procedures prescribed in the most recent CDM 'Tool to calculate the emission factor for an electricity system'. The grid emission factor shall be monitored following either the *Ex ante* option or the *Ex post* option within the CDM Tool.

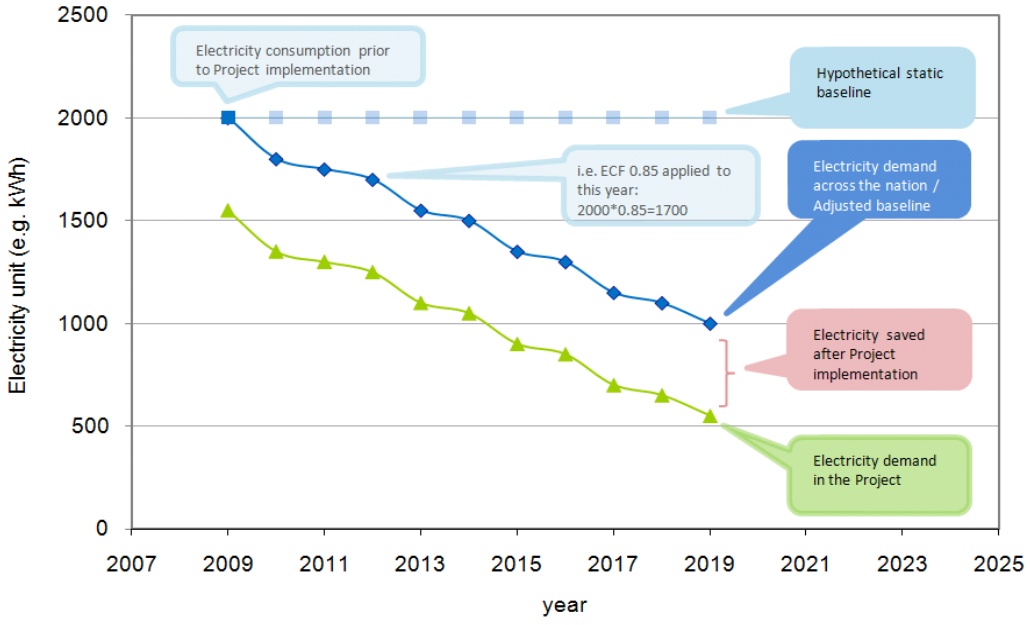
Or

The weighted average emissions (in tCO2e/kWh) of the current generation mix obtained from a regulated source. The data from the most recent year for which data are available shall be used. The grid emission factor shall be monitored annually, and updated as the regulated source publishes data. If the grid emission factor is published later than year *y*, the emission factor from an earlier year, up to three years prior (*y-3*), may be used.

1.3 The ECF represents the trend in electricity demand based on average electricity consumption within a region or state over a period of at least ten years. Historical data from a recognized national authority may be used to determine the ECF. Projected trends in changes in the rate of electricity demand reported by a national authority may also be used as the ECF[13]. The ECF shall be stated as a multiplier. For example, 0.98 represents an electricity consumption growth rate of -2%.

The Electricity Correction Factor ("ECF") is used to update the baseline electricity consumption based on decreases in electricity demand over time. The ECF shall only be applied when it is less than 1 to maintain conservativeness in the emission reduction calculation. This factor shall be applied to the calculation of the emission reductions after Project implementation because electricity consumption in the baseline may not remain the same (see Figure 3). The factor shall be determined from local, regional or national electricity household consumption data from a government agency, a public utility or regulatory agency, or a recognized energy research organization.

In a situation where overall electricity consumption decreases, the Electricity Correction Factor ensures against over-estimation of emission reductions (see Figure 4).



[13] Examples of reported values that may be used as an ECF are available at the Department of Energy website: http://apps1.eere.energy.gov/states/electricity.cfm/state=ME.

Figure 4 : This graph shows how the adjusted consumption approach takes into account a reduction in electricity consumption over time. Failure to adjust for decreasing consumption over time would result in an over-estimation of emission reductions.

1.4 The Heating/Cooling Degree Day Correction Factors (HDDCF and CDDCF) are used to update the baseline energy consumption annually based on changes in temperature. These factors account for changes in heating/cooling degree days and associated changes in heating and cooling loads (see Figure 3). The factors shall be determined based on data from reputable regional or national meteorological organizations[14].

The Heating Degree Day Correction Factor shall be calculated as follows:

Equation 10

$$HDDCF_y = \frac{HDD_y}{HDD_b}$$

The Cooling Degree Day Correction Factor shall be calculated as follows:

Equation 11

$$CDDCF_y = \frac{CDD_y}{CDD_b}$$

Where:

HDD_y = Heating degree days for year *y* after the retrofit

HDD_b = Heating degree days for one year before the retrofitCDD_y= Cooling degree days for year *y* after the retrofit

CDD_b = Cooling degree days for one year before the retrofit

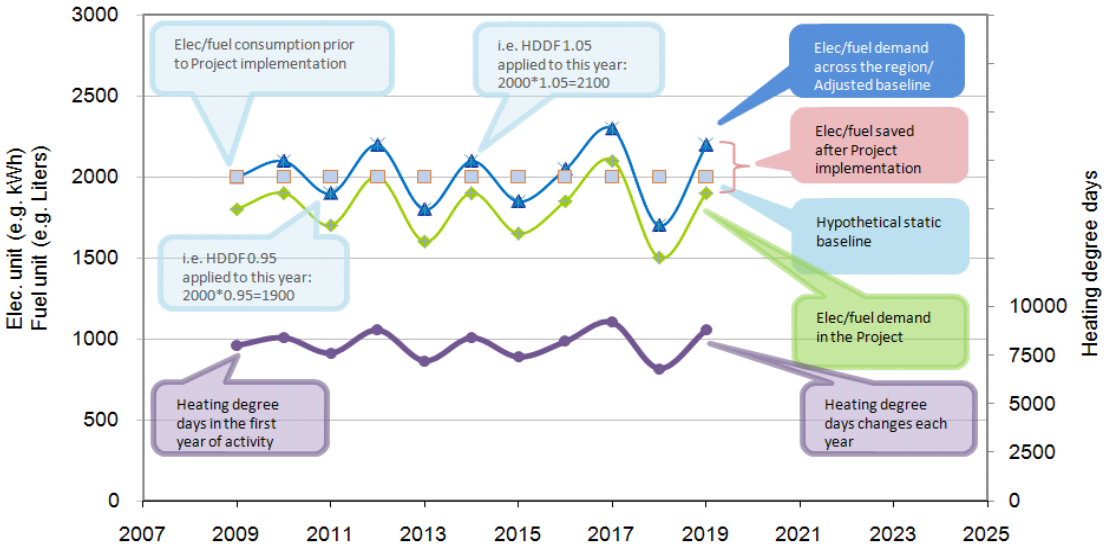


Figure 5: This graph shows how heating degree days affect fuel/electricity consumption over time. Failure to adjust the baseline based on changes in temperature would result in inaccurate calculation of emission reductions.

[14] An example of such organization is the National Oceanic and Atmospheric Administration (NOAA) in the United States.

Quality Assurance

1.5 When using the adjusted consumption approach, a sample group of Dwellings Weatherized as part of the Project shall be monitored to ensure the reduction in energy consumption and resulting reduction in emissions is real. The sample group shall measure the emission reductions resulting from the change in energy consumption. In case of a significant discrepancy between emission reductions calculated according to the approach and emission reductions calculated from the sample group, the adjusted baseline consumption approach shall be calibrated accordingly. The sample size of the sample group shall be established by multiplying 0.6 by the square root of the total number of Dwellings, *i*, or Appliances, included in the Project[15]. Monitoring of the sample group for quality assurance shall occur for two years and shall consist of collecting electricity and fuels bills that represent a twelve month period.

When the data come from two different processes, such as the adjusted consumption calculation and the measurements from the sample group, significant discrepancy is defined on the basis of an independent 2-sample t-test for equality of two means. If the value T of the above statistic obtained from a t-value table or calculation is greater than the corresponding value of the t-distribution for a 95% confidence level and degrees of freedom given by 2n-2, then the null hypothesis of equal means is rejected and the observed discrepancy is concluded to be significant.

A t-test is a standard statistical tool and readily available. One of the t-tests set forth below shall be applied. The particular test shall be determined by the type of samples, samples sizes and assumptions made on the underlying population variances.

1. An independent 2-sample t-test for samples of equal sizes and equal variances shall be used when the number of observations (data points) in both samples is equal and it can reasonably be assumed that the population variance of both samples is the same.

2. An independent 2-sample t-test for unequal sample sizes and equal variances shall be used when the number of observations (data points) in both samples is not equal and it can reasonably be assumed that the population variance of both samples is the same.

3. An independent 2-sample t-test for unequal sample sizes and unequal variances shall be used when the two data samples are of unequal size and it can be reasonably assumed that the population variance is different. This test is referred to as Welch's t-test.

1.6 The parameters to be monitored in the adjusted consumption approach are listed in Table 5 below.

Table 5. Monitoring parameters for the adjusted consumption approach

Parameter Description	Parameter	Unit	Source	Frequency
Electricity consumed in the year prior to Project implementation in	$Elec_{b,i}$	kWh/yr	Electricity bills for 12 months pre-retrofit. Bills for a sample of the Dwellings in the	Once

[15] The equation for determining the minimum sample size number for quality assurance purposes was taken from the surveillance requirements in the IAF Guidance on the Application of ISO/IEC Guide 66 Issue 4 IAF GD: 2006.

Dwelling i (baseline consumption)			Same Building Stock shall be monitored, or bills may be collected for all Dwellings in the Project.	
Electricity consumed by the Project in year *y* for Dwelling *i*	$Elec_{p,y,i}$	kWh/yr	Post-retrofit electricity bills	Collected monthly, recorded annually
Fuel type *j* consumed in the year prior to Project implementation for Dwelling *i* (baseline consumption)	$F_{b,i,j}$	Mass or volume per Dwelling per year	Pre- retrofit fuel bills covering a twelve month period. Bills for a sample of the Dwellings in the Same Building Stock shall be monitored, or bills may be collected for all Dwellings in the Project.	Once
Fuel type *j* consumed by the Project in year y for Dwelling *i*	$F_{p,y,i,j}$	Mass or volume per Dwelling per year	Post- retrofit fuel bills covering a twelve month period[16,17]	Annually
Calorific value of fuel type *j*	Cal_j	GJ/mass or GJ/volume	Local, regional or national data. If unavailable, IPCC default values may be used.	Once
Grid emission factor for the regional electricity source	$Elec_{CO2}$	tCO_2e/kWh	Obtained from a recognized authority; or calculated by the Project proponent based on raw data	As per approach listed in Part C, section 1.2.

[16] Fuel consumption shall be based on fuel purchased as reflected in the billing. Some households may store some fuel, or refill the tank before it is empty. However, the fuel storage level will become inconsequential over time as any fuel purchased to fill the fuel tank above the storage level will be consumed and therefore reflected in the billing upon refueling. Any remaining differences in the filling level, before Project implementation and at the end of the Project lifetime, of individual households will cancel each other out over the entire sample of Dwellings.

[17] In the case where consumed energy for each household cannot be measured separately or in the case of district heating, the temperature in/out and water discharge (flow rate) of the heating system shall be monitored. Fuel consumption monitoring shall take place using the utility company fuel inventory for that specific district heating system.

			obtained from a local, or national electric utility.	
CO2 emission factor for fuel type *j* (baseline fuel)	F_{CO2j}	tCO_2e / GJ	Local, regional or national data. If unavailable, IPCC default emission factors may be used.	Once
Electricity correction factor for year *y* The ECF is only to be applied in the equation if it is negative.	ECF_y	-	Calculated by the Project based on national energy statistics.	Applied annually
Cooling degree days for year *y*	CDD_y	Degree Days	Regional statistics	Annually
Cooling degree days in the year prior to Project implementation	CDD_b	Degree Days	Regional statistics	Once
Heating degree days for year *y*	HDD_y	Degree Days	Regional statistics	Annually
Heating degree days in the year prior to Project implementation	HDD_b	Degree Days	Regional statistics	Once
Number of fuel types	*J*	-	Project proponent database	Annually
Number of retrofitted Dwellings	*I*	-	Project proponent database	Annually
Continued operation of the installed measures	*C*	-	This parameter will be monitored in the sample of Dwellings selected for quality assurance monitoring. Non-operational measures shall be excluded from ER calculations.	Annually
Replaced Appliance of type *k* not properly disposed of	$a_{np,k,y}$	-	Disposal documentation and Project proponent	Annually

in year *y*			database	
Electricity demand of Appliance *k* before replacement	$E_{dem.pre,k}$	kW	Nameplate, or manufacturer's specification sheet, or direct metering of the Appliance	Once pre-replacement
Annual working hours of Appliance *k*	h_k	Hours	Sampling, consumer surveys, or common practice based on local, regional or national data[18]	Once, may be updated
The refrigerant charge capacity of the cooling Appliance not properly disposed of.	RCCa	Grams	Manufacturer's specification sheet on the cooling Appliance.	Once
Type of refrigerant used in the cooling Appliance.	R	-	Manufacturer's specification sheet on the cooling Appliance.	Once
Quality assurance sample group of fuel consumption within the Dwelling	-	Mass or volume per Dwelling per year	Fuel bills covering a twelve month period. Bills for the sample group sample of Dwellings in the Same Building Stock shall be monitored.	Annually, for 2 years
Quality assurance sample group of electricity consumption within the Dwelling	-	kWh/yr	Electricity bills covering a twelve month period. Bills for the sample group sample of Dwellings shall be monitored.	Annually, for 2 years

2. Pre- and post-retrofit audit approach

Monitoring emission reductions shall be based on the data generated by a pre- and post- retrofit energy audit for a sample of the Dwellings. A pre-retrofit audit shall take place once before Project

[18] For example, in the United States, the US Department of Energy publishes annual operating hours of common household appliances in the Buildings Energy Data Book. This information is publically available at http://buildingsdatabook.eren.doe.gov/TableView.aspx?table=2.1.16

implementation for every Dwelling and a post-retrofit audit shall take place once after the retrofit has been completed for a sample of the Dwellings. In every multi-family building, a representative sample of the Dwellings shall undergo a pre- and post-retrofit audit. The pre-retrofit audit shall determine the electricity demand and heat load in the baseline. The pre-retrofit electricity demand and heat load shall then be compared to the post-retrofit electricity demand and heat load. This comparison shall provide the Electricity Demand Reduction Factor and the Heat Load Reduction Factor, which shall be used to calculate emission reductions created by the Project.

2.1 To calculate emission reductions, the reduction factors obtained from the pre- and post- energy audit shall be applied to the baseline consumption of electricity and fuel. The result shall then be multiplied by the emission factor of the fuel type. Emission reductions shall be adjusted for changes in electricity demand over time and adjusted for heating/cooling degree days during the crediting period.

2.2 Energy auditors must be certified by a public authority or a private certification program recognized by a public authority. Energy audits shall be conducted using industry best-practices, cover both fuel and electricity consumption, include diagnostic tests (such as a blower door test, pressure pan test or thermal imaging) and use energy modeling software, or appropriate calculations[19].

2.3 The Electricity Demand Reduction Factor ("EDF") shall be calculated for a sample of the Dwellings as follows:

Equation 12

$$EDF = 1 - \frac{\sum_{s=1}^{S} E_{dem,post,s}}{\sum_{s=1}^{S} E_{dem,pre,s}}$$

The Heat Load Reduction Factor (HLF) shall be calculated for a sample of the Dwellings as follows:

Equation 13

$$HLF = 1 - \frac{\sum_{s=1}^{S} H_{load,post,s}}{\sum_{s=1}^{S} H_{load,pre,s}}$$

Where:

EDF	= Electricity demand reduction factor (no unit)
$E_{dem,post,s}$	= Electricity demand post-retrofit for Dwelling *s*, kW
$E_{dem,pre,s}$	= Electricity demand pre-retrofit for Dwelling *s*, kW
HLF	= Heat load reduction factor (no unit)
$H_{load,post,s}$	= Heat load post-retrofit for Dwelling *s*, kWh/m^2
$H_{load,pre,s}$	= Heat load pre-retrofit for Dwelling *s*, kWh/m^2
S	= Number of sample Dwellings
s	= sample Dwelling undergoing post retrofit audit

[19] In the United States there are several established energy auditing programs that are credible and accepted as industry best practice. Examples include, but are not limited to RESNET HERS rating, Building Performance Institute Audit, Home Performance with Energy Star, Maine Certified Energy Audit. The certification process is a substitute for a single industry standard.

2.4 Emission reductions shall be calculated as follows:

Equation 14

$$ER_y = \sum_{i=1}^{I} Elec_{b,i} * EDF * ECF_y * CDDCF_y * Elec_{CO2} + \sum_{i,j=1}^{I,J} F_{b,i,j} * HLF * HDDCF_y * Cal_j * F_{CO2} - L_y$$

Leakage, L_y, shall be calculated using Equation 7.

Quality Assurance

2.5 When using the pre- and post-audit approach, energy bills based on direct metering of consumption shall be collected for one year pre-retrofit and compared with post-retrofit energy bills based on direct metering of consumption in a sample of Dwellings. When dealing with non-regulated fuels, an acceptable alternative measure shall be compared to that same measure as shown in the post-retrofit audit to ensure the energy savings were achieved. The sample size for quality assurance samples shall be established by multiplying the 0.6 by square root of the total number of Dwellings, *i*, or Appliances, included in the Project. The reduction in demand as calculated in Equation 12 and Equation 13, shall be compared to the reduction in consumption based on directly metered electricity or natural gas consumption data, or in the case of non-regulated fuels an acceptable alternative measure. The sample group shall be tested for a significant discrepancy between the calculated reduction in energy demand as shown in the post-retrofit audit and actual reduction in consumption calculated from directly metered energy bills. When dealing with non-regulated fuels an acceptable alternative measure shall be used, as noted above. If the discrepancy between the two mean values is found to be significant, the mean energy consumption from the directly metered value shall be used to calculate the HLF or EDF.

When the two data samples come from the same Dwelling, significant discrepancy is defined on the basis of a dependent 2-sample t-test for equality of two means. If the t-value of the above statistic obtained from a t-value table or calculation is greater than the corresponding value of the t-distribution for a 95% confidence level and degrees of freedom given by n-1, then the null hypothesis of equal means is rejected and the observed discrepancy is concluded to be significant.

A dependent 2-sample t-test shall be applied to test for the difference of the two means. The two means to be compared shall be from the sample group of weatherized Dwellings, and shall be the mean of the energy demand determined by the post-retrofit audit and the mean of the directly metered energy bill in the case of electricity and natural gas. However, in the case of non-regulated fuels, the two means compared shall be based on an acceptable alternative measure, such as blower door test value as shown in the post-retrofit audit, and the blower door test value recorded one year post-retrofit.

2.6 The parameters to be monitored in the pre-and post-retrofit audit approach are listed in Table 6.

Table 6. Monitoring parameters for pre- and post-retrofit audit approach

Parameter Description	Parameter	Unit	Source	Frequency
Electricity consumed in the year prior to	$Elec_{b,i}$	kWh/yr	Electricity bills for 12 months pre-retrofit. Bills for a	Once

Project implementation in Dwelling *i* (baseline consumption)			sample of the Dwellings in the Same Building Stock shall be monitored, or bills may be collected for all Dwellings in the Project.	
Electricity demand pre-retrofit for Dwelling *i*	$E_{dem,pre,i}$	kW	Pre-retrofit audit report	Once
Electricity demand post-retrofit for Dwelling *i*	$E_{dem,post,i}$	kW	Post-retrofit audit report	Once
Grid emission factor for the regional electricity source	$Elec_{CO2}$	tCO_2e/kWh	Obtained from a recognized authority; or calculated by the Project proponent based on raw data obtained from a local, or national electric utility.	As per approach listed in Part C, section 1.2.
Fuel type *j* consumed in the year prior to Project implementation for Dwelling *i* (baseline consumption)	$F_{b,i,j}$	Mass or volume per Dwelling per year	Pre- retrofit fuel bills covering a twelve month period. Bills for a sample of the Dwellings in the Same Building Stock shall be monitored, or bills may be collected for all Dwellings in the Project.	Once
Heat load pre-retrofit for Dwelling *i*	$H_{load,pre,i}$	$kWh/m^2/HDD$ $GJoules/m^2/HDD$	Pre-retrofit audit report	Once
Heat load post-retrofit for	$H_{load,post,i}$	$kWh/m^2/HDD$ $GJoules/m^2/HDD$	Post-retrofit audit report	Once

Dwelling *i*				
Calorific value of fuel type *j*	Cal_j	GJ/mass or GJ/volume	Local, regional or national data. If unavailable, IPCC default values may be used.	Once
CO2 emission factor for fuel type *j* (baseline fuel)	F_{CO2j}	tCO_2e / GJ	Local, regional or national data. If unavailable, IPCC default emission factors may be used.	Once
Electricity correction factor for year *y*	ECF_y	-	Calculated by the Project based on national energy statistics.	Applied annually
Cooling degree days for year *y*	CDD_y	Degree Days	Regional statistics. Use localized data when available	Annually
Cooling degree days in the year prior to Project implementation	CDD_b	Degree Days	Regional statistics. Use localized data when available	Once
Heating degree days for year *y*	HDD_y	Degree Days	Regional statistics. Use localized data when available	Annually
Heating degree days in the year prior to Project implementation	HDD_b	Degree Days	Regional statistics. Use localized data when available	Once
Number of fuel types	*J*	-	Project proponent database	Annually
Number of retrofitted Dwellings	*I*	-	Project proponent database	Annually
Number of sample Dwellings	*S*	-	Pre- and Post-retrofit audit reports	Once
Replaced Appliance of type *k* not properly disposed of in year *y*	$a_{np,k,y}$	-	Disposal documentation and Project proponent database	Annually

Annual working hours of Appliance *k*	h_k	Hours	Sampling, consumer surveys, or common practice based on local, regional or national data	Once, may be updated
Electricity demand of Appliance *k* before replacement	$E_{dem.pre,k}$	kW	Nameplate, or manufacturer's specification sheet, or direct metering of the Appliance	Once pre-replacement
The refrigerant charge capacity of the cooling Appliance not properly disposed of.	*RCCa*	Grams	Manufacturer's specification sheet on the cooling Appliance.	Once
Type of refrigerant used in the cooling Appliance.	*R*	-	Manufacturer's specification sheet on the cooling Appliance.	Once

3. Control group approach

In this approach a control group and a sample group shall be defined. The control group shall be comprised of Dwellings from the Same Building Stock that are not, and shall not be Weatherized[20]. The sample group shall be comprised of Dwellings to be Weatherized, or, in the case of mobile homes, replaced. Electricity and fuel bills shall be collected for both groups annually throughout the crediting period. The control group shall consist of Dwellings that have not been weatherized as part of the Project. The Project shall not prevent or deny Weatherization to any homeowner, or individual for the purpose of maintaining the control group. Instead, as the population of Weatherized Dwellings increases, the control group sample may include different Dwellings as long as the control group contains only non-Weatherized Dwellings.

3.1 The difference in the energy consumption between the control group and the sample group each year will constitute the fuel and electricity savings for all Dwellings in the Project for that year and shall serve as the basis for calculating emission reductions[21].

The sample group shall come from Dwellings included in the Project activity. The control group shall be selected from Dwellings not included in the Project activity and shall have the following requirements in addition to the requirements established in section 1.9 Part A:

1) Participants shall not have the ability to "opt-in" to the control group.
2) Once selected, homeowners shall be required to make their fuel and electricity bills available to the Project. Where appropriate, the homeowner will be requested to sign a waiver granting the Project proponent electronic access to directly metered electricity and gas bills.
3) Dwellings shall be in the Same Building Stock.

3.2 Emission reductions shall be calculated as follows:

Equation 15

$$ER_y = \sum_{b=1}^{B} \left\{ \{(Elec_{CG,y,b} - Elec_{SG,y,b}) * Elec_{CO2}\} + \sum_{j=1}^{J} \{(F_{CG,y,j,b} - F_{SG,y,j,b}) * Cal_j * F_{CO2\,j}\} \right\} * I_b - L_{y,b}$$

Leakage, $L_{y,b}$, shall be calculated for each Building Stock using Equation 7.

Where:

$Elec_{SG,y,b}$ = Mean electricity consumed by sample group Dwellings in Building Stock *b* in year *y*
$Elec_{CG,y,b}$ = Mean electricity consumed by control group Dwellings in Building Stock *b* in year *y*
$F_{SG,y,j,b}$ = Mean fuel type *j* consumed by sample group Dwellings in Building Stock *b* year *y*

[20] The control group sample size must be large enough to be statistically valid. When approaching complete saturation of Weatherized homes, the control group will diminish in size as the number of non-Weatherized homes diminishes. This is a risk that must be weighed when choosing the control group approach. One option for addressing the diminishing control group is to use the control group approach for as long as possible and then switch to the adjusted consumption approach. The control group monitoring will be able to be used as the baseline in the adjusted consumption approach.

[21] Since the energy consumed by retrofitted dwellings shall be directly compared to the energy consumed by non-retrofitted Dwellings within the Same Building Stock and the same year, there is no need to apply the Electricity and Heating/Cooling Degree Day Correction Factors.

$F_{CG,y,j,b}$ = Mean fuel type *j* consumed by control group Dwellings in Building Stock *b* in year *y*
I_b = Number of Dwellings in Building Stock *b*
$L_{y,b}$, = Leakage in Building Stock *b* in year *y*

To ensure conservativeness in the emission reduction calculation approach, a 95% confidence interval, with an alpha value equal to 5% (α =0.05) shall be applied to the fuel and/or electricity consumption within the control group and the sample group, denoted by $Elec_{SG,y,b}$, $Elec_{CG,y,b}$, $F_{SG,y,j,b}$, $F_{CG,y,j,b}$ above. The lower bound of the confidence interval of the control group, and the upper bound of the confidence interval of the sample group shall be the values compared to determine the emission reductions resulting from Project activity.

The 95% confidence interval shall be calculated as follows:

$$\bar{x} - Z_{0.025}(SE) < \mu < \bar{x} + Z_{0.025}(SE)$$

$$SE = \hat{\sigma} / \sqrt{n} \quad \text{and} \quad \hat{\sigma} = s * \sqrt{n/(n-1)}$$

Where:

$\bar{x}$ = the mean energy consumption calculated from the sample

$Z_{0.025}$ = 1.960, established standard value

s = the standard deviation calculated from the sample

n = the sample size

n-1 = the sample size minus one

μ = the mean of the population. This value is not actually calculated, instead it is contained within the upper and lower bounds of the equation.

SE = standard error

$\hat{\sigma}$ = standard deviation that approximates the standard deviation of the population, used to calculate the standard error.

3.3 The parameters to be monitored in the control group approach are listed in Table 7.

Table 7. Monitoring parameters for control group approach

Parameter Description	Parameter	Unit	Source	Frequency
Mean electricity consumed by sample group Dwellings in Building Stock b in year *y*	$Elec_{SG,y,b}$	kWh/yr	Electricity bills	Monitored monthly, calculated annually
Mean electricity consumed by control group Dwellings in	$Elec_{CG,y,b}$	kWh/yr	Electricity bills	Monitored monthly, calculated

Building Stock b in year *y*				annually
Mean fuel type *j* consumed by sample group Dwellings in Building Stock *b* year *y*	$F_{SG,y,j,b}$	Mass or volume, per Dwelling per year	Fuel bills	Monitored monthly, or as fuel is delivered, totaled annually
Mean fuel type *j* consumed by control group Dwellings in Building Stock *b* year *y*	$F_{CG,y,j,b}$	Mass or volume, per Dwelling per year	Fuel bills	Monitored monthly, or as fuel is delivered, totalled annually
Calorific value of fuel type *j*	Cal_j	GJ/mass or GJ/volume	Local, regional or national data. If unavailable, IPCC default values may be used.	Once
Grid emission factor for the regional electricity source	$Elec_{CO2}$	tCO_2e/kWh	Obtained from a recognized authority; or calculated by the Project based on raw data obtained from a local, or national electric utility.	As per approach listed in Part C, section 1.2.
CO2 emission factor for fuel type *j* (baseline fuel)	F_{CO2j}	tCO_2e / GJ	Local, regional or national data. If unavailable, IPCC default emission factors may be used.	Once
Number of fuel types	J	-	Project proponent database	Annually
Number of Dwellings in Building Stock b	I_b	-	Project proponent database	Annually
Replaced Appliance of type *k* not properly disposed of in year *y*	$a_{np,k,y}$	-	Disposal documentation and Project proponent database	Annually
Annual working hours of Appliance *k*	h_k	Hours	Sampling, consumer surveys, or common practice based on local,	Once, may be updated

			regional or national data	
Electricity demand of Appliance *k* before replacement	$E_{dem,pre,k}$	kW	Nameplate, manufacturer's specification sheet, or direct metering of the Appliance	Once pre-replacement
The refrigerant charge capacity of the cooling Appliance not properly disposed of.	RCCa	Grams	Manufacturer's specification sheet on the cooling Appliance.	Once
Type of refrigerant used in the cooling Appliance.	R	-	Manufacturer's specification sheet on the cooling Appliance.	Once

4. The deemed savings approach

4.1 Emission reductions for the replacement of Appliances shall be calculated as follows:

4.1.1 The electricity demand (rated capacity) of both the Appliance to be replaced and of the replacement Appliance shall be determined from the nameplate, manufacturer's specification sheet, or direct metering;

4.1.2 The typical annual hours of operation of the Appliance to be replaced in the Project area shall be recorded;

4.1.3 The emission reductions from an individual Appliance shall be calculated by comparing the electricity demand of the replacement Appliance with that of the replaced Appliance, multiplied by annual hours of operation and by the grid emission factor. To account for failed operation of Appliances a correction factor shall be applied.

4.1.4 Emission reductions shall be calculated as follows:

Equation 16

$$ER_y = \sum_{k=1}^{K} a_k (E_{dem.pre,k} - E_{dem.post,k}) * h_k * Elec_{CO2} * Corr_k - L_y$$

Leakage, L_y, shall be calculated using Equation 7.

Where:

$E_{dem,pre,k}$ =Electricity demand of Appliance type *k* before the replacement takes place
$E_{dem.post,,k}$ =Electricity demand of Appliance type *k* after the replacement

h_k =Annual working hours of the Appliance type *k*
$Corr_k$ =Correction factor for failed operation of each Appliance type *k*
a_k =Number of Appliances of each Appliance type *k*
K =Number of Appliance types
k = Appliance type

4.2 Monitoring shall consist of verifying the operation of a sample of the Appliances within the first year of installation and in three year intervals thereafter.

The parameters to be monitored in the deemed savings approach are listed in Table 8.

Table 8. Monitoring parameters for replacement of Appliances

Parameter Description	Parameter	Unit	Source	Frequency
Electricity demand of Appliance *k* pre-replacement	$E_{dem,pre,k}$	kW	Nameplate, manufacturer's specification sheet, or direct metering of the Appliance	Once, pre-replacement
Electricity demand of Appliance *k* post-replacement	$E_{dem,post,k}$	kW	Nameplate, manufacturer's specification sheet, or direct metering of the Appliance	Once, post-replacement
Annual working hours of Appliance *k*	h_k	Hours	Sampling, consumer surveys, or common practice based on local, regional or national data	Once, may be updated
Grid emission factor for the regional electricity source	$Elec_{CO2}$	tCO_2e/kWh	Obtained from a recognized authority; or calculated by the Project based on raw data obtained from a local, or national electric utility.	As per approach listed in Part C, section 1.2.
Correction factor for the failed operation of type	$Corr_k$	-	Surveys conducted by Project	Within the first year of installation and

of Appliance *k*			proponent	in years 1, 4 and 7 thereafter
Replaced Appliance of type *k* not properly disposed of in year *y*	$a_{np,k,y}$	-	Disposal documentation and Project proponent database	Annually
The refrigerant charge capacity of the cooling Appliance not properly disposed of.	*RCCa*	Grams	Manufacturer's specification sheet on the cooling Appliance.	Once
Type of refrigerant used in the cooling Appliance.	*R*	-	Manufacturer's specification sheet on the cooling Appliance.	Once
Number of Appliance type	*K*	-	Project proponent database	Once
Number of Appliances of each Appliance type k	a_k	-	Project proponent database	Once

5. The mobile homes approach

5.1 Emission reductions for the replacement of mobile homes shall be calculated as follows:

5.1.1 The heat load of both the mobile home to be replaced and of the replacement home shall be determined from best practice heat load modelling. In the case of the home to be replaced, the heat load may be calculated by applying a heat load formula that applies a default energy consumption value determined from statistically significant fuel consumption records[22]. In the case of the replacement home, the heat load shall be modelled taking into account the building specifications. The building specifications may include but are not

[22] The heat load formula shall be based on best practice energy modeling software that takes into account the number of rooms, the metric size of the rooms, the energy load per meter, and the degree days of the region. In the United States, for example, the design heat load calculation that is used to determine fuel award amounts in the national Low Income Home Energy Assistance Program may be used. That equation is: number of rooms multiplied by the square feet per room, multiplied by the BTU consumption per square foot per degree day multiplied by degree days, all divided by 1,000,000 BTUs to yield the MBTU needed to heat/cool the space. In metric the equation would be: number of rooms multiplied by the square meters per room, multiplied by the KJ consumption per square meter per degree day multiplied by degree days, all divided by 1,000,000 KJ to determine the GJ needed to heat/cool the space.

limited to; R-value of insulation in the floor, walls and ceiling, U-value and size of the windows, and the R-value of the skirting.

5.1.2 Emission reductions shall be based on the difference between pre- and post-replacement heat load[23] and pre-and post-replacement size of the mobile home, multiplied by the annual heating/cooling degree days, and both the calorific value and the emission factor of the fuel consumed within the Dwelling[24].

5.1.3 If Appliances are replaced at the same time the mobile home is replaced, the calculation of emission reductions from Appliance replacement shall follow the deemed savings approach. Total emission reductions shall be the sum of emission reductions from the replacement of the mobile home plus the emission reductions from replacement of the Appliances, minus leakage.

5.1.4 Emission reductions shall be calculated as follows:

Equation 17

$$ER_y = \sum_{i=1}^{I}((H_{load,pre,i} * S_{pre,i} - H_{load,post,i} * S_{post,i}) * HDD_y * F_{CO2\,j}) + ER_{ARy}$$

Note* In a region with a predominantly hot climate, the equation can be changed to incorporate cooling load $C_{load,pre,j}$ and Cooling Degree Days CDD_y, which would replace $H_{load,pre,j}$ and Heating Degree Days HDD_y respectively.

Where:

$H_{load,\ pre,i}$	= Heat load of mobile Dwelling *i* to be replaced
$H_{load,post,i}$	= Heat load of replacement Dwelling *i*
HDD_y/CDD_y	= Heating/cooling degree days
$S_{pre,i}$	= Size of Dwelling *i* to be replaced in m^2
$S_{post,i}$	= Size of replacement Dwelling *i* in m^2
ER_{ARy}	= Emission reductions from Appliance replacement
I	= Number of Dwellings

Emission reductions from Appliance replacement, ER_{ARy}, shall be calculated using Equation 16.

5.2 The parameters to be monitored in the mobile homes approach are listed in

[23] The heat load of a Dwelling shall include cooling load when both heating and cooling are provided by one central system.

[24] When electricity is the central heating/cooling source, the grid electricity factor shall replace both the fuel calorific value (Cal_j) and the fuel emission factor ($F_{CO_2,j}$). In this case, the heat load shall be expressed in kWh per square meter per degree day.

Table 9.

Table 9. Monitoring parameters for mobile homes approach

Parameter Description	Parameter	Unit	Source	Frequency
Heat load of mobile Dwelling *i* to be replaced	$H_{load,pre,i}$	kWh/m^2/HDD GJoules/m^2/HDD	Calculating the heat load by applying a heat load formula with default values derived from reliable regional energy consumption data.	Once
Heat load of replacement Dwelling *i*	$H_{load,post,i}$	kWh/m^2/HDD GJoules/m^2/HDD	Calculated using best practice heat load modeling based on the specification sheet provided by the manufacturer.	Once
Heating degree days in year *y*	HDD_y	Degree Days	Regional statistics	Annually
Cooling degree days in year *y*	CDD_y	Degree Days	Regional statistics	Annually
Size of Dwelling *i* to be replaced	$S_{pre,i}$	m^2	Project proponent database	Once for each Dwelling
Size of replacement Dwelling *i*	$S_{post,i}$	m^2	Project proponent database	Once for each Dwelling
CO2 emission factor for fuel type *j* (baseline fuel)	F_{CO2j}	tCO_2e / GJ	Local, regional or national data. If unavailable, IPCC default emission factors may be used.	Once
Electricity demand of Appliance *k* before replacement	$E_{dem,pre,k}$	kW	Nameplate, or manufacturer's specification sheet, or direct metering of the Appliance	Once pre-replacement
Electricity demand of Appliance *k* post-replacement	$E_{dem,post,k}$	kW	Nameplate, or manufacturer's specification sheet, or direct metering of the Appliance	Once post-replacement

Annual working hours of Appliance *k*	h_k	Hours	Sampling, consumer surveys, or common practice based on local, regional or national data	Once, may be updated
Correction factor for the failed operation of type of Appliance *k*	$Corr_k$	-	Surveys conducted by Project proponent	Within the first year of installation and in three year intervals thereafter
Grid emission factor for the regional electricity source	*ElecCO2*	tCO2e/kWh	Obtained from a recognized authority; or calculated by the Project based on raw data obtained from a local, or national electric utility.	As per approach listed in Part C, section 1.2.
Replaced Appliance of type *k* not properly disposed of in year *y*	$a_{np,k,y}$	-	Disposal documentation and Project proponent database	Annually
The refrigerant charge capacity of the cooling Appliance not properly disposed of.	*RCCa*	Grams	Manufacturer's specification sheet on the cooling Appliance.	Once
Type of refrigerant used in the cooling Appliance.	*R*	-	Manufacturer's specification sheet on the cooling Appliance.	Once
Number of retrofitted Dwellings	*I*	-	Project proponent database	Annually