Energy Efficiency of Existing Buildings Retrofits Quantification Protocol

Important Caveat: This is a historical document; the scope of the proposed federal GHG offset system has not been finalized. This protocol was not approved by the federal government and may not reflect current federal policy decision.

INTRODUCTION

[1] The purpose of this document is to establish a protocol to quantify the reductions of greenhouse gases (GHGs) achieved by retrofitting existing (not new) buildings.

Deleted: to be eligible to receive credits under the Offset System for GHGs in Canada

Background

[2] The Offset System is a key component of the market-based mechanism for achieving project-based GHG reductions and removals outlined in the new climate change plan for Canada. The role of the Offset System is to establish and implement the rules and processes for the identification of eligible projects, quantification and verification of reductions achieved from these projects, and the issuance of resulting tradable offset credits.

[3] A project proponent (PP) must quantify emission reductions in order to be allocated Offset Credits that can be traded in the Offset System. One way to quantify emission reductions is to use an Offset System Quantification Protocol (OSQP): a standardized Quantification Protocol pre-validated by the Minister for use in the Offset System via reference.

Core References

[4] This PROTOCOL complies with, and is subordinate to the requirements of the Offset System as contained in the *Offset System for Greenhouse Gases 2005 Overview Paper and Technical Background Document*. In the event of a conflict between this PROTOCOL and the *Technical Background Document*, the requirements of the latter shall govern. Some of the general elements contained in this Annex 2 reference have been streamlined and/or modified to suit the specific nature of this PROTOCOL.

[5] This PROTOCOL is consistent with the key concepts and approach contained in "*Draft International Standard ISO/DIS 14064-2, Greenhouse Gases – Part 2*" ("ISO 14064-2"). In the event of a conflict between this PROTOCOL and ISO 14064-2, the requirements of this PROTOCOL shall govern.

[6] For the sake of consistency and brevity, some requirements of these two core reference documents (*Technical Background Document* and ISO 14064-2) are incorporated into this PROTOCOL by reference only.

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[7] Practices of historical and existing protocols such as Canadian pilots (PERRL and GERT), CDM methodologies, and other initiatives have been taken into consideration when writing this PROTOCOL. Relevant information from these sources has been incorporated into the PROTOCOL in a manner to suit the requirements of the Offset System.

Scope of the Protocol

[8] This protocol deals with the quantification of direct emission reductions through the retrofit of an existing building.

[9] If the PP abides by all the procedures in this Protocol it is sufficient to achieve validation of a project.

[10] Through the Offset System, individuals, businesses and organizations will be able to earn offset credits when they implement projects that result in incremental emission reduction or removals beyond what they would have done under normal business activities (i.e. "business as usual"). Once created, verified offset credits can be sold to the Climate Fund, to Large Final Emitters (LFEs) (i.e. sectors that contribute significantly to GHG emissions, such as oil and gas, mining and manufacturing and thermal electricity sectors), and potentially to other domestic buyers.

[11] This document deals with the quantification of direct emission reductions by retrofitting existing buildings through improved energy efficiency and fuel switching.

[12] If the PP abides by all the procedures in this Protocol it is sufficient to achieve validation of a project.

Offset System Eligibility Criteria

[13] In providing information to the PA and following any action required by this Protocol, the PP should adhere to the ISO/DIS 14064-2 [January 2005].

Scope

[14] To qualify for credits, the reductions or removals must meet several criteria. These include the following criteria:

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Deleted: The Program Authority (PA) will also use this Protocol as a guide for certification of Offset Credits.

Deleted: The PA will also use this Protocol as a guide for certification of Offset Credits. Please see the Offset System Design Paper [the Offset System Specification will replace the Design Paper as a reference document] for further details on how a project will be registered, validated, verified, and certified.

Deleted: and the Offset System Design Paper [the Offset System Specification will replace the Design Paper as a reference document]. The requirements below outline how an existing-building retrofit project must be in accordance with the Offset System criteria.

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Start Date

[15] Projects must have a start date no earlier than XXXXXX. Verifiable information confirming the start date of the project must be provided to the Offset System PA. The start date for a retrofit project is considered to be when an existing building has been completely retrofitted. The registration date is the point after which offset credits may be issued, and may be later than the start date of the project. Registration will begin January 1, 2008.

Quantifiable

[16] The reductions or removals of GHGs from a registered offset project must be quantifiable (i.e. measurable) using recognized protocols or methodologies. Such protocols are currently under development, and to the extent possible will be developed and approved in advance so as to facilitate the timely processing of projects by the Offset System.

Achieve Reductions within the Registration Period

[17] The registration period begins on January 1st, 2000; Offset Credits will not be issued for emission reductions created prior to this registration period.

[18] A project may be registered for eight years; registration can extend beyond the first Kyoto commitment period (2008-2012).

Deleted: However, the Government of Canada does not make any commitment related to the value of Offset Credits during any period.

Real

[19] An offset project must be a specific and identifiable action that results in GHG emission reductions and removals (and does not simply result in emissions moving to another site or source).

Surplus

[20] Offset project reductions or removals will only be eligible to generate offset credits if such reductions or removals have not occurred as the result of a specified federal greenhouse gas regulation, program, or incentive.

[21] Relevant documentation to establish the effect of these requirements must be provided in the description of the project for validation by the Offset System PA.

Verifiable

[22] Qualified, accredited third parties must be able to verify that the reductions or removals have been achieved as claimed.

Unique

[23] Any emission reductions quantified using this document's methodology cannot have already received Offset Credits; the emission reductions must be unique. A

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precise description of the location of the building site and a clear definition of the ownership of the reductions should prevent double issuance.

Ownership

[24] The PP is to provide an ownership claim and evidence to support the claim including quit claims or private contracts with potential claimants of ownership. Potential claimants of ownership should be listed by the PP and at minimum include the: owner and operator of the building.

APPLICATION OF THE QUANTIFICATION PROTOCOL

Describing the Project

[25] The PP will prepare a project plan that includes the following components:

a) Project title, purpose(s), and objective(s);

b) Description of the project and justification that it is in the scope of this protocol;

c) Project location, including geographic and physical information allowing the unique identification and delineation of the building. The delineation of the retrofit project must cover the entire building site in order for the PA to validate that GHGs will be accounted in the calculation of the emission reductions;

d) Annual GHG emission reductions stated in tonnes of CO_2 equivalent, likely to occur from the retrofit project;

e) Identification of risks that may substantially affect the project's GHG emission reductions;

f) Roles and responsibilities, including contact information of the PP, other project participants, relevant regulator(s) and/or administrators of any GHG program(s) or clean energy crediting scheme to which the project subscribes;

g) Any information relevant for project eligibility and quantification of emission reductions including legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and temporal information;

h) A summary of the environmental impact assessment (if available) must be submitted to the PA, before issuance of offset credits;

i) Chronological plan of the start date, end date, frequency of monitoring and reporting and frequency of verification and certification according to OS

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specification, including relevant project activities in each step of the GHG project cycle.

QUANTIFICATION AND VERIFICATION

[26] Following the customary procedure to demonstrate measurable GHG emission reductions, the PP must document the calculation methodology of the emissions before the existing-building retrofit takes place (baseline scenario) and the emissions after the existing-building retrofit takes place (project scenario). Using this approach for existing-building retrofit projects would mean that GHG emissions of the existing building would be quantified before and after the project.

[27] Baseline emissions are those emissions that are offset by the energy efficiency and fuel switching measures in existing buildings. Those baseline emissions are associated with the consumption of natural gas, oil and/or electricity supplied from the power grid. Baseline emissions comprise four components:

1) *CO_2 from combustion*. Average annual CO_2 emissions from combustion of natural gas and/or oil that was consumed in the existing building in the three years prior to the retrofit.

2) *CH_4 from combustion*. Average annual CH_4 emissions from combustion of natural gas and/or oil that was consumed in the existing building in the three years prior to the retrofit.

3) *N_2O from combustion*. Average annual N_2O emissions from combustion of natural gas and/or oil that was consumed in the existing building in the three years prior to the retrofit.

4) *CO_2 from electricity supplied from the power grid*. Average annual CO_2 emissions associated with the electricity supplied from the power grid and consumed in the existing building in the three years prior to the retrofit.

Baseline Scenario: Emissions from Natural Gas, Oil and Electricity from the Power Grid

[28] The determination of the baseline equation is broken into three separate equations that additively account for the four components for the baseline emissions. The first equation accounts for emissions from the combustion of natural gas; the second accounts for the emissions from the combustion of oil;

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and the third accounts for the emissions from the consumption of electricity supplied from the power grid.

[29] The first three components of the baseline emissions are proportional to the natural gas, oil and/or electricity consumption by the building. Those emissions can be represented as the product of an emissions intensity factor for natural gas in equation 1, oil in equation 2 and electricity in equation 3.

[30] The consumption of natural gas for the baseline is determined as follows:

Annual baseline emissions from combustion of natural gas, ABE_{NG} (CO_2/year)

$$ABE_{NG} = NEF_{NG} \times VNG_B / year \qquad \text{(Eq. 1)}$$

$$= \left[\frac{1891\,g}{m^3} + \left(\frac{1.9\,g}{m^3} \times 21 \right) + \left(\frac{0.033\,g}{m^3} \times 310 \right) \right] \times \left(VNG_B / year \right)$$

Where NEF_{NG} = National emissions factor of natural gas (grams of CO_2 equivalent emissions per cubic meter of natural gas for CO_2, CH_4 and N_2O, respectively)
VNG_B = Volume of natural gas input in m^3 in baseline scenario

[31] The consumption of oil for the baseline is determined as follows:

Annual baseline emissions from combustion of oil, ABE_O (CO_2/year)

$$ABE_O = NEF_O \times VO / year \qquad \text{(Eq. 2)}$$

$$= \left[\frac{283{,}000\,g}{m^3} + \left(\frac{0.6\,g}{m^3} \times 21 \right) + \left(\frac{3.1\,g}{m^3} \times 310 \right) \right] \times \left(VO_B / year \right)$$

Where NEF_O = National emissions factor of natural gas (grams of CO_2 equivalent emissions per cubic meter of natural gas for CO_2, CH_4 and N_2O, respectively)
VO_B = Volume of oil input in m^3 in baseline scenario

[32] The consumption of electricity consumed from the power grid for the baseline is determined as follows:

Annual baseline emissions from consuming electricity from the power grid, ABE_{ELEC} (CO_2/year)

$$ABE_{ELEC} = \frac{\left(\frac{MWh}{year}\right)}{0.88} \times NIF_{ELEC} \quad \text{(Eq. 3)}$$

Where NIF_{ELEC} = National intensity factor of electricity production (kg/MWh).

[33] The emissions from electricity from the power grid are accounted for using the National Intensity Factor to measure GHG intensity of electricity generation. The National Intensity Factor is the average intensity of all electricity generation (thermal and non-thermal) in Canada. The National Intensity Factor may be adjusted periodically.

[34] Equation 2 represents the annual baseline for consumption of electricity from the grid. The equation reflects the electricity used by the PP as well as the average12% transmission (8%) and distribution (4%) losses.[1] Since consumption of electricity is measured at the facility, the 12% loss is accounted for by dividing the consumption of electricity by 0.88. The National Intensity Factor (NEF_{ELEC}) is a value derived by the Offset System Program.

[35] The PP must demonstrate that the electricity used in the baseline scenario would have been purchased from the Canadian electricity grid.

[36] Equation 4 is the emissions baseline for consumption of natural gas, oil and electricity from the grid by the existing building. It accounts for all of the four components of baseline emissions. The value for an energy type not used by the existing building for the three years prior to the retrofit will be zero.

[37] The emissions for the baseline is determined as follows:

[1] MK Jaccard and Associates, *Strategic Options for Combined Heat and Power in Canada*. 15. 2004. Prepared for OEE, NRCan. According the MK Jaccard and Associates, the values of transmission and distribution loss are the factors used by BC Hydro load forecasting, consistent with data from the IEA.

Annual baseline emissions, ABE (CO_2/year)

$$ABE = ABE_{NG} + ABE_{O} + ABE_{ELEC} \quad \text{(Eq. 4)}$$

Project Scenario: GHG Emissions from a Retrofit Project

[38] The reduction in GHG emissions is primarily derived by either reducing the amount or energy consumed or by switching from one energy type to another as a result of the retrofit project for the existing building.

[39] The consumption of natural gas for the retrofit project is determined as follows:

Annual retrofit project emissions from combustion of natural gas, APE_{NG} (CO_2/year)

$$APE_{NG} = NEF_{NG} \times VNG_{R} / year \quad \text{(Eq. 5)}$$

$$= \left[\frac{1891g}{m^3} + \left(\frac{1.9g}{m^3} \times 21 \right) + \left(\frac{0.033g}{m^3} \times 310 \right) \right] \times \left(VNG_{R} / year \right)$$

Where NEF_{NG} = National emissions factor of natural gas (grams of CO_2 equivalent emissions per cubic meter of natural gas for CO_2, CH_4 and N_2O, respectively)
VNG_R = Volume of natural gas input in m^3 in project scenario

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[40] The consumption of oil for the retrofit project is determined as follows:

Annual retrofit project emissions from combustion of oil, APE_O (CO_2/year)

$$APE_O = NEF_O \times VO_R / year \qquad \text{(Eq. 6)}$$

$$= \left[\frac{283{,}000\,g}{m^3} + \left(\frac{0.6\,g}{m^3} \times 21 \right) + \left(\frac{3.1\,g}{m^3} \times 310 \right) \right] \times \left(VO_R / year \right)$$

Where NEF_O = National emissions factor of natural gas (grams of CO_2 equivalent emissions per cubic meter of natural gas for CO_2, CH_4 and N_2O, respectively)
VO_R = Volume of oil input in m^3 in project scenario

[41] The consumption of electricity consumed from the power grid for the retrofit project is determined as follows:

Annual retrofit project emissions from consuming electricity from the power grid, APE_{ELEC} (CO_2/year)

$$APE_{ELEC} = \frac{\left(\frac{MWh}{year} \right)}{0.88} \times NIF_{ELEC} \qquad \text{(Eq. 7)}$$

Where NIF_{ELEC} = National intensity factor of electricity production (kg/MWh).

[42] Equation 8 is the retrofit project emissions for consumption of natural gas, oil and electricity from the grid by the existing building. It accounts for all of the four components of baseline emissions. The value for an energy type not used by the existing building for the three years prior to the retrofit will be zero.

[43] The emissions for the retrofit project is determined as follows:

Annual retrofit project emissions, APE (CO_2/year)

$$APE = APE_{NG} + APE_{O} + APE_{ELEC} \quad \text{(Eq. 8)}$$

[44] The emissions reductions (ER) from retrofitting an existing building are equal to the difference between the baseline scenario emissions in equation 4 and the retrofit project scenario emission in equation 8. Equation 9 shows the ER.

Annual emissions reductions from existing building retrofits, ER (CO_2/year)

$$ER = ABE - APE \quad \text{(Eq. 9)}$$

JUSTIFICATION

[45] The baseline and project scenarios presented in this Protocol provide the simplest means possible of measuring GHG emissions from the project site. Other baseline and project scenarios that account for efficiency of equipment, such as boilers and furnaces, are more subject to measurement error and efficiency estimations that fluctuate with the intensity of equipment use and the type of the equipment used.

Identifying GHG Sources for the Project

[46] The sources of GHG emissions related to retrofit projects are outlined below.

- The average annual combustion of natural gas as an input over the three years prior to the retrofit project.
- The average annual combustion of oil as an input over the three years prior to the retrofit project.
- The average annual electricity taken from the power grid as an input over the three years prior to the retrofit project.
- The annual combustion of natural gas as an input following the retrofit project.
- The annual combustion of oil as an input following the retrofit project.
- The annual electricity taken from the power grid following the retrofit project.

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Selecting GHG Sources Relevant for Quantification

[47] The PP will select and justify the baseline scenario that best represents what would have occurred in the absence of the project. Baselines for projects will be determined on a case by case basis.

[48] The baseline and project scenarios presented in this protocol may be complemented or modified by including net reductions of emissions that result from any aspect of the retrofit that involves improved energy efficiency or switch between energy sources that reduces GHG emissions. For example, the baseline scenario may be adapted to account for replacement boilers for boilers that use oil for ones that use biomass or hydrogen.

Relevant Sources Subject to Monitoring

[49] All the relevant GHG sources of the project should be quantified using monitoring methodology described in the following section.

[50] Baseline emissions should be estimated based on historical levels of emissions generated from the combustion of natural gas, oil and electricity supplied by the power grid.

Relevant Sources Subject to Monitoring

[51] The sources of GHG emissions related to building retrofit projects are outlined below.

- The average annual combustion of natural gas as an input over the three years prior to the retrofit project.
- The average annual combustion of oil as an input over the three years prior to the retrofit project.
- The average annual electricity taken from the power grid as an input over the three years prior to the retrofit project.
- The average annual combustion of natural gas as an input following the retrofit project.
- The average annual combustion of oil as an input following the retrofit project.
- The average annual electricity taken from the power grid following the retrofit project.

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Quantification of the Emissions from Relevant GHG Sources

[52] For all retrofit projects, it will be assumed that CH_4 has a Global Warming Potential of 21 and that N_2O has a global warming potential of 310 relative to CO_2 on a mass basis.

[53] The emissions from electricity supplied from the power grid will be calculated using the National Intensity Factor for electricity production, which has a value of X.

Quantifying Emissions Reductions

[54] The ER achieved by the retrofit project activity during a given year is the difference between the amount of CO_2 equivalent emissions produced at a building before and after the retrofit project. The ER is calculated by equation 8 above.

Data quality Management

[55] The data should be such that a mass balance may be easily performed with the need for minimal assumptions. The data should be of sufficient quantity that it could be fed into a model or software package for performance evaluation. The data provided should be validated with company records.

[56] The PP shall establish and apply quality management procedures to manage data and information, including the assessment of uncertainty, relevant to the project and baseline scenario. The PP should reduce as far as practical uncertainties related to the quantification of GHG emission reductions. Written procedures should be established for each measurement task outlining who's responsible, when the task is to be performed, and where the records are to be kept.

[57] Several quality assurance/quality control (QA/QC) steps have already been outlined in the sections above, however, some general QA/QC procedures can also be applied to add confidence that all measurements and calculations have been made correctly. These include but are not limited to:

- Protecting monitoring equipment (sealed metre and data logger);
- Protecting records of monitored data (hard copy and electronic storage);

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- Checking data integrity (manual assessment, comparing redundant metered data, detection of outstanding records/data);
- Comparing current estimates with previous estimates as a 'reality check';
- Following manufacturers specifications for instrument calibration and maintenance;
- Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
- Establish minimum experience and requirements for operators in charge of project and monitoring;
- Performing recalculations to make sure no mathematical errors have been made; and
- Use the Excel Template provided with this protocol.

Reporting and Record Keeping

[58] For reporting purposes, the PP is required to include:

- Annual consumption of fuels, such as oil and natural gas, and electricity used prior to the retrofit project;
- Annual consumption of fuels, such as oil and natural gas, and electricity used after the completion of the retrofit project; and
- Records of all calibration events.

Deleted: Reporting will be done through certification reports needed to generate Offset Credits. Please see the Offset System Design Paper [the Offset System Specification will replace the Design Paper as a reference document] for further details on certification reports.

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References

MK Jaccard and Associates, *Strategic Options for Combined Heat and Power in Canada*. 15. 2004. Prepared for Office of Energy Efficiency, Natural Resources Canada.

Natural Resources Canada, *Canada's Emissions Outlook: An Update*.

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APPENDIX A

[59] An example is provided to indicate how a PP may apply the baseline and project equations in the protocol to a specific project. It is assumed in this example that that PP has accurately monitored the energy inputs, natural gas and electricity.

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[60] This example assumes that the retrofitted building uses only natural gas and electricity for energy sources.

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[61] The baseline is includes equations 1, 2, 3 and 4. However, since oil consumption is not included in this example equation 2 equals zero.

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Annual baseline emissions for heat supply, ABE_{NG} (CO_2/year)

$$ABE_{NG} = NEF_{NG} \times VNG_B / year$$

$$= \left[\frac{1891g}{m^3} + \left(\frac{1.9g}{m^3} \times 21\right) + \left(\frac{0.033g}{m^3} \times 310\right)\right] \times (VNG_B / year) \qquad \text{(Eq. 1)}$$

$$= 1{,}941.13 * 40{,}000{,}000\, m^3$$

$$= 409{,}201{,}930.9\, g / year \cong 409.2\_tonnes\_CO2 / year$$

Annual baseline emissions from consuming electricity from the power grid, ABE_{ELEC} (CO_2/year)

$$ABE_{ELEC} = \frac{\left(\frac{MWh}{year}\right)}{0.88} \times NIF_{ELEC} = \frac{1000}{.88} \times 220 = \qquad \text{(Eq. 3)}$$

$$1136 \times 220 = 249{,}920\, kg\_CO2 / year \cong 250\_tonnes\_CO2 / year$$

Where NIF_{ELEC} = 220 kg/MWh.

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Annual baseline emissions, ABE (CO_2/year)

$$ABE = ABE_H + ABE_{ELEC}$$

(Eq. 4)

$$= 409.2 + 250 = 659.2 \quad tonnes \quad CO2 / year$$

[62] The baseline emissions are 659.2 tonnes of CO2 per year

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Annual retrofit project emissions from combustion of natural gas, APE_{NG} (CO_2/year)

$$APE_{NG} = NEF_{NG} \times VNG_P / year$$

$$= \left[\frac{1891g}{m^3} + \left(\frac{1.9g}{m^3} \times 21\right) + \left(\frac{0.033g}{m^3} \times 310\right)\right] \times (VNG_P / year)$$

(Eq. 5)

$$= 1{,}941.13 * 30{,}000{,}000 m^3$$

$$= 306{,}901{,}930.9 g / year \cong 306.9 tonnes\_CO2 / year$$

Annual retrofit project emissions from consuming electricity from the power grid, ABE_{ELEC} (CO_2/year)

$$APE_{ELEC} = \frac{\left(\frac{MWh}{year}\right)}{0.88} \times NIF_{ELEC} = \frac{900}{.88} \times 220 =$$

(Eq. 7)

$$1022.7 \times 220 = 225{,}000 kg\_CO2 / year = 225\_tonnes\_CO2 / year$$

Annual retrofit project emissions, ABE_R (CO_2/year)

$$APE = APE_{NG} + APE_{ELEC} = 306.9 + 225$$

(Eq. 8)

$$= 531.9\_tonnes\_CO2 / year$$

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[63] The project emissions are 531.9 tonnes of CO2 per year

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Annual emissions reductions from existing building retrofits, ER (CO_2/year)

$$ER = ABE - APE = 659.2 - 531.9$$

(Eq. 9)

$$= 127.3\_tonnes\_CO2 / year$$

[64] The difference between the baseline and project emissions is the emissions reduction, 127.3 tonnes of CO2 per year.

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