Efficient Refrigeration Systems

Project Protocol

Use of low or no-GWP commercial and industrial refrigeration systems

Technical Draft Protocol

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# Introduction

This protocol sets out the requirements that will enable a project developer to undertake an Efficient Refrigeration Systems (ERS) GHG reduction project for the purpose of registering and receiving offset credits in Ontario or Quebec’s cap and trade program.

The following sections outline the definition of an ERS GHG reduction project, the specific eligibility criteria, baseline scenario and project scenario calculation methods, monitoring, data management and reporting requirements that apply to ERS GHG reduction projects.

## Introduction to the Technical Draft

1. This document represents a technical draft of the ERS project protocol, which will ultimately be redrafted into official, regulatory drafts in order for project developers to register GHG emission reductions with either the Ontario Cap and Trade Program[[1]](#footnote-2) or the Québec Cap and Trade System.[[2]](#footnote-3)
2. The following notes on terminology apply to the technical draft of the ERS protocol:
	1. For the purposes of this protocol, the term “Regulation” is used to refer to the following:
		1. For projects to be registered with the Ontario Cap and Trade Program, the term “Regulation” shall refer to the Ontario Regulation concerning *The Cap and Trade Program*, made under the Climate Change Mitigation and Low-Carbon Economy Act;
		2. For projects to be registered with the Québec Cap and Trade Program, the term “Regulation” shall refer to the Québec *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances*, made under the Environment Quality Act.
	2. For the purposes of this protocol, the term “Ministry” is used to refer to the following:
		1. For projects to be registered with the Ontario Cap and Trade Program, the term “Ministry” shall refer to the Ontario Ministry of Environment and Climate Change (MOECC).
		2. For projects to be registered with the Québec Cap and Trade Program, the term “Ministry” shall refer to the Québec Ministry of Sustainable Development, Environment, and Fight Against Climate Change (MDDELCC).
	3. For the purposes of this protocol, the term “project” is equivalent to the term “offset initiative” in the Ontario Regulation.
	4. For the purposes of this protocol, the term “Project Developer” is used to refer to the following:
		1. For projects to be registered with the Ontario Cap and Trade Program, the equivalent term is “Offset Initiative Operator.”[[3]](#footnote-4)
		2. For projects to be registered with the Québec Cap and Trade Program, the equivalent term is “Project Promoter.”

# Definitions

**Additionality** means project activities that are above and beyond “business as usual” operation, exceed the baseline characterization, and are not mandated by regulation.

**Aerosol Product** means a product pressurized by a propellant that expels its contents from a canister through a nozzle. Propellants include compressed gases and liquefied gases. Liquefied gases include HFCs, including HFC-134a, which can be recovered and reclaimed for re-use as a refrigerant, at which point it is considered a reclaimed HFC refrigerant.

**Ammonia (NH3)** means a chemical compound composed of nitrogen and hydrogen. Can be used as a low-GWP refrigerant.

**Carbon dioxide (CO2)** means the greenhouse gas consisting of a single carbon atom and two oxygen atoms.

**Centralized refrigeration system** means a refrigeration system with a cooling evaporator in the refrigerated space connected to a compressor rack located in a machinery room and to a condenser located outdoors.

**Certified reclaimed HFC refrigerant** means recovered refrigerant that has been cleaned and certified to meet or exceed the AHRI-700-2011 standard for fluorocarbon refrigerants.

**Chiller** mean a refrigeration or air-conditioning system that has a compressor, an evaporator, and a secondary coolant, other than an absorption chiller.

**Chlorofluorocarbon (CFC)** means a class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.

**CO2 equivalent (CO2e)** means the quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.

**Direct emissions** means GHG emissions from sources that are owned or controlled by the reporting entity.

**Direct expansion refrigeration system** means a system where refrigeration happens directly in the coolers without separate fluid pumping equipment.

**Effective Date** means the date of adoption of this protocol by the MOECC or the MDDELCC.

**Emission factor (EF)** means a unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).

**Emission reduction** means baseline GHG emissions minus project GHG emissions, measured in CO2 equivalent.

**Environment and Climate Change Canada** means Governmental organization responsible for accurate and transparent monitoring, reporting, and verification of Canada's greenhouse gas emissions and removals.

**Fossil fuel** means a fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

**Greenhouse gas (GHG)** means carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), sulfur hexafluoride (SF6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).

**GHG reservoir** means a physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.

**GHG sink** means a physical unit or process that removes GHG from the atmosphere.

**GHG source** means a physical unit or process that releases GHG into the atmosphere.

**Global Warming Potential (GWP)** means the ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO2 over a defined period of time (e.g., 100 years). GWPs for this protocol are defined by the Regulation.

**Hydrocarbon (HC)** means a class of compounds containing predominantly hydrogens and carbons (e.g. propane, isobutene, propylene). Certain HCs can be used as low-GWP refrigerants.

**Hydrochlorofluorocarbon (HCFC)** means a class of compounds of carbon, hydrogen, chlorine, and fluorine that are commonly used as refrigerants.

**Hydrofluorocarbon (HFC)** means a class of compounds that contain carbon, fluorine, and hydrogen that are commonly used as refrigerants, as well as solvents, aerosol propellants, and foam blowing agents.

**Hydrofluoroolefins (HFO)** means a class of compounds composed of hydrogen, fluorine, and carbon. This class of compounds can be used as low-GWP refrigerants. Some HFO refrigerants are comprised of a mix of HFOs, referred to as an HFO blend.

**HFC Refrigerant** means refrigerant comprised of either a mix of hydrofluorocarbons (HFCs) referred to as an “HFC blend”, or a single HFC.

**Indirect emissions** means GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.

**Metric ton (t, tonne)** means a common international measurement for mass, equivalent to about 2204.623 pounds or 1.1 short tons.

**Methane (CH4)** means a GHG consisting of a single carbon atom and four hydrogen atoms. The GWP for methane is defined by the Regulation.

**Ministry** means Ontario Ministry of the Environment and Climate Change (MOECC) or Québec Ministry of Sustainable Development, Environment, and Fight Against Climate Change (MDDELC).

**Project baseline** means a “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.

**Project emissions** means actual GHG emissions that occur within the GHG Assessment Boundary as a result of project activities. Project emissions are calculated at a minimum on an annual, ex post basis.

**Project Developer** means an entity that undertakes a GHG project, as identified in Section 2.1 of this protocol.

**Project refrigeration system** means the specific combination of refrigeration equipment and refrigerant which is used to provide refrigeration services to the project facility.

**Refrigeration equipment** means an appliance, or component parts of a system, that uses refrigerant to provide cooling under controlled conditions.

**Reporting period** means specific time period of project operation for which the Project

Developer has calculated and reported emission reductions and is seeking verification and issuance of credits. The reporting period must be no longer than 12 months.

**Secondary Loop Refrigeration System (or Indirect System)** means an advanced refrigeration system where a heat transfer medium (e.g. glycol) is used in conjunction with a primary refrigerant.

**Stand-alone refrigeration system** means a self-contained refrigeration system with components that are integrated within its structure.

**Verification** means the process used to ensure that a given Project Developer’s GHG emissions or emission reductions have met the minimum quality standard and complied with the respect to the province’s (Ontario’s or Québec’s procedures and protocols for calculating and reporting GHG emissions and emission reductions).

**Verification organization** means an organization that is accredited under ISO 14065 by a member of the International Accreditation Forum in Canada or the United States according to an ISO 17011 program.

# Advanced Refrigeration Systems GHG Reduction Project

## Project Definition

1. The project shall avoid emissions of high-GWP refrigerants at commercial and industrial facilities in Canada through the use of low or zero-GWP refrigeration systems.[[4]](#footnote-5) The following three project scenarios are eligible:
	1. For projects at a facility in an eligible sector, as per (b), with an existing, high-GWP refrigeration system:
		1. Replacing the previous system (including all components utilizing fluorinated gas refrigerants) with a new system which operates using a low or zero-GWP refrigerant; or
		2. Retrofitting the previous system (including all components utilizing fluorinated gas refrigerants) in order to operate using a low or zero-GWP refrigerant
	2. For projects at a new facility in an eligible sector:
		1. Installation of a new refrigeration system which operates using a low or zero-GWP refrigerant;
2. Eligible refrigeration system categories include (as defined in Section 2):
	1. Stand-alone commercial refrigeration
	2. Centralized commercial refrigeration
	3. Centralized industrial refrigeration
	4. Condensing units
	5. Commercial or industrial chillers

## Project Start Date

1. The Project Start Date is the date on which the project refrigeration system begins providing refrigeration services to the project facility.

# Eligibility

## General Requirements

1. A legal requirement to use low- or no-GWP refrigerant must not be applicable to the project facility. Applicable legal requirements include legislative or regulatory provisions, permits or other types of authorization, orders made under an Act or regulation, or court decisions.

## Eligibility Criteria

1. The Refrigeration project must install a system that uses a 100-year GWP equal to or lower than the business as usual value calculated for the relevant system sub-category and time period, as summarized in Table 4.1.

Table 4.1 Business as usual GWP values by system sub-category

| **Category** | **Sub-Category** | **Phase 1 GWP** | **Phase 1 End Date** | **Phase 2 GWP** | **Phase 2 End Date** |
| --- | --- | --- | --- | --- | --- |
| Stand-alone refrigeration | Medium temperature (>0 C) | 1430 | December 31, 2019 | 3.3 | December 31, 2029 |
| Stand-alone refrigeration | Low temperature (<0 C) | 3922 | December 31, 2019 | 511.4 | December 31, 2029 |
| Condensing units | Medium temperature (>0 C) | 1430 | December 31, 2019 | 3.3 | December 31, 2029 |
| Condensing units | Low temperature (<0 C) | 3922 | December 31, 2019 | 1580.6 | December 31, 2029 |
| Centralized refrigeration, commercial | Medium temperature (>0 C) | 3423.6 | December 31, 2019 | 1690.9 | December 31, 2029 |
| Centralized refrigeration, commercial | Low temperature (<0 C) | 3423.6 | December 31, 2019 | 1690.9 | December 31, 2029 |
| Centralized refrigeration, industrial | Small/medium systems (<100 kW), medium temperature (>0 C) | 3423.6 | December 31, 2019 | 1580.7 | December 31, 2029 |
| Centralized refrigeration, industrial | Small/medium (<100 kW), low temperature (<0 C) | 3423.6 | December 31, 2019 | 1580.7 | December 31, 2029 |
| Chillers | Large (>750 kW) | 1430 | December 31, 2024 | 1.3 | December 31, 2029 |
| Chillers | Industrial, small/medium (<750 kW) | 1931 | December 31, 2024 | 476.3 | December 31, 2029 |
| Chillers | Air conditioning, small/medium scroll, reciprocating, or screw compressors (<750 kW) | 1759 | December 31, 2024 | 635 | December 31, 2029 |

1. The project baseline assumption must not include the use of a HFC which is, as of the Project Start Date, prohibited for that particular use in the State of California.[[5]](#footnote-6)
2. Table 4.2 lists the 100-year GWP values for several baseline and substitute refrigerants. GWP values for refrigerants not listed in Table 4.2 shall be referenced from the following sources. If the first source on the list does not list a 100-year GWP value for the refrigerant in question, then the next source on the list shall be referenced, descending the list in order until a value is found.
	1. Canada’s National Inventory Report, 1990-2015[[6]](#footnote-7)
	2. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change[[7]](#footnote-8)
	3. The Fifth Assessment Report of the Intergovernmental Panel on Climate Change[[8]](#footnote-9)
	4. IPCC/TEAP Special Report: Safeguarding the Ozone Layer and the Global Climate System.[[9]](#footnote-10)
3. GWP values for blends are calculated as a mass-weighted average of the GWP values for the constituent chemicals.

Table 4.2 Potential Refrigerants for the Baseline and Project Scenarios

| **Refrigerant** | **Trade Name** | **100-Year Global Warming Potential (GWP)** |
| --- | --- | --- |
| H2O (Water) | R-718 | 0 |
| NH3 (Ammonia) | R-717 | 010 |
| HFO-1234ze | R-1234ze | <19 |
| HFO-1234yf | R-1234yf | <19 |
| CO2 | R-744 | 17 |
| 1,2- Dichloroethane | R-1130(E) | 19 |
| E-170 (Dimethyl Ether) | R-E710 | 18 |
| HFO-1233zd | R-1233zd | 19 |
| Propylene | R-1270 | 1.88 |
| HFO-1336mzz | R-1336mzz | 29 |
| Isobutane | R-600a | 3[[10]](#footnote-11) |
| Propane | R-290 | 3.38 |
| HFC-152a | R-152a | 1247 |
| HFC-32 | R-32 | 6757 |
| HFC-245fa | R-245fa | 10307 |
| HFC-134a | R-134a | 14307 |
| HFC-125 | R-125 | 35007 |
| HFC-143a | R-143a | 44707 |
| HFC-23 | R-23 | 148007 |
| **Refrigerant Blends** |  |  |
| R-1336mzz (74.7%), R-1130(E) (25.3%) | R-514A | 1 |
| R-1270 (80%), R-E170 (20%) | R-432A | 2 |
| R-170 (3.1%), R-290 (54.8%), R-600a (6%), 600 (36.1%) | R-441A | 3 |
| R-290 (56%), R-600a (44%) | R-436A | 3 |
| R-32 (21%), R-1234yf (69%), R-1234ze (10%)  | R-459B | 142 |
| R-1234yf (75.5%), R-32 (21.5%), R-744 (3%) | R-455A | 145 |
| R-32 (21.5%), R-1234yf (78.5%) | R-454C | 145 |
| R-1234yf (89.8%), R-134a (10.2%) | R-451A | 146 |
| R-1234yf (88.8%), R-134a (11.2%) | R-451B | 160 |
| R-32 (35%), R-1234yf (65%) | R-454A | 236 |
| R-32 (68%), R-1234yf (26%), R-1234ze (6%) | R-459A | 459 |
| R-32 (68.9%), R-1234yf (31.1%) | R-454B | 465 |
| R-1234yf (58.5%), R-134a (41.5%) | R-513B | 593 |
| HFC-134a (42%), HFO-1234ze (58%) | R-450A | 601 |
| HFC-134a (44%), HFO-1234yf (56%) | R-513A | 629 |
| R-32 (67%), R-125 (7%), R-1234yf (26%) | R-452B | 697 |
| R-32 (68%), R-125 (8%), R-1234ze (24%) | R-447B | 739 |
| HFC-32 (26%), HFC-125 (26%), HFC-134a (21%), HFO-1234ze (7%), HFO-1234yf (20%) | R-448A | 1386 |
| HFC-32 (24.3%), HFC-125 (24.7%), HFC-134a (25.7%), HFO-1234yf (25.3%) | R-449A | 1396 |
| HFC-125 (27%), HFC-32 (27%), R-227ea (6%), R-1234ze (40%) | R-464A | 1320 |
| R-32 (25.2%), R-125 (24.3%), R-134a (27.3%) R-1234yf (23.2%) | R-449B | 1411 |
| R-32 (32.5%), R-125 (25%), R-134a (52.5%) | R-407H | 1495 |
| HFC-32 (20%), HFC-125 (20%), HFC-134a (53.8%), HFC-227ea (5%), R-600 (0.6%), R-601a (0.6%) | R-453A | 1765 |
| HFC-32 (23%), HFC-125 (25%), HFC-134a (52%) | R-407C | 1774 |
| R-32 (30%), R-125 (30%), R-134a (40%) | R-407F | 1825 |
| HFC-32 (31%), HFC-125 (31%), HFC-134a (30%), R-227ea (5%), R-152a (3%) | R-442A | 1888 |
| HFC-32 (50%), HFC-125 (50%) | R-410A | 2088 |
| HFC-32 (20%), HFC-125 (40%), HFC-134a (40%) | R-407A | 2107 |
| HFC-32 (11%), HFC-125 (59%), HFO-1234yf (30%) | R-452A | 2139 |
| HFC-125 (44%), HFC-134a (4%), HFC-143a (52%) | R-404A | 3922 |
| HFC-125 (50%), HFC-143a (50%) | R-507A | 3985 |

1. For projects at existing facilities (either new installations or retrofits for new refrigerants), the baseline shall incorporate the refrigerant type and charge size of the system which is being replaced by the project system.
	1. The baseline system shall be characterized using data from regulatory compliance reporting and/or other, verifiable, historical operating documentation.
	2. The baseline GWP value shall be referenced from Table 4.2.
	3. Projects using historical baselines must provide documentation to prove that there is no legal or technical barrier to continued use of the baseline system for the entire project crediting period.
		1. Absence of legal barrier: a project developer should prove that based on current regulations, a refrigeration system could have continued operation or could have been replaced with a new system using the same technology.
		2. Absence of technical barrier: if there would be a legal barrier to the replacement of the existing system with a new system utilizing the same technology and refrigerant, the project developer should prove that the system to be replaced could reasonably have been expected to continue operating for the entire project crediting period, or could have been repaired or refurbished such that the operational life would be extended through the entire project crediting period.
2. For new facilities, or existing facilities where there are legal or technical barriers to the continued use of the baseline system for the entire crediting period, the baseline emissions which are being avoided are calculated from an emission factor based on the current common practice refrigerant for the specific refrigerant system category, depending upon the project start date and cooling capacity, as referenced in Table 4.3.
	1. If the emission factor found in Table 4.3 for the project system is equal to zero, then the project is not eligible to use a default baseline.
	2. It is anticipated that common practice for refrigerant installations will continue to change over time as Canada responds to its phase-down commitments under the Kigali Amendments of the Montreal Protocol. Thus, the Phase 2 emission factor is only valid for projects with start dates as late as December 31, 2029. It is anticipated that this protocol will be updated before that date in order to incorporate new emission factors.

Table 4.3 Default baseline emission factors

| **Category** | **Sub-Category** | **Phase 1 Annual Emission Factor (kgCO2e/kW/yr)** | **Phase 1 End Date** | **Phase 2 Annual Emission Factor (kgCO2e/kW/yr)** | **Phase 2 End Date** |
| --- | --- | --- | --- | --- | --- |
| Stand-alone refrigeration | Medium temperature (>0 C) | 15 | Dec 31, 2019 | 0 | Dec 31, 2029 |
| Stand-alone refrigeration | Low temperature (<0 C) | 265 | Dec 31, 2019 | 35 | Dec 31, 2029 |
| Condensing units | Medium temperature (>0 C) | 325 | Dec 31, 2019 | 1 | Dec 31, 2029 |
| Condensing units | Low temperature (<0 C) | 1530 | Dec 31, 2019 | 616 | Dec 31, 2029 |
| Centralized refrigeration, commercial | Medium temperature (>0 C) | 1558 | Dec 31, 2019 | 769 | Dec 31, 2029 |
| Centralized refrigeration, commercial | Low temperature (<0 C) | 3060 | Dec 31, 2019 | 1511 | Dec 31, 2029 |
| Centralized refrigeration, industrial | Small/medium systems (<100 kW), medium temperature (>0 C) | 2165 | Dec 31, 2019 | 1000 | Dec 31, 2029 |
| Centralized refrigeration, industrial | Small/medium (<100 kW), low temperature (<0 C) | 3465 | Dec 31, 2019 | 1600 | Dec 31, 2029 |
| Chillers | Large (>750 kW) | 23 | Dec 31, 2024 | 0 | Dec 31, 2029 |
| Chillers | Industrial, small/medium (<750 kW) | 30 | Dec 31, 2024 | 8 | Dec 31, 2029 |
| Chillers | Air conditioning, small/medium scroll, reciprocating, or screw compressors (<750 kW) | 28 | Dec 31, 2024 | 10 | Dec 31, 2029 |

# GHG Assessment Boundary

1. The following GHG sources, sinks, and reservoirs (SSRs) have been considered in determining the GHG Assessment Boundary.
	1. Figure 5.1 illustrates all relevant GHG SSRs associated with ERS activities and delineates the GHG Assessment Boundary.
	2. Table 5.1 provides greater detail on each relevant GHG SSR associated with ERS activities and includes justification for their inclusion or exclusion from the GHG Assessment Boundary.

Figure 5.1. GHG Assessment Boundary for Advanced Refrigeration Systems Projects



Table 5.1. Description of all Sources, Sinks, and Reservoirs

| **SSR** | **SSR Name** | **Source Description** | **GHG** | **Relevant to Baseline (B) or Project (P)** | **Included or Excluded** | **Justification/Explanation** |
| --- | --- | --- | --- | --- | --- | --- |
| 1 | Refrigerant Production | Fossil fuel emissions from the production of refrigerants | CO2 and CH4 | B,P | E | Excluded, as this emission source is assumed to be very small |
| 1 | Refrigerant Production | Refrigerant leaks during production | HFC and HCFCs | B | E | Excluded, as this emission source is assumed to be very small |
| 1 | Refrigerant Production | Refrigerant leaks during production | Low and zero-GWP refrigerants | P | E | Excluded, as this emission source is assumed to be very small |
| 2 | Refrigerant Transport | Fossil fuel emissions from the transport of refrigerants | CO2 and CH4 | B,P | E | Excluded, as this emission source is assumed to be very small |
| 2 | Refrigerant Transport | Fossil fuel emissions from the transport of refrigerants | N2O | B,P | E | Excluded, as this emission source is assumed to be very small |
| 2 | Refrigerant Transport | Refrigerant leaks during transport | HFC and HCFCs | B | E | Excluded, as this emission source is assumed to be very small |
| 2 | Refrigerant Transport | Refrigerant leaks during transport | Low and zero-GWP refrigerants | P | E | Excluded, as this emission source is assumed to be very small |
| 3 | Equipment Manufacture | Emissions of refrigerant during the manufacture of refrigeration systems | HFC and HCFCs | B | E | Excluded, as project activity is unlikely to affect emissions relative to baseline activity |
| 3 | Equipment Manufacture | Emissions of refrigerant during the manufacture of refrigeration systems | Low and zero-GWP refrigerants | P | E | Excluded, as project activity is unlikely to affect emissions relative to baseline activity |
| 4 | Equipment Installation | Emissions of refrigerant during the installation of refrigeration systems | HFC and HCFCs | B | E | Excluded, as this emission source is assumed to be very small |
| 4 | Equipment Installation | Emissions of refrigerant during the installation of refrigeration systems | Low and zero-GWP refrigerants | P | E | Excluded, as this emission source is assumed to be very small |
| 5 | Equipment Operations | Fossil fuel emissions from the operation of the refrigeration or A/C equipment system | CO2, CH4 and N2O | B,P | E | Excluded, as project activity is unlikely to affect emissions relative to baseline activity |
| 5 | Equipment Operations | Refrigerant leaks from the operation of the refrigeration system | HFC and HCFCs | B,P | I | Baseline and project emissions are expected to be significant. |
| 5 | Equipment Operations | CO2 leaks from operation of a new refrigeration system | CO2 | P | I | Baseline and project emissions are expected to be significant. |
| 5 | Equipment Operations | Leaks of non-GHG refrigerants from operation of a new refrigeration system | NH3, others | P | E | Project emissions are excluded for advanced refrigerants with no global warming potential. |
| 6 | Equipment Servicing | Fossil fuel emissions from servicing refrigeration or A/C equipment or system to replace leaked refrigerant | CO2, CH4 and N2O | B,P | E | Excluded, as this emission source is assumed to be very small |
| 6 | Equipment Servicing | Refrigerant emissions from servicing refrigeration or A/C equipment or system to replace leaked refrigerant | HFCs, HCFCs, HFOs, others | B,P | I | Baseline and project emissions are expected to be significant. |
| 7 | Equipment Disposal | Emissions from the disposal of the equipment at end-of-life including destruction of refrigerant | CO2, CH4, CFCs, HCFC and HFCs | B,P | E | Excluded for simplification. This emission source is not expected to increase in the project scenario. |

# Calculation of Emission Reductions

1. Reductions of GHG emission from the project shall be calculated in accordance with Equation 6.1.

Equation 6.1. GHG Emission Reductions

$$ER=BE-PE$$

| *Where,* |  |  | Units |
| --- | --- | --- | --- |
| ER | = | GHG emission reductions attributable to the project during the project reporting period | tCO2e |
| BE | = | Emissions under the baseline scenario during the project reporting period, calculated using Equation 6.2 or Equation 6.3, as appropriate. | tCO2e |
| PE | = | Project emissions during the project reporting period, calculated using Equation 6.4. | tCO2e |

## Calculation of Baseline Scenario Emissions

1. For projects at existing facilities where the project activity involves installation of a new refrigeration system or the retrofit of an existing system (i.e., projects employing baselines according to Section 4.2.a), baseline GHG emissions shall be calculated using Equation 6.2.
	1. For the value of the annual leak rate, LRi, project developers shall reference the appropriate category from Table 6.1, below.

Table 6.1 Default annual leak rates by refrigeration system category

| **System Category** | **Annual Leak Rate (% of total charge)[[11]](#footnote-12)** |
| --- | --- |
| Stand-alone systems | 4.5% |
| Centralized commercial systems and condensing units | 16.25% |
| Centralized industrial systems | 11.5% |
| Chillers (commercial or industrial) | 5.25% |

Equation 6.2. Calculating Baseline Emissions at Pre-Existing Facilities

$$BE=\sum\_{i,j}^{}[\left(Q\_{BR,i,j}×LR\_{j}\right)\left.÷1000×GWP\_{REF,k}\right]$$

| *Where,* |  |  | Units |
| --- | --- | --- | --- |
| BE | = | Baseline emissions during the project reporting period | tCO2e |
| QBR,i,j | = | Quantity of refrigerant *i* in equipment *j* used in baseline system (documented full charge of baseline system) | kg refrigerant |
| LRj | = | Annual leak rate (referenced from Table 6.1) | fraction |
| 1000 | = | Conversion from tonnes to kilograms | kg/t |
| GWPREF,k | = | Global warming potential of baseline refrigerant *k* (see Table 4.2) | tCO2e/t refrigerant |

1. For all other projects (i.e., projects employing baselines according to Section 4.2.f), the project developer shall use the default emission factor for the relevant market sector and project start date, from Table 4.3, applied to Equation 6.3:

Equation 6.3. Calculating Baseline Emissions with Default Values

$$BE=\sum\_{j}^{}\left[\left(CAP\_{PR,j}×BEF\_{j}\right)\right]\left.÷1000\right]$$

| *Where,* |  |  | Units |
| --- | --- | --- | --- |
| BE | = | Baseline emissions during the project reporting period | tCO2e |
| CAPPR,j | = | Cooling capacity of the project refrigeration system *j*, expressed in total kW. For systems rated in MBTU/hr, a conversion of 3.412 MBTU/hr per kW shall be applied. | kW |
| BEFj | = | Baseline emission factor for system *j*, as found in Table 4.3. | kgCO2e/kW |
| 1000 | = | Conversion from tonnes to kilograms | kg/t |

## Calculation of Project Emissions

1. Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary calculated in accordance with Equation 6.4.
2. The quantity of project refrigerant which has leaked out of the project refrigeration system during the reporting period is determined through one of the following options:
	1. For systems where the GWP value for the project refrigerant is less than 1% of the GWP value of the baseline refrigerant (either default or site-specific, according to Section 4.2), the value for LEAKk,i may be equal to the total charge size of refrigerant *k* in the project refrigeration system *j*, multiplied by the appropriate default annual leak rate from Table 6.1;
	2. For projects which may not (or choose not to) use the approach above, the value for LEAKk,i shall be the actual quantity of refrigerant *k* added to the project refrigeration system *j* during the reporting period, as determined through maintenance records.

Equation 6.4. Calculating Project Emissions

$$PE=\sum\_{j}^{}LEAK\_{k,j}÷1000×GWP\_{REF,k}$$

| *Where,* |  |  | Units |
| --- | --- | --- | --- |
| PE | = | Project emissions during the project reporting period | tCO2e |
| LEAKk,i | = | Quantity of alternative refrigerant *k* that leaked out of the project system *j* during the reporting period (not including the initial system charge) | kg |
| 1000 | = | Conversion from tonnes to kilograms | kg/t |
| GWPREF,k | = | Global warming potential of refrigerant *k* used in the project (Table 4.2) | tCO2e/t refrigerant |

### Leakage

1. ERS projects are not expected to result in either activity-shifting or market-shifting leakage. Thus, quantification of project leakage is not required.

# Data Management and Project Monitoring

## Data Collection

1. A data management system shall be implemented to collect, manage, and store information related to the project in a way that ensures the integrity, exhaustiveness, accuracy, and validity of the information.
2. The data management system for the project shall include procedures to:
	1. Monitor the performance of the project and the operation of all project-related equipment, in accordance with Sections 7.2, 7.3, and 7.4.
	2. Manage information, including data in respect of the baseline scenario and the project;
	3. Assess whether the project meets the eligibility criteria set out in the Regulation and this protocol;
	4. Identify and record any violations of legal requirements that apply to the project and that may have an impact on the amount of GHG reductions, avoidances, or removals; and
	5. Assess and record a description of the impact of each violation identified under 5.
3. The data management system for the project shall include records required by the Regulation and this protocol, including the following information:
	1. Methods used to collect and record the data required for all the relevant parameters in Table 7.1;
	2. The frequency of data acquisition;
	3. A record keeping plan;
	4. Refrigeration system maintenance records for all project equipment;
	5. Description of the refrigerant tracking system, if applicable;
	6. The role and qualifications of the personnel responsible for each monitoring activity, as well as the quality assurance and quality control measures taken to ensure that data acquisition is carried out consistently and with precision;
	7. Identification of the refrigerant service provider and description of their qualifications; and
	8. Procedures which will be followed to ascertain and demonstrate that he project is not in violation of any applicable regulations.
4. The Project Developer is responsible for collecting the information required for project monitoring. The Project Developer must show that the data collected are actual and that rigorous supervision and record-keeping procedures are applied at the project site.
5. For all projects, the installation, servicing, testing, and charging of the project refrigeration system (excluding systems for which these requirements do not apply) must be carried out in conformance with the requirements of the Federal Halocarbon Regulations of 2003 (FHR, as amended in 2009).[[12]](#footnote-13) For projects which involve the decommissioning and/or removal of a pre-existing refrigeration system, such activities shall be carried out in conformance with the applicable sections of the FHR.
6. The Project Developer must institute a transparent, verifiable methodology for the validation of all project data to ensure that any erroneous or unusual data are identified, subject to verifier review and approval.
7. Provide the accredited verification body access to the project site, operational staff, and where necessary, the third-party refrigeration maintenance service provider, and any other information or persons that the accredited verification body may require to verify the project.

## Monitoring Requirements

1. Project Developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer’s recommendations. GHG emission reductions from advanced refrigeration system projects must be monitored through the following:
	1. Identifying and logging the equipment/systems to be installed, including:
		1. Description of the system(s) and/or equipment used
		2. Refrigerant(s) used
		3. Initial charge size(s), in kg
		4. kW cooling capacity of the project system(s)
	2. Recordkeeping of project-related refrigerant usage, including records of any servicing and recharge of the project system.
		1. Each project system must be checked for the level of refrigerant at least once during the reporting period by an appropriately-trained and certified refrigerant service provider, with the as-found and as-left pressures recorded, as well as the amount of any refrigerant added to the system, in kg.

## Instrument Quality Assurance and Quality Control (QA/QC)

1. All project refrigeration equipment must be operated and maintained according to the manufacturers’ specifications and recommendations.

## Monitoring Parameters

1. Table 7.1 sets out the monitoring parameters required to be used in the calculation of baseline scenario and project scenario emissions.

Table 7.1. Efficient Refrigeration Systems Project Monitoring Parameters

| **Eq. #** | **Parameter** | **Description** | **Units** | **Calculated (c) Measured (m) Reference (r)****Operating Records (o)** | **Measurement Frequency** | **Comment** |
| --- | --- | --- | --- | --- | --- | --- |
| Equation 6.1 | ER | GHG emission reductions during the reporting period | tCO2e | c | Per reporting period |  |
| Equation 6.1, Equation 6.2, Equation 6.3 | BE | Baseline emissions during the reporting period | tCO2e | c | Per reporting period |  |
| Equation 6.1, Equation 6.4 | PE | Project emissions during the reporting period | tCO2e | c | Per reporting period |  |
| Equation 6.2 | QBR,i,i | Quantity of refrigerant *i* that would have been used in initial charge of system *j* in absence of project activity | kg | o | Once |  |
| Equation 6.2 | LRj | Average annual leak rate of historical system *j* | % per year | r | Once | Default referenced from Table 6.1 |
| Equation 6.2 | GWPREF,i | 100-year global warming potential of refrigerant *i* | tCO2e/t refrigerant | r | Once | GWP values are included in Table 4.2 |
| Equation 6.3 | CAPPR,j | Cooling capacity of the project refrigeration system | kW | o | Once |  |
| Equation 6.2 | BEFj | Baseline emission factor for system *j* | kgCO2e/kW | r | Once | Referenced from Table 4.3 |
| Equation 6.4 | LEAKk,j | Quantity of refrigerant *k* leaked from project system *j* during the reporting period | kg | M,r | Per reporting period | Determined according to Section 6.2(b) |

# Reversals

## Errors, Omissions, or Misstatements

1. In the event that an error, omission, or misstatement is discovered after offset credits have been created and issued for a reporting period, the Project Developer shall determine the total amount of the reversal by:
	1. Using this protocol to re-calculate the corrected value of the GHG emission reductions from the project during the reporting period for each project report affected by the reversal.
	2. Calculating the total reversal of GHG emission reductions from the initiative using

Equation 8.1 Calculation of reversals

$$RE=\sum\_{r=1}^{n}ER\_{c,r}-ER\_{i,r}$$

|  |  |  |  |
| --- | --- | --- | --- |
| *Where,* |  |  | Units |
| RE | = | GHG emission reductions reversed | tCO2e |
| N | = | Total number of project reports affected by the reversal |  |
| R | = | Specific project reports affected by the reversal |  |
| ERc,r | = | Corrected GHG emission reductions from the project during the specific reporting period, *r*, calculated in accordance with Subsection 8.1(a)(1) | tCO2e |
| ERi,r | = | Initially reported GHG emission reductions from the project during the reporting period, *r* | tCO2e |

# Reporting

1. The following information shall be set out in a project report or a reversal report in addition to the information required by the Regulation

## Project Report

### Eligibility Criteria Information

1. The location of the project facility
2. The nature of the project activity (i.e., new facility, new system at existing facility, or retrofit of existing system)
3. The baseline scenario
	1. Refrigerant used in the baseline scenario and the appropriate GWP
	2. Charge size (kg) of the baseline refrigeration system
	3. Source of these data (default values or site-generated data, and relevant documentation)
4. The project scenario
	1. Refrigerant used in the project scenario and the appropriate GWP
	2. Charge size (kg) of the project refrigeration system
	3. Source of these data (relevant documentation)

### Monitoring Information

1. Identification of refrigeration maintenance and monitoring procedures
	1. The frequency and method of monitoring for leaks, and identification of any instances where leaks were detected, including actions taken in response.
	2. The frequency of system maintenance and/or recharge by qualified service technicians
	3. The quantity of refrigerant added to the project system during the reporting period, in kg.
2. Identification of the measurement frequency used for each monitoring parameter.

### Quantification Information

1. All calculations set out in Section 6 that were used.
2. Supporting documentation related to the calculations.

## Reversal Report

### General

1. Information about the circumstances and causes of the reversal including the number of reporting periods affected.
2. For each project report that was affected by the reversal, all information that has changed as a result of the reversal and a description of those changes.
3. In the case of an error, omission, or misstatement reversal, a description of the corrective actions taken to address the circumstances and causes of the reversal.
4. Supporting documentation for each of the items in paragraphs (a) through (c) above.

### Quantification Information

1. All calculations set out in Section 8, including supporting calculations set out in Section 6, that were used to determine the amount of the reversal.
2. Supporting documentation related to the calculations.

# Record Keeping

1. The following records and documents shall be kept, in addition to the records that are required to be kept under the Regulation:
	1. The information and data required under the monitoring plan, including all GHG calculations and their related data inputs;
	2. Information on equipment operation including initial HFC charge;
	3. The maintenance records for servicing of refrigeration or A/C equipment or systems;
	4. Operating records showing:
		1. Project related refrigerant usage
		2. Identifying and logging the equipment/system to be installed
		3. Historical refrigerant usage (existing facilities only)
	5. All documentation related to permits related to the refrigeration or A/C equipment or system (e.g., permits, air quality, water quality, land use, system construction, etc.), as well as documentation related to any regulatory compliance inquiries, warnings, or violations.
2. Development of Default Baseline Emission Factors

For projects subject to the baseline described in Section 4.2(f) (i.e., projects at new facilities or those at pre-existing facilities who are unable to continue use of the baseline system), this protocol provides an option for the application of a default baseline emission factor, which is scaled to the size of the project system (in kW). The default baseline emission factors represent the kilograms of CO2e that would have been released to the atmosphere every year per kW of cooling capacity of a refrigeration system in a baseline scenario. The default baseline emission factors are specific to each category of refrigeration system (see Table 4.3).

**Approach for the derivation of default baseline emission factors**

The default baseline emission factors were derived using Equation A.1:

**Equation A.1** Calculation of the default baseline emission factors

$$EF=\left(Charge ratio\right)×\left(Leak rate\right)×\left(Blended GWP\right)$$

|  |  |  |  |
| --- | --- | --- | --- |
| *Where,*  |  |  | Units |
| EF | = | Annual emission factor per refrigerant system category | kgCO2e/kW/yr |
| Charge ratio | = | kg of refrigerant per kW of cooling capacity | kg/kW |
| Leak rate | = | percentage of refrigerant released to the atmosphere in a year | kg leaked/kg installed |
| Blended GWP | = | Market-weighted 100-year GWP value for all refrigerants assumed to be used for the system sub-category and time period. | kgCO2e/kg refrigerant |

Default charge ratios for each system sub-category were determined using a study commissioned for the California Air Resources Board which examined the specific characteristics of many types of refrigeration systems installed at hundreds of facilities across California (Table A.1).

Table A.1 Default charge ratios for refrigeration systems by sub-category

| **Category** | **Sub-Category** | **Charge Ratio (kg/kW)** |
| --- | --- | --- |
| Stand-alone refrigeration systems  | Medium temperature (>0 C) | 0.23 |
| Stand-alone refrigeration systems  | Low temperature (<0 C) | 1.5 |
| Condensing units | Medium temperature (>0 C) | 1.4 |
| Condensing units | Low temperature (<0 C) | 2.4 |
| Centralized refrigeration, commercial | Medium temperature (>0 C) | 2.8 |
| Centralized refrigeration, commercial | Low temperature (<0 C) | 5.5 |
| Centralized refrigeration, industrial | Small/medium systems (<100 kW), medium temperature (>0 C) | 5.5 |
| Centralized refrigeration, industrial | Small/medium (<100 kW), low temperature (<0 C) | 8.8 |
| Chillers | Large (>750 kW) | 0.3 |
| Chillers | Industrial, small/medium (<750 kW) | 0.3 |
| Chillers | Air conditioning, small/medium scroll, reciprocating, or screw compressors (<750 kW) | 0.3 |

Leak rates used for the calculation of default baseline emission factors in this protocol represent the lower quartile of the refrigerant leak rates per refrigeration subsector in IPCC 2006 (Table A.2). The lower quartile was used as the range in IPCC is applicable to all countries (developed and developing) and it is assumed that developed countries would have technologies and maintenance practices which result in lower leak rates than in developing countries.

Table A.2 Default leak rate assumptions

| **Subsector** | **IPCC leak rate range[[13]](#footnote-14)** | **Lower quartile** |
| --- | --- | --- |
| Stand alone | 1-15% | 4.5% |
| Centralized commercial and condensing units | 10-35% | 16.25% |
| Centralized industrial | 7-25% | 11.5% |
| Chillers | 2-15% | 5.25% |

Blended GWP values were derived using the following equation:

Equation A.2 Calculation of blended GWP values

$$Blended GWP=\sum\_{i}^{}\left[\left(Refrigerant market share\right)\_{i}×GWP\_{i}\right]$$

|  |  |  |  |
| --- | --- | --- | --- |
| *Where,* |  |  | Units |
| Blended GWP | = | Market-weighted 100-year GWP value for all refrigerants assumed to be used for the system sub-category and time period. | kgCO2e/kg refrigerant |
| *i* | = | Indicator for each individual type of refrigerant used by that market sector. |  |
| Refrigerant market sharei | = | Portion of the Canadian refrigerant market controlled by the particular refrigerant for the refrigerant system sub-category | % |
| GWPi | = | 100-year GWP for refrigerant *i* | kgCO2e/kg refrigerant |

In order to reflect the coming changes to business as usual resulting from the implementation of product-specific controls mandated by the 2017 updates to the ODSHAR regulations, as well as proposed prohibitions in California, two different blended GWP values were created for each sub-category: Phase 1 and Phase 2. Phase 1 represents common practice as it exists today Table A.3. Phase 2 represents the expected substitutes which will be adopted in response to the regulatory changes. Phase 2 ends on December 31, 2029, reflecting the assumption that common practice refrigerant installations will undergo another major shift as the industry responds to the continued phase-down of HFC usage under the Kigali Amendments to the Montreal Protocol.

Table A.3 Calculation of blended GWP values for Phase 1

| **Category** | **Sub-Category** | **Phase 1 BAU Refrigerant (GWP, Market Share)** | **Phase 1 Blended GWP** |
| --- | --- | --- | --- |
| Stand-alone refrigeration | Medium temperature (>0 C) | HFC-134a (1430, 100%) | 1430 |
| Stand-alone refrigeration | Low temperature (<0 C) | R-404A (3922, 100%) | 3922 |
| Condensing units | Medium temperature (>0 C) | HFC-134a (1430, 100%) | 1430 |
| Condensing units | Low temperature (<0 C) | R-404A (3922, 100%) | 3922 |
| Centralized refrigeration, commercial | Medium temperature (>0 C) | R-404A (3922, 80%)HFC-134a (1430, 20%) | 3423.6 |
| Centralized refrigeration, commercial | Low temperature (<0 C) | R-404A (3922, 80%)HFC-134a (1430, 20%) | 3423.6 |
| Centralized refrigeration, industrial | Small/medium systems (<100 kW), medium temperature (>0 C) | R-404A (3922, 80%)HFC-134a (1430, 20%) | 3423.6 |
| Centralized refrigeration, industrial | Small/medium (<100 kW), low temperature (<0 C) | R-404A (3922, 80%)HFC-134a (1430, 20%) | 3423.6 |
| Chillers | Large (>750 kW) | HFC-134a (1430, 100%) | 1430 |
| Chillers | Industrial, small/medium (<750 kW) | R-407C (1774, 50%)R-410A (2088, 50%) | 1931 |
| Chillers | Air conditioning, small/medium scroll, reciprocating, or screw compressors (<750 kW) | HFC-134a (1430, 50%)R-410A (2088, 50%) | 1759 |

Table A.4 Calculation of blended GWP values for Phase 2

| **Category** | **Sub-Category** | **Phase 2 BAU Refrigerant (GWP, Market Share)** | **Phase 2 Blended GWP** |
| --- | --- | --- | --- |
| Stand-alone refrigeration | Medium temperature (>0 C) | R-290 (3.3, 100%) | 3.3 |
| Stand-alone refrigeration | Low temperature (<0 C) | R-448A/449A (1387, 33.3%R-455A (145, 33.3%)R-290 (3.3, 33.3%) | 511.8 |
| Condensing units | Medium temperature (>0 C) | R-290 (3.3, 100%) | 3.3 |
| Condensing units | Low temperature (<0 C) | R-407A (2107, 75%)R-717 (0, 6.25%)R-290 (3.3, 6.25%)R-1233zd (5, 6.25%)R-1234ze (1, 6.25%) | 1580.8 |
| Centralized refrigeration, commercial | Medium temperature (>0 C) | R-407A (2107, 75%)R-448A/449A (1387, 6.25%)R-454A (238,6.25%)R-455A (146, 6.25%)R-744 (1, 6.25%) | 1691 |
| Centralized refrigeration, commercial | Low temperature (<0 C) | R-407A (2107, 75%)R-448A/449A (1387, 6.25%)R-454A (238,6.25%)R-455A (146, 6.25%)R-744 (1, 6.25%) | 1691 |
| Centralized refrigeration, industrial | Small/medium systems (<100 kW), medium temperature (>0 C) | R-407A (2107, 75%)R-717 (0, 6.25%)R-290 (3.3, 6.25%)R-744 (1, 6.25%)R-600a (3, 6.25%) | 1580.7 |
| Centralized refrigeration, industrial | Small/medium (<100 kW), low temperature (<0 C) | R-407A (2107, 75%)R-717 (0, 6.25%)R-290 (3.3, 6.25%)R-744 (1, 6.25%)R-600a (3, 6.25%) | 1580.7 |
| Chillers | Large (>750 kW) | R-290 (3.3, 25%)R-1233zd (5, 25%)R-1234ze (1, 25%)R-717 (0, 25%) | 2.3 |
| Chillers | Industrial, small/medium (<750 kW) | R-450A (604, 25%)R-513A (631, 25%)HFC-32 (675, 25%)R-717 (0, 25%) | 477.5 |
| Chillers | Air conditioning, small/medium scroll, reciprocating, or screw compressors (<750 kW) | R-450A (604, 33.3%)R-513A (631, 33.3%)HFC-32 (675, 33.3%) | 636.7 |

1. As created by the Climate Change Mitigation and Low-Carbon Economy Act, 2016, Ontario Regulation 144/16, *The Cap and Trade Program*. [↑](#footnote-ref-2)
2. As created by the Environmental Quality Act, Chapter Q-2, r. 46.1, *Regulation respecting a cap-and-trade system for greenhouse gas emission allowances*. [↑](#footnote-ref-3)
3. In certain circumstances, the Ontario Regulation may allow for an Offset Initiative Sponsor to fulfill duties that this protocol assigns to the Project Developer. [↑](#footnote-ref-4)
4. For a general discussion of advanced refrigeration systems, see the United State EPA discussion here (accessed July 3, 2017): <https://www.epa.gov/greenchill/advanced-refrigeration>. [↑](#footnote-ref-5)
5. As of the writing of this protocol, the California prohibitions are not final, but a list of HFCs prohibited for specific end-uses has been proposed. Information regarding the rulemaking activity may be accessed online at: <https://www.arb.ca.gov/regact/2018/casnap/casnap.htm> (accessed April 27, 2018). [↑](#footnote-ref-6)
6. Table 1-1 IPCC Global Warming Potentials (page 34) in Environment and Climate Change Canada. 2015. National Inventory Report 1990-2015: Greenhouse gas sources and sinks in Canada. Part 1. Gatineau Qc. (Page 34) [↑](#footnote-ref-7)
7. Table 2.14 (Errata) and Table 2.15 in Changes in Atmospheric Constituents and in Radiative Forcing. In IPCC. 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp. [↑](#footnote-ref-8)
8. Appendix 8.A: Lifetimes, Radiative Efficiencies and Metric Values (page 732) in Anthropogenic and Natural Radiative Focing. In: IPCC. 2013. Climate Change: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp. [↑](#footnote-ref-9)
9. Table 2.6. Lifetimes, radiative efficiencies, and direct global warming potentials (GWPs) relative to carbon dioxide, for the ODs and their replacements (page 160) in IPCC/TEAP. 2005. Special Report: Safeguarding the Ozone Layer and the Global Climate System. Cambridge University Press, New York. [↑](#footnote-ref-10)
10. US EPA. n.d. Significant New Alternatives Policy (SNAP). Substitutes in Stand-alone Equipment. Website available at: <https://www.epa.gov/snap/substitutes-stand-alone-equipment#self> [↑](#footnote-ref-11)
11. Annual leak rates are calculated as the lower quartile of the range of Operation Emissions provided in Table 7.9 of Chapter 7, Volume 3, of the 2006 Intergovernmental Panel on Climate Change Guidelines for National Greenhouse Gas Inventories. [↑](#footnote-ref-12)
12. Consolidated Canadian Federal Halocarbon Regulations, 2003, SOR/2003-289, (last amended on July 30, 2009). [↑](#footnote-ref-13)
13. IPCC 2006. 2006 IPCC guidelines for national greenhouse gas inventories. 2013-04-28]. http://www. ipcc-nggip. iges. or. jp./public/2006gl/index. html. [↑](#footnote-ref-14)