VM0001 REFRIGERANT LEAK DETECTION

Version 2.0

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CONTENTS

1 SOURCES

This methodology draws upon the latest approved versions of the following documents:

- CDM: *TOOL1 Tool for the demonstration and assessment of additionality*
- WRI/WBCSD: *The GHG Protocol for Project Accounting*

2 SUMMARY DESCRIPTION OF THE METHODOLOGY

Additionality and Crediting Method	
Additionality	Project method
Crediting Baseline	Project method

This methodology applies to project activities that install real-time leak detection systems on retail direct expansion refrigeration equipment to reduce leaks of hydrofluorocarbon (HFC) refrigerants. It is globally applicable.

3 DEFINITIONS

DX refrigeration equipment
Direct expansion (DX) refrigeration equipment that uses a two-phase fluid directly in an evaporator to absorb heat through an expansion and evaporation process

HVAC system
A heat, ventilation and air conditioning (HVAC) system that provides comfort heating and cooling to a room, area or entire building

Real-time automatic leak detection system
Refrigerant leak detection system that automatically monitors refrigerant at regular intervals throughout the day and communicates readings back to a central monitoring center on a real-time basis

Seasonal top-offs and draw-downs
Adjustments to the refrigerant charge quantity of a system to compensate for the additional refrigerant needed for condenser flooding in winter to maintain head pressure and for the removal of refrigerant in the summer to prevent overfilling of the system receiver

4 APPLICABILITY CONDITIONS

This methodology applies to project activities that install real-time leak detection systems on retail direct expansion refrigeration equipment to reduce leaks of hydrofluorocarbon (HFC) refrigerants. It is globally applicable.

This methodology is applicable where all of the following conditions are met:

1) The project installs real-time automatic leak detection/management systems onto commercial direct expansion (DX) refrigeration systems in retail stores;
2) Installations are on existing refrigeration systems. There must be no other efficiency improvement in the system or technology;
3) The leak detection equipment is new or has been sourced from replaced or decommissioned refrigeration equipment to ensure that no leakage occurs (i.e., leak detection equipment must not be removed from a functioning refrigeration system);
4) The refrigerant used in the refrigeration system is a hydrofluorocarbon (HFC); and
5) The installation is supported by data systems for leak reporting/management that are used for ozone- depleting substance (ODS) reporting compliance purposes.

5 PROJECT BOUNDARY

The physical project boundary is the set of retail stores in which automatic, real-time leak detection systems have been installed and HFC refrigerants are used. Where HVAC systems in these stores are supported by the same leak detection systems, the physical boundary includes these HVAC systems.

The methodology covers the following categories of HFC emissions reductions from equipment within the project boundary:

1) HFC emissions during DX refrigeration equipment operations and/or repairs/maintenance; and
2) HFC emissions during seasonal top-offs and draw-downs.

The greenhouse gases included in or excluded from the project boundary are shown in Table 1 below.

Table 1: GHG sources included in or excluded from the project boundary

Source		Gas	Included?	Justification/Explanation
Baseline	Retail refrigeration equipment	HFC	Yes	Project activity is prevention of HFC leaks from refrigeration circuits to the atmosphere.
		CO_2 CH_4 N_2O	No	Leak detection systems do not impact energy efficiency of underlying DX systems; rather, more timely maintenance of refrigerant levels enables refrigeration equipment to consume less energy. GHG reductions due to reduced energy consumption are conservatively set to zero.
Project	Retail refrigeration equipment	HFC	Yes	Project activity is the prevention of HFC leaks from refrigeration circuits to the atmosphere.
		CO_2 CH_4 N_2O	No	Leak detection systems do not impact energy efficiency of underlying systems; rather, more timely maintenance of refrigerant levels enables refrigeration equipment to consume less energy. GHG reductions due to reduced energy consumption are conservatively set to zero. Electricity required to run leak detection systems is de minimis (less than 0.01%; 91 kWh/year versus 3–4 million kWh/year for each store of which 1.5–2 million kWh/year is for refrigerant equipment/HVAC systems)

6 BASELINE SCENARIO

Since leak detection systems are retrofitted to existing refrigeration management systems, the baseline scenario must be determined by analyzing the following potential alternatives:

1) Implementing a leak detection system without revenues from carbon credits; and
2) Continuation of the pre-project practice without automatic leak detection systems.

The project proponent must demonstrate through the additionality analysis (Section 7) that the most likely scenario without revenues from carbon credits is the continuation of the pre-project practice without automatic leak detection systems.

7 ADDITIONALITY

This methodology uses a project method for the demonstration of additionality.

Step 1: Regulatory surplus

Project proponents must demonstrate regulatory surplus in accordance with the rules and requirements regarding regulatory surplus set out in the latest version of the *VCS Methodology Requirements*. The following guidance must be considered:

All national or regional policies and regulations relevant to HFC must be assessed, including those that:

a) Place a fixed limit on a cumulative basis for total HFC emissions within a given year's operations;

b) Transfer ownership of all resulting HFC reductions to other entities to meet their separate compliance obligations (e.g., such as would arise in upstream cap/trade requirements);

c) Stipulate the installation of leak detection systems as the only option to fulfill retail operations' compliance purposes; and

d) Other policies/regulations that may impact the compliance of the practice without an automatic leak detection system

For projects in non-Annex 1 countries, the enforcement of existing policies must be assessed.

Where the above-mentioned policies/regulations exist (and are enforced in case of a non-Annex 1 Country), the project activity is not eligible.

This methodology is applicable only where the baseline scenario includes the continuation of the present practice without automatic leak detection systems.

Step 2: Investment analysis

Project proponents must use the latest version of the CDM *Tool for the demonstration and assessment of additionality*.

Proponents must apply the investment comparison analysis (2b Option III) to compare alternatives (1) and (2) from Section 6 or the investment benchmark analysis (2b Option III):

- Where an investment comparison analysis is applied, project activities are additional if the analysis shows that the project would not be the economically most attractive scenario in the absence of GHG credits.

- Where a benchmark analysis is applied, project activities are additional if:
    a) The project does not meet the required financial benchmark without carbon credit revenues;
    b) The economic performance of the project increases decisively through carbon credit revenues; and
    c) Carbon credit revenues can raise the economic performance at or above the required financial benchmark.
- For both options, cost savings from reduced refrigerant use must be included as a positive cash flow.
- A sensitivity analysis must be conducted to show whether the conclusion regarding the financial attractiveness is robust to reasonable variation in the critical assumptions.

Step 3: Common practice

The project shall not be common practice, determined as follows:

1) Project type shall not be common practice in sector/region, compared with projects that have received no carbon finance.
2) Where it is common practice, the project proponent shall identify barriers faced compared with existing projects.
3) Demonstration that the project is not common practice shall be based on guidance provided in *The GHG Protocol for Project Accounting, Chapter 7 (WRI-WBCSD)* or the CDM *Tool for the demonstration and assessment of additionality.*

8 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

Baseline emissions are determined using the annual average leak rate from HFCs of each retail store during the baseline period. This includes HFCs emitted during operations, repair and maintenance of the equipment within the project boundary.

The baseline period for store equipment consists of at least three years prior to the installation of the leak detection equipment for that store equipment.

Where such historical data records prior to the installation of the leak detection equipment are unavailable, subsequent consecutive years must be included.

If refills are less frequent than three years, the baseline period must be adjusted to cover at least one full refill cycle.

The project proponent must demonstrate that the selected baseline period is conservative.

The data inputs are based on those the company uses for ODS/refrigerant reporting compliance purposes. Therefore, baseline data must be based on such corporate records for the relevant project locations. Data must include the equipment's refrigerant charges and refills/replacements/leaks/use data (based on leak records and/or purchase records for replacement refrigerant as reflected in the compliance systems) according to the steps described below.

Since this is a retrofit project and the number of stores with leak detection systems may increase over time, the historical baseline must be recalculated each year *y* to account for new stores added or stores removed. The historical baseline is based on all store equipment with leak detection systems installed by year *y*. This ensures that the historical baseline is taken from the same set of systems against which the new total leak detection systems have been retrofitted and against which the leak rates for year *y* will be estimated. Thus, baseline emissions are given by a baseline leak rate BLR_y for each year *y*.

The baseline leak rates are estimated using the following procedures and equations.

The historical baseline is calculated as a three-year average based on HFC refrigerants. Calculations use totals for leaks and charges across all the refrigeration systems in stores where leak detection systems have been installed and HFCs are in use by year *y*.

$$BLR_y = \frac{1}{3} \times \sum_{x=1}^{x=X} \left(\sum_s L_{x,s} / \sum_s C_{x,s} \right) \tag{1}$$

Where:

BLR_y	=	Baseline leak rate from all store equipment with leak detection systems installed and HFCs in use by year *y* (%)
$L_{x,s}$	=	Total leaks from HFC refrigerants in baseline year *x* from store equipment *s* that has leak detection systems installed and HFCs in use by year *y* (kg)
$C_{x,s}$	=	Total charge for HFC refrigerants in baseline year *x* from store equipment *s* that has leak detection systems installed and HFCs in use by year *y* (kg)
s	=	Store equipment included in the project activity
x	=	Baseline year for each store equipment s, including at least three consecutive years x.

The total leaks and charge volumes are estimated from the database systems used for ODS management. These systems measure the refrigerants used to refill the equipment each time a leak occurs, reflecting the amount of refrigerant leaked. Each system entry describes the amount of refrigerant injected into the equipment at the time of a leak, thus providing data inputs that, summed over a year, give totals for $L_{x,s}$. These same data systems also document the refrigerant charges for each piece of store equipment. Summing the refrigerant charges for each piece of relevant equipment in the store s gives the total for $C_{x,s}$.

$L_{x,s}$ includes adjustments for seasonal top-offs and draw-downs where practiced in the store equipment. These are seasonal increases and decreases in refrigerant charge levels to adjust for seasonal temperature changes in the environment. Top-offs are considered a leak (thus an addition to $L_{x,s}$), while draw-downs are considered the opposite and thus a deduction to $L_{x,s}$ where recovered and not vented.

Where three years historical leak rate information prior to leak detection system installation is not available, a more conservative alternative historical baseline may be created by including emission rates from subsequent consecutive years.

For instance, if only two years historical data is available in a store, the baseline period (x_1, x_2, x_3) for that store will include two years before project implementation and one year after implementation.

If only one-year historical data is available, the baseline period for that store will be one year before and one year after, for the first project year; and one year before and two years after, for the second project year.

Baseline Cap

A baseline leak rate cap ($CAP\ BLR_y$) must be applied using the regional default values from Table 2.

Table 2: Baseline caps by region

Region	$CAP\ BLR_y$[1] (%)
United States	25
Canada	25
Europe and other Annex I countries	22
Rest of the world	35

[1] Sources: US EPA average leak rate for supermarkets (US); Crediting baseline-Federal Offset Protocol: Reducing Greenhouse Gas Emissions from Refrigeration Systems (Canada); 2030 goal-European refrigerant leak data from ADC3R report (2022) by CITEPA operator for the French Environment Ministry- (Europe and other Annex I countries); and R19 IPCC (2006) value for developing countries (rest of the world).

Final Baseline Selection

Where the historical project baseline (BLR_y) is greater than the baseline cap ($CAP\ BLR_y$), the baseline leak rate cap must be the baseline.

$$Final\ BLR_y = min(BLR_y\ , CAP\ BLR_y) \quad (2)$$

Where:

$Final\ BLR_y$ =Baseline leak rate to be adopted for the project in year *y* (%)

BLR_y =Baseline leak rate from stores with leak detection systems installed and HFCs in use by year *y* (%)

$CAP\ BLR_y$ =Baseline leak rate cap for stores by region as outlined in Table 2 (%)

8.2 Project Emissions

Project emissions are determined using the average leak rate arising from the total HFCs emitted during year *y*, the year in which VCUs are sought, whether emitted during operations, repair or maintenance of the equipment within the project boundary.

The project emissions from HFCs are estimated using the following approach and equations.

$$PLR_y = \sum_s L_{y,s} / \sum_s C_{y,s} \quad (3)$$

Where:

PLR_y = Project leak rate from stores equipment that has leak detection systems installed and HFCs in use by year *y* (%)

$L_{y,s}$ = Total leaks from HFC refrigerants in year *y* from store equipment s that has leak detection systems installed and HFCs in use by year *y* (kg)

$C_{y,s}$ = Total charge for HFC refrigerants in year *y* from store equipment s that has leak detection systems installed and HFCs in use by year *y* (kg)

Note – $L_{y,s}$ includes adjustments for HFC top-offs and draw-downs where practiced in the store equipment.

8.3 Leakage Emissions

There is no requirement for the project to consider leakage as it is not likely to occur for the following reasons:

- Any refrigerant savings achieved in the store location due to lower leak rates will result in smaller refrigerant purchases. Thus, any upstream leaks during manufacture or transportation of the refrigerant (which are estimated to be a relatively low percentage of total supply chain leaks from refrigerant use) will also be reduced. Such “positive leakage” is conservatively set at zero.

- Any top-off or draw-down changes in refrigerant use for the relevant period are already captured under $L_{y,s}$ and $L_{x,s}$.
- The leak detection systems do not control, influence or impact the release of refrigerants when equipment is decommissioned.
- This methodology does not apply to used leak detection equipment sourced from outside the project boundary, since in this case emissions may increase in the external location while emissions reductions are counted within the project. Leak detection equipment already installed in DX equipment within the project boundary may be removed (e.g., where DX equipment is being decommissioned) and used again (e.g., where new DX equipment is purchased) since these changes all take place within the project boundary.

8.4 Net GHG Emission Reductions and Removals

Emission reductions are calculated as follows:

$$LRR_y = Final\ BLR_y - PLR_y \tag{4}$$

Where:

LRR_y = Leak rate reduction for project in year *y* (%)

$Final\ BLR_y$ = Final baseline leak rate (the lower of historical leak rate BLR_y and the baseline cap) (%)

PLR_y = Project leak rate from stores equipment that has leak detection systems installed and HFCs in use by year *y* (%)

$$ER_y = \frac{LRR_y \times \sum_s C_{y,s} \times GWP_{HFC,y}}{1000} \tag{5}$$

Where:

ER_y = Emissions reductions in year *y* (t CO_2e)

LRR_y = Leak rate reduction for project in year *y* (%)

$C_{y,s}$ = Total charge for HFC refrigerants in year *y* from store equipment s that has leak detection systems installed and HFCs in use by year *y* (kg)

$GWP_{HFC,y}$ = Weighted average global warming potential of HFCs installed/used in year *y* (t CO_2e/t HFC)

The weighted average global warming potential $GWP_{HFC,y}$ is calculated by the following equation:

$$GWP_{HFC,y} = \frac{\sum_T (L_{T,y} \times GWP_T)}{\sum L_{T,y}} \quad (6)$$

Where:

$L_{T,y}$ = Total leaks from HFC refrigerant type T in year y from all store equipment that has leak detection systems installed and HFCs in use (kg)

GWP_T = Global warming potential of HFC type T installed/used in year y (t CO_2e/t HFC)

Table 3: Example of $GWP_{HFC,y}$ calculation

	$L_{T,y}$	GWP_T	$L_{T,y} \times GWP_T$
HFC 1	110	600	66 000
HFC 2	50	3 000	150 000
HFC 3	40	1 000	40 000
SUM_T	**200**		**256 000**
$GWP_{HFC,y}$		1 280	

Data for illustrative purposes only

9 MONITORING

9.1 Data and Parameters Available at Validation

In addition to the parameters listed in the tables below, the provisions on data and parameters available at validation in the tools referred to in this methodology apply.

Data/Parameter	$L_{x,s}$
Data unit	kg
Description	Total leaks from HFC refrigerants in baseline year x from store equipment s in stores has leak detection systems installed and HFCs in use by year y
Equations	(1)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Value applied	Sum of historical HFC leaks in the store equipment s during the baseline years x x is the baseline year for each store equipment s, including historical data of at least three consecutive years x. If refills are less frequent than three years, the baseline period must be adjusted to cover at least one full refill cycle.

	The project proponent must demonstrate that the selected baseline period is conservative.
Justification of choice of data or description of measurement methods and procedures applied	Since historical data are logged in compliance programs, baseline leak data will be available at the time of validation to ensure a proper reduction in leak rates is achieved. If historical data is not available, this parameter will be included under monitoring tables
Purpose of data	Calculation of baseline emissions
Comments	

Data/Parameter	$C_{x,s}$
Data unit	kg
Description	Total charge for HFC refrigerants in year x from store equipment s in stores that have leak detection systems installed and HFCs in use by year y
Equations	(1)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Value applied	Sum of historical HFC total charge size in the store equipment s. x is the baseline year for each store equipment s, including historical data of at least three consecutive years x. If refills are less frequent than three years, the baseline period must be adjusted to cover at least one full refill cycle. The project proponent must demonstrate that the selected baseline period is conservative.
Justification of choice of data or description of measurement methods and procedures applied	Since historical data are logged in compliance programs, baseline charge data will be available at the time of validation to ensure a proper reduction in leak rates is achieved. If historical data is not available, this parameter will be included under monitoring tables
Purpose of data	Calculation of baseline emissions
Comments	

Data/Parameter	GWP_T
Data unit	t CO_2e/t HFC
Description	Global warming potential of HFC type T installed/used in year y
Equations	(6)
Source of data	According to the most recent version of the *VCS Standard*

Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	According to the most recent version of the VCS Standard.
Purpose of data	Calculation of emission reductions
Comments	

9.2 Data and Parameters Monitored

Data/Parameter	$L_{x,s}$
Data unit	kg
Description	Total leaks from HFC refrigerants in baseline year x from store equipment s in stores has leak detection systems installed and HFCs in use by year y
Equations	(1)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Description of measurement methods and procedures to be applied	Total leak volumes are derived from the database systems used for ODS management. Each system entry describes the amount of refrigerant used to refill the refrigeration equipment each time a leak occurs during year *x*, reflecting the amount of refrigerant leaked. This provides the data inputs which summed over year *x* give the total leak volumes for $L_{x,s}$. x is the baseline year for each store equipment s, including historical data of at least three consecutive years x. If refills are less frequent than three years, the baseline period must be adjusted to cover at least one full refill cycle. The project proponent must demonstrate that the selected baseline period is conservative.
Frequency of monitoring/recording	$L_{x,s}$ is recorded every time refrigerant is added, and where leak detection systems are installed in new stores each year is updated annually. Leaks are typically reported in compliance logs as new refrigerant is installed in the equipment. Compliance logs report these at different frequencies (typically monthly totals) from which annual totals are calculated.
QA/QC procedures to be applied	Check for consistency among project data logs, compliance logs and refrigerant purchase records.

Purpose of data	Calculation of baseline emissions
Calculation method	Sum
Comments	Ensure that any seasonal top-off or draw-down additions/removals are included/netted out in $L_{x,s}$ even where these are not incorporated into compliance logs.

Data/Parameter	$C_{x,s}$
Data unit	kg
Description	Total charge for HFC refrigerants in year x from store equipment s in stores that have leak detection systems installed and HFCs in use by year y
Equations	(1)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Description of measurement methods and procedures to be applied	The ODS management data systems document refrigerant charges for each piece of equipment in the stores. $C_{x,s}$ is obtained by summing the refrigerant charges for each piece of relevant equipment as itemized for year *x*. x is the baseline year for each store equipment s, including historical data of at least three consecutive years x. If refills are less frequent than three years, the baseline period must be adjusted to cover at least one full refill cycle. The project proponent must demonstrate that the selected baseline period is conservative.
Frequency of monitoring/recording	Where leak detection systems are installed in new project stores each year, $C_{x,s}$ is annually updated to include the total HFC capacity charges for those new stores.
QA/QC procedures to be applied	Check for consistency among project data logs, compliance logs and equipment specifications from manufacturer.
Purpose of data	Calculation of baseline emissions
Calculation method	Sum
Comments	Charge capacities for HFCs may change over the baseline period because HFCs are gradually replacing HCFCs, whose charge levels may be declining. Since $C_{x,s}$ may fractionally change where leak detection systems are installed in new stores, annual monitoring of data/compliance logs in year *y* for total HFC charge amounts in baseline years is required to take into account stores where new leak detection systems have been installed by year *y*.

	$C_{x,s}$ measurement is consistent with the requirements for ODS reporting.

Data/Parameter	$L_{y,s}$
Data unit	kg
Description	Total leaks from HFC refrigerants in year *y* from store equipment s that has leak detection systems installed and HFCs in use by year *y*
Equations	(3)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Description of measurement methods and procedures to be applied	Total leak volumes are derived from the database systems used for ODS management. Each system entry describes the amount of refrigerant used to refill the refrigeration equipment each time a leak occurs during year *y*, reflecting the amount of refrigerant leaked. This provides the data inputs which summed over year *y* give the total leak volumes for $L_{y,s}$.
Frequency of monitoring/recording	Each time a refill takes place. Assessed once for year *y*. Leaks are typically totaled monthly in compliance logs.
QA/QC procedures to be applied	Check for consistency among project data logs, compliance logs and refrigerant purchase records.
Purpose of data	Calculation of project emissions
Calculation method	Sum
Comments	Ensure that any seasonal top-off or draw-down additions/removals are included/netted out in $L_{y,s}$ even where these are not incorporated into compliance logs.

Data/Parameter	$C_{y,s}$
Data unit	kg
Description	Total charge for HFC refrigerants in year *y* from store equipment s in stores that have leak detection systems installed and HFC in use by year *y*
Equations	(3), (5)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Description of measurement methods and procedures to be applied	The ODS management data systems document the refrigerant charges for each piece of equipment in the stores. $C_{y,s}$ is obtained by summing the refrigerant charges for each piece of relevant equipment as itemized for year *y*.

Frequency of monitoring/recording	Assessed once for year *y*
QA/QC procedures to be applied	Check for consistency among project data logs, compliance logs and equipment specifications from manufacturer.
Purpose of data	Calculation of project emissions
Calculation method	Sum
Comments	Charge capacities for HFCs are likely to increase over time as HFCs are installed across more equipment in a given store, replacing HCFCs. Thus, annual monitoring of data/compliance logs in year *y* for total HFC charge amounts is required.

Data/Parameter	$L_{T,y}$
Data unit	kg
Description	Total leaks from HFC refrigerant type *T* in year *y* from all store equipment that has leak detection systems installed and HFCs in use
Equations	(6)
Source of data	Refrigerant compliance logs for relevant stores/equipment
Description of measurement methods and procedures to be applied	As above for $L_{x,s}$ and $L_{y,s}$ for relevant HFC leaks by individual type *T*
Frequency of monitoring/recording	Assessed once for year *y*. Leaks typically totaled monthly in compliance logs.
QA/QC procedures to be applied	Check for consistency among project data logs, compliance logs and total amount of refrigerant ($\Sigma_T(L_{T,y}) = \Sigma_s(L_{y,s})$)
Purpose of data	Calculation of project emissions
Calculation method	Sum
Comments	Ensure that any seasonal top-off or draw-down additions/removals are included/netted out in $L_{T,y}$ even where these are not incorporated into compliance logs.

9.3 Description of the Monitoring Plan

All parameters indicated in Section 9.2 must be monitored unless indicated otherwise. All measurements must be conducted with calibrated equipment and according to industry standards.

As an overview, the monitoring system must include:

a) Leak management data taken from companies' compliance records for ODS refrigerants under the Montreal Protocol. The data management systems from which a project's core leak/charge data is obtained will already be in place and used for complementary regulatory purposes.

b) Review of further calculations performed in order to establish cumulative annual leak rates for systems and relevant averages (historical leak rates and current year leak rates), which will typically be conducted separately from compliance records:

c) Including a review of seasonal invoices or data logs for top-off and draw-down changes in refrigerants where these are not automatically included in real- time compliance data systems.

d) Review of calculations of average weighted GWP based on the volume of refrigerants used by a store in the crediting year, allocating GWP savings across HFCs on an accurate pro-rata annual basis as established by the methodology.

While leak detection systems have a real-time, electronic management system to provide timely alerts and communications, this methodology does not assume that monitoring and verification systems are electronically based.

The monitoring frequencies and measurement procedures from which refrigerant leaks are tracked are established by the underlying compliance requirements for ODS and will be considered sufficient. In the US, refrigerant leaks are typically aggregated monthly, while refrigerant charges are updated annually based on data from underlying ODS compliance databases. The measurement and monitoring equipment in the leak detection systems must be calibrated according to current good practices consistent with such compliance requirements.

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APPENDIX 1: UNCERTAINTY ASSESSMENT

The uncertainty associated with the application of this methodology was assessed according to the 2006 IPCC Guidelines following the linear error propagation approach.

Leaks are expected to have low uncertainty since they are measured during project implementation. They rely on ODS reporting systems and are based on HFC purchases throughout the year. A value of 2 percent is assumed for individual values but the uncertainty decreases radically when total values are obtained by addition. For example, by aggregating only ten individual values, the uncertainty decreases to 0.6 percent. A value of 1 percent is assumed for propagation.

The charge of the refrigeration systems used is also expected to have very low uncertainty since it is monitored and obtained from the technical specifications of the equipment installed. A value of 0.5 percent is assumed for aggregated charge in the propagation.

The equations applied to propagate the uncertainty of individual parameters are:

For multiplication: $U = \sqrt{U_1^2 + U_2^2 + \cdots + U_n^2}$

For addition and subtraction: $U = \frac{\sqrt{(U_1 \, . \, x_1)^2 + (U_2 \, . \, x_2)^2 + \cdots + (U_n \, . \, x_n)^2}}{|x_1 + x_2 + \cdots + x_n|}$

The resulting estimation of the uncertainty of emission reductions is 4 percent, so the quantification excludes random uncertainty according to the *VCS Methodology Requirements*.

The figure below contains details of the values applied, intermediate results and final uncertainty.

L_x and C_x below must be understood as the sum of $L_{x,s}$ and $C_{x,s}$ respectively. Idem with L_y and C_y.

Eq. 1 $BLR_y = [L_x/C_x + L_{x-1}/C_{x-1} + L_{x-2}/C_{x-2}] / 3$

			Uncertainty %
BLR_y	21.5%		1.9%
L_x	699	t	1.0%
C_x	3,650	t	0.5%
L_{x-1}	825	t	1.0%
C_{x-2}	3,600	t	0.5%
L_{x-2}	810	t	1.0%
C_{x-2}	3,600	t	0.5%

Eq. 4 $PLR_y = [L_y/C_y]$

PLR_y	9.1%		1.1%
L_y	333	t	1.0%
C_y	3,650	t	0.5%

Eq. 5 $LRR_y = Final\ BLR_y - PLR_y$

LRR_y	12.4%	3.5%
BLR_y	21.5%	
PLR_y	9.1%	

Eq. 6 $ER_y = \frac{LRR_y \times C_y \times GWP_{HFC,y}}{1000}$

ER_y	**1,625**	**tCO2e**	**3.6%**
LRR_y	12.4%		
C_y	4	t	
$GWP_{HFC,y}$	3,591		0.9%

Eq. 7 $GWP_{HFC,y} = \frac{\sum_T [L_{T,y} \times GWP_T]}{\sum L_{T,y}}$

HFC	$L_{T,y}$	U%	GWP_T	$L_{T,y} \times GWP_T$	U%
HFC32	11.6	1.0%	677	7853.2	1.0%
HFC125	144.2	1.0%	3170	457114	1.0%
HFC134a	34.2	1.0%	1300	44460	1.0%
HFC143a	143	1.0%	4800	686400	1.0%
SUM	333	0.6%		1,195,827	0.7%
$GWP_{HFC,y}$	3,591	0.9%			

DOCUMENT HISTORY

Version	Date	Comment
v1.0	16 Feb 2010	Initial version, developed by CN Business Network
v1.1	17 Mar 2017	Clarified that GWP values must be derived from sources specified by the VCS rules (GWP parameter tables listed below paragraph 26)
v2.0	05 Feb 2024	Major revision, including the following changes: • The methodology title was updated from *VM0001 Infrared Automatic Refrigerant Leak Detection Efficiency Project Methodology* to *VM0001 Refrigerant Leak Detection* • Expansion to other leak detection systems besides infra-red • Expansion of the methodology to be globally applicable, including regional baseline leak rate caps • Uncertainty assessment added • General improvements, simplification and clarifications