VCS Methodology

VM0001

REFRIGERANT LEAK DETECTION

Version 1.2

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Sectoral Scope 11: Fugitive emissions – from Industrial gases (halocarbons and sulphur hexafluoride)

Version 1.0 of this methodology was developed by Climate Neutral Business Network (CNBN) and Giant Eagle.

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1 SUMMARY DESCRIPTION

Additionality, Crediting Method, and Mitigation Outcome	
Additionality	Project method
Crediting Baseline	Project method
Mitigation Outcome	Reductions

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

2 SOURCES

This methodology uses the most recent version of the following tool:

- *VT0008 Additionality Assessment*

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.

Metric tonnes
A unit of mass equal to 1,000 kilograms, used in the metric system. All references to tonnes in this methodology refer to metric tonnes.

Real-time automatic leak detection system
Refrigerant leak detection system that automatically monitors refrigerant at regular intervals throughout the day 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 DX refrigeration equipment in retail stores to reduce leaks of hydrofluorocarbon (HFC) refrigerants. It is applicable in the United States.

This methodology is applicable under the following conditions:

1) The project installs real-time automatic leak detection/management systems onto commercial DX refrigeration systems in retail stores.
2) Real-time automatic leak detection/management systems are installed on existing refrigeration systems.
3) The leak detection equipment meets one of the following conditions to ensure no leakage occurs:
    a) It is a new leak detection system;
    b) It is sourced from other refrigeration equipment that has been fully decommissioned; or
    c) It is sourced from other refrigeration equipment where it has been permanently replaced with a different leak detection system.
4) The refrigerant used in the refrigeration system is:
    a) A pure hydrofluorocarbon (HFC) (i.e., a single HFC);
    b) A blend of different HFCs; or
    c) A blend of HFCs and HFOs.

Note – While blends of HFCs and HFOs are permitted, only the HFCs will be credited.

5) The installation is supported by data systems for leak reporting/management that are used for HFC reporting compliance purposes under the Kigali amendment of the Montreal Protocol.
6) The project activity is located in the United States.

Note – A revision may be submitted to expand applicability to other countries or regions.

This methodology is not applicable under the following conditions:

7) Other efficiency improvements than the leak detection system are implemented.

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 negatively impact energy efficiency of underlying DX systems; rather, more timely maintenance of refrigerant levels enables refrigeration equipment to consume less energy. GHG emission reductions from reduced energy consumption are conservatively excluded.
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 negatively impact energy efficiency of underlying systems; rather, more timely maintenance of refrigerant levels enables refrigeration equipment to consume less energy. Note: electricity required to run leak detection systems is negligible (typically around 100 kWh/year for a retail store, representing less than 0.1 tCO_2/year)

6 BASELINE SCENARIO

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

1) Continuation of the pre-project practice without automatic leak detection systems.
2) The project activity undertaken without carbon credit revenues; and

The project proponent must apply the additionality analysis (Section 7) to demonstrate that the most likely scenario is the continuation of the pre-project practice without automatic leak detection systems in the absence of the project activity.

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 set out in the most recent versions of the *VCS Standard* and *VCS Methodology Requirements*. The following additional 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.
d) may impact otherwise the compliance of the practice without an automatic leak detection system.

Where the project activity demonstrates regulatory surplus, proceed to Step 2 (investment analysis). Otherwise, the project activity is not additional.

Step 2: Investment analysis

The project proponent must apply an investment comparison analysis (option 1) of the most recent version of *VT0008 Additionality Assessment*.

For the baseline scenario, ongoing refrigerant costs must be included as cash flows. For the project scenario, cash flows must include the investment cost of the leak detection system, ongoing refrigerant costs, and any other relevant expenses or revenues associated with the implementation, operation, and maintenance of the leak detection system.

Where the investment comparison analysis (including sensitivity analysis) shows that the project activity would not be the economically most attractive scenario in the absence of carbon credit revenues, proceed to Step 3 (common practice analysis). Otherwise, the project activity is not additional.

Step 3: Common practice

The project proponent must apply the common practice analysis following the most recent version of *VT0008 Additionality Assessment*.

Where the proposed project activity is not considered common practice, and Step 1 (regulatory surplus) and Step 2 (investment analysis) are met, the project activity is additional.

Where the proposed project activity is considered common practice, the project activity is not additional.

8 QUANTIFICATION OF REDUCTIONS AND REMOVALS

8.1 Baseline Emissions

Baseline emissions are determined using the annual average leak rate from refrigerants of each retail store during the baseline period. This includes refrigerant 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 HFC refrigerant reporting compliance purposes under the Kigali amendment of the Montreal Protocol. 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 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 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 HFC 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 data from the GreenChill Program of the U.S. Environmental Protection Agency (EPA) as per Table 2.

Table 2: Baseline leak rate cap (*CAP BLR$_y$*)

EPA Green Chill share	*CAP BLR$_y$* (%)
If Green Chill members' share of industry is less than 50%	Highest leak rate from among their members' averages
If Green Chill members' share of industry is more than 50%	Leak rate achieved by the supermarket member which, on a ranked basis from highest performing to lowest performing (that is lowest leak rate to highest leak rate) represents the 50th percentile of retail stores (see example below)

Example:

Supermarket "i" (anonymous)	LR_i Avg. leak rate for supermarket i	IC_i % Industry capacity	Sumi = 0 through i (IC_i) Cumulative Capacity
Supermarket A	7%	3%	3%
Supermarket B	9%	15%	18%
Supermarket C	11%	4%	22%
Supermarket D	13%	12%	34%
Supermarket E	15%	8%	42%
Supermarket F	17%	10%	52%
Supermarket G	19%	5%	57%
Supermarket H	21%	3%	60%

Additionally, a second cap of 25%, based on the EPA's estimate for the U.S. industry average leak rate, is applied.

Final Baseline Selection

The final baseline leak rate (*Final* BLR_y) is determined per Equation 2:

$$Final\ BLR_y = min(BLR_y\,, CAP\ BLR_y, 25\%) \quad (2)$$

Where:

Final BLR_y	=	Final baseline leak rate in year *y* (%)
BLR_y	=	Baseline leak rate from all store equipment with leak detection systems installed and HFCs in use by year *y* (%)
CAP BLR_y	=	Baseline leak rate cap for Green Chill members as outlined in Table 2 (%)
25%	=	EPA's estimate for the U.S. industry average leak rate

8.2 Project Emissions

Project emissions are determined using the average leak rate in year *y* arising from the total refrigerants 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 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 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 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 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 in year *y* (%)

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 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 refrigerant substance 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 refrigerant substance* type T installed/used in year y (t CO_2e/t HFC_T)

Where HFC/HFOs blends are used, the GWP of HFO is zero as illustrated in Table 3.

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

	$L_{T,y}$	GWP_T	$L_{T,y} \times GWP_T$
HFC 1	100	600	60 000
HFC 2	50	3 000	150 000
HFC 3	40	1 000	40 000
HFO 1*	10	0	0
SUM_T	**200**		**250 000**
$GWP_{HFC,y}$		**1 250**	

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 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 refrigerant 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 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 refrigerant total charge size in the store equipment s, using the more conservative value of the initial charge and the nameplate charge. If the equipment lacks a nameplate, the initial charge must be used. 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_T
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 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/HFC 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 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 HFC 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*, using the more conservative value of the initial charge and the nameplate charge. If the equipment lacks a nameplate, the initial charge must be used. 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/HFC reporting.

Data/Parameter	$L_{y,s}$
Data unit	kg
Description	Total leaks from 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 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 HFC 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*, as the initial charge or nameplate, using the more conservative value of the initial charge and the nameplate charge. If the equipment lacks a nameplate, the initial charge must be used.
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 refrigerant substance 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 refrigerant 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 HFC/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 HFC/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 $BLR_y = [L_x/C_x + L_{x-1}/C_{x-1} + L_{x-2}/C_{x-2}] / 3$

	Value	Unit	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 $PLR_y = [L_y/C_y]$

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

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

	Value	Uncertainty %
LRR_y	12.4%	3.5%
BLR_y	21.5%	
PLR_y	9.1%	

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

	Value	Unit	Uncertainty %
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)
v1.2	05 Nov 2024	Minor 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 • Update to use the most recent version of *VT0008 Additionality Assessment* • Uncertainty assessment (Appendix 1) included • General improvements, simplification and clarifications