Draft approved baseline and monitoring methodology AM00XX

"Manufacturing of energy efficient domestic refrigerators"

I. SOURCE, DEFINITIONS AND APPLICABILITY

Sources

This baseline and monitoring methodology is based on the case NM0235 "Manufacturing of energy efficient domestic refrigerators" (by M/s Godrej & Boyce Mfg. Ltd) prepared by Winrock International India, INFRAS - Consulting, Policy Analysis & Research and South Pole Carbon Asset Management Ltd.

This methodology also refers to the latest approved versions of the "Tool to calculate the emission factor for an electricity system".

For more information regarding the proposed new methodology and the tools as well as their consideration by the Executive Board please refer to <https://cdm.unfccc.int/methodologies/PAmethodologies/approved.html>.

Selected approach from paragraph 48 of the CDM modalities and procedures

"Existing actual or historical emissions, as applicable"

Definitions

For the purpose of this methodology, the following definitions apply:

The term **refrigerator** under this methodology refers to electric plug-in type refrigeration appliances, which are typically used by households and have a fresh food compartment for storing goods at few degrees Celsius above the freezing point of water. This includes household refrigerators and household refrigerator/freezer combinations. Refrigeration appliances specially designed for commercial purposes such as refrigerators with glass doors, and household freezers, which do not have a fresh food compartment, are excluded under this methodology. The storage volume of a domestic refrigerator does not exceed 600 litres.

Freezer is a cooling device for food storage. It comprises a thermally insulated compartment and a mechanism to transfer heat from it to the external environment, cooling the contents to a temperature below the freezing point of water.

The term **year** may correspond to a calendar year, fiscal year or business year whichever is more relevant for the data collection by the project participant. Throughout the CDM-PDD the same delineation for **year** has to be applied, including any historical reference periods.

The term **sales** refers to ex works sales of a manufacturer to distributors or regional branches, unless specified otherwise. Throughout the CDM-PDD the same delineation for **sales** has to be applied.

The term **manufacturer** refers to any national or international company producing and selling domestic refrigerators in the Host country.

The term **rated electricity consumption** refers to the annual electricity consumption of refrigerators measured according to national or international standards under no-load conditions, as further specified in Step 3 of "Project emissions".

The term **adjusted storage volume** is the storage volume of refrigerators, adjusted to take into account the effect on electricity consumption from different temperature zones (fresh food, ice tray, etc.) of a refrigerator.

The term **refrigerator model** refers to a refrigerator series or type produced by one manufacturer. Refrigerators that have a different adjusted storage volume or a different rated electricity consumption should be considered as different models. This means that if an existing model is modified in a manner that affects the adjusted storage volume or the rated electricity consumption, the modified refrigerator should be considered as a different model.

Applicability

This methodology is applicable to project activities undertaken by manufacturers of refrigerators that increase the energy efficiency of manufactured refrigerators.

The methodology is applicable under the following conditions:

- Refrigerators targeted under this methodology are not designed to be switched on and off and are used by households on a continuous basis;
- The methodology only accounts for refrigerators that are produced by a manufacturer, involved in the project activity, and that are produced and sold in the Host country. Project activities that involve import or export of refrigerators from or to other countries are not eligible under this methodology;
- The project participants have the necessary historic data on the quantities of refrigerator models manufactured and sold in the Host country during that period and their standard electricity use and adjusted storage volume;
- The Global Warming Potential (GWP) of refrigerants and foam blowing agents used by the manufacturer to produce refrigerators under the project activity is not larger than GWP of refrigerants and foam blowing agents used by the manufacturer during the three most recent historical years prior to the start of the project activity;
- To avoid potential double counting of emission reductions, the DOE performing validation of the project activity shall confirm in the validation report that no other project activity, involving the same refrigerator models as the proposed project activity, has been registered as a CDM project activity, submitted for registration or uploaded for public comments.

The energy efficiency improvements in refrigerators, undertaken under project activities covered by this methodology, may include *inter alia* the following technical measures:

- Increased insulation foam thickness or improved thermal properties of insulation foam;
- Optimisation of appliance geometry for reducing heat losses;
- Improvement of door gasket design;
- Optimisation of heat exchanger design, including condenser fans, etc.;
- Optimisation of system balancing;
- Improvement of compressor EER, including use of more efficient refrigerant gas;
- Optimisation of system controls, etc.

Under this methodology emission reduction credits cannot be claimed for reducing refrigerant emissions by switching from a refrigerant or a foam blowing agent with a higher GWP to a substance with a lower GWP. Project participants wishing to claim credits for such a switch may refer to the approved methodology AM00XX.

Emission reduction credits can also not be claimed for the replacement of existing types of refrigerator models by a different type of refrigerators (e.g. replacement of "Frost Free" refrigerators by "Direct Cool" ones, or refrigerator/freezer by refrigerator etc.).

In addition, the applicability conditions included in the tools referred to above apply.

II. BASELINE METHODOLOGY PROCEDURE

Identification of the baseline scenario and demonstration of additionality

Under this methodology a benchmark approach is applied to establish the baseline scenario and demonstrate additionality. A benchmark approach is used because project activities under this methodology can involve a range of energy efficiency improvement measures, implementation of which will be spread over the duration of the crediting period. For this reason, it would be difficult to undertake a solid barrier or investment analysis for the whole range of measures at the start of the project activity. Moreover, the benchmark approach provides a good basis to assess whether the efficiency of refrigerators manufactured under the project activity exceeds what is the common practice in the respective market.

The calculation of the benchmark is outlined in the section "Baseline emissions" below. It is considered that the baseline scenario is the manufacturing of refrigerators with the specific electricity consumption corresponding to the calculated benchmark for the respective storage volume class, taking into account autonomous energy efficiency improvement.

As long as the specific electricity consumption of refrigerators produced and sold in the Host country by the manufacturer, involved in the project activity, is lower than the benchmark for specific electricity consumption during each year of the crediting period, the project activity is deemed additional. A separate assessment of additionality is therefore not required under this methodology.

Project boundary

The **spatial extent** of the project boundary encompasses the area in the Host country or region, covering the end users that bought the project refrigerators, and the project electricity system(s) that these end-users are connected to.

The spatial extent of the project electricity system is as per that defined in the latest version of "Tool to calculate emission factor for an electricity system".

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

Source		Gas	Included?	Justification / Explanation
Baseline	Power plants servicing the project electricity system	CO_2	Yes	Emissions from power generation represent the major emission source in the baseline
		CH_4	No	Negligible
		N_2O	No	Negligible
Project activity	Power plants servicing the project electricity system	CO_2	Yes	Emissions from power generation represent the major emission source in the project scenario
		CH_4	No	Negligible
		N_2O	No	Negligible

Project emissions

Project emissions are determined through the following steps:

Step 1: Collect data on annual sales of refrigerators produced by the manufacturer involved in the project activity

Establish a database and collect information on sales of refrigerators, produced by the manufacturer involved in the project activity, for each model *i* and each vintage year *v*[1]. In case the refrigerators are sold within the geographical boundary of more than one electricity grid, sales data has to be established for each electricity grid.

Sales data must be based on total sales numbers minus imported units minus exported units. Sales data must account for 100% of the sales volume of the manufacturer involved in the project activity, i.e. cover all models and the whole geographical area where the project activity is implemented.

The project participants have to register in the database the name, address and intended country of use of the refrigerator for all buyers of project refrigerators (e.g. local retailers). Based on this database, all refrigerators, which are procured for the use outside the Host country, have to be excluded from consideration.

Step 2: Classify refrigerators

Allocate each refrigerator model *i* to a storage volume class *j* as per the classification scheme based on the total adjusted storage volume (ASV) of the refrigerator and the refrigerator design, i.e. "Direct Cool" or "Frost Free" as shown in Table 2. The total adjusted storage volume takes into account the effect on energy consumption from different temperature zones (fresh food, ice tray, etc.) of a refrigerator and shall be determined as per the specifications in the relevant standards (see also Step 3 for references on relevant standards). The class width for the storage volume classes is set at a fixed value of 50 litres and starting from 0 litres (i.e. 0- 50 litres, 51-100 litres, 101 – 150 litres, etc.).

Table 2: Classification system for refrigerators according to storage volume and technology

Storage volume (litres)	0-50	51-100	101-150	151-200	201-250	etc.
Direct Cool (DC)						
Frost Free (FF)						

[1] Vintage year *v* is the year, when a certain project refrigerator is sold. At the start of the project activity the year of the crediting period *y*=1 and the vintage year *v*=1.

Step 3: Establish rated electricity consumption per project refrigerator model

For each refrigerator model *i* belonging to class *j* and design DC or FF, which is represented in the sales statistics for vintage year *v* and included in the project activity, determine the rated electricity consumption $AEC_{DC,i,j}$ or $AEC_{FF,i,j}$. The model-specific rated electricity consumption should be measured on the basis of relevant national standards (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country[2]. While utilizing an applicable standard, the measurements for establishing the rated electricity consumption have to be conducted under no load conditions (i.e. measurement of electricity consumption under steady state operation of a refrigerator without user load incorporated) and appropriate ambient temperature (i.e. 32º C for class T (Tropical) appliances and 25º C for other classes).

The project participants can choose which adjusted storage volume classes *j* and refrigerator design DC or FF are included in the project activity and which are not. This provides flexibility to exclude a class *j* if the project emissions from that class exceed the respective baseline emissions. This may, for example, be the case, if the project activity is focused on certain storage classes *j*. Note also that combinations of storage classes *j* and refrigerator design (DC or FF), for which the sample group for calculation of the market benchmark contains less than 3 models, should be excluded from the project activity (see the section "Baseline emissions" for further guidance).

The decision on which adjusted storage volume classes *j* and design (DC or FF) are considered under the project activity and which are excluded should be made:

(a) Once at the beginning of the crediting period if the market benchmark is fixed for the duration of the crediting period (Option A in Sub-step 1.1 of the section "Baseline emissions");
(b) For each year of the crediting period if the market benchmark is updated annually (Option B in Sub-step 1.1 of the section "Baseline emissions").

The decision which classes *j* are included in or excluded from the project activity should be consistently applied to both project and baseline emissions (i.e. the same classes *j* should be excluded in both project and baseline emissions).

Step 4: Establish correction factor for actual against rated electricity consumption based on field monitoring

Calculation of emission reductions in this methodology is primarily based on the rated electricity consumption of the baseline and project refrigerators as per laboratory tests. To take into account various influencing factors on actual electricity consumption of a refrigerator in the field, such as the use pattern (food load, door opening, etc), environmental conditions at the actual place of installation (ambient temperatures, humidity, air flow, etc.) and possible idling periods of the refrigerator (e.g. due to temporarily disconnect from the grid for defrosting, time to repair after appliance failure, etc.), a correction factor for actual against rated electricity consumption (CFM_y) is introduced. This factor establishes the relationship between actual (field) electricity consumption and rated electricity consumption (as per laboratory testing).

The correction factor is applied to project and baseline electricity consumption, assuming that the relationship between actual (field) electricity consumption and rated electricity consumption does not depend on individual characteristics of a particular refrigerator, such as energy efficiency, cabinet

[2] The provisions of the respective standard with regard to the number of repeat measurements and number of individual samples to be measured for a particular model have to be followed. Typically, this will require at least 3 measurements to take into account uncertainties from single measurements.

size, proportion of food and freezer cabinet, door arrangement, etc., but only on the deviation of actual load (i.e. usage pattern) and actual climatic and operational conditions at the point of installation from the standard test conditions as described in the test standards for rated electricity consumption. Therefore, if a less energy efficient baseline refrigerator is operated at the same place by the same user as a more energy efficient project refrigerator, it can be expected that for both refrigerators a very similar *ratio* of actual against rated electricity consumption applies (i.e. the actual electricity consumption is the same percentage of the rated electricity consumption for different refrigerator models operated under the same field conditions).[3]

Project participants can choose between the following two options to determine CFM_y:

Option A: Use a default value of $CFM_y = 0.95$;
Option B: Establish a field monitoring scheme for at least three years to determine CFM_y.

Project participants should document their choice in the CDM-PDD. The option chosen should be implemented throughout the crediting period and not be changed within this period.

Implementation of option B

Through field monitoring the relationship between actual (field) electricity consumption and rated electricity consumption (as per laboratory testing) is established.

In case of the mean value for the ratio of actual electricity consumption against rated electricity consumption (taking into account statistical uncertainties) in a monitoring sampling group being *lower* than 1 (i.e. actual electricity consumption is less than rated electricity consumption), a correction factor is applied in calculation of emission reductions (i.e. in project emissions and baseline emissions) to support the conservativeness of the methodology. In case of the mean value for the ratio of actual electricity consumption against rated electricity consumption (taking into account statistical uncertainties) in a monitoring sampling group being *bigger* than 1 (i.e. actual electricity consumption is higher than rated energy consumption), only the values for rated electricity consumption are used and no correction is applied. This restriction is introduced to avoid that the monitoring sample group households be influenced in order to claim higher emission reductions. The field monitoring has to be undertaken for at least the three first years of the crediting period. From the fourth year onwards, project participants may either continue to monitor or use the most the conservative value from the first three years (see Sub-step 4.5 below).

The following Sub-steps describe the field monitoring procedure.

Sub-step 4.1: Establish monitoring sampling group

Monitoring is based on the measurement of electricity consumption during a monitoring period for refrigerators installed in households belonging to a monitoring sampling group (MSG). It should be ensured that the households included in the MSG receive the same level of service and information as other households and therefore use the refrigerator in the normal way. This means that they should not receive more information than other households and should not be forced to provide access to the refrigerator for monitoring purposes.

To yield statistically representative results, the size of MSG should be above an established minimum size. In this methodology, baseline and project emissions are adjusted by the margin of error at a 95% confidence interval from sampling the ratio of actual electricity consumption against rated electricity consumption. Emission reductions can only be claimed if ≥ 60 refrigerators are sampled

[3] With this, the ratio of actual against rated electricity consumption becomes a universal factor for all refrigerator models. Therefore the field sampling can be done over the full range of project refrigerators and the sampling procedure does not need to distinguish between different models under the project activity.

for each of the three first years of the crediting period.[4] This minimum number refers to the number of refrigerators, for which useful monitoring data are available in a particular monitoring interval. Therefore, to compensate for any possible dropouts from the MSG during the monitoring period, it will be necessary to initially select a sample size. Project participants may deliberately choose any size for the MSG ≥ 60 , taking into account the risk of dropouts from MSG, the overhead costs for monitoring and the effect from reduced statistical errors on account of a larger sample size in calculating emission reductions. Different sample group sizes may be chosen for each vintage year.

The selection of refrigerators to be included in the MSG has to be made in a random manner from the full range of refrigerators sold in a particular vintage year *v* and registered in the end user database (see Step 1) to ensure that the MSG is representative. The selection process for the MSG may take place as soon as the number of refrigerators sold in a particular vintage year *v* and registered in the end user database exceeds 1,000.[5] The CDM-PDD should include the explanation of the process and tools for effecting the random selection.

In case of dropouts from the MSG during the monitoring period, additional samples for replacement of the dropouts can be selected by applying the identical procedure as described above.

Sub-step 4.2: Install measurement equipment

The electricity consumption of a refrigerator in the MSG has to be metered by a specially installed electricity consumption meter. The electricity consumption meter can be either electronic or electro-mechanic but it has to have a non-volatile memory in case of power failure.[6] The meters must be fixed to the refrigerator or to the power supply cord in a permanent way to enable verification by the DOE during a spot check confirming that the meter has not been temporarily removed from the refrigerator.

Sub-step 4.3: Establish a monitoring database

The project participants have to establish a database to record all relevant information for the MSG, including, *inter alia*:

- A list of the households included in the MSG (name, address, telephone, GPS data);[7]
- Dates when each household was added to the MSG and removed from it, if applicable;
- For each spot check undertaken at a household in the MSG, the date of the spot check and information on the refrigerator included under the spot check:
    - Information that allows a clear identification of the refrigerator (brand, model, type, serial number, year of production, rated electricity consumption as per the specifications);
    - The date of installation of the measurement equipment;

[4] According to Sachs (1992), a sample of n>60 is necessary to yield meaningful data for the mean and the standard deviation. Note that due to the provisions in this methodology a large sample size involves higher transaction costs but might result in a low margin of error and thus more CERs, whereas a small sample size involves lower transaction costs for sampling but is likely to result in a higher margin of error and thus might result in less CERs.

[5] This is seen as a statistically representative number. Note that the monitoring parameter (i.e. ratio of actual/rated electricity consumption) does not depend on the geographical location or refrigerator model, therefore no significant bias will occur if the project refrigerators initially are not available throughout the geographical area.

[6] It is assumed that inaccuracy of the electricity consumption meter will statistically balance out over the MSG and therefore is not relevant.

[7] This information may be treated as confidential and only made available to the DOE, the CDM Executive Board and its support structure.

- The type of measurement equipment being used (brand, model);
- Information on whether the measurement equipment is working appropriately;
- Information on any changes made to the measurement equipment (exchange, repair, etc);
- Information on whether the refrigerator is working and connected to the electricity grid;
- Measurement results obtained (total electricity consumption recorded by meter in kWh);
- Any other relevant information.

An extract of the database should be attached to each monitoring report under the project activity covering a monitoring period within the first three years of the crediting period.

Sub-step 4.4: Monitor electricity consumption in the MSG

The project participants monitor the electricity consumption of project refrigerators in the MSG by undertaking spot checks at all households included in the MSG. The initial installation of measurement equipment at the household as per Sub-step 4.2 is regarded as the first spot check undertaken in the household.

The frequency of spot checks is by default every 12 month (i.e. annually) with a minimum of 10.5 month and a maximum of 13.5 month between two spot checks in any of the households. When undertaking a spot check, all households should be visited within a distinct short time period no longer than three weeks, i.e. the last household should be visited no later than three weeks after the visit to the first household.

During the spot checks, no additional written or oral information or recommendations on the use of refrigerator should be provided to the households.[8] All results of the spot check should be entered in the monitoring database established under Sub-step 4.3.

For the purpose of calculating the correction factor for actual against rated electricity consumption, the duration T_z of the monitoring interval z is defined as the time between two spot checks in days. As a simplification, the day in the middle between the first and the last visit to a household should be assumed as the point in time when the spot check has been undertaken in all households.

For a spot check at a household, the following provisions apply:

- A person carrying out the spot check should check if the refrigerator is still installed at the household. If the refrigerator cannot be found anymore, this should be noted in the database including the reason for removal of the refrigerator from the household. If the cause for removal of the refrigerator is permanent (e.g. not only for repair purposes but due to selling of the refrigerator to another household), the electricity consumption of the relevant refrigerator should, as a simplification, not be taken into account for this monitoring interval;
- A person carrying out the spot check should check and document in the database whether the electricity consumption meter installed at the household is working appropriately. If measurement equipment is not working appropriately, it should be exchanged by new measurement equipment, and, as a simplified approach, the electricity consumption from that refrigerator should not be considered for this monitoring interval z;
- The electricity consumption meter should be read and the results should be entered into the monitoring database. Where measurement equipment has been replaced during the spot check visit, the meter should be set to zero;
- If the household cannot be found anymore, this should be noted in the database. If the household has moved within the project boundary and can be traced to the new location, the household may either remain in the MSG or may be removed from the MSG. If the household

[8] This provision is required to ensure that the households in the MSG behave in a manner that is representative for all households.

has moved outside the project boundary and cannot be traced to the new location or does not exist anymore, it should be removed from the MSG.

From the monitored data obtained during spot checks, the annual electricity consumption of any sample refrigerator *m* belonging to the MSG is calculated as follows:

$$MAEC_{m,z} = MEC_{m,z} * \frac{365}{T_z} \quad \textbf{(1)}$$

Where:

$MAEC_{m,z}$ = Monitored annual electricity consumption of sample refrigerator *m* in monitoring interval *z* (kWh/year)
$MEC_{m,z}$ = Measured electricity consumption of sample refrigerator *m* in monitoring interval *z* (kWh/year)
T_z = Duration of monitoring interval *z* (time between spot checks) (days)
m = All refrigerators included in the MSG

Sub-step 4.5: Determine the correction factor for actual against rated electricity consumption

Calculate for each sample refrigerator *m* belonging to the MSG a correction factor $CFM_{m,z}$ for the ratio of actual electricity consumption against rated electricity consumption in monitoring interval *z*:

$$CFM_{m,z} = \frac{MAEC_{m,z}}{AEC_m} \quad \textbf{(2)}$$

Where:

$CFM_{m,z}$ = Correction factor for actual against rated electricity consumption for refrigerator *m* belonging to the MSG in monitoring interval *z*
$MAEC_{m,v,z}$ = Monitored annual electricity consumption of sample refrigerator *m* in monitoring interval *z* (kWh/year)
AEC_m = Rated electricity consumption of refrigerator *m* (kWh/year)
m = All refrigerators included in the MSG

Calculate for each monitoring interval *z* the mean value and standard error of mean value for the correction factor $CFM_{m,z}$:

$$\mu_{CFM,z} = \frac{\sum_{m=1}^{n_{MSG,z}} CFM_{m,z}}{n_{MSG,z}} \quad \textbf{(3)}$$

$$\sigma_{CFM,z} = \sqrt{\frac{\sum_{m=1}^{n_{MSG,z}} (CFM_{m,z} - \mu_{CFM,z})}{n_{MSG,z} - 1}} \quad \textbf{(4)}$$

Where:

$\mu_{CFM,z}$ = Mean correction factor for actual against rated electricity consumption from all refrigerators *m* included in the MSG during monitoring interval *z*

$\sigma_{CFM,z}$ = Standard deviation of the correction factor for actual against rated electricity consumption from all refrigerators *m,* included in the MSG during monitoring interval *z*

$n_{MSG,z}$ = Total number of refrigerators in the MSG monitored during monitoring interval *z* (see also the guidance in Sub-step 5.1 on the required size of a sample group)

$CFM_{m,z}$ = Correction factor for actual against rated electricity consumption for refrigerator *m* belonging to the MSG in monitoring interval *z*

m = All refrigerators included in the MSG

In the field monitoring scheme, it is required to measure at least three monitoring intervals (i.e. min (*z*) = 3), i.e. for approximately three years. The start date for the first monitoring period (*z*=1) shall be the start of the crediting period or the start of the year *y* in which the first refrigerator has been sold, whichever is later. The results from the monitoring period *z* = 1 will be applied to the data of the project year *y* = 2, the results from the monitoring period *z* = 2 to the data of the project year *y* = 3, and so on, i.e. y = z+1.

The aggregated correction factor CFM_y to be applied for calculating emission reductions is based on the monitoring results from the monitoring period *z* preceding the year *y* and taking into account a statistical margin of error at a 95% confidence interval:

$$CFM_y = \left(\mu_{CFM,z-1} - \frac{k * \sigma_{CFM,z-1}}{\sqrt{n_{MSG,z-1}}} \right) \quad if\ CFM_y < 1.0 \qquad \textbf{(5)}$$

otherwise: $CFM_y = 1.0$ **(6)**

Where:

CFM_y = Correction factor for actual against rated electricity consumption in year *y*

$\sigma_{CFM,z}$ = Standard deviation of the correction factor for actual against rated electricity consumption from all refrigerators *m* included in the MSG during monitoring interval *z*

$\mu_{CFM,z}$ = Mean correction factor for actual against rated electricity consumption from all refrigerators *m* included in the MSG during monitoring interval *z*

$n_{MSG,z}$ = Total number of refrigerators in the MSG monitored during monitoring interval *z* (see also the guidance in Sub-step 5.1 on the required size of a sample group)

z = Monitoring intervals

k = Two sided tolerance limit for 95% percentile of a normal distribution with 95% confidence level (k=2.38 for $n_{MSG,v,z}$ =50, k=2.23 for $n_{MSG,v,z}$ =100, k=1.96 for $n_{MSG,v,z} \geq 200$) [9] [10]

For any year *y* of the crediting period during the lifetime of refrigerators for which no directly monitored data are available (i.e. at the earliest with $z \geq 4$), the minimum value for CFM_y in any of the first three monitoring intervals *z* should be used:[11]

[9] Sachs (1992).

[10] For n > 200 identical provision as per Equation (17) in AM0046/Version 01 is used for simplification.

$$CFM_y = \min\{CFM_{z=1}; CFM_{z=2}; CFM_{z=3}\} \quad \textbf{(7)}$$

Step 5: Calculate electricity consumption from refrigerators sold in vintage year v

Calculate the electricity consumption in the project activity in year *y* of refrigerators that were sold in vintage year *v* within the geographical area of electricity grid *ec* ($EC_{PJ,ec,v,y}$), as follows:

$$EC_{PJ,ec,v,y} = \frac{\sum_j \sum_i \left(SN_{DC,i,j,ec,v} \times AEC_{DC,i,j} + SN_{FF,i,j,ec,v} \times AEC_{FF,i,j}\right)}{1000} \quad \textit{if } (v+1) \leq y < (v+12) \quad \textbf{(8)}$$

$$EC_{PJ,ec,v,y} = 0, \textit{ if } (v+1) > y \textit{ or } y \geq (v+12) \quad \textbf{(9)}$$

Where:

$EC_{PJ,ec,v,y}$	=	Electricity consumption in the project activity in year *y* from refrigerators that are sold in vintage year *v* within the geographical area of electricity grid *ec* (MWh/year)
$SN_{DC,i,j,ec,v}$	=	Number of units of refrigerator models *i,* belonging to storage volume class *j* and design DC, that was manufactured by the manufacturer, involved in the project activity, and sold in vintage year *v* within the geographical area of electricity grid *ec*
$SN_{FF,i,j,ec,v}$	=	Number of units of refrigerator models *i* belonging to storage volume class *j* and design FF that was manufactured by the manufacturer, involved in the project activity, and sold in vintage year *v* within the geographical area of electricity grid *ec*
$AEC_{DC,i,j}$	=	Rated electricity consumption of refrigerator model *i* belonging to storage volume class *j* and design DC (kWh/year)
$AEC_{FF,i,j}$	=	Rated electricity consumption of refrigerator model *i* belonging to storage volume class *j* and design FF (kWh/year)
i	=	All refrigerator models manufactured by the manufacturer, involved in the project activity, and sold during vintage year *v*
j	=	Adjusted storage volume classes included in project and baseline emissions
v	=	Vintage year (1 in the first year of the crediting period, 2 in the second year and so on)
ec	=	All electricity grids in the Host country or region included in the project activity

It is assumed that a refrigerator lifetime is 12 years for both DC and FF refrigerators. This value for lifetime is the lower range end of IPCC default values for domestic refrigerators, which is a conservative assumption[12], especially for the market conditions of non-Annex I countries. Equation (8) and (9) also ensure that electricity consumption of any refrigerator sold in year *v* is only accounted for from the start of the first full year of operation (*v*+1) onwards. With this requirement the time lag between selling by the manufacturer and commissioning of the refrigerator at the household is accounted for.

[11] This provision is used to minimise the monitoring costs. It is justified on the basis of the assumption that major effects on electricity consumption can be identified with sufficient reliability from the first three years of the crediting period.

[12] IPCC 2000, p. 3.106.

Step 6: Calculate the electricity consumption in the project activity per grid in year y

Project electricity consumption in electricity grid *ec* in year *y* is calculated by totalizing over the different vintages and adjusting for potential differences between actual and rated electricity consumption, as follows:

$$EC_{PJ,ec,y} = \sum_{v} EC_{PJ,ec,v,y} * CFM_{y} \quad \textbf{(10)}$$

Where:

$EC_{PJ,ec,y}$ = Project electricity consumption in electricity grid *ec* in year *y* (MWh/year)
$EC_{PJ,ec,v,y}$ = Electricity consumption in the project activity in year *y* from refrigerators that were sold in vintage year *v* within the geographical area of electricity grid *ec* (MWh/year)
CFM_y = Correction factor for actual against rated electricity consumption in year *y*

Step 7: Calculate project emissions

Project emissions related to electricity consumption by refrigerators in year *y* are calculated based on the electricity consumption in the project activity, the grid emission factor and transmission and distribution losses of the grid, and summed up over the different grids *ec* included in the project activity, as follows:

$$PE_{y} = \sum_{ec} \frac{EC_{PJ,ec,y} * EF_{CO2,ELEC,ec,y}}{1 - TDL_{ec,y}} \quad \textbf{(11)}$$

Where:

PE_y = Project emissions in year *y* (t CO_2/year)
$EC_{PJ,ec,y}$ = Project electricity consumption in electricity grid *ec* in year *y* (MWh/year)
$EF_{CO2,ELEC,ec,y}$ = CO_2 emission factor for electricity grid *ec* for year *y* (t CO_2/MWh), calculated as the combined margin emission factor in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
$TDL_{ec,y}$ = Technical distribution losses in the electricity grid *ec* in year *y* (kWh of technical electric losses in the electricity grid / kWh of electricity supplied to final consumers)

Baseline emissions

The methodology for estimating baseline emissions is based on the following assumptions:

- The baseline refrigerator location is identical to the project refrigerator location. This is valid because there is no influence of the project activity on the place of use of the refrigerator;
- The baseline refrigerator has the same lifetime as the project refrigerator. This is valid because there is no systematic impact from energy efficiency improvements on the reliability or lifetime of a refrigerator.

Baseline emissions are calculated based on benchmarks for the specific electricity consumption (in kWh/year*litre) of refrigerators in the baseline. A separate benchmark is established for each storage volume class *j* and refrigerator design (DC or FF).

For each class j and refrigerator design DC or FF, the benchmark corresponds to the lower value between:

(a) The specific electricity consumption of the top 20% performer refrigerators in the market of the Host country (market benchmark); and
(b) The average historical specific electricity consumption of the refrigerators produced by the manufacturer, involved in the project activity (manufacturer benchmark).

The following steps are applied to determine the baseline emissions:

Step 1: Calculate the market benchmark

Sub-step 1.1: Collect data on refrigerators sold in the market of the Host country

This step provides procedures to collect data on refrigerator models sold in the market of the Host country.

Project participants can choose between two data vintages to establish the market benchmark:

Option A: Determine the benchmark before the start of the project activity using data from a historical year *x* and fix it for the duration of the crediting period. The historical year *x* should refer to the most recent year prior to the start of the project activity, for which sales records for refrigerators are available. The historical year *x* should at the maximum be three years before the start of the project activity. In this option, the autonomous improvement of energy efficiency of refrigerators is reflected in the calculation of emission reductions through a factor to account for autonomous technical improvements (ATD);

Option B: Update the benchmark annually. In this option, the historical year *x*, as defined above, should be used as the basis for the calculation of the benchmark for refrigerators sold in the first year of the crediting period.

The data to establish the fixed market benchmark in case of Option A or the initial market benchmark for the historical year *x* in case of Option B should be collected for all models *f* of refrigerators that were manufactured and sold in the Host country. This should include refrigerators produced by the manufacturer, involved in the project activity. Imported refrigerators and those produced for export shall be excluded. In case of Option A, the data are collected once for the historical year *x*. In case of Option B, the data are collected annually, starting from the historical year *x*, as defined above. Refrigerators produced by the manufacturer, involved in the project activity, should be excluded from the data used for update of the manufacturer benchmark in Option B.

Data to be collected on refrigerator models *f* should at least include the following:

- Brand of refrigerator;
- Model;
- Refrigerator design (DC or FF);
- Adjusted storage volume;
- Year/period of production;
- Number of units sold in the Host country in the year *x*.

Sub-step 1.2: Classify refrigerators

Allocate each refrigerator model *f* to a storage volume class *j* and refrigerator design DC or FF using Table 2 as per the classification scheme described in Step 2 of the section "Project emissions". Only those storage volume classes *j* need to be considered, in which the manufacturer, involved in the project activity, produces project refrigerators.

Sub-step 1.3: Determine the refrigerator models to be considered for establishing the market benchmark

This step provides a possibility to exclude refrigerators with a low market share from further consideration in calculating the market benchmark. This may reduce the transaction costs for establishing the benchmark.

In the case where the data listed in Step 1 and the rated electricity consumption of all refrigerator models *f* are available, project participants should include all models *f,* represented in the market in the Host country in the historic year *x*, in the calculation of the benchmark.

In the case where these data are not available, project participants may use the following approach: Sort the refrigerator models in the storage volume class *j* and refrigerator design DC or FF by the number of units sold in the historic year *x*. Start with the model with the highest market share and include other models according to their market share subsequently, until the models cover 90% of the total number of units sold in that class in year *x*. Exclude all remaining models from further consideration in the subsequent Sub-steps to determine the market benchmark.

Project participants may choose different approaches for different storage volume classes *j* and refrigerator design DC or FF, if the data availability is different for different classes *j*. However, in the case of an annual update of the market benchmark (Option B above), the approach chosen for a storage volume classes *j* and refrigerator design DC or FF should be consistently used throughout the crediting period.

The sample group for a storage volume class *j* and refrigerator design DC or FF should at least contain three models *f*. If the class contains less than three models, no benchmark can be established and thus no emission reductions can be claimed for this class.

Sub-step 1.4: Determine the rated electricity consumption of each model f

Determine the rated electricity consumption ($AEC_{DC,f,j}$ or $AEC_{FF,f,j}$) in kWh per year for each refrigerator model *f* included in the group of refrigerators in Sub-step 1.3. The model specific rated electricity consumption should be determined by measurements according to the national or international standards as described under Step 3 in the section "Project emissions".

Sub-step 1.5: Determine the specific electricity consumption of each model f

Determine the specific electricity consumption ($SEC_{DC,f,j}$ or $SEC_{FF,f,j}$) of each model *f* included in the group of refrigerators in Sub-step 1.3, as follows:

$$SEC_{DC,f,j} = \frac{AEC_{DC,f,j}}{ASV_{DC,f,j}} \quad \textbf{(12)}$$

$$SEC_{FF,f,j} = \frac{AEC_{FF,f,j}}{ASV_{FF,f,j}} \quad \textbf{(13)}$$

Where:

$SEC_{DC,f,j}$ = Specific electricity consumption of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design DC (kWh/year*litre)

$SEC_{FF,f,j}$ = Specific electricity consumption of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design FF (kWh/year*litre)

$AEC_{DC,f,j}$ = Rated electricity consumption of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design DC (kWh/year)

$AEC_{FF,f,j}$ = Rated electricity consumption of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design FF (kWh/year)

$ASV_{DC,f,j}$ = Adjusted storage volume of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design DC (litres)

$ASV_{FF,f,j}$ = Adjusted storage volume of refrigerator model *f* belonging to a storage volume class *j* and refrigerator design FF (litres)

Sub-step 1.6: Determine the sample group to calculate the market benchmark

For each storage volume class *j* and refrigerator design DC or FF construct a sample group (refrigerator models *n*) by selecting refrigerator models with the lowest specific electricity consumption in each class, representing 20% of sales in the Host country's market, as follows: Sort the refrigerators models *f* by their specific electricity consumption ($SEC_{DC,f,j}$ or $SEC_{FF,f,j}$), starting with the model with the lowest specific electricity consumption. Include the model with the lowest specific electricity consumption in the sample group *n*. If this model has a market share of less than 20% in year *x* in its class, include subsequent models in the sample group *n*, until the models included in the sample group *n* have reached or exceeded a market share of 20%.

Sub-step 1.7: Calculate the market benchmark for year x

Calculate the market benchmark for specific electricity consumption ($SEC_{BM,market,DC,j,x}$ and $SEC_{BM,market,FF,j,x}$) in year *x* for each storage volume class *j* and refrigerator design DC or FF, as follows:

$$SEC_{BM,market,DC,j,x} = \frac{\sum_{n}(SN_{DC,n,j,x} * AEC_{DC,n,j})}{\sum_{n}(SN_{DC,n,j,x} * ASV_{DC,n,j})} \quad \textbf{(14)}$$

$$SEC_{BM,market,FF,j,x} = \frac{\sum_{n}(SN_{FF,n,j,x} * AEC_{FF,n,j})}{\sum_{n}(SN_{FF,n,j,x} * ASV_{FF,n,j})} \quad \textbf{(15)}$$

Where:

$SEC_{BM,market,DC,j,x}$ = Market benchmark for specific electricity consumption in year *x* of refrigerators belonging to storage volume class *j* and refrigerator design DC (kWh/year*litre)

$SEC_{BM,market,FF,j,x}$ = Market benchmark for specific electricity consumption in year *x* of refrigerators belonging to storage volume class *j* and refrigerator design FF (kWh/year*litre)

$SN_{DC,n,j,x}$ = Number of units of refrigerator model *n* belonging to storage volume class *j* and refrigerator design DC that were manufactured in the Host country and sold to the market in year *x*

$SN_{FF,n,j,x}$ = Number of units of refrigerator model *n* belonging to storage volume class *j* and refrigerator design FF that were manufactured in the Host country and sold to the market in year *x*

$AEC_{DC,n,j}$ = Rated electricity consumption of refrigerator model *n* belonging to storage volume class *j* and refrigerator design DC (kWh/year)

$AEC_{FF,n,j}$ = Rated electricity consumption of refrigerator model *n* belonging to storage volume class *j* and refrigerator design FF (kWh/year)

$ASV_{DC,n,j}$ = Adjusted storage volume of refrigerator model *n* belonging to storage volume class *j* and refrigerator design DC (litres)

$ASV_{FF,n,j}$ = Adjusted storage volume of direct cool refrigerator model *n* belonging to storage volume class *j* and refrigerator design FF (litres)

n = All refrigerator models in the sample group, belonging to class *j* and refrigerator design DC or FF, and sold to the market in year *x*

Sub-step 1.8: Determine the market benchmark for vintage year v

It is assumed that the energy efficiency of manufactured refrigerators in the market increases over time due to technical improvements. To reflect this in the calculation of the market benchmark, an autonomous technical development rate (ATD) is introduced, which expresses the annual autonomous improvement in energy efficiency of market appliances over time in the baseline.

The market benchmark for specific electricity consumption of refrigerators sold in vintage year *v* is calculated for each storage volume class *j* and refrigerator design DC or FF by multiplying the market benchmark for year *x* by a factor to account for autonomous technical development (ATD_{market}) to reflect the improvements that would have likely occurred in the market between year *x* and year *v*, as follows:

$$SEC_{BM,market,DC,j,v} = SEC_{BM,market,DC,j,x} * (1 - ATD_{market})^{v-x} \quad \textbf{(16)}$$

$$SEC_{BM,market,FF,j,v} = SEC_{BM,market,FF,j,x} * (1 - ATD_{market})^{v-x} \quad \textbf{(17)}$$

Where:

$SEC_{BM,market,DC,j,v}$ = Market benchmark for specific electricity consumption of refrigerators belonging to storage volume class *j* and refrigerator design DC and sold in year *v* (kWh/year*litre)

$SEC_{BM,market,FF,j,v}$ = Market benchmark for specific electricity consumption of refrigerators belonging to storage volume class *j* and refrigerator design FF and sold in year *v* (kWh/year*litre)

$SEC_{BM,market,DC,j,x}$ = Market benchmark for specific electricity consumption of refrigerators belonging to storage volume class *j* and refrigerator design DC in year *x* (kWh/year*litre)

$SEC_{BM,market,FF,j,x}$ = Market benchmark for specific electricity consumption of refrigerators belonging to storage volume class *j* and refrigerator design FF in year *x* (kWh/year*litre)

ATD_{market} = Factor to account for autonomous technical development that would have likely occurred in the market per annum (applicable to all storage volume classes *j* and refrigerator design DC or FF)

v = Year of the crediting period in which refrigerators are sold

x = Historic year for which the market benchmark for specific electricity consumption of refrigerators is established

ATD_{market} can be determined using one of the following options:

Option A: Use a default value of ATD_{market} = 3.5% per annum;[13]

Option B: ATD_{market} is determined based on the evolution of energy efficiency of refrigerators produced in the Host country and sold in the Host country's market over a ten year historic reference period. This requires that sales data for all refrigerator models *g* and data on the rated electricity consumption and adjusted storage volume of each model *g* were available for the historic year *h* that is ten years before the year *x* for which the market benchmark is established. ATD_{market} is then calculated as follows:

$$ATD_{market} = 1 - \left(\frac{SEC_{market,x}}{SEC_{market,h}} \right)^{1/10} \quad \textbf{(18)}$$

with

$$SEC_{market,x} = \frac{\sum_j \sum_f (SN_{DC,f,j,x} * AEC_{DC,f,j} + SN_{FF,f,j,x} * AEC_{FF,f,j})}{\sum_j \sum_f (SN_{DC,f,j,x} * ASV_{DC,f,j} + SN_{FF,f,j,x} * ASV_{FF,f,j})} \quad \textit{and} \quad \textbf{(19)}$$

$$SEC_{market,h} = \frac{\sum_j \sum_g (SN_{DC,g,j,h} * AEC_{DC,g,j} + SN_{FF,g,j,h} * AEC_{FF,g,j})}{\sum_j \sum_f (SN_{DC,g,j,h} * ASV_{DC,g,j} + SN_{FF,g,j,h} * ASV_{FF,g,j})} \quad \textbf{(20)}$$

Where:

ATD_{mar} = Factor to account for autonomous technical development that would have likely occurred in the market per annum (applicable to all storage volume classes *j* and refrigerator design DC or FF)

$SEC_{market,x}$ = Average specific electricity consumption of refrigerators produced in the Host country and sold to the market in year *x* (kWh/year*litre)

$SEC_{market,h}$ = Average specific electricity consumption of refrigerators produced in the Host country and sold to the market in year *h* (kWh/year*litre)

$SN_{DC,f,j,x}$ = Number of units of refrigerator model *f*, belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *x*

$SN_{FF,f,j,x}$ = Number of units of refrigerator model *f*, belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *x*

$AEC_{DC,f,j}$ = Rated electricity consumption of refrigerator model *f,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *x* (kWh/yr)

$AEC_{FF,f,j}$ = Rated electricity consumption of refrigerator model *f,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *x* (kWh/yr)

[13] The proposed default value is based on scientific literature (EIA 2009, p.98, AHAM 2003, Kim et al. 2005).

$ASV_{DC,f,j}$ = Adjusted storage volume of refrigerator model *f*, belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *x* (litres)

$ASV_{FF,f,j}$ = Adjusted storage volume of refrigerator model *f*, belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *x* (litres)

$SN_{DC,g,j,h}$ = Number of units of refrigerator model *g,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *h*

$SN_{FF,g,j,h}$ = Number of units of refrigerator model *g,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *h*

$AEC_{DC,g,j}$ = Rated energy consumption of refrigerator model *g,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *h* (kWh/year)

$AEC_{FF,g,j}$ = Rated energy consumption of refrigerator model *g,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *h* (kWh/year)

$ASV_{DC,g,j}$ = Adjusted storage volume of model *g,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured in the Host country and sold to the market in year *h* (litres)

$ASV_{FF,g,j}$ = Adjusted storage volume of model *g,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured in the Host country and sold to the market in year *h* (litres)

x = Historic year, for which the market benchmark for specific electricity consumption of refrigerators is established (in the case when the benchmarks are updated annually, *x* is the historic year that is used to establish the first benchmark)

h = Historic year that is ten years before the year *x*

f = All refrigerator models, belonging to class *j* and refrigerator design DC or FF, that were manufactured in the Host country and sold to the market in the year *x*

g = All refrigerator models, belonging to class *j* and refrigerator design DC or FF, that were manufactured in the Host country and sold to the market in the year *h*

j = All storage volume classes as listed in Table 2

Step 2: Calculate the manufacturer benchmark

Sub-step 2.1: Collect data on refrigerators manufactured and sold by the manufacturer, involved in the project activity

Establish annual sales data by the manufacturer, involved in the project activity, per refrigerator model *i* for a historical 3 years reference period *k*. The end year of the historic reference period *k* shall be the year, for which the most recent complete set of sales data are available. In any case, the end date of the historic reference period shall not be more than two years before the start of the project activity. Sales data must be based on the total sales number minus imported units minus exported units. Sales data must account for 100% of the sales volume of the manufacturer, involved in the project activity, i.e. covering all models and all regions of the Host country.

Project participants should establish an electronic database where all data are documented in a transparent manner. Based on this database, all refrigerators, which are produced by the manufacturer and exported outside the Host country, should be documented and excluded from the project activity.

Data to be collected on refrigerator models should include at least the following:

- Model;
- Refrigerator design ("Frost Free" or "Direct Cool");
- Adjusted storage volume;
- Year/period of production.

Data to be collected on sales of refrigerators should include at least the following:

- Number of units sold in the Host country, per model *i* and retailer;
- Information on the sales dates;
- Information to clearly identify the retailer (address, etc);
- A written statement by the retailer that the refrigerators are not exported.

The source of the sales data should be industry data certified by financial auditors or audited ISO 9001 records of the project activity.

Sub-step 2.2: Classify refrigerators

Allocate each refrigerator model *i* to a storage volume class *j* and refrigerator design DC or FF using Table 2 as per the classification scheme described in Step 2 of the section "Project emissions".

Sub-step 2.3: Determine the rated electricity consumption

Determine the rated electricity consumption ($AEC_{DC,i,j}$ or $AEC_{FF,i,j}$) in kWh per year for each model *i* belonging to a storage volume class *j* and refrigerator design DC or FF. The model-specific rated electricity consumption should be determined by measurements according to the national or international standards as described under Step 3 in the section "Project emissions".

Sub-step 2.4: Determine the manufacturer benchmark for historic reference period k

Calculate the manufacturer benchmark for specific electricity consumption in historic reference period *k* ($SEC_{BM,manufacturer,DC,j,k}$ and $SEC_{BM,manufacturer,FF,j,k}$) for each storage volume class *j* and refrigerator design DC or FF, as follows:

$$SEC_{BM,manufacturer,DC,j,k} = \frac{\sum_{i}(SN_{DC,i,j,k} * AEC_{DC,i,j})}{\sum_{i}(SN_{DC,i,j,k} * ASV_{DC,i,j})} \quad \textbf{(21)}$$

$$SEC_{BM,manufacturer,FF,j,k} = \frac{\sum_{i}(SN_{FF,i,j,k} * AEC_{FF,i,j})}{\sum_{i}(SN_{FF,i,j,k} * ASV_{FF,i,j})} \quad \textbf{(22)}$$

Where:

$SEC_{BM,manufacturer,DC,j,k}$ = Manufacturer benchmark for specific electricity consumption in the historic reference period *k* of refrigerators belonging to storage volume class *j* and refrigerator design DC (kWh/year*litre)

$SEC_{BM,manufacturer,FF,j,k}$ = Manufacturer benchmark for specific electricity consumption in the historic reference period *k* of refrigerators belonging to storage volume class *j* and refrigerator design FF (kWh/year*litre)

$SN_{DC,i,j,k}$ = Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured by the manufacturer involved in the project activity and sold in historic reference period *k*

$SN_{FF,i,j,k}$ = Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured by the manufacturer involved in the project activity and sold in historic reference period *k*

$AEC_{DC,i,j}$ = Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC (kWh/year)

$AEC_{FF,i,j}$ = Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF (kWh/year)

$ASV_{DC,i,j}$ = Adjusted storage volume of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC (litres)

$ASV_{FF,i,j}$ = Adjusted storage volume of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF (litres)

i = All refrigerator models produced by the manufacturer, involved in the project activity, and sold in the Host country in the historic reference period *k*

k = Three year historical reference period (as defined above)

Sub-step 2.5: Determine the manufacturer benchmark for vintage year v

It is assumed that the energy efficiency of refrigerators produced by the manufacturer would increase over time due to technical improvements in the absence of the project activity. To reflect this in the calculation of the baseline emissions, an autonomous technical development rate ($ATD_{manufacturer}$) is introduced, which expresses the annual autonomous improvement in energy efficiency in the absence of the project activity.

The manufacturer benchmark for specific electricity consumption of refrigerators sold in vintage year *v* is calculated for each storage volume class *j* and refrigerator design DC or FF by multiplying the manufacturer benchmark for the historic reference period *k* by a factor to account for autonomous technical development to reflect the improvements that would have occurred between the historical reference period *k* and the year *v*:

$$SEC_{BM,manufacturer,DC,j,v} = SEC_{BM,manufacturer,DC,j,k} * (1 - ATD_{manufacturer})^{v-k2} \quad \textbf{(23)}$$

$$SEC_{BM,manufacturer,FF,j,v} = SEC_{BM,manufacturer,FF,j,k} * (1 - ATD_{manufacturer})^{v-k2} \quad \textbf{(24)}$$

Where:

$SEC_{BM,manufacturer,DC,j,v}$ = Manufacturer benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design DC, sold in year *v* (kWh/year*litre)

$SEC_{BM,manufacturer,FF,j,v}$ = Manufacturer benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design FF, sold in year *v* (kWh/year*litre)

$SEC_{BM,manufacturer,DC,j,k}$ = Manufacturer benchmark for specific electricity consumption in the historic reference period *k* of refrigerators belonging to storage volume class *j* and refrigerator design DC (kWh/year*litre)

$SEC_{BM,manufacturer,FF,j,k}$ = Manufacturer benchmark for specific electricity consumption in the historic reference period *k* of refrigerators belonging to storage volume class *j* and refrigerator design FF (kWh/year*litre)

$ATD_{manufacturer}$ = Factor to account for autonomous technical development that would have likely occurred in the fleet of refrigerators produced by the manufacturer, involved in the project activity, per annum (applicable to all storage volume classes *j* and refrigerator design DC or FF)

v = Year of the crediting period in which refrigerators are sold

k = Three year historical reference period (as defined above)

k2 = Middle year of the three year historical reference period

$ATD_{manufacturer}$ can be determined using one of the following options:

Option A: Use a default value of $ATD_{manufacturer}$ = 3.5% per annum;[14]

Option B: $ATD_{manufacturer}$ is determined based on the evolution of energy efficiency of refrigerators produced by the manufacturer, involved in the project activity, over a ten year historic reference period. This requires that sales data for all refrigerator models manufactured and data on the rated electricity consumption and adjusted storage volume of each model were available for the historic year *a* that is ten years before the last year of the historic reference period *k3* used in the previous steps. $ATD_{manufacturer}$ is calculated as follows:

$$ATD_{manufacturer} = 1 - \left(\frac{SEC_{manufacturer,k3}}{SEC_{manufacturer,a}} \right)^{1/10} \quad \textbf{(25)}$$

with

$$SEC_{manufacturer,k3} = \frac{\sum_j \sum_i (SN_{DC,i,j,k3} * AEC_{DC,i,j} + SN_{FF,i,j,k3} * AEC_{FF,i,j})}{\sum_j \sum_i (SN_{DC,i,j,k3} * ASV_{DC,i,j} + SN_{FF,i,j,k3} * ASV_{FF,i,j})} \quad \textit{and} \quad \textbf{(26)}$$

$$SEC_{manufacturer,a} = \frac{\sum_j \sum_l (SN_{DC,l,j,a} * AEC_{DC,l,j} + SN_{FF,l,j,a} * AEC_{FF,l,j})}{\sum_j \sum_l (SN_{DC,l,j,a} * ASV_{DC,l,j} + SN_{FF,l,j,a} * ASV_{FF,l,j})} \quad \textbf{(27)}$$

[14] The proposed default value is based on scientific literature (EIA 2009, p.98, AHAM 2003, Kim et al. 2005).

Where:

$ATD_{manufacturer}$	=	Factor to account for autonomous technical development that would have likely occurred in the fleet of refrigerators produced by the manufacturer, involved in the project activity, per annum (applicable to all storage volume classes *j* and refrigerator design DC or FF)
$SEC_{manufacturer,k3}$	=	Average specific electricity consumption of refrigerators sold by the manufacturer in year *k3* (kWh/year*litre)
$SEC_{manufacturer,a}$	=	Average specific electricity consumption of refrigerators sold by the manufacturer in year *h* (kWh/year*litre)
$SN_{DC,i,j,k3}$	=	Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC, that was manufactured by the manufacturer, involved in the project activity, and sold in year *k3*
$SN_{FF,i,j,k3}$	=	Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF, that was manufactured by the manufacturer, involved in the project activity, and sold in year *k3*
$AEC_{DC,i,j}$	=	Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC (kWh/yr)
$AEC_{FF,i,j}$	=	Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF (kWh/yr)
$ASV_{DC,i,j}$	=	Adjusted storage volume of refrigerator model *i*, belonging to storage volume class *j* and refrigerator design DC (litres)
$ASV_{FF,i,j}$	=	Adjusted storage volume of refrigerator model *i*, belonging to storage volume class *j* and refrigerator design FF (litres)
$SN_{DC,l,j,a}$	=	Number of units of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design DC, that was sold by the manufacturer in year *h*
$SN_{FF,l,j,a}$	=	Number of units of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design FF, that was sold by the manufacturer in year *h*
$AEC_{DC,l,j}$	=	Rated energy consumption of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design DC (kWh/year)
$AEC_{FF,l,j}$	=	Rated energy consumption of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design FF (kWh/year)
$ASV_{DC,l,j}$	=	Adjusted storage volume of model *l,* belonging to storage volume class *j* and refrigerator design DC (litres)
$ASV_{FF,l,j}$	=	Adjusted storage volume of model *l,* belonging to storage volume class *j* and refrigerator design FF (litres)
k3	=	Last year of the three year historical period *k* that was used to calculate the manufacturer benchmark
a	=	Historic year that is ten years before the year *k3*
i	=	All refrigerator models belonging to class *j* and refrigerator design DC or FF and sold by the manufacturer involved in the project activity during the year *k3*
l	=	All refrigerator models belonging to class *j* and refrigerator design DC or FF and sold by the manufacturer involved in the project activity during the year *h*
j	=	All storage volume classes as listed in Table 2

Step 3: Determine the benchmarks for vintage year v

Determine the benchmark for specific electricity consumption in the baseline for each storage volume class *j* and refrigerator design DC or FF and each vintage year *v,* in which refrigerators are sold under the project activity, as the lower value between the market benchmark and the manufacturer benchmark:

$$SEC_{BM,DC,j,v} = \min\left\{SEC_{BM,market,DC,j,v}; SEC_{BM,manufacturer,DC,j,v}\right\} \quad \textbf{(28)}$$

$$SEC_{BM,FF,j,v} = \min\left\{SEC_{BM,market,FF,j,v}; SEC_{BM,manufacturer,FF,j,v}\right\} \quad \textbf{(29)}$$

Where:

$SEC_{BM,DC,j,v}$ = Benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design DC, that are sold in vintage year *v* (kWh/year*litre)

$SEC_{BM,market,DC,j,v}$ = Market benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design DC, that are sold in vintage year *v* (kWh/year*litre)

$SEC_{BM,manufacturer,DC,j,v}$ = Manufacturer benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design DC, that are sold in vintage year *v* (kWh/year*litre)

$SEC_{BM,FF,j,v}$ = Benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design FF, that are sold in vintage year *v* (kWh/year*litre)

$SEC_{BM,market,FF,j,v}$ = Market benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design FF, that are sold in vintage year *v* (kWh/year*litre)

$SEC_{BM,manufacturer,FF,j,v}$ = Manufacturer benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design FF, that are sold in vintage year *v* (kWh/year*litre)

j = All storage volume classes as listed in Table 2

Step 4: Estimate baseline electricity consumption of refrigerators sold within the geographical area of electricity grid ec

For refrigerators sold in vintage year *v*, the baseline electricity consumption $EC_{BL,ec,v,y}$ in year *y* is calculated for each electricity grid *ec* as follows:

$$EC_{BL,ec,v,y} = \frac{\sum_{j}(SEC_{BM,DC,j,v} * TSV_{DC,j,ec,v} + SEC_{BM,FF,j,v} * TSV_{FF,j,ec,v})}{1000}, \quad \textit{if } (v+1) \le y < (v+13) \quad \textbf{(30)}$$

$$EC_{BL,ec,v,y} = 0, \quad \textit{if } (v+1) > y \textit{ or } y \ge (v+13) \quad \textbf{(31)}$$

with

$$TSV_{DC,j,ec,v} = \sum_{i} SN_{DC,i,j,ec,v} \times ASV_{DC,i,j,v} \quad \textit{and} \quad \textbf{(32)}$$

$$TSV_{FF,j,ec,v} = \sum_{i} SN_{FF,i,j,ec,v} \times ASV_{FF,i,j,v} \quad \textbf{(33)}$$

Where:

$EC_{BL,ec,v,y}$ = Baseline electricity consumption in year *y* from the use of refrigerators that would have been sold by the manufacturer, involved in the project activity, in year *v* within the geographical boundary of electricity grid *ec* (MWh/year)

$SEC_{BM,DC,j,v}$ = Benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design DC, sold in year *v* (kWh/year*litre)

$SEC_{BM,FF,j,v}$ = Benchmark for specific electricity consumption of refrigerators, belonging to storage volume class *j* and refrigerator design FF, sold in year *v* (kWh/year*litre)

$TSV_{DC,j,ec,v}$ = Total aggregate storage volume of refrigerators, belonging to storage volume class *j* and refrigerator design DC, that are sold by the manufacturer, involved in the project activity, in vintage year *v* in the geographical boundary of electricity grid *ec* (litres)

$TSV_{FF,j,ec,v}$ = Total aggregate storage volume of refrigerators, belonging to storage volume class *j* and refrigerator design FF, that are sold by the manufacturer, involved in the project activity, in vintage year *v* in the geographical boundary of electricity grid *ec* (litres)

$SN_{DC,i,j,ec,v}$ = Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC, sold by the manufacturer, involved in the project activity, in vintage year *v*

$SN_{FF,i,j,ec,v}$ = Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF, sold by the manufacturer, involved in the project activity, in vintage year *v*

$ASV_{DC,i,j}$ = Adjusted storage volume of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC, sold by the manufacturer, involved in the project activity, in vintage year *v* (litres)

$ASV_{FF,i,j}$ = Adjusted storage volume of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design FF, sold by the manufacturer, involved in the project activity, in vintage year *v* (litres)

j = All storage volume classes as listed in Table 2

ec = All electricity grids in the Host country or region included in the project activity

It is assumed that a refrigerator lifetime is 12 years for both DC and FF refrigerator design. This value for lifetime is the lower range end of IPCC default values for domestic refrigerators, which is a conservative assumption[15], especially for the market conditions of non-Annex I countries. Equations (30) and (31) also ensure that electricity consumption of any refrigerator sold in year *v* is only accounted for from the start of the first full year of operation (*v*+1) onwards. With this requirement the time lag between selling by the manufacturer and commissioning of the refrigerator at the household is accounted for.

The annual baseline electricity consumption from the use of refrigerators in electricity grid *ec* for year *y* is calculated through summing over the different vintage years and factoring in the correction factor for actual against rated electricity consumption, as follows:

$$EC_{BL,ec,y} = \sum_{v} (EC_{BL,ec,v,y} * CFM_{y}) \quad \textbf{(34)}$$

[15] IPCC 2000, p. 3.106.

Where:

$EC_{BL,ec,y}$ = Annual baseline electricity consumption from the use of refrigerators in electricity grid *ec* in year *y* (MWh/year)

$EC_{BL,ec,v,y}$ = Baseline electricity consumption in year *y* from the use of refrigerators that would have been sold by the manufacturer, involved in the project activity, in year *v* within the geographical boundary of electricity grid *ec* (MWh/year)

CFM_y = Correction factor for actual against rated electricity consumption in year *y*, calculated as described in Step 4 in the section "Project emissions"

Step 5: Calculate baseline emissions

Baseline emissions related to electricity consumption from the use of refrigerators in year *y* are calculated based on the electricity consumption in the baseline, the grid emission factor and transmission and distribution losses of the grid, and summed up over the different grids, as follows:

$$BE_y = \sum_{ec} \frac{EC_{BL,ec,y} * EF_{CO2,ELEC,ec,y}}{1 - TDL_{ec,y}} \quad \textbf{(35)}$$

Where:

BE_y = Baseline emissions in the year *y* (t CO_2/year)

$EC_{BL,ec,y}$ = Annual baseline electricity consumption from the use of refrigerators in electricity grid *ec* in year *y* (MWh/year)

$EF_{CO2,ELEC,ec,y}$ = CO_2 emission factor for electricity grid *ec* for year *y* (t CO_2/MWh), calculated as the combined margin emission factor in accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"

$TDL_{ec,y}$ = Technical distribution losses in the electricity grid *ec* in year *y*, as defined in the section "Project emissions" (kWh of technical electric losses in the electricity grid / kWh of electricity supplied to final consumers)

Leakage

This methodology does not account for leakage.

Emission reductions

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y \quad \textbf{(36)}$$

Where:

ER_y = Emission reductions in the year *y* (t CO_2/year)

BE_y = Baseline emissions in year *y* (t CO_2/year)

PE_y = Project emissions in year *y* (t CO_2/year)

Changes required for methodology implementation in 2nd and 3rd crediting periods

At the renewal of the crediting period, project participants shall assess the continued validity of the baseline scenario. This shall include an assessment of the status and trends at the national market of domestic refrigerators as to availability and introduction of energy saving technologies.

The calculation of the market benchmark should be updated, using the data vintages outlined in the methodology above, but with reference to the start of the 2nd or 3rd crediting period (instead of the start of the project activity).

Furthermore, all relevant data contained under "Data and parameters not monitored" should be updated. Regarding the grid emission factor, the provisions in the latest approved version of "Tool to calculate the emission factor for an electricity system" on the update of the emission factor apply.

Data and parameters not monitored

In addition to the parameters listed in the tables below, the provisions on data and parameters not monitored in the "Tool to calculate the emission factor for an electricity system" apply.

Data / parameter:	ATD_{market} and $ATD_{manufacturer}$
Data unit:	Absolute number
Description:	Factor to account for autonomous technical development that would have likely occurred in the market per annum
Source of data:	Default value is based on scientific literature (EIA 2009, p.98, AHAM 2003, Kim et al. 2005)
Measurement procedures (if any):	-
Any comment:	Default value is used if Option A has been selected by project participants. Applicable to all storage volume classes *j* and refrigerator design DC or FF.

Data / parameter:	CFM_y
Data unit:	Absolute number
Description:	Correction factor for actual against rated electricity consumption in year *y*
Source of data:	Default value =0.95
Measurement procedures (if any):	-
Any comment:	Default value is used if Option A has been selected by project participants. Applicable to all storage volume classes *j* and refrigerator design DC or FF

Data / parameter:	$SN_{DC,f,j,x}$ and $SN_{FF,f,j,x}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *f*, belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *x*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	Sales data shall be based on total sales numbers minus imported units minus exported units. Sales data must account for 100% of the sales volume, i.e. covering all manufactures, all models and all regions of the Host country, included in the project activity. *x* is the historic year, for which the market benchmark for specific electricity consumption of refrigerators is established (in the case when the benchmarks are updated annually, *x* is the historic year that is used to establish the first benchmark)
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market})

Data / parameter:	$SN_{DC,g,,j,h}$ and $SN_{FF,g,,j,h}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *g*, belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *h.*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	Sales data shall be based on total sales numbers minus imported units minus exported units. Sales data must account for 100% of the sales volume, i.e. covering all manufactures, all models and all regions of the Host country, included in the project activity. *h* is the historic year that is 10 years before the historic year *x* used for calculating the market benchmarks
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market})

Data / parameter:	$AEC_{DC,f,j}$ and $AEC_{FF,f,j}$
Data unit:	kWh/year
Description:	Rated electricity consumption of refrigerator model *f,* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *x*
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption.
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market})

Data / parameter:	$ASV_{DC,f,j}$ and $ASV_{FF,f,j}$
Data unit:	Litres
Description:	Adjusted storage volume of refrigerator model *f* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *x*
Source of data:	Direct measurement for each model *f*
Measurement procedures (if any):	Measurement as per the standard tests prescribed by the authorized agency in the Host country
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market})

Data / parameter:	$AEC_{DC,g,j}$ and $AEC_{FF,g,j}$
Data unit:	kWh/year
Description:	Rated electricity consumption of refrigerator model *g,* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *h*
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption.
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market}).

Data / parameter:	$ASV_{DC,g,j}$ and $ASV_{FF,g,j}$
Data unit:	Litres
Description:	Adjusted storage volume of refrigerator model *g* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *h*
Source of data:	Direct measurement for each model *g*
Measurement procedures (if any):	Measurement as per the standard tests prescribed by the authorized agency in the Host country
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development (ATD_{market})

Data / parameter:	$SN_{DC,n,,j,x}$ and $SN_{FF,n,,j,x}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *n*, belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured in the Host country and sold to the market in historic year *x*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	Sales data shall be based on total sales numbers minus imported units minus exported units. Sales data must account for 100% of the sales volume, i.e. covering all manufactures, all models and all regions of the Host country, included in the project activity. *n* refers to all refrigerators included in the sample group for calculating the market benchmark for storage volume class *j* and refrigerator design DC or FF. *x* is the historic year, for which the market benchmark for specific electricity consumption of refrigerators is established (in the case when the benchmarks are updated annually, *x* is the historic year that is used to establish the first benchmark).
Any comment:	The parameter is used for calculating a market benchmark for storage volume class *j* and refrigerator design DC or FF

Data / parameter:	$SN_{DC,i,,j,k}$ and $SN_{FF,i,,j,k}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured by the manufacturer involved in the project activity and sold in historic reference period *k*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	*k* is a tree-year historic reference period used to establish the manufacturer benchmark for specific electricity consumption. The end year of the historic reference period *k* shall be the year, for which the most recent complete set of sales data are available. In any case, the end date of the historic reference period shall not be more than two years before the start of the project activity. Sales data must to be based on the total sales number minus imported units minus exported units. Sales data must account for 100% of the sales volume of the manufacturer, involved in the project activity, i.e. covering all models and all regions of the Host country.
Any comment:	The parameter is used for calculating the manufacturer benchmark for specific electricity consumption

Data / parameter:	$AEC_{DC,i,j}$ and $AEC_{FF,i,j}$
Data unit:	kWh/year
Description:	Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC or FF, that was produced by the manufacturer, involved in the project activity, and sold to the market in historic reference period *k*
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption. *k* is a tree-year historic reference period used to establish the manufacturer benchmark for specific electricity consumption
Any comment:	The parameter is used for calculating the manufacturer benchmark for specific electricity consumption

Data / parameter:	$ASV_{DC,i,j}$ and $ASV_{FF,i,j}$
Data unit:	Litres
Description:	Adjusted storage volume of refrigerator model *i* belonging to storage volume class *j* and refrigerator design DC or FF, that that was produced by the manufacturer, involved in the project activity, and sold to the market in historic reference period *k*
Source of data:	Direct measurement for each model *i*
Measurement procedures (if any):	Measurement as per the standard tests prescribed by the authorized agency in the Host country *k* is a tree-year historic reference period used to establish the manufacturer benchmark for specific electricity consumption
Any comment:	The parameter is used for calculating the manufacturer benchmark for specific electricity consumption

Data / parameter:	$SN_{DC,i,,j,k3}$ and $SN_{FF,i,,j,k3}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *i,* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured by the manufacturer involved in the project activity and sold in historic year *k3*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	*k3* is the last year of the three year historical period *k* that was used to calculate the manufacturer benchmark. Sales data must to be based on the total sales number minus imported units minus exported units. Sales data must account for 100% of the sales volume of the manufacturer, involved in the project activity, i.e. covering all models and all regions of the Host country.
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development ($ATD_{manufacturer}$)

Data / parameter:	$SN_{DC,l,,j,a}$ and $SN_{FF,l,,j,a}$
Data unit:	Absolute number
Description:	Number of units of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design DC or FF, that was manufactured by the manufacturer involved in the project activity and sold in historic year *a*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	Sales data must to be based on the total sales number minus imported units minus exported units. Sales data must account for 100% of the sales volume of the manufacturer, involved in the project activity, i.e. covering all models and all regions of the Host country. *a* is the historic year that is 10 years before the year *k3*
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development ($ATD_{manufacturer}$)

Data / parameter:	$AEC_{DC,l,j}$ and $AEC_{FF,l,j}$
Data unit:	kWh/year
Description:	Rated electricity consumption of refrigerator model *l,* belonging to storage volume class *j* and refrigerator design DC or FF, that was produced by the manufacturer, involved in the project activity, and sold to the market in historic year *a*
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption. *a* is the historic year that is 10 years before the year *k3*
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development ($ATD_{manufacturer}$)

Data / parameter:	$ASV_{DC,l,j}$ and $ASV_{FF,l,j}$
Data unit:	Litres
Description:	Adjusted storage volume of refrigerator model *l* belonging to storage volume class *j* and refrigerator design DC or FF, that that was produced by the manufacturer, involved in the project activity, and sold to the market in historic year *a*
Source of data:	Direct measurement for each model *l*
Measurement procedures (if any):	Measurement as per the standard tests prescribed by the authorized agency in the Host country. *a* is the historic year that is 10 years before the year *k3*
Any comment:	The parameter is used for calculating a factor to account for autonomous technical development ($ATD_{manufacturer}$)

III. MONITORING METHODOLOGY

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last crediting period. 100% of the data should be monitored if not indicated otherwise in the tables below. All measurements should be conducted with calibrated measurement equipment according to relevant industry standards.

The key variables to be monitored are number of units sold in different refrigerator classes and in different electricity grids per annum. The data collection effort will take place throughout the crediting period and shall comprise the following:

(1) *Eligibility verification*: The basic eligibility characteristics of refrigerators must be established such as: each refrigerator must fall within the class defined and be produced by the manufacturer, involved in the project activity, and sold in the domestic market (i.e., with in the project boundary). There should be supporting documents for this;
(2) *Rated electricity consumption measurement and adjusted storage volume test*: These tests should be carried out on every model (minimum value from three samples for every model), which entered/is entering the market. There should be supporting documentation pertaining to test results, and testing should be carried out as per methodology specified by the authorised national agency. The tests should be carried out by certified laboratories;
(3) *Number of refrigerators sold within geographic boundary of each electricity grid, included in the project activity*: There should be monitoring of number of refrigerator units sold under each model produced by the manufacturer, involved in the project activity. There should be documentary evidence for the sold units under each class and in each electricity grid;
(4) *Field monitoring of electricity consumption* from the actual use of refrigerators belonging to the monitoring sample group (MSG);
(5) *Database*: In addition, a database for the above information shall be established to keep track of all the data collected for the refrigerators. This database can be used to generate the reports that would support the CER claims. The database should include *inter alia* the following information:

- Adjusted storage volume and rated electricity consumption test results for each model;
- Annual electricity consumption data for the each class;
- Monitoring data for annual electricity consumption for each of the refrigerators belonging to the MSG;
- Units sold under each class within the geographical boundary of each electricity grid, included in the project activity;
- Supporting documents for the test results and sale of units.

Data and parameters monitored

Data / parameter:	$SN_{DC,i,j,ec,v}$ and $SN_{FF,i,j,ec,v}$
Data unit:	Absolute number
Description:	Number of units of refrigerator models *i,* belonging to storage volume class *j* and design DC or FF, that was manufactured by the manufacturer, involved in the project activity, and sold in vintage year *v* within the geographical boundary of electricity grid *ec*
Source of data:	The source for the sales data is industry data certified by financial auditors or audited ISO 9001 records of the project
Measurement procedures (if any):	The annual sales data per refrigerator model *i* for vintage *v* be monitored by any of the above sources. In a database the project proponent has to register end user data for all buyers of project refrigerators. This includes at least the following information: sales date, refrigerator model, year of production of refrigerator, name or company, street, city, city code, country of residence of buyer, telephone number and intended country of use of the appliance. Based on this database, all refrigerators, which are procured for use outside the Host country have to be deducted. The number of units sold per refrigerator model *i* is further divided in to different electricity grids
Monitoring frequency:	Once in a year
QA/QC procedures:	Certification from the Association or certification by the certified financial auditors, published data by the trade journal or market research institutions
Any comment:	

Data / parameter:	$AEC_{DC,i,j}$ and $AEC_{FF,i,j}$
Data unit:	kWh/year
Description:	Rated electricity consumption of refrigerator model *i,* belonging to storage volume class *j* and design DC or FF, which is sold in vintage year *v*
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption.
Monitoring frequency:	Initially at the entry to the market and also as and when refrigerator undergoes changes in its volume or design
QA/QC procedures:	The test shall be conducted at authorized test labs only
Any comment:	

Data / parameter:	$ASV_{DC,i,j}$ and $ASV_{FF,i,j}$
Data unit:	Litres
Description:	Adjusted storage volume of model *i,* belonging to storage volume class *j* and refrigerator design DC or FF, which is sold in vintage year *v*
Source of data:	Direct measurement of each model *i*
Measurement procedures (if any):	Measurement as per the standard tests prescribed by the authorized agency in the Host country
Monitoring frequency:	Initially at the entry to the market and also as and when refrigerator undergoes changes in its volume or design
QA/QC procedures:	The test shall be conducted at authorized test labs only
Any comment:	

Data / parameter:	$MEC_{m,z}$
Data unit:	kWh/year
Description:	Measured electricity consumption of sample refrigerator *m* during the monitoring interval *z*
Source of data:	Measurements by project participants
Measurement procedures (if any):	Use an electricity consumption meter, which can totalize the electricity consumption of the refrigerator in kWh. The type of electricity consumption meter can be either electronic or electro-mechanic, but it has to have a non-volatile memory in case of power failure. Electricity consumption should be measured separately for each refrigerator, included in the MSG.
Monitoring frequency:	Continuous metering, reading of the meter at each spot check
QA/QC procedures:	Check consistency of meter readings with the readings from previous monitoring intervals
Any comment:	

Data / parameter:	AEC_m
Data unit:	kWh/year
Description:	Rated electricity consumption of a sample refrigerator *m,* included in the MSG
Source of data:	
Measurement procedures (if any):	The model specific rated energy consumption shall be measured data on basis of the national standard (e.g. AS/NZS 4471.1:1997, IS 1476: Part 1: 2000, etc.) or international standards (e.g. ISO 15502:2005, DIN EN 153, etc.) applicable in the Host country for measuring the rated energy consumption of domestic refrigerators. Any applicable standard shall apply no load conditions for evaluating the rated energy consumption.
Monitoring frequency:	Once at the beginning of the crediting period or when a new refrigerator is included in the MSG
QA/QC procedures:	The test shall be conducted at authorized test labs only
Any comment:	

Data / parameter:	T_z
Data unit:	Days
Description:	Duration of monitoring interval *z*
Source of data:	Measurements by project participants
Measurement procedures (if any):	T_z is equal to the time between spot checks for monitoring actual electricity consumption of refrigerators belonging to the monitoring sample group
Monitoring frequency:	Annually during the first three years of the crediting period
QA/QC procedures:	
Any comment:	The frequency of undertaking repeat spot checks is by default every 12 month (i.e. annually) with a minimum of 10.5 month and a maximum of 13.5 month between two spot checks in any of the households. When undertaking a spot check, all households should be visited within a distinct short time period not longer than three weeks, i.e. the last household should not be visited later than three weeks after the first household has been visited.

Data / parameter:	$TDL_{ec,y}$
Data unit:	kWh of technical electric losses in the electricity grid divided by kWh of electricity supplied to final consumers
Description:	Technical distribution losses in the electricity grid *ec* in year *y*
Source of data:	(National) utility or an official government body
Measurement procedures (if any):	Technical distribution losses in the electricity grid serving the households $TDL_{ec,y}$, should be estimated using recent, accurate and reliable data available within the Host country. The technical distribution losses should not contain other types of grid losses (e.g. commercial losses/theft). The distribution losses can either be calculated by a (national) utility or an official governmental body or by project participants. The appropriateness, accuracy / uncertainty and reliability of the data should be checked by project participants and the DOE upon verification, especially with regard to the exclusion of other potential grid losses. A default value of 5% may be used for technical grid losses, if no recent data are available or the data cannot be regarded accurate and reliable.
Monitoring frequency:	Most recent data to be used, not older than 5 years
QA/QC procedures:	
Any comment:	Make sure that technical distribution losses do not contain other types of grid losses (e.g. commercial losses/theft)

Data / parameter:	$EF_{CO2,ELEC,ec,y}$
Data unit:	tCO_2/MWh
Description:	Carbon dioxide emission factor for electricity generation in electricity grid *ec* for year *y*
Source of data:	Calculated based on national published data for power supplies and Government monitoring agency
Measurement procedures (if any):	In accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
Monitoring frequency:	In accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system"
QA/QC procedures:	In accordance with the latest approved version of the "Tool to calculate the emission factor for an electricity system "
Any comment:	

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History of the document

Version	Date	Nature of revision(s)
01	EB 42, Annex # 26 September 2008	To be considered at EB 42.