CLEAN DEVELOPMENT MECHANISM

**AM0120**

# Large-scale Methodology

# Energy-efficient refrigerators and air-conditioners

Version 01.0

Sectoral scope(s): 03

United Nations
Framework Convention on
Climate Change

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# 1. Introduction

1. The following table describes the key elements of the methodology:

**Table 1. Methodology key elements**

| | |
|---|---|
| **Typical project(s)** | Installation of new energy-efficient refrigerators and air conditioners as replacement or new sales projects. |
| **Type of GHG emissions mitigation action** | Energy efficiency:<br>Displacement of more-GHG-intensive service by use of more-efficient technology. |

# 2. Scope, applicability, and entry into force

## 2.1. Scope

2. The methodology provides guidance to estimate emission reductions for project activities that involve the installation of new, energy-efficient refrigerators and air conditioners (RACs) for residential/household applications as replacement or new sales projects.

3. This methodology credits emission reductions due to the reduction in electricity consumption from use of new and more efficient units as well as the avoidance of use of high GWP refrigerants in the refrigeration and air conditioning equipment.

## 2.2. Applicability

4. Project units are Refrigerators and Air Conditioners[1] that use refrigerants and PUR foam blowing agents with no ozone depleting potential (ODP) and low GWP (e.g. Refrigerants and blowing agents such as Hydrofluoroolefins or Hydrocarbons with GWPs<10).

5. The households receiving project units are connected to a national or regional electricity grid.

## 2.3. Entry into force

6. The date of entry into force is the date of the publication of the EB 97 meeting report on 1 November 2017.

## 2.4. Applicability of sectoral scope

7. For validation and verification of CDM projects and programme of activities by a designated operational entity (DoE) using this methodology sectoral scope 03 is mandatory.

[1] This excludes centralized and packaged RAC systems.

# 3. Normative references

8. Relevant provisions from the latest approved versions of the following documents shall be applied:

   (a) TOOL29: Determination of standardized baselines for energy-efficient refrigerators and air-conditioners (hereafter RAC tool);

   (b) TOOL28 “Calculation of baseline, project and leakage emissions from the use of refrigerants” (hereafter refrigerant tool);

   (c) “Guidelines for quality assurance and quality control of data used in the establishment of standardized baselines”;

   (d) “Procedure for development, revision, clarification and update of standardized baselines”;

   (e) “Standard for data coverage and validity of standardized baselines”.

9. When tools/standards are used in conjunction with the methodology, all applicability conditions and requirements stated in the referred tools/standards shall also apply.

# 4. Definitions

10. The definitions contained in the Glossary of CDM terms shall apply.

11. For the purpose of this methodology the remaining lifetime of the equipment is defined as the time for which the existing equipment can continue to operate before it has to be replaced/discarded for technical reasons, such as, safety reasons, or deteriorated performance. The remaining lifetime is expressed in years or hours of operation.

# 5. Baseline methodology

## 5.1. Project boundary

12. The project boundary is the physical, geographical location of all equipment and systems affected by the project activity.

## 5.2. Identification of the baseline scenario and demonstration of additionality for new sales RACs

13. Under this methodology, a benchmark approach is applied using the tool referred above under paragraph 8 (a) to establish the baseline scenario and demonstrate additionality, recognizing that one or several measures for GHG emission reductions may be undertaken within RAC sector.

14. As long as the annual electricity consumption or the electricity intensity of new RACs (e.g., kWh/litre/y or kWh/cooling capacity/y) of a particular class and design, introduced by the project activity, is lower than the benchmark established, the emission reductions for this class and design, calculated as per this methodology, are deemed additional. A separate assessment of additionality is therefore not required under this methodology. This

approach is in line with the approved “Guidelines for the establishment of the sector specific standardized baselines”

## 5.3. Identification of baseline for projects involving replacements Refrigerators

15. For project activities that involve replacement of existing refrigerators, the baseline scenario is the continuing operation of the existing equipment. In the absence of the CDM project activity, the existing refrigerators would continue to provide services to historical average levels until the time at which it would be likely to be replaced in the absence of the CDM project activity. For the refrigerators whose life time have been expired, the baseline shall be based on the approach used for new-sales refrigerators. The remaining lifetime of appliances shall be estimated using the procedure provided in the following section.

### 5.3.1. Procedure for estimating the end of the remaining lifetime of existing refrigerator

16. **Step 1**: Determine the average age of the replaced refrigerators: The average age of the replaced refrigerators shall be determined using the nameplates information of at least 25 per cent of the replaced refrigerators based on all available data

17. **Step 2**: Determine the typical average end-of-life and the remaining lifetime of the replaced refrigerators: Where data from central disposal sites or recycling sites have been used to establish average end-of-life, the composition of brands in those sites and among the replaced refrigerators shall be comparable. Subtract the average age of the replaced refrigerators from the average end-of-life or a default average lifetime of 16 years, the difference is the remaining lifetime.

18. Where it is not feasible or data from central disposal sites or recycling sites to estimate the remaining life is not available, use Weibull distribution curve to establish remaining life time based on the average age of the refrigerators replaced and the following conditions apply:

    (a) Use Weibull distribution curves for household refrigerators applicable for the region with a default average lifetime of 16 years;

    (b) Where Weibull distribution is not available for the region, apply a typical Weibull distribution curve with a default average lifetime of 16 years. Appendix provides a typical Weibull distribution curve and examples to estimate remaining life time.

### 5.3.2. Baseline calculation for new sales refrigerators

19. This baseline accounts for introducing efficient new units (new refrigerator appliances).

20. The equations for calculating baseline emissions are as follows:

21. **Option 1 (corresponding to approach 1 in RAC tool)**:

$$BE_y = \frac{\sum_{i,p} EF_{grid,y} \times n_{i,p,y} \times EC_{rn,p}}{(1 - TD_{loss,y})} \quad \text{Equation (1)}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* ($tCO_2e$) |
| $EC_{rn,p}$ | = | Baseline electricity intensity factor (kWh/refrigerator/year) as determined using approach 1 prescribed under section 4.1 Refrigerator new sales of RAC tool. ‘p’ is index for volume class for approach 1 of the RAC tool. |
| $TD_{loss,y}$ | = | Average annual technical grid losses (transmission and distribution) during year *y* for the grid serving the locations where the devices are installed, expressed as a fraction as determined using Data/Parameter Table 1. |
| $EF_{grid,y}$ | = | Emission factor of a grid determined ($tCO_2$/kWh) (as determined in Data/Parameter Table 2) |
| $n_{i,p,y}$ | = | Number of refrigerators model *i* of volume class p introduced by the project activity operating in year y (as determined in Data/Parameter Table 3) |

22. **Option 2 (Corresponding to Approach 2 in RAC tool):**

$$BE_y = \frac{\sum_{i,q} EF_{grid,y} \times n_{i,q,y} \times SEC_{rn,q} \times V_{avg,q}}{(1 - TD_{loss,y})} \quad \text{Equation (2)}$$

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* ($tCO_2e$) |
| $SEC_{rn,q}$ | = | Baseline electricity intensity factor (kWh/litre/year) as determined using approach 2 prescribed under section 4.1 Refrigerator new sales of RAC tool. ‘q’ is index for volume class for approach 2 of the RAC tool. |
| $n_{i,q,y}$ | = | Number of refrigerator model *i* of volume class q introduced by the project activity operating in year y (as determined in Data/Parameter Table 3) |
| $V_{avg,q}$ | = | Average volume of refrigerators of volume class q introduced in year y as determined in Data/Parameter Table 8. |

23. **Option 3**:

$$BE_y = \frac{\sum_{i,r} EF_{grid,y} \times n_{i,r,y} \times EEI_{rn,r} \times SAE_{avg,\mathrm{r}}}{(1 - TD_{loss,y})} \quad \text{Equation (3)}$$

Where:

| | | |
|---|---|---|
| $EEI_{rn,r}$ | = | Baseline Energy Efficiency Index (dimensionless) of volume class ‘r’ as determined using approach 3 prescribed under section 4.1 Refrigerator new sales of RAC tool. |
| $n_{i,r,y}$ | = | Number of refrigerator model *i* of volume class r introduced by the project activity operating in year y (as determined in Data/Parameter Table 3) |

| | | |
|---|---|---|
| $SAE_{avg,r}$ | = | Average Standard annual electricity consumption of refrigerators of volume class ‘r’ introduced in year y as determined in Data/Parameter Table 9. |

### 5.3.3. Baseline calculation for refrigerators replacement

24. This baseline accounts for replacements of existing, functional domestic refrigerators, with more efficient new units. The equations for calculating baseline energy use and emissions are as follows:

$$BE_y = \frac{\sum_k EF_{grid,y} \times n_{k,y} \times EC_{rr} \times V_{avg,k}}{(1 - TD_{loss,y})}$$ Equation (4)

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* ($tCO_2e$) |
| $EC_{rr}$ | = | Average specific electricity consumption of the existing refrigerators in kWh/litre/y as determined using one of the approaches prescribed under section 4.3 of RAC tool |
| $n_{,k,y}$ | = | Number of refrigerators k replaced by the project activity operating in year y (as determined in Data/Parameter Table 4) |
| $V_{avg,k}$ | = | Average volume of refrigerators of volume class k introduced in year y as determined in Data/Parameter Table 8. |

### 5.3.4. Baseline calculation for new sales air-conditioners

25. This baseline accounts for introducing efficient new units (greenfield air-conditioners) and the equations for calculating baseline energy use and emissions are as follows:

$$BE_y = \frac{\sum_j EF_{grid,y} \times n_{j,y} \times EC_{an} \times P_{cap,j,y}}{(1 - TD_{loss,y})}$$ Equation (5)

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* ($tCO_2e$) |
| $EC_{an}$ | = | Baseline Electricity intensity factor (kWh/air-conditioner/cooling capacity/year) as determined using one of the approaches prescribed under section 4.2 of the RAC tool |
| $P_{cap,j,y}$ | = | Cooling capacity of the project air conditioners model *j* (kW) (as determined in Data/Parameter Table 5) |
| $n_{j,y}$ | = | Number of air-conditioners model *j* introduced by the project activity (as operating in year y determined in Data/Parameter Table 6) |

### 5.3.5. Adjustment to the baseline estimation to account for autonomous efficiency improvement due to regulation and market transformation

26. The energy efficiency of RAC equipment in the market will likely increase over time due to regulatory interventions and market factors. While the regular update of the SB (e.g. every 3 years or earlier as required by the RAC tool) would capture the transformation in efficiency, the registered project activities or CPAs of PoAs applying the parameter values in an approved SB may need to undertake additional adjustments to be conservative. This methodology requires that an annual autonomous energy efficiency improvement factor is applied as per the equation below:

$$BE_{y,adjusted} = BE_y \times (1 - AEI)^{v-x} \qquad \text{Equation (6)}$$

Where:

| | | |
|---|---|---|
| $BE_{y,adjusted}$ | = | The adjusted baseline emissions accounting for autonomous improvement in energy efficiency for refrigerators/air-conditioners |
| $AEI$ | = | Factor to account for annual autonomous efficiency improvement (use a default value of 0.02 (2 per cent) for air-conditioners and 0.015 (1.5 per cent) for refrigerators[2]; where the SB is updated following the expiry of 3 years validity, the actual market data used for the update may be used to determine annual efficiency increase instead of the default values) |
| $\boldsymbol{v-x}$ | = | Difference of years since the latest valid SB is approved |
| $\boldsymbol{v}$ | = | Year of the crediting period |
| $\boldsymbol{x}$ | = | Historic year in which the latest valid SB was approved |

### 5.3.6. Baseline calculations for refrigerant emissions in new sales air conditioners[3]

27. Only baseline refrigerant emissions (physical leaks of refrigerants) from baseline air-conditioners are eligible[1]. Only avoided emissions of HFCs are eligible under this methodology whereas avoided HCFC emissions are ineligible. Refrigerant baseline emissions are eligible for inclusion only when the penetration of air-conditioners which use refrigerants with no ODP and low GWP in the host country is less than 20 per cent i.e. the share of air conditioners using the refrigerant in question is under 20 per cent of all air conditioners.

[2] *IEA Energy Efficiency Market Report 2016* on page 76 notes that “the average total efficiency improvement over the last ten years of the specific products to which standards and labels have been applied in IEA member countries and key emerging economies was: 16 per cent for refrigerator-freezers, 26 per cent for lighting products (lamps), 21 per cent for washing machines, 23 per cent for room air conditioners”. As annual efficiency increase is an exponential function, AEI values are approximated to yield the typical efficiency increase in 10 years reported in this IEA study.

[3] For the specific purpose of this methodology, refrigerants emissions associated with refrigerators are not included

28. Calculate the baseline emissions from refrigerants in air conditioners using the following equation:

$$BE_{REF,y} = \sum_{j} n_{j,y} \times \left(SRCF \times P_{cap,j}\right) \times L_{avr}$$ Equation (7)

Where:

| | | |
|---|---|---|
| $BE_{REF,y}$ | = | Baseline emissions due to leakage of refrigerants in year y ($tCO_2e$) |
| $SRCF$ | = | Specific refrigerant charge factor as determined using section 4.4 of RAC tool (tCO2e/kW) |
| $n_{j,y}$ | = | Number or air conditioners model *j* introduced by the project activity operating in year *y* as determined in data/parameter table 5 |
| $P_{cap,j}$ | = | Cooling capacity of the project air conditioners model *j* (kW) (as determined in Data/Parameter Table 4) |
| $L_{avr}$ | = | Average physical leakage rates of refrigerants in project air conditioners in the year *y* as determined using TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants. |

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

29. Project participants shall refer to the methodological tool “Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”.

## 5.5. Project activity emissions

30. Project emissions consist of electricity used in the project equipment, determined as follows.

$$PE_y = EC_{PJ,y} \times EF_{grid,y} + PE_{ref,y}$$ Equation (8)

Where:

| | | |
|---|---|---|
| $PE_y$ | = | Project emissions in year *y* (tCO2e) |
| $EC_{PJ,y}$ | = | Total electricity consumption of RAC appliance in project activity in year y, as determining using paragraph 31 and 26 below |
| $PE_{ref,y}$ | = | Project emissions from physical leakage of refrigerant from air conditioners in year *y* ($tCO_2e/y$) as determined using TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants. |

31. For refrigerators, project electricity consumption is determined as follows:

$$EC_{PJ,y} = \frac{\sum_{i,m} n_{i,m,y} \times EC_{ref,m,y}}{(1 - TD_{loss,y})}$$ Equation (9)

Where:

| | | |
|---|---|---|
| $EC_{ref,m,y}$ | = | Electricity consumption of refrigerators of model i and volume class “m” in project activity in year y (kWh) as determined in Data/Parameter Table 7 |
| m | = | index for volume class p/q/r corresponding to baseline refrigerators |

32. For air conditioners, project electricity consumption is determined as follows:

$$EC_{PJ,y} = \frac{\sum_j n_{j,y} \times P_{cap,j} \times hrs_y \times \beta_L}{(1 - TD_{loss,y}) \times EER_{P,avr}}$$ Equation (10)

Where:

| | | |
|---|---|---|
| $P_{cap,j}$ | = | Cooling capacity of the project air conditioners j (kW) (as determined in Data/Parameter Table 4) |
| $hrs_y$ | = | Annual average operating hours or usage (number, see data/ parameter table 10) |
| $\beta_L$ | = | Load factor (proportion, see data parameter table 11) |
| $EER_{P,avr}$ | = | Average Energy Efficiency Ratio (W/W) of the project air conditioners as determined in Data/Parameter Table 11) |

## 5.6. Leakage

33. Leakage associated with the destruction of refrigerants from the displaced air conditioners hall be determined using TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants.

## 5.7. Emission reduction

34. The emission reduction achieved by the project activity shall be determined as the difference between the baseline emissions and the project emissions and leakage.

$$ER_y = \left(BE_{y,adjusted} + BE_{REFy} - PE_y\right) - LE_y$$ Equation (11)

Where:

| | | |
|---|---|---|
| $ER_y$ | = | Emission reductions in year *y* ($tCO_2e$) |
| $BE_{y,adjusted}$ | = | The adjusted baseline emissions accounting for autonomous improvement in energy efficiency for refrigerators/air-conditioners |
| $BE_{REF,y}$ | = | Baseline emissions due to leakage of refrigerants in year y ($tCO_2e$) |
| $PE_y$ | = | Project emissions in year *y* ($tCO_2e$) |
| $LE_y$ | = | Leakage emissions in year *y* ($tCO_2e$) |

# 6. Monitoring methodology

## 6.1.1. Data and parameters not monitored during the crediting period

**Data / Parameter table 1.**

| **Data / Parameter:** | $TD_{loss,y}$ |
| --- | --- |
| Data unit: | fraction |
| Description: | Transmission and distribution of loss of electricity system supplying to project activities |
| Source of data: | The average annual technical grid losses shall be determined using recent, accurate and reliable data available for the host country.<br>This value can be determined from recent data published either by a national utility or an official governmental body. The reliability of the data used (e.g. appropriateness, accuracy/uncertainty, especially exclusion of non-technical grid losses) shall be established and documented by the project participant. |
| Measurement procedures (if any): | This value shall not include non-technical losses such as commercial losses (e.g. theft).<br><br>A default value of 0.1 shall be used for average annual technical grid losses, if no recent data are available or the data cannot be regarded accurate and reliable |
| Any comment: | - |

## 6.1.2. Data and parameters monitored during the crediting period

**Data / Parameter table 2.**

| **Data / Parameter:** | $EF_{grid,y}$ |
| --- | --- |
| Data unit: | $tCO_2$/kWh |
| Description: | $CO_2$ emission factor of the grid electricity in year *y* |
| Source of data: | As per the requirements in “Tool to calculate the emission factor for an electricity system” |
| Measurement procedures (if any): | As per the requirements in “Tool to calculate the emission factor for an electricity system” |
| Any comment: | - |

**Data / Parameter table 3.**

| **Data / Parameter:** | $n_{i,p,y}$; $n_{i,q,y}$ ; $n_{i,r,y}$ ; |
| --- | --- |
| Data unit: | Number |
| Description: | Number of refrigerators of model i of volume class p/q/r introduced by the project activity operating in year *y* |
| Source of data: | Project activity monitoring and documentation |

| | |
|---|---|
| Measurement procedures (if any): | Annual/biennial checks that refrigerators are still working, done with a statistically significant sample of end-users. Use 90/10 and 95/10 confidence/precision for annual and biennial checks, respectively<br><br>The sample size shall be estimated following the requirements under "Standard on sampling and surveys for CDM project activities and PoAs". |
| Any comment: | The CDM-PDD or CDM-PoA-DD/CPA-DD shall explain the proposed method of distribution of refrigerators will be conducted and documented.<br><br>The CDM-PDD or CDM-PoA-DD/CPA-DD shall also explain how the proposed procedures eliminate double counting of emission reductions, for example due to manufacturers, wholesale providers or others possibly claiming credit for emission reductions from the project activities. |

**Data / Parameter table 4.**

| **Data / Parameter:** | $n_{,k,y}$ |
|---|---|
| Data unit: | Number |
| Description: | Number of refrigerators of model k replaced operating in year *y* |
| Source of data: | Project activity monitoring and documentation |
| Measurement procedures (if any): | Annual/biennial checks that units are still working, done with a statistically significant sample of end-users. Use 90/10 and 95/10 confidence/precision for annual and biennial checks, respectively<br><br>The sample size shall be estimated following the requirements under "Standard on sampling and surveys for CDM project activities and PoAs". |
| Any comment: | The number and "volume" of the replaced refrigerators shall be recorded in a way that allows for a physical verification by a designated operational entity (DOE)<br><br>The CDM-PDD or CDM-PoA-DD/CPA-DD shall explain the proposed method of distribution of refrigerators and how collection and destruction of baseline refrigerators will be conducted and documented.<br><br>The CDM-PDD or CDM-PoA-DD/CPA-DD shall also explain how the proposed procedures eliminate double counting of emission reductions, for example due to manufacturers, wholesale providers or others possibly claiming credit for emission reductions from the project activities. |

**Data / Parameter table 5.**

| **Data / Parameter:** | $P_{cap,j,y}$ |
|---|---|
| Data unit: | kW |

| | |
|---|---|
| Description: | Average cooling capacity of the air conditioners of model j |
| Source of data: | Manufacturer information or retailer information or reported as per efficiency label |
| Measurement procedures (if any): | |
| Any comment: | |

**Data / Parameter table 6.**

| **Data / Parameter:** | $\boldsymbol{n_{j,y}}$ |
|---|---|
| Data unit: | Number |
| Description: | Number of air-conditioners of model j that are operating in year *y* |
| Source of data: | Project activity monitoring and documentation |
| Measurement procedures (if any): | Annual/biennial checks that air-conditioners are still working, done with a statistically significant sample of end-users. Use 90/10 and 95/10 confidence/precision for annual and biennial checks, respectively<br><br>The sample size shall be estimated following the requirements under “Standard on sampling and surveys for CDM project activities and PoAs”. |
| Any comment: | The CDM-PDD or CDM-PoA-DD/CPA-DD shall explain the proposed method of distribution of air-conditioners will be conducted and documented.<br><br>The CDM-PDD or CDM-PoA-DD/CPA-DD shall also explain how the proposed procedures eliminate double counting of emission reductions, for example due to manufacturers, wholesale providers or others possibly claiming credit for emission reductions from the project activities. |

**Data / Parameter table 7.**

| **Data / Parameter:** | $EC_{ref,y}$ |
|---|---|
| Data unit: | kWh |
| Description: | Electricity consumption of refrigerator or air-conditioners |
| Source of data: | Metering the “energy use” of an appropriate sample of the equipment installed |
| Measurement procedures (if any): | |
| Any comment: | |

**Data / Parameter table 8.**

| **Data / Parameter:** | $V_{avg,q}$ , $V_{avg,k}$ |
|---|---|
| Data unit: | Liters |

| | |
|---|---|
| Description: | Average volume of refrigerators of volume class q/k introduced in year *y* |
| Source of data: | For refrigerators introduced by the project activity:<br>Project activity monitoring and documentation, model specifications from manufacturers.<br>For all refrigerators in the market:<br>Data for all models from Standard & Labelling database, commercial database, importers, retailers or manufacturer specifications |
| Measurement procedures (if any): | |
| Any comment: | - |

**Data / Parameter table 9.**

| | |
|---|---|
| **Data / Parameter:** | $SAE_{avg,r}$ |
| Data unit: | kWh/yr |
| Description: | Average Standard annual electricity consumption of volume class ‘r’ of the project refrigerators year *y* |
| Source of data: | For refrigerators introduced by the project activity:<br>Project activity monitoring and documentation, model specifications from manufacturers.<br>For all refrigerators in the market:<br>Data for all models from Standard & Labelling database, commercial database, importers, retailers or manufacturer specifications |
| Measurement procedures (if any): | |
| Any comment: | - |

**Data / Parameter table 10.**

| | |
|---|---|
| **Data / Parameter:** | $hrs_y$ |
| Data unit: | Hours |
| Description: | Annual average operating hours or usage (in a country or a climatic zone) |
| Source of data: | Survey or grid load curve analysis<br><br>Option 1: The operating hours of the baseline air conditioners shall be determined using surveys by continuous measurement of usage hours for a minimum of 90 days representative of the year. For a large population of project air conditioners: (a) use a representative sample (sampling determined by a minimum 90 per cent confidence interval and 10 per cent maximum error margin); (b) ensure that sampling is statistically robust and relevant.<br><br>**Option 2.** Load analysis by utility companies is used to determine an accurate range of average operating hours across the year |
| Measurement procedures (if any): | Where a survey is applied, sampling should be as per Guidelines for sampling and surveys for CDM project activities and programme of activities |

| Any comment: | |
|---|---|

**Data / Parameter table 11.**

| **Data / Parameter:** | $\beta_L$ |
|---|---|
| Data unit: | Load factor |
| Description: | Proportion of hours per year during the cooling periods of the year when air conditioners operate at full capacity. |
| Source of data: | In accordance with TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants |
| Measurement procedures (if any): | In accordance with TOOL28: Calculation of baseline, project and leakage emissions from the use of refrigerants |

**Data / Parameter table 12.**

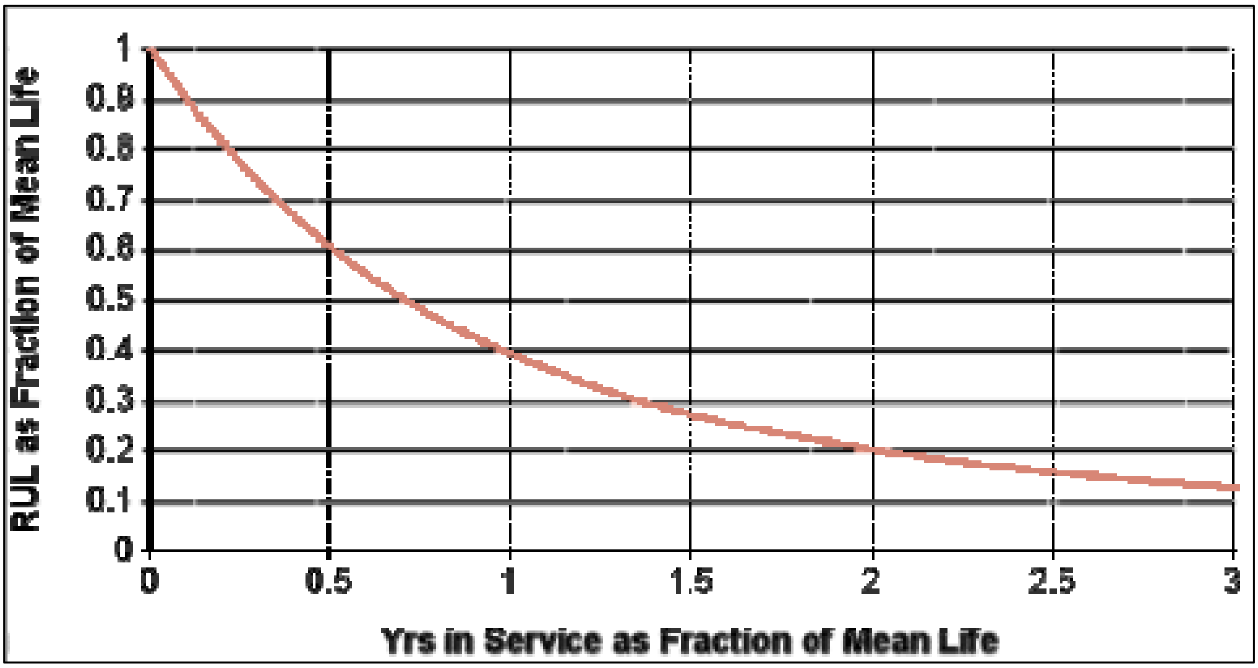
| **Data / Parameter:** | *EER or SEER* |
|---|---|
| Data unit: | decimal (Wth/Welec ) |
| Description: | Energy Efficiency Ratio |
| Source of data: | (a) Standard & Labelling database;<br>(b) Commercial marketing data;<br>(c) Manufacturers (industry) data<br>(d) efficiency labels on the equipment |
| Measurement procedures (if any): | Only efficiency metrics determined by applying ISO5151(any version) are eligible to use. All national standards are based on ISO5151. For using SEER data, the conversions in Appendix 3 RAC Tool shall be used. |
| Any comment: | - |

# Appendix. Application of Weibull Distribution to estimate remaining life time of refrigerators

1. A Weibull distribution is a probability distribution function. It is often applied to estimate lifetime and reliability of mechanical and electronic equipment. For appliance survival rates, Weibull distributions are used instead of normal or linear distributions. Weibull distributions imply that the occurrence of an event in any part of an object may be said to have occurred in the object as a whole, statistical or dynamical strengths, electrical insulation breakdowns, life of lightbulbs, as the probability of surviving depends on the probability of not succumbing to many possible causes for failure (Lutz et al.2011).

2. Households appliances have similar curves, the Weibull Shape Factor for dishwashers is 2.18, refrigerators 2.15, freezers 2.46, cloth washers 2.31. Such results have been widely studied from large household survey data in Canada and the US. Because the Shape Factors fall in a narrow range, in the absence of particular mortality curve data, the average lifetime can provide the remaining useful life as a function of years in service with minimal uncertainty. An average of 2.34 for the Shape Factor is generally used to define the remaining useful life as a function of the years an appliance has been in service.

**Figure 1. Typical Weibull distribution curve derived for household refrigerators**




*Note*: RUL: Remaining useful life

*Source*: Welch C and Rogers B, 2011

3. The table below provides an illustrative example on determining remaining life time of refrigerators based on average age of functioning refrigerators

**Table 1. Example application of Weibull distribution curve**

| | |
|---|---|
| 1 | Average age of functioning refrigerators: 24 years<br><br>Data source: Based on the nameplates information of at least 25 per cent of the replaced refrigerators based on all available data |
| 2 | Years in service as a fraction of Mean life: 1.5 years<br><br>Data source: Based on a default average lifetime of 16 years [24/16= 1.5] |
| 3 | Remaining Useful Lifetime as a fraction of Mean Life (RUL): 0.28<br><br>Data source: Estimated from the figure 1 above (The value 0.28 corresponds to 1.5 years in service as fraction of mean life ) |
| 4 | Remaining Lifetime (RLT): 4.3 years<br><br>Data Source:<br>RLT= RUL (from 3 above) * Average lifetime (default =16 yrs) = 0.28 * 16 = 4.3 years<br><br>RLT is the number of years for which the electricity savings/ emission reductions from new refrigerators can be claimed, when a refrigerator replacement programme collects functioning refrigerators and retires them before these would be dumped otherwise. |

4. Similarly, if average age of functioning refrigerator is 8 years old, years in service as a fraction of mean life will be 0.5 and the RLT would be 0.6 x 16 = 9.6 yrs.

## 1. References:

Welch C and Rogers B, 2011, *Estimating the Remaining Useful Life of Residential Appliances*, ACEEE Summer Study on Energy Efficiency in Buildings, Washington DC.]

Lutz JD, Hopkins A, Letschert V, Franco VH and Sturges A, 2011, “Using national survey data to estimate lifetimes of residential appliances”, HVAC&R Research 17/5: 726-736.

Young D, 2008, “When do energy-efficiency appliances generate energy savings? Some evidence from Canada”, *Energy Policy*, 36: 34-46.

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