Joint Crediting Mechanism Approved Methodology MM_AM002
"Installation of Energy-efficient Refrigerators Using Natural Refrigerant at Cold Storage"

A. Title of the methodology

Installation of Energy-efficient Refrigerators Using Natural Refrigerant at Cold Storage, Version 01.0

B. Terms and definitions

Terms	Definitions
Secondary loop cooling system	A secondary loop cooling system is an indirect cooling system that cools the object with a secondary refrigerant (e.g., brine) which is cooled by a primary refrigerant (e.g., HFC). The secondary loop cooling system primarily consists of the refrigerator which is mainly composed of the compressor and heat exchangers as the primary refrigeration cycle and pumps, heat exchangers and fans as the secondary refrigeration cycle. The secondary loop cooling system is described as "primary refrigerant/secondary refrigerant" (e.g., "HFC/brine").
Coefficient of Performance (COP)	COP is defined as a value calculated by dividing refrigeration capacity by electricity consumption of a refrigerator under a full load condition. Electricity consumption of a refrigerator is defined in this methodology as the electricity used to operate the compressor. Electricity consumption of pumps for circulating the secondary refrigerant, and other ancillary equipment are not included in the COP calculation. The room temperature conditions at which COPs are calculated in this methodology are shown below: •*Room temperature condition: - 25 deg. C, 0 deg. C, 5 deg. C* •*Cooling water fed to condenser: inlet 32 deg. C*
Natural refrigerant	Natural refrigerant refers to naturally occurring substances with refrigeration capacity and with zero ozone depletion potential (ODP) (e.g. CO_2 and NH_3).

Periodical check	Periodical check is a periodical maintenance operation done by the manufacturer or an agent who is authorized by the manufacturer to maintain refrigerator performance (not including part replacement or overhaul).

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Energy-efficient refrigerators using natural refrigerant is introduced for energy saving at the food industry cold storage.
Calculation of reference emissions	Reference emissions are GHG emissions from reference refrigerators, calculated by using data of power consumption of project refrigerator, ratio of COPs of reference/project refrigerators and CO_2 emission factor for consumed electricity.
Calculation of project emissions	Project emissions are GHG emissions from project refrigerator, calculated with power consumption of project refrigerator and CO_2 emission factor for consumed electricity.
Monitoring parameters	● Amount of electricity consumed by project refrigerator

D. Eligibility criteria

This methodology is applicable to projects that satisfy all of the following criteria.

<table>
<tr><td>Criterion 1</td><td>Refrigerator(s) with a secondary loop cooling system using CO₂ as a refrigerant and equipped with inverter is installed at food industry cold storage.</td></tr>
<tr><td>Criterion 2</td><td>COP for the project refrigerator(s) installed in the project cooling system is more than the threshold COP values set in the tables below. (“x” in the table represents cooling capacity per unit.)
<table>
<tr><th>Room temperature condition</th><th>Cooling capacity (kW)</th><th>Threshold COP value</th></tr>
<tr><td>- 25 deg. C</td><td>42.4 ≤ x ≤ 340.0</td><td>1.71</td></tr>
<tr><td>0 deg. C</td><td>73.6 ≤ x ≤ 516.4</td><td>2.79</td></tr>
<tr><td>5 deg. C</td><td>86.2 ≤ x ≤ 612.6</td><td>3.20</td></tr>
</table>
COP for the project refrigerator(s) are calculated with the following conditions:
• Room temperature condition: - 25 deg. C or 0 deg. C or 5 deg. C</td></tr>
</table>

	• *Cooling water fed to condenser: inlet 32 deg. C*
Criterion 3	Periodical check is planned at least one (1) time annually.
Criterion 4	In the case of replacing the existing refrigerator with the project refrigerator, a plan for prevention of releasing refrigerant used in the existing refrigerator to the air (e.g. re-use of the equipment) is prepared. Execution of this plan is checked at the time of verification, in order to confirm that refrigerant used for the existing one replaced by the project is prevented from being released to the air.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Power consumption by the reference refrigerator	CO_2
Project emissions	
Emission sources	GHG types
Power consumption by the project refrigerator	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated by multiplying the power consumption of project refrigerator, ratio of COPs for reference/project refrigerators and CO_2 emission factor for electricity consumed.

The following types of cooling system are identified as possible cooling systems other than the project system to be installed at food industry cold storage:

- For room temperature condition of -25 deg. C: HFC dry expansion (single loop), NH_3 flooded, pump system (single loop), HFC/brine (secondary loop) and NH_3/brine (secondary loop)
- For room temperature condition of 0 deg. C and 5 deg. C: HFC dry expansion (single loop)

This methodology ensures that net emission reductions are achieved by applying the following conservative assumptions:

- Determination of default values for COP_{RE}:

The maximum COP values of refrigerators among the data of possible type cooling systems available in Myanmar market within the range specified by Criterion 2 is defined as the default values of COP_{RE} (1.71 for temperature condition of - 25 deg. C, 2.79 for temperature condition of 0 deg. C and 3.20 for 5 deg. C) to ensure net emission reductions.

- Emissions associated with leakage of refrigerant in operation:

Among the possible types of cooling systems, two cooling systems use HFCs (R404A, GWP: 3,000-4,000) as refrigerant. The project cooling system uses a natural refrigerant that has a very small GWP (CO_2: 1, NH_3: less than 1). Emissions associated with leakage of refrigerant are not counted in the emission reduction calculation.

- Project refrigerator equipped with inverter:

The project refrigerator is controlled by inverter technology. In this methodology, COP is defined under the condition of full load although in reality a cold storage is often operated under the condition of partial load where the efficiency of the refrigerator without inverter tends to decrease because of its intermittent operation. Calculating emissions based on the COPs of full load conditions is deemed conservative since the efficiency of the project refrigerator is likely to be maintained either at the full load or at partial load condition as it is equipped with inverter.

F.2. Calculation of reference emissions

$$RE_p = \sum_i \left(EC_{PJ,i,p} \times \frac{COP_{PJ,i}}{COP_{RE,i}} \times EF_{elec} \right)$$

Where

RE_p	Reference emissions during the period p [tCO_2/p]
$EC_{PJ,i,p}$	Power consumption of the project refrigerator i during the period p [MWh/p]
$COP_{PJ,i}$	COP of the project refrigerator i
$COP_{RE,i}$	COP of the reference refrigerator i
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]
i	Identification number of refrigerator

G. Calculation of project emissions

$$PE_p = \sum_i (EC_{PJ,i,p} \times EF_{elec})$$

Where

PE_p	Project emissions during the period *p* [tCO_2/p]
$EC_{PJ,i,p}$	Power consumption of the project refrigerator *i* during the period *p* [MWh/p]
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]
i	Identification number of refrigerator

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where

ER_p	Emission reductions during the period *p* [tCO_2/p]
RE_p	Reference emissions during the period *p* [tCO_2/p]
PE_p	Project emissions during the period *p* [tCO_2/p]

I. Data and parameters fixed *ex ante*

The source of each data and parameter fixed *ex ante* is listed as below.

Parameter	Description of data	Source
$COP_{PJ,i}$	COP of the project refrigerator *i* The room temperature conditions at which COPs are calculated in this methodology are shown below: • *Room temperature condition: - 25 deg. C, 0 deg. C, 5 deg. C* • *Cooling water fed to condenser: inlet 32 deg. C*	Specifications for the quotation or factory acceptance test data at the time of shipment by manufacturer.
$COP_{RE,i}$	COP of the reference refrigerator *i*	Specifications for the quotation or factory acceptance test data

<table>
<tr>
<td></td>
<td>The default values for $COP_{RE,i}$ is applied depending on the room temperature condition set for the project refrigerator i:
<table>
<tr><th>Temperature condition</th><th>Cooling capacity</th><th>Default values</th></tr>
<tr><td>- 25 deg. C</td><td>42.4 $\leq$ x $\leq$ 340kW</td><td>1.71</td></tr>
<tr><td>0 deg. C</td><td>73.6 $\leq$ x $\leq$ 516.4kW</td><td>2.79</td></tr>
<tr><td>5 deg. C</td><td>86.2 $\leq$ x $\leq$ 612.6kW</td><td>3.20</td></tr>
</table>
*”x” in the table represents cooling capacity per unit.</td>
<td>at the time of shipment by manufacturer.
The default COP values are derived from the maximum value of COP among the available data of the possible types of refrigerators except project within the range specified by Criterion 2.
The survey should prove the use of clear methodology.
Default values of $COP_{RE,i}$ should be revised if necessary from survey result which is conducted by JC or project participants.</td>
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<tr>
<td>EF_{elec}</td>
<td>CO_2 emission factor for consumed electricity

When project refrigerator consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively.

When project refrigerator may consume both grid electricity and captive electricity, the project participant applies the CO_2 emission factor with lower value.

[CO_2 emission factor]
For grid electricity: The most recent value available from the source stated in this table at the time of validation

For captive electricity, it is determined based on the following options:

a) Calculated from its power generation</td>
<td>[Grid electricity]
PDD of the most recently registered CDM project hosted in Myanmar or the latest version of the “Tool to calculate the emission factor for an electricity system” under the CDM at the time of validation.

[Captive electricity]
For the option a)
Specification of the captive power generation system provided by the manufacturer (η_{elec} [%]).
CO_2 emission factor of the fossil fuel type used in the captive power generation system (EF_{fuel} [tCO_2/GJ])</td>
</tr>
</table>

	efficiency (η_{elec} [%]) obtained from manufacturer's specification The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec}} \times EF_{fuel}$$ b) Calculated from measured data The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{PJ,p}$) and the amount of electricity generated ($EG_{PJ,p}$) during the monitoring period p is applied. The measurement is conducted with the monitoring equipment to which calibration certificate is issued by an entity accredited under national/international standards; $$EF_{elec} = FC_{PJ,p} \times NCV_{fuel} \times EF_{fuel} \times \frac{1}{EG_{PJ,p}}$$ Where: NCV_{fuel} : Net calorific value of consumed fuel [GJ/mass or weight] Note: In case the captive electricity generation system meets all of the following conditions, the value in the following table may be applied to EF_{elec} depending on the consumed fuel type. • The system is non-renewable generation system • Electricity generation capacity of the system is less than or equal to 15 MW	For the option b) Generated and supplied electricity by the captive power generation system ($EG_{PJ,p}$ [MWh/p]). Fuel amount consumed by the captive power generation system ($FC_{PJ,p}$ [mass or weight/p]). Net calorific value (NCV_{fuel} [GJ/mass or weight]) and CO_2 emission factor of the fuel (EF_{fuel} [tCO_2/GJ]) in order of preference: 1) values provided by the fuel supplier; 2) measurement by the project participants; 3) regional or national default values; 4) IPCC default values provided in tables 1.2 and 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied. [Captive electricity with diesel fuel] CDM approved small scale methodology: AMS-I.A. [Captive electricity with natural gas] 2006 IPCC Guidelines on National GHG Inventories for the source of EF of natural gas.

<table>
<tr>
<td></td>
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<table>
<tr><th>fuel type</th><th>Diesel fuel</th><th>Natural gas</th></tr>
<tr><td>EF_{elec}</td><td>0.8 *1</td><td>0.46 *2</td></tr>
</table>

*1 The most recent value at the time of validation is applied.
*2 The value is calculated with the equation in the option a) above. The lower value of default effective CO_2 emission factor for natural gas (0.0543tCO_2/GJ), and the most efficient value of default efficiency for off-grid gas turbine systems (42%) are applied.
</td>
<td>CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems version 02.0" for the default efficiency for off-grid power plants.</td>
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</table>

History of the document

Version	Date	Contents revised
01.0	16 January 2020	Electronic decision by the Joint Committee Initial approval.