Joint Crediting Mechanism Approved Methodology ID_AM003
"Installation of Energy-efficient Refrigerators Using Natural Refrigerant at Food Industry Cold Storage and Frozen Food Processing Plant"

A. Title of the methodology

Installation of Energy-efficient Refrigerators Using Natural Refrigerant at Food Industry Cold Storage and Frozen Food Processing Plant, Version 2.0

B. Terms and definitions

Terms	Definitions
Two stage compressor	A two stage compressor is a compressor equipped with a low stage compressor and a high stage compressor between an evaporator and a condenser which increases the pressure of low pressure refrigerant gas from the evaporator up to the intermediate pressure using the low stage compressor and further increases the pressure of the refrigerant gas using the high stage compressor to feed it to the condenser.
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. 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

	equipments are not included in the COP calculation. The temperature conditions at which COPs are calculated in this methodology are shown below: <For cold storage> *Note : Temperature condition: - 25 deg. C* *Cooling water fed to condenser: inlet 32 deg. C* <For individual quick freezer> *Note : Temperature condition: - 35 deg. C* *Cooling water fed to condenser: inlet 32 deg. C* Individual quick freezer is used for the purpose of continuous freezing for food products fed by a belt conveyor system.
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	This methodology applies to projects that aim to save energy by introducing high efficiency refrigerators to the food industry cold storage and frozen food processing plants in Indonesia.
Calculation of reference emissions	Reference emissions are GHG emissions from the usage of 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 electricity consumed.
Calculation of project emissions	Project emissions are GHG emissions from the usage of project refrigerator, calculated with power consumption of project refrigerator and CO_2 emission factor for electricity consumed.
Monitoring parameters	● Amount of electricity consumed by project refrigerator

	● Electricity imported from the grid, where applicable ● Operating time of captive electricity generator, where applicable

D. Eligibility criteria

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

Criterion 1	The project installs cooling system at food industry cold storage and frozen food processing plants for the purpose of chilling the food products to below -20 deg. C.
Criterion 2	The project system is a secondary loop cooling system using natural refrigerant. CO_2 is used as the secondary refrigerant in the system.
Criterion 3	The refrigerator applied in the project cooling system is a two stage compressor refrigerator with a cooling capacity as shown below: For cold storage: less than 340kW For individual quick freezer: less than 260kW
Criterion 4	The compressor of the project refrigerator is controlled by inverter.
Criterion 5	COP of the project refrigerator *i* ($COP_{PJ,i}$) is shown below: For cold storage: more than 2.0 For individual quick freezer: more than 1.5
Criterion 6	Periodical check at least once a year is planned.
Criterion 7	Plan for not releasing the primary refrigerant used for project refrigerator is prepared. In the case of replacing the existing refrigerator with the project refrigerator, refrigerant used for the existing refrigerator is not released to the air.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Electricity consumption by the reference refrigerator	CO_2
Project emissions	
Emission sources	GHG types
Electricity 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.

Four types of cooling system are identified as possible cooling systems except for the project system: HFC dry expansion (single loop), NH_3 flooded, pump system (single loop), HFC/brine (secondary loop) and NH_3/brine (secondary loop). This methodology ensures that a net emission reduction is achieved by applying the following conservative assumptions:

- COP_{RE} value adopted:

The maximum COP values of refrigerators among the available data of the possible type cooling systems within the range specified by Criterion ~~2~~3 is defined as COP_{RE} (1.71 for cold storage, 1.32 for individual quick freezer). The most common COP values lie between 1.60 and 1.65 for cold storages and between 1.20 and 1.25 for individual quick freezers.

- Electricity consumption of the pump for the secondary refrigerant:

Among the possible types of refrigerators, two possible cooling systems that use the secondary loop consume more electricity since the brine pump consumes more electricity than the CO_2 pump in the project cooling system. However, emissions from electricity consumption by the pump are not included in the emission calculations. The other two possible cooling systems using single loop have pumps that require almost equal amount of electricity to the project cooling system.

- Emissions associated with refrigerant loss from refrigerator:

Among the four possible types of cooling systems, two cooling systems use HFCs (R404A, R507A) as refrigerant and these have high GWP (3,000-4,000). 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 the loss of refrigerant are not counted in the emission reduction calculation.

- Project refrigerator equipped with inverter:

The project refrigerator is controlled by inverter (as specified by Criterion 4). 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. Although it is not clear whether all the refrigerators of the four possible types of cooling systems are equipped with inverter, 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

Reference emissions are calculated by the following equation.

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

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

G. Calculation of project emissions

Project emissions are calculated by the following equation.

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

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

H. Calculation of emissions reductions

Emissions reductions are calculated as the difference between the reference emissions and the project emissions, as follows:

$$ER_p = RE_p - PE_p$$

ER_p : Emissions 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
EF_{elec}	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 factors for grid and captive electricity proportionately. Proportion of captive electricity is derived from dividing captive electricity generated by total electricity consumed at the project site. The total electricity consumed is a summation of grid electricity imported ($EI_{grid,p}$) and captive electricity generated ($EG_{gen,p}$)* during the monitoring period. * Captive electricity generated can be derived from metering electricity generated or multiplying monitored operating time ($h_{gen,p}$) byand rated capacity of generator (RC_{gen}).	[Grid electricity] The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. The data is sourced from "Emission Factors of Electricity Interconnection Systems", National Committee on Clean Development Mechanism Indonesian DNA for CDM unless otherwise instructed by the Joint Committee. [Captive electricity] CDM approved small scale methodology: AMS-I.A.

	[CO_2 emission factor] For grid electricity (EF$_{elec,grid}$): The most recent value available from the source stated in this table at the time of validation For captive electricity (EF$_{elec,cap}$): 0.8* [tCO_2/MWh] *The most recent value available from CDM approved small scale methodology AMS-I.A. at the time of validation is applied.	
$COP_{RE,i}$	COP of the reference refrigerator *i*. The default values for $COP_{RE,i}$ are set as follows: For cold storage: 1.71 For individual quick freezer: 1.32	Specifications for the quotation or factory acceptance test data 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 23. The survey should prove the use of clear methodology. The $COP_{RE,i}$ should be revised if necessary from survey result which is conducted by JC or project participants every three years.
$COP_{PJ,i}$	COP of the project refrigerator *i*	Specifications for the quotation or factory acceptance test data at the time of shipment by manufacturer.
RC_{gen}	Rated capacity of generator, where applicable.	Specification of generator for captive electricity

History of the document

Version	Date	Contents revised

02.0	10 November 2015	Electronic decision by the Joint Committee Revisions to: ● Change the description of CO_2 emission factor for consumed electricity and COP of the reference refrigerator *i* in Section I: ● Change the description of “Measurement methods and procedures” for the amount of electricity consumption of the project refrigerator, grid electricity imported and monitored operating time in the “Table 1: Parameters monitored *ex post*” of the Monitoring Spreadsheet; ● Add a parameter of captive electricity generated in the “Table 1: Parameters monitored *ex post*” of the Monitoring Spreadsheet; and ● Make editorial changes to the descriptions in “Table 2: Project-specific parameters to be fixed *ex ante*” of the Monitoring Spreadsheet.
01.0	30 October 2014	JC3, Annex 5 Initial approval.

Monitoring Plan Sheet (Input Sheet) [Attachment to Project Design Document]

Table 1: Parameters to be monitored *ex post*

(a) Monitoring point No.	(b) Parameters	(c) Description of data	(d) Estimated Values	(e) Units	(f) Monitoring option	(g) Source of data	(h) Measurement methods and procedures	(i) Monitoring frequency	(j) Other comments
(1)	$EC_{PJ,i,p}$	Amount of electricity consumption of the project refrigerator *i* during the period *p*		MWh/p	Option C	Monitored data	Data is measured by measuring equipments in the factory. - Specification of measuring equipments: Electrical power meter is applied for measurement of electrical power consumption of project refrigerator. - Measuring and recording: Measured data is automatically sent to a server where data is recorded and stored. - Data collection and reporting: Inputting the recorded data to a spreadsheet electrically. - QA/QC: 1) Recorded data is checked its integrity once a month by responsible staff. ~~2) Calibration is conducted every year after the installation by a qualified entity.~~ 2) In case a calibration certificate issued by an entity accredited under national/international standards is not provided, such measuring equipment is required to be calibrated.	Continuously	
(2)	$EI_{grid,p}$	Electricity imported from the grid to the project site during the period *p*		MWh/p	Option B or Option C	Invoice from the power company for Option B or monitored data for Option C	[for Option B] Data is collected and recorded from invoices from the power company. [for Option C] Data is measured by measuring equipments in the factory. - Specification of measuring equipments: Electrical power meter is applied for measurement of electrical power consumption of project refrigerator. - Measuring and recording: Measured data is automatically sent to a server where data is recorded and stored. - Data collection and reporting: Inputting the recorded data to a spreadsheet electrically. - QA/QC: 1) Recorded data is checked its integrity once a month by responsible staff. ~~2) Calibration is conducted every year after the installation by a qualified entity.~~ 2) In case a calibration certificate issued by an entity accredited under national/international standards is not provided, such measuring equipment is required to be calibrated.	Every month	

(3)	$h_{gen,p}$	Operating time of captive electricity generator during the period *p*		hours/p	Option C	Monitored data	Data is measured by meter equipped to a generator. - Specification of measuring equipments: Meter is applied for measurement of the operation time of captive electricity generator. - Measuring and recording: Measured data is recorded and stored electrically. - Data collection and reporting: Inputting the recorded data to a spreadsheet electrically. - QA/QC: 1) Recorded data is checked its integrity once a month by responsible staff. ~~2) Calibration is conducted every year after the installation by a qualified entity.~~ 2) In case a calibration certificate issued by an entity accredited under national/international standards is not provided, such measuring equipment is required to be calibrated.	Continuously	
(4)	$EG_{gen,p}$	Captive electricity generated		MWh/p	Option C	Monitored data	Data is measured by measuring equipments in the factory. - Specification of measuring equipments: Electrical power meter is applied for measurement of electrical power consumption of project refrigerator. - Measuring and recording: Measured data is automatically sent to a server where data is recorded and stored. - Data collection and reporting: Inputting the recorded data to a spreadsheet electrically. - QA/QC: 1) Recorded data is checked its integrity once a month by responsible staff. 2) In case a calibration certificate issued by an entity accredited under national/international standards is not provided, such measuring equipment is required to be calibrated.	Continuously	If multiple generators are present, captive electricity generated ($EG_{gen,p}$) can be derived either from metering total electricity generated from multiple generators and/or from summing up multiplications of monitored operating time by each rated capacity of generators. If monitored operating time is used for deriving captive electricity generated, (i) of $h_{gen,p}$ must be applied.

Table 2: Project-specific parameters to be fixed *ex ante*

(a) Parameters	(b) Description of data	(c) Estimated Values	(d) Units	(e) Source of data	(f) Other comments
$EF_{elec,grid}$	[For grid electricity] CO_2 emission factor for consumed electricity		tCO_2/MWh	The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. The data is sourced from “Emission Factors of Electricity Interconnection Systems”, National Committee on Clean Development Mechanism Indonesian DNA for CDM unless otherwise instructed by the Joint Committee.	
$EF_{elec,cap}$	[For captive electricity] CO_2 emission factor for consumed electricity		tCO_2/MWh	Default value set in the CDM approved small scale methodology: AMS-I.A	
$COP_{RE,i}$	COP of the ~~project~~ reference refrigerator type *i*		-	~~Specifications of project refrigerator i prepared for the quotation or factory acceptance test data by manufacturer~~ Default value set in the latest version of JCM Approved Methodology ID_AM003.	
$COP_{PJ,i}$	COP of the ~~reference~~ project refrigerator type *i*		-	Specifications of project refrigerator *i* prepared for the quotation or factory acceptance test data by manufacturer	
RC_{gen}	Rated capacity of generator		kW	Specification of generator for captive electricity	

Table3: *Ex-ante* estimation of CO_2 emission reductions

CO_2 emission reductions	Units
#DIV/0!	tCO_2/p

[Monitoring option]

Option A	Based on public data which is measured by entities other than the project participants (Data used: publicly recognized data such as statistical data and
Option B	Based on the amount of transaction which is measured directly using measuring equipments (Data used: commercial evidence such as invoices)
Option C	Based on the actual measurement using measuring equipments (Data used: measured values)

Monitoring Plan Sheet (Calculation Process Sheet) [Attachment to Project Design Document]

1. Calculations for emission reductions	Fuel type	Value	Units	Parameter
Emission reductions during the period *p*	N/A	#DIV/0!	tCO_2/p	ER_p
2. Selected default values, etc.				
COP of the reference refrigerator type *i*	N/A	0.00	-	$COP_{RE,i}$
COP of the project refrigerator type *i*	N/A	0.00	-	$COP_{PJ,i}$
3. Calculations for reference emissions				
Reference emissions during the period *p*	N/A	#DIV/0!	tCO_2/p	RE_p
CO_2 emission factor for consumed electricity [grid]	Electricity	0.000	tCO_2/MWh	$EF_{elec,grid}$
CO_2 emission factor for consumed electricity [captive]	Electricity	0.00	tCO_2/MWh	$EF_{elec,cap}$
Proportion of grid electricity over total electricity consumed at the project site	N/A	#DIV/0!	-	-
Proportion of captive electricity over total electricity consumed at the project site	N/A	#DIV/0!	-	-
Amount of electricity consumption of the project refrigerator *i* during the period *p*	Electricity	0	MWh/p	$EC_{PJ,i,p}$
COP of the reference refrigerator type *i*	N/A	0.00	-	$COP_{RE,i}$
COP of the project refrigerator type *i*	N/A	0.00	-	$COP_{PJ,i}$
4. Calculations of the project emissions				
Project emissions during the period *p*		#DIV/0!	tCO_2/p	PE_p
CO_2 emission factor for consumed electricity [grid]	Electricity	0.000	tCO_2/MWh	$EF_{elec,grid}$
CO_2 emission factor for consumed electricity [captive]	Electricity	0.00	tCO_2/MWh	$EF_{elec,cap}$
Proportion of grid electricity over total electricity consumed at the project site	N/A	#DIV/0!	-	-
Proportion of captive electricity over total electricity consumed at the project site	N/A	#DIV/0!	-	-
Amount of electricity consumption of the project refrigerator *i* during the period *p*	Electricity	0	MWh/p	$EC_{PJ,i,p}$

[List of Default Values]

	$COP_{RE,i}$	
For cold storage	1.71	
For individual quick freezer	1.32	