Joint Crediting Mechanism Approved Methodology TH_AM013
"Energy Saving by Introduction of High Efficiency Screw Chiller for freezing and refrigeration"

A. Title of the methodology

Energy Saving by Introduction of High Efficiency Screw Chiller for freezing and refrigeration, Ver.01.0

B. Terms and definitions

Terms	Definitions
Screw chiller	Screw chiller is a cooling and refrigeration machine utilizing a vapor compression refrigeration cycle equipped with screw type compressor, a condenser, an expansion valve and an evaporator in one unit. Assembly of compressor, condenser, expansion valve and evaporator with interconnections, is defined as one module. As for products of screw chiller, there are the type of single module and multiple modules in one unit. This methodology is applicable to a unit of multiple modules as well as the one of single module.
Cooling capacity	Cooling capacity is the capability of individual chiller to remove heat. In this methodology, "cooling capacity" is used to represent a cooling capacity per one individual chiller unit and not to represent package units which consist of multiple screw chillers.
Periodical check	Periodical check is a periodical investigation of screw chiller(s) done by manufacturer or agent who is authorized by the manufacturer, in order to maintain screw chiller(s) performance.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	This methodology applies to the project that aims for saving energy by introducing high efficiency chiller(s).
Calculation of reference emissions	Reference emissions are GHG emissions from the usage of reference chiller unit, calculated by using data of power consumption of project screw chiller(s), ratio of COPs (Coefficient of Performance) of reference/project screw chiller and CO_2 emission factor for consumed electricity.
Calculation of project emissions	Project emissions are GHG emissions from the usage of screw chiller(s), calculated with power consumption of screw chiller(s) and CO_2 emission factor for consumed electricity.
Monitoring parameters	● Power consumption of project screw chiller ● Amount of fuel consumed and amount of electricity generated by captive power, where applicable.

D. Eligibility criteria

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

Criterion 1	The project installs brine screw chiller(s) for freezing and refrigeration. Cooling capacity of a screw chiller per one module is less than or equals to 1,000 kW.
Criteria 2	COP for project screw chiller(s) calculated under the standardizing temperature conditions ($COP_{PJ,tc,i}$) is more than COP of the reference screw chiller, with the cooling capacity range same as the project screw chiller. [equation to calculate $COP_{PJ,tc,i}$] $$\mathbf{COP_{PJ,tc,i}} = \mathbf{COP_{PJ,i}} \times [(\mathbf{TC_{cooling-out,i}} - \mathbf{TC_{chilled-out,i}} + \mathbf{TD_{chilled}} + \mathbf{TD_{cooling}}) \div (\mathbf{37 - 7 + TD_{chilled} + TD_{cooling}})]$$ $\mathrm{COP_{PJ,tc,i}}$: COP of project screw chiller *i* calculated under the standardizing temperature conditions* [-] $\mathrm{COP_{PJ,i}}$: COP of project screw chiller *i* under the catalog conditions of the project screw chiller [-] $\mathrm{TC_{cooling-out,i}}$: Output cooling water temperature of project screw chiller *i* set under the catalog conditions of the project screw chiller [degree Celsius] $\mathrm{TC_{chilled-out,i}}$: Output chilled water temperature of project screw chiller *i* set under the catalog conditions of the project

	screw chiller [degree Celsius] $TD_{cooling}$: Temperature difference between condensing temperature of refrigerant and output cooling water temperature, 1.5 degree Celsius set as a default value [degree Celsius] $TD_{chilled}$: Temperature difference between evaporating temperature of refrigerant and output chilled water temperature, 1.5 degree Celsius set as a default value [degree Celsius] The standardizing temperature conditions at which COP for project screw chiller(s) calculated in this methodology are shown below: Chilled water : output 7 degrees Celsius input 12 degrees Celsius Cooling water : output 37 degrees Celsius input 32 degrees Celsius
Criterion 3	Ozone Depletion Potential (ODP) of the refrigerant used for screw chiller(s) is zero.
Criterion 4	A plan for prevention of releasing refrigerant used for project screw chiller is prepared. In the case of replacing the existing chiller with the project screw chiller(s), a plan for prevention of releasing refrigerant used in the existing chiller 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.
Criterion 5	Periodical check at least once a year is planned.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Power consumption by reference screw chiller(s)	CO_2
Project emissions	
Emission sources	GHG types
Power consumption by project screw chiller(s)	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated by multiplying power consumption of project screw chiller(s), ratio of COPs for reference/project screw chiller, and CO_2 emission factor for consumed electricity.

Two types of cooling systems are identified as possible systems for freezing and refrigeration in Thailand to supply cold water for production process: ice storage system with reciprocation type compressor, and brine/water chiller with screw type compressor.

Considering the efficiency and current implementation situation, this methodology sets the cooling system with screw type compressor as the reference chiller available to brine/water chilling.

This methodology ensures net emission reductions through the following manners:

- Reference COP is set to be the highest COP value (for each of two cooling capacity ranges) among the marketed reference chilling system in Thailand.

F.2. Calculation of reference emissions

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

RE_p : Reference emissions during the period p [tCO_2/p]

$EC_{PJ,i,p}$: Power consumption of project screw chiller i during the period p [MWh/p]

$COP_{PJ,tc,i}$: COP of project screw chiller i calculated under the standardizing temperature conditions [-]

$COP_{RE,i}$: COP of reference screw chiller i under the standardizing temperature conditions [-]

EF_{elec} : CO_2 emission factor for consumed electricity [tCO_2/MWh]

G. Calculation of project emissions

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

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

H. Calculation of emissions reductions

$$\boldsymbol{ER_p = RE_p - PE_p}$$

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
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]. When the project screw chiller consumes only 1) grid electricity, 2) captive electricity or 3) electricity directly supplied from other sources (e.g. independent power producer (IPP), small power producer (SPP) and very small power producer (VSPP)) to the project site, the project participant applies the CO_2 emission factor respectively. When the project screw chiller may consume electricity supplied from more than 1 electric source, the project participant applies the CO_2 emission factor with the lowest value. [CO_2 emission factor] **Case 1) Grid electricity** The most recent value available from the source stated in this table at the time of validation **Case 2) Captive electricity including**	**Case 1)** [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 "Grid Emission Factor (GEF) of Thailand", endorsed by Thailand Greenhouse Gas Management Organization (TGO) unless otherwise instructed by the Joint Committee. **Case2)** [Captive electricity] <u>For Option a)</u> Specification of the captive

	cogeneration system EF_{elec} is determined based on the following options: a) Calculated from its power generation 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; $$EF_{gen} = 3.6 \times \frac{100}{\eta_{elec}} \times EF_{fuel}$$ 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 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 volume] 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	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]) For 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 volume/p]). Net calorific value (NCV_{fuel} [GJ/mass or volume]) 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

	<table><tr><td>fuel type</td><td>Diesel fuel</td><td>Natural gas</td></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. **Case 3) Electricity directly supplied from other sources including cogeneration system** EF_{elec} is determined based on the following options: a) The value provided by the electricity supplier with the evidence; b) The value calculated in the same manner for the option a) of 2) captive electricity as instructed above; c) The value calculated in the same manner for the option b) of 2) captive electricity as instructed above; When the project screw chiller may consume electricity supplied from more than 1 electric source, the project participant applies the CO_2 emission factor with the lowest value.	methodology: AMS-I.A. [Captive electricity with natural gas] 2006 IPCC Guidelines on National GHG Inventories for the source of EF of natural gas. 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. **Case 3)** [Electricity directly supplied from other sources including cogeneration system] <u>For Option a)</u> The evidence stating information relevant to the value of emission factor (e.g. data of power generation, type of power plant, type of fossil fuel, period of time).
$COP_{RE,i}$	COP of the reference screw chiller *i* under the standardizing temperature conditions The COP of the reference screw chiller *i* is selected from the default COP values in the following tables in line with cooling capacity of the project screw chiller *i*. ("x" in the table represents cooling capacity per unit.)	The default COP value is derived from the result of survey on COP of chillers. The survey should prove the use of clear methodology. The $COP_{RE,i}$ should be revised if necessary from survey result which is conducted

	<table><tr><td>Cooling capacity per unit (kW)</td><td>**x≤520**</td><td>**520<x≤1,000**</td></tr><tr><td>$COP_{RE,i}$</td><td>4.97</td><td>5.02</td></tr></table>	by JC or project participants.
$COP_{PJ,i}$	COP of the project screw chiller *i* under the catalog conditions of the project screw chiller	Specifications of project screw chiller *i* prepared for the quotation or factory acceptance test data by manufacturer

History of the document

Version	Date	Contents revised
01.0	20 September 2021	Electronic decision by the Joint Committee Initial approval.