Joint Crediting Mechanism Approved Methodology CR_AM002

"Energy Saving by Introduction of High Efficiency Centrifugal Chiller"

A. Title of the methodology

Energy Saving by Introduction of High Efficiency Centrifugal Chiller, Version 1.0

B. Terms and definitions

Terms	Definitions
Centrifugal chiller	A centrifugal chiller is a chiller equipped with a centrifugal compressor. It is commonly used for air-conditioning with huge cooling load, e.g., buildings, shopping malls or factories etc.
Cooling capacity	Cooling capacity is the ability of individual chiller to remove heat. In this methodology, "cooling capacity" is used to represent a cooling capacity per one chiller unit and not for a system with multiple chiller units.
Periodical check	Periodical check is a periodical investigation of chiller done by manufacturer or agent who is authorized by the manufacturer, in order to maintain chiller performance.
IPLV (Integrated Part Load Value)	IPLV is a performance indicator of chillers described as a weighted average of the energy efficiency ratio (EER [kW/kW]) under four different part loads and it is defined in the standard "AHRI Standard 550/590(I-P)" or "AHRI Standard 551/591(SI)" by the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) of the United States.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Saving energy by introducing high efficiency centrifugal chiller for the target factory, hotel, and commerce facilities etc. in Costa Rica.
Calculation of reference emissions	GHG emissions from using reference chiller, calculated with power consumption of project chiller, ratio of IPLVs of

	reference/project chillers and CO_2 emission factor for electricity consumed.
Calculation of project emissions	GHG emissions from using project chiller, calculated with power consumption of project chiller and CO_2 emission factor for electricity consumed.
Monitoring parameters	● Power consumption of project chiller ● Electricity imported from the grid, where applicable ● Operating time of captive electricity generator, where applicable ● The amount of fuel consumed and/or the 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	Project chiller is an inverter type centrifugal chiller with a capacity greater than or equal to 165USRt but less than 3500USRt. Note : 1 USRt = 3.52 kW
Criterion 2	IPLV for project chiller *i* certified by AHRI is more than the threshold IPLV values set in the table below. (“x” in the table represents cooling capacity per unit.)
Criterion 3	Periodical check is planned more than one (1) time annually.
Criterion 4	Ozone Depletion Potential (ODP) of the refrigerant used for project chiller is zero.
Criterion 5	A plan for prevention of releasing refrigerant used for project chiller is prepared. In the case of replacing the existing chiller with the project chiller, 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.

Cooling capacity per unit [USRt]	**165≤x<2000**	**2000≤x<3500**
Threshold IPLV value	8.04	9.60

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Power consumption by reference chiller	CO_2
Project emissions	
Emission sources	GHG types
Power consumption by project chiller	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 chiller, ratio of IPLVs for reference/project chillers, and CO_2 emission factor for electricity consumed.
The IPLV of reference chiller is conservatively set as a default value in the following manner to ensure the net emission reductions.
1. The reference IPLV value varies by its cooling capacity.
2. The maximum values of IPLV in each cooling capacity range set for this methodology are defined as $IPLV_{RE,i}$ as described in Section I.

F.2. Calculation of reference emissions

$$\mathbf{RE_p} = \sum_{\mathbf{i}} \left\{ \mathbf{EC_{PJ,i,p}} \times \left(\mathbf{IPLV_{PJ,i}} \div \mathbf{IPLV_{RE,i}} \right) \times \mathbf{EF_{elec}} \right\}$$

RE_p : Reference emissions during the period *p* [tCO_2/p]
$EC_{PJ,i,p}$: Power consumption of project chiller *i* during the period *p* [MWh/p]
$IPLV_{PJ,i}$: IPLV of project chiller *i* certified by AHRI [-]
$IPLV_{RE,i}$: IPLV of reference chiller *i* certified by AHRI [-]
EF_{elec} : CO_2 emission factor for consumed electricity [tCO_2/MWh]

G. Calculation of project emissions

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

PE_p	: Project emissions during the period *p* [tCO_2/p]
$EC_{PJ,i,p}$	: Power consumption of project 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

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

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. When project chiller consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When project chiller may consume both grid electricity and captive electricity, the project participant applies the CO_2 emission factor 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 ($h_{gen,p}$) by 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 "Factores de emisión de gases efecto invernadero", Instituto Meteorológico Nacional unless otherwise instructed by the Joint Committee. [Captive electricity] For the option a) Specification of the captive power

Parameter	Description of data	Source
	[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: <u>a) Calculated from its power generation efficiency (η_{elec} [%]) obtained from manufacturer's specification</u> The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec}} \times EF_{fuel}$$ <u>b) Calculated from measured data</u> 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 volume] Note: In case the captive electricity generation system meets all of the following conditions, the value in the	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 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 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

<table>
<tr><th>Parameter</th><th>Description of data</th><th>Source</th></tr>
<tr><td></td><td>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

<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.</td><td>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.
CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems version02.0" for the default efficiency for off-grid power plants.</td></tr>
<tr><td>$IPLV_{RE,i}$</td><td>The IPLV of the reference chiller i is selected from the default IPLV value in the following table in line with cooling capacity of the project chiller i.
(“x” in the table represents cooling capacity per unit.)

<table><tr><td>Cooling capacity per unit [USRt]</td><td>165≤x<2000</td><td>2000≤x<3500</td></tr></table></td><td>The default IPLV value is derived from the result of survey on IPLV of chillers from manufacturers that has high market share. The survey should prove the use</td></tr>
</table>

Parameter	Description of data	Source
	Reference IPLV value: 8.04 / 9.60	of clear methodology. The $IPLV_{RE,i}$ should be revised if necessary from survey result which is conducted by JC or project participants.
$IPLV_{PJ,i}$	The IPLV of project chiller *i* certified in accordance with the AHRI certification program of Water-Cooled Water Chilling Packages Using Vapor Compression Cycle, which is based on AHRI Standard 550/590 (I-P) and AHRI Standard 551/591 (SI).	Specifications of project chiller *i* from catalogue or prepared for the quotation or factory acceptance test data by manufacturer

History of the document

Version	Date	Contents revised
01.0	12 March 2018	Electronic decision by the Joint Committee Initial approval.