JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Kingdom of Cambodia
Name of the methodology proponents submitting this form	AEON MALL Co., Ltd.
Sectoral scope(s) to which the Proposed Methodology applies	3.Energy demand
Title of the proposed methodology, and version number	Introduction of High Efficiency Centrifugal Chiller, Ver01.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☒Additional information
Date of completion	14/11/2018

History of the proposed methodology

Version	Date	Contents revised
1.0	14/11/2018	First edition

A. Title of the methodology

Introduction of High Efficiency Centrifugal Chiller, Ver01.0

B. Terms and definitions

Terms	Definitions
Centrifugal chiller	A centrifugal chiller is a chiller applying 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.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	High efficiency centrifugal chiller is introduced to save energy, which leads to GHG emission reductions.
Calculation of reference emissions	Reference emissions are GHG emissions from using reference chiller, calculated with power consumption of project chiller, ratio of COPs (Coefficient Of Performance) of reference/project chillers and CO_2 emission factor for electricity consumed.
Calculation of project emissions	Project emissions are 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 ● 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.

<table>
<tr>
<td>Criterion 1</td>
<td>Project chiller is a centrifugal chiller with a capacity of less than or equal to 1,300 USRt.
* 1 USRt = 3.52 kW</td>
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<tr>
<td>Criterion 2</td>
<td>COP for project chiller i calculated under the standardizing temperature conditions* ($COP_{PJ,tc,i}$) is more than the threshold COP values set in the tables below. ("x" in the table represents cooling capacity per unit.)

[Threshold COP values for project chiller]
<table>
<tr><th>Cooling capacity per unit (USRt)</th><th>300≤x≤350</th><th>350<x≤550</th><th>550<x≤750</th><th>750<x≤1,300</th></tr>
<tr><td>Threshold COP value</td><td>5.46</td><td>5.76</td><td>5.90</td><td>6.03</td></tr>
</table>

$COP_{PJ,tc,i}$ is a recalculation of COP of project chiller i ($COP_{PJ,i}$) adjusting temperature conditions from the project specific conditions to the standardizing conditions. $COP_{PJ,i}$ is derived from specifications prepared for the quotation or factory acceptance test data at the time of shipment by manufacturer.

[equation to calculate $COP_{PJ,tc,i}$]
$$\mathbf{COP_{PJ,tc,i}} = \mathbf{COP_{PJ,i}} \times [(\mathbf{T_{cooling-out,i}} - \mathbf{T_{chilled-out,i}} + \mathbf{TD_{chilled}} + \mathbf{TD_{cooling}}) \div (\mathbf{37} - \mathbf{7} + \mathbf{TD_{chilled}} + \mathbf{TD_{cooling}})]$$

$COP_{PJ,tc,i}$: COP of project chiller i calculated under the standardizing temperature conditions* [-]
$COP_{PJ,i}$: COP of project chiller i under the project specific conditions [-]
$T_{cooling-out,i}$: Output cooling water temperature of project chiller i set under the project specific condition [degree Celsius]
$T_{chilled-out,i}$: Output chilled water temperature of project chiller i set under the project specific condition [degree Celsius]
$TD_{cooling}$: Temperature difference between condensing temperature of refrigerant and output cooling water temperature 1.5 degrees Celsius set as a default value [degree Celsius]
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</table>

	$TD_{chilled}$: Temperature difference between evaporating temperature of refrigerant and output chilled water temperature, 1.5 degrees Celsius set as a default value [degree Celsius] *The standardizing temperature conditions to calculate $COP_{PJ,tc,i}$ Chilled water: output 7 degrees Celsius input 12 degrees Celsius Cooling water: output 37 degrees Celsius input 32 degrees Celsius
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.

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 COPs for reference/project chillers, and CO_2 emission factor for electricity consumed.

The COP of reference chiller is conservatively set as a default value in the following manner to ensure the net emission reductions.

1. The COP value tends to increase as the cooling capacity becomes larger.

2. The reference COP, which has a certain cooling capacity, is set at a maximum value in corresponding cooling capacity range.
3. The maximum values of COP in each cooling capacity ranges are defined as $COP_{RE,i}$ as described in Section I.

F.2. Calculation of reference emissions

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

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]
$COP_{PJ,tc,i}$: COP of project chiller *i* calculated under the standardizing temperature conditions [-]
$COP_{RE,i}$: COP of reference chiller *i* under the standardizing temperature conditions [-]
EF_{elec} : CO_2 emission factor for consumed electricity [tCO_2/MWh]

G. Calculation of project emissions

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

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

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

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 and captive electricity, the project participant applies the CO_2 emission factor with lower value. In case the captive electricity is generated by renewable energy source(s) and the amount of the captive electricity generated by the renewable source(s) estimated from its generation capacities is equal to or less than half of the total electricity consumption at the project site, the portion of electricity generated by the renewable source(s) may be neglected in the calculation of the captive CO_2 emission factor. If the amount of captive electricity generated by renewable source(s) is more than half, the captive CO_2 emission factor is determined by the following option (b) of "(2) For captive electricity" using the total amount of captive electricity generated by both fossil fuel and renewable sources for $EG_{PJ,CG,p}$. [CO_2 emission factor] (1) For grid electricity The most recent value available from the source stated in this table at the time of	[Grid electricity] The most recent published value by the Ministry of Environment of Cambodia at the time of validation. [Captive electricity] For the option (a) Specification of the captive power generation system provided by the manufacturer ($\eta_{elec,CG}$ [%]). CO_2 emission factor of the fossil fuel type used in the captive power generation system ($EF_{fuel,CG}$ [tCO_2/GJ]) For the option (b) Generated and supplied electricity by the captive power generation system ($EG_{PJ,CG,p}$ [MWh/p]). Fuel amount consumed by the captive power generation system ($FC_{PJ,CG,p}$ [mass or volume/p]). Net calorific value ($NCV_{fuel,CG}$ [GJ/mass or volume]) and CO_2 emission factor ($EF_{fuel,CG}$ [tCO_2/GJ]) of the fuel consumed by the captive power generation system in order of preference: 1) values provided by the fuel supplier;

	validation is applied. (2) For captive electricity Option (a) Calculated from its power generation efficiency ($\eta_{elec,CG}$ [%]) 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; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec,CG}} \times EF_{fuel,CG}$$ Option (b) Calculated from measured data The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{PJ,CG,p}$) and the amount of electricity generated ($EG_{PJ,CG,p}$) 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; $$EF_{elec} = FC_{PJ,CG,p} \times NCV_{fuel,CG} \times EF_{fuel,CG} \times \frac{1}{EG_{PJ,CG,p}}$$ Where: $NCV_{fuel,CG}$: Net calorific value of fuel consumed by the captive power generation system [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.	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. 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.

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The system is non-renewable generation system
Electricity generation capacity of the system is less than or equal to 15 MW

<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 (0.0543 tCO_2/GJ), and the most efficient value of default efficiency for off-grid gas turbine systems (42%) are applied.
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<tr>
<td>$COP_{RE,i}$</td>
<td>
The COP of the reference chiller i is selected from the default COP values in the following table in line with cooling capacity of the project chiller i.
<table>
<tr><th>Cooling capacity /unit (USRt)</th><th>300≤x ≤350</th><th>350<x ≤550</th><th>550<x ≤750</th><th>750<x ≤1,300</th></tr>
<tr><td>$COP_{RE,i}$</td><td>5.46</td><td>5.76</td><td>5.90</td><td>6.03</td></tr>
</table>
</td>
<td>
Specifications of project chiller i prepared for the quotation or factory acceptance test data by manufacturer.
The default COP value is derived from the result of survey on COP of chillers from manufacturers that has high market share. 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.
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<tr>
<td>$COP_{PJ,i}$</td>
<td>The COP of project chiller i under the project specific condition.</td>
<td>Specifications of project chiller i prepared for the quotation or factory acceptance test data by</td>
</tr>
</table>

		manufacturer
$T_{cooling-out,i}$	Output cooling water temperature of project chiller *i* set under the project specific condition.	Specifications of project chiller *i* prepared for the quotation or factory acceptance test data by manufacturer
$T_{chilled-out,i}$	Output chilled water temperature of project chiller *i* set under the project specific condition.	Specifications of project chiller *i* prepared for the quotation or factory acceptance test data by manufacturer