JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Viet Nam
Name of the methodology proponents submitting this form	Sapporo Breweries Limited
Sectoral scope(s) to which the Proposed Methodology applies	3. Energy demand
Title of the proposed methodology, and version number	Energy Saving by Introduction of High Efficiency Screw Chiller(s), Version 01.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☒Additional information
Date of completion	03/09/2019

History of the proposed methodology

Version	Date	Contents revised
01.0	03/09/2019	First Edition

A. Title of the methodology

Energy Saving by Introduction of High Efficiency Screw Chiller(s), Version 01.0

B. Terms and definitions

Terms	Definitions
Screw chiller	Screw chiller is equipment to cool water by utilizing a vapor compression refrigeration cycle and an assembly of screw type compressor(s), condenser and evaporator, with interconnections.
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 for each chiller and not for a system with multiple chiller units.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	High efficiency screw chiller(s) is introduced to save energy, which leads to GHG emission reductions.
Calculation of reference emissions	Reference emissions are GHG emissions from the usage of reference chiller(s), calculated with amount of electricity consumed by project chiller(s), 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 the usage of project chiller(s), calculated with amount of electricity consumed by project chiller(s) and CO_2 emission factor for electricity consumed.
Monitoring parameters	Amount of electricity consumed by the project chiller(s)

D. Eligibility criteria

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

<table>
<tr><td>Criterion 1</td><td>The project installs screw chiller(s) with a cooling capacity which is more than or equal to 75 USRt and less than 270 USRt.
*1 USRt = 3.52 kW</td></tr>
<tr><td>Criterion 2</td><td>COP of project chiller i calculated under the standardizing temperature conditions* ($COP_{PJ,tc,i}$) is more than the threshold COP values set in the table below. (“x” in the table represents cooling capacity per individual chiller)

<table>
<tr><td>Cooling capacity per chiller (USRt)</td><td>75≤x<150</td><td>150≤x<270</td></tr>
<tr><td>Threshold COP value</td><td>4.65</td><td>4.77</td></tr>
</table>

[Equation to calculate $COP_{PJ,tc,i}$]
$$\mathbf{COP_{PJ,tc,i}} = \mathbf{COP_{PJ,i}} \times [(\mathbf{T_{cooling-out,i}} - \mathbf{T_{chilled-out,i}} + \mathbf{TD_{chilled}} + \mathbf{TD_{cooling}}) \div (\mathbf{37 - 7} + \mathbf{TD_{chilled}} + \mathbf{TD_{cooling}})]$$
$COP_{PJ,tc,i}$: COP of project chiller i calculated under the standardizing temperature conditions* [-]
$COP_{PJ,i}$: COP of project chiller i on the catalog conditions of the project chiller [-]
$T_{cooling-out,i}$: Output cooling water temperature of project chiller i set on the catalog conditions of the project chiller [degree Celsius]
$T_{chilled-out,i}$: Output chilled water temperature of project chiller i set on the catalog conditions of the project chiller [degree Celsius]
$TD_{chilled}$: Temperature difference between evaporating temperature of refrigerant and output chilled water temperature:
1.5 degrees Celsius set as a default value [degree Celsius]
$TD_{cooling}$: Temperature difference between condensing temperature of refrigerant and output cooling water temperature:
1.5 degrees Celsius set as a default value [degree Celsius]

* The standardizing temperature conditions at which COP(s) for project 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</td></tr>
<tr><td>Criterion 3</td><td>Ozone Depletion Potential (ODP) of the refrigerant used for project chiller(s) is zero.</td></tr>
</table>

Criterion 4	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 the pure refrigerants and/or recover and destroy blend refrigerants) 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
Electricity consumption by reference chiller(s)	CO_2
Project emissions	
Emission sources	GHG types
Electricity consumption by project chiller(s)	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

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

Taking into the cooling capacity which is less than 300 USRt, a chiller with screw type compressor is possible to be used to cool water. As the efficiency of air-cooled screw type chillers are lower than those of water-cooled type, COP of reference chiller is conservatively set as a default value in the following manner to ensure net emission reductions based on the COP values of the marketed water-cooled screw chillers with a standard/an average efficiency in Viet Nam.

1. The COP values vary by its cooling capacity.
2. The maximum value of COP in each cooling capacity range set for this methodology is defined as $COP_{RE,i}$ as described in Section I.

F.2. Calculation of reference emissions

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

RE_p: Reference emissions during the period p [tCO_2/p]
$EC_{PJ,i,p}$: Amount of electricity consumed by 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

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

PE_p: Project emissions during the period p [tCO_2/p]
$EC_{PJ,i,p}$: Amount of electricity consumed by 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

$$ER_p = RE_p - PE_p$$

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].	[Grid electricity] Ministry of Natural Resources and Environment of Vietnam

	When project chiller(s) consume only grid electricity or captive electricity generated by fossil fuel, the project participant applies the CO_2 emission factor respectively. When project chiller(s) may consume all or two of the three electricity types (grid, captive by fossil fuel, and captive by renewable energy), the project participant applies the CO_2 emission factor with lower value. [CO_2 emission factor] (1) For grid electricity The most recent value available from the source stated in this table at the time of validation (2) For captive electricity If the amount of electricity generated by renewable energy sources estimated from their generation capacities is equal to or less than half of the total electricity consumption at the project site, the captive CO_2 emission factor is determined from the following options using the data of fossil fuel generation only by option (a) or option (b). If the amount is more than half, the CO_2 emission factor is determined by option (b) using total of the amount of electricity generated by both fossil fuel and renewable sources for $EG_{PJ,CG,p}$. 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	(MONRE), Vietnamese DNA for CDM unless otherwise instructed by the Joint Committee. [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; 2) measurement by the project participants; 3) regional or national default

	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. $FC_{PJ,CG,p}$ includes the amount of fossil fuel input only but does not include renewable energy. The amount of electricity generated includes both by fossil fuel and renewable energy when necessary. 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. ● The system is non-renewable generation system	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 version 02.0" for the default efficiency for off-grid power plants.

<table>
<tr>
<td></td>
<td>
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 (0.0543 tCO_2/GJ), and the most efficient value of default efficiency for off-grid gas turbine systems (42%) are applied.
</td>
<td></td>
</tr>
<tr>
<td>$COP_{RE,i}$</td>
<td>COP of reference chiller i under the standardizing temperature conditions [-]

The project participant selects the default value in the following table in line with cooling capacity of the project chiller i. (“x” in the table represents cooling capacity per individual chiller)
<table>
<tr><td>Cooling capacity per chiller (USRt)</td><td>75≤x<150</td><td>150≤x<270</td></tr>
<tr><td>$COP_{RE,i}$</td><td>4.65</td><td>4.77</td></tr>
</table>
*1 USRt = 3.52 kW
</td>
<td>The default COP values are derived from the result of survey on COPs of chillers. The survey should prove the use of clear methodology. The default values of $COP_{RE,i}$ should be revised if necessary from survey result which is conducted by the Joint Committee or project participants.</td>
</tr>
<tr>
<td>$COP_{PJ,i}$</td>
<td>COP of project chiller i on the catalog conditions of the project chiller [-]</td>
<td>Specifications of project chiller(s) prepared for the quotation or factory acceptance test data by manufacturer</td>
</tr>
<tr>
<td>$T_{cooling-out,i}$</td>
<td>Output cooling water temperature of project chiller i set on the catalog conditions of the project chiller [degree Celsius]</td>
<td>Specifications of project chiller(s) prepared for the quotation or factory acceptance</td>
</tr>
</table>

		test data by manufacturer
$T_{chilled-out,i}$	Output chilled water temperature of project chiller *i* set on the catalog conditions of the project chiller [degree Celsius]	Specifications of project chiller(s) prepared for the quotation or factory acceptance test data by manufacturer