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 Inverter Type Multi-Stage Oil-Free Air Compressor, 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 Inverter Type Multi-Stage Oil-Free Air Compressor, Version 01.0

B. Terms and definitions

Terms	Definitions
Inverter type multi-stage oil-free air compressor	An inverter type multi-stage oil-free air compressor is a compressor which contains inverter, an apparatus to control the speed of the compressor motor, and which has more than one compression stages, and also a compressor without using lubricating oil to compress air, nitrogen or inert gases to make the pressure of gas higher than that of the inlet.
Specific conditions	The specific conditions for this methodology are defined as below, following ISO 1217:2009. Ambient temperature = 20 degrees Celsius, Ambient pressure = 0 MPa (Gauge pressure*), Relative humidity = 0%, Cooling water/air = 20 degrees Celsius, Effective working pressure at discharge valve = 0.7 MPa (Gauge pressure). *Note) Gauge pressure is the difference between absolute pressure and atmospheric pressure. Gauge pressure is a relative pressure that sets the atmospheric pressure as zero, against absolute pressure that sets the vacuum state as zero.
Free air delivery (FAD)	The actual quantity of compressed air converted to the inlet conditions of the compressor. The unit is m^3/min.
Specific power (SP)	Specific power is an indicator of efficiency of air compressor, calculated with electric motor power (nominal output power) [kW] and free air delivery [m^3/min]. $$\mathbf{SP} = \frac{\mathbf{Motor\ power\ [kW]}}{\mathbf{FAD\ [m^3/min]}}$$

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	High efficiency inverter type multi-stage oil-free air compressor(s) is introduced to save energy, which leads to GHG emission reductions. Inverter contributes to save power consumption through frequently controlling output based on operating status of related machines. In multi-stage compressor, thermal energy of compressed air can be decreased by heat exchange during the interval of each compression stage, it leads to energy saving.
Calculation of reference emissions	Reference emissions are GHG emissions from using reference air compressor, calculated with power consumption of project air compressor, specific power (SP) of reference/project air compressors and CO_2 emission factor for electricity consumed.
Calculation of project emissions	Project emissions are GHG emissions from using project air compressor, calculated with power consumption of project air compressor and CO_2 emission factor for electricity consumed.
Monitoring parameters	● Power consumption of project air compressor ● The amount of fuel consumed and 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 air compressor is an inverter type multi-stage oil-free air compressor with an electric motor power of 37kW, 55kW, 75kW, 100kW, or 160kW.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Power consumption by project air compressor	CO_2
Project emissions	

Emission sources	GHG types
Power consumption by reference air compressor	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 air compressor, specific power (SP) for reference/project air compressors, and CO_2 emission factor for electricity consumed.

SP of reference air compressor is conservatively set as a default value in the following manner to ensure the net emission reductions.

1. The most efficient value is selected for each motor power of air compressors from the collected SP values available in Vietnamese market and determined as the reference SP.
2. The value of SP is defined as $SP_{RE,sc,i}$ described in Section I.

F.2. Calculation of reference emissions

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

RE_p : Reference emissions during the period *p* [tCO_2/p]
$EC_{PJ,i,p}$: Power consumption of project air compressor *i* during the period *p* [MWh/p]
$SP_{PJ,sc,i}$: SP of project air compressor *i* calculated under the specific conditions [$kW \cdot min/m^3$]
$SP_{RE,sc,i}$: SP of reference air compressor *i* under the specific conditions [$kW \cdot min/m^3$]
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 air compressor *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 air compressor(s) consume only grid electricity or captive electricity generated by fossil fuel, the project participant applies the CO_2 emission factor respectively. When project air compressor(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	[Grid electricity] Ministry of Natural Resources and Environment of Vietnam (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 for the fossil fuel type used in the captive power generation system ($EF_{fuel,CG}$ [tCO_2/GJ]) For the option b)

	(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 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	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 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

<table>
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<td>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
● 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>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>$SP_{RE,sc,i}$</td>
<td>The SP of the reference air compressor i for each motor power is set as a default value in</td>
<td>Specifications of project air compressor i prepared for the</td>
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<td>this methodology as shown in the table below.

<table>
<tr><th>Motor Power [kW]</th><th>Reference SP</th></tr>
<tr><td>37</td><td>6.80</td></tr>
<tr><td>55</td><td>5.98</td></tr>
<tr><td>75</td><td>5.63</td></tr>
<tr><td>100</td><td>5.28</td></tr>
<tr><td>160</td><td>5.32</td></tr>
</table>

It is noted that the SP value is calculated under the specific conditions.</td>
<td>quotation or factory acceptance test data by manufacturer.

The default SP value is derived from the result of survey on SP of inverter type multi-stage oil-free air compressors from manufacturers that have high market share in Vietnam.

The $SP_{RE,sc,i}$ is revised if necessary from survey result which is conducted by JC or project participants every three years.</td>
</tr>
<tr>
<td>$SP_{PJ,i}$</td>
<td>SP of project air compressor i under the project specific conditions.</td>
<td>Specifications of project air compressor i prepared for the quotation or factory acceptance test data by manufacturer.</td>
</tr>
<tr>
<td>$SP_{PJ,sc,i}$</td>
<td>SP of project air compressor i under the specific conditions is calculated by the following equation:

$$SP_{PJ,sc,i} = SP_{PJ,i} \times \frac{T_{s,PJ,sc,i}}{T_{s,PJ,i}} \times \left[\left(\frac{P_{d,PJ,sc,i}}{P_{s,PJ,sc,i}}\right)^{\frac{k-1}{m_i k}} - 1\right] \div \left[\left(\frac{P_{d,PJ,i} + 0.101}{P_{s,PJ,i}}\right)^{\frac{k-1}{m_i k}} - 1\right]$$
k: Heat capacity ratio (Dried Air) = 1.4
m_i: Number of compression stages of project air compressor i
$P_{s,PJ,i}$: Suction pressure of project air compressor i under the project specific conditions [MPa(abs)] (Default value is set at atmospheric pressure = 0.101[MPa(abs)])
$P_{s,PJ,sc,i}$: Suction pressure of project air compressor i under the specific conditions</td>
<td>[Parameter m_i]
Catalogues or specifications of project air compressor i

[Other parameters]
Specifications of project air compressor i prepared for the quotation or factory acceptance test data by manufacturer.</td>
</tr>
</table>

	[MPa(abs)] (Default value is set at atmospheric pressure = 0.101[MPa(abs)]) $T_{s,PJ,i}$: Suction temperature of project air compressor *i* under the project specific conditions [K] (Value from the product catalogue or manufacturer's specification) $T_{s,PJ,sc,i}$: Suction temperature of project air compressor *i* under the specific conditions [K] (Default value is set at 293.0[K]) $P_{d,PJ,i}$: Discharge pressure of project air compressor *i* under the project specific conditions [MPa(Gauge pressure)] (Value from the product catalogue or manufacturer's specification) $P_{d,PJ,sc,i}$: Discharge pressure of project air compressor *i* under the specific conditions [MPa(abs)] (= 0.101[MPa(abs)] + 0.7 [MPa(Gauge pressure)] = 0.801[MPa(abs)])	