JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	Indonesia
Name of the methodology proponents submitting this form	NTT DATA INSTITUTE OF MANAGEMENT CONSULTING, INC
Sectoral scope(s) to which the Proposed Methodology applies	1 Energy Industry 3 Energy demand
Title of the proposed methodology, and version number	Power generation and chilled water supply from Combined Heat and Power
List of documents to be attached to this form (please check):	☒The attached draft JCM-PDD: ☐Additional information
Date of completion	xx/xx/2015

History of the proposed methodology

Version	Date	Contents revised
1.0	xx/xx/2015	First Edition

A. Title of the methodology

Power generation and chilled water supply by Combined Heat and Power

B. Terms and definitions

Terms	Definitions
Combined Heat and Power (CHP)	CHP is a system which generates and utilizes heat and power simultaneously from same primary energy source.
Absorption Chiller	*Absorption Chiller* is a system which uses heat (steam or hot water) to produce chilled water for air conditioning. Water as refrigerant and lithium bromide as the absorbent are used in the *Absorption Chiller*.
Centrifugal chiller	A *centrifugal chiller* is a type 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*" represents the performance of chiller per unit, not per a system consisting of multiple chiller units.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	CHP which consists of gas engine generator and *Absorption Chiller* generates both electricity and heat which displaces electricity import from the grid
Calculation of reference emissions	Reference emissions are GHG emissions from the displacement of grid electricity and electricity consumed by reference centrifugal chillers, which are calculated based on the amount of electricity generated by project gas engine generator and the amount of chilled water produced by project *Absorption Chiller*.
Calculation of project	Project emissions are GHG emissions from the consumption of

emissions	natural gas by gas engine generator and electricity consumed by auxiliary equipment of project *Absorption Chiller*, which are calculated based on the amount of natural gas consumed by gas engine generator and amount of electricity consumed by auxiliary equipment of project *Absorption Chiller*.
Monitoring parameters	・ Amount of net electricity generated by gas engine generator ・ Amount of chilled water produced by *Absorption Chiller* ・ Average inlet temperature of the chilled water entering the *Absorption Chiller* ・ Average outlet temperature of the chilled water leaving the *Absorption Chiller* ・ Amount of natural gas consumed by gas engine generator ・ Net calorific value of natural gas consumed by gas engine generator ・ Amount of electricity consumed by auxiliary equipment of *Absorption Chiller*

D. Eligibility criteria

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

Criterion 1	CHP consists of gas engine generator fueled by natural gas and *Absorption Chiller* which uses waste heat from generator. CHP generates both electricity and heat which displaces grid electricity imported from the grid.
Criterion 2	A *Cooling capacity* of project *Absorption Chiller* per unit is less than 1,200 USRt. (1 USRt = 3.52 kW), and total *Cooling capacity* of *Absorption Chiller* does not exceed that of *existing centrifugal chiller.*
Criterion 3	Chilled water produced by *Absorption Chiller* displaces water produced by *existing centrifugal chillers.*
Criterion 4	Electricity generated by gas engine generator is not sold to the grid and used only for self-consumption.
Criterion 5	COP of project *Absorption Chiller* calculated under the standard temperature conditions is not less than 0.7. $COP_{absorp,tc,\ i}$ is derived from the recalculation of COP of project *Absorption Chiller* i ($COP_{absorp,spec,\ i}$) by adjusting temperature conditions from the project specific condition to the standardizing conditions. $COP_{absorp,spec,\ i}$ is given from the specifications prepared for the quotation or factory acceptance test data at the time of shipment by manufacturer.

	[Equation to calculate $COP_{absorp,tc,i}$] $COP_{absorp,tc,i} = COP_{absorp,spec,i} * [(T_{cooling\ out,i} - T_{chilled\ out,i} + TD_{chilled} + TD_{cooling}) / (37 - 7 + TD_{chilled} + TD_{cooling})]$ $COP_{absorp,tc,i}$ COP of project *Absorption Chiller i* calculated under the standard temperature conditions* [-] $COP_{absorp,spec,i}$ COP of project *Absorption 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] $TD_{chilled}$ Temperature difference between condensing temperature of refrigerant and output cooling water temperature, 1.5 degree Celsius set as a default value [degree Celsius] $TD_{cooling}$ Temperature difference between evaporating temperature of refrigerant and output chilled water temperature, 1.5 degree Celsius set as a default value [degree Celsius] *The standard temperature conditions to calculate $COP_{PJ,tc,i}$ are as follows: Chilled water: Output 7°C; Input 12 °C Cooling water: Output 37 °C; Input 32 °C
Criterion 6	Electricity generation efficiency of gas engine is not less than 40% (LHV basis) in specifications prepared for the quotation or test data at the time of shipment by manufacturer.
Criterion 7	In the case of replacing the existing chiller with the project chiller, the plan for not releasing refrigerant used for the *existing centrifugal chiller* is prepared.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Grid electricity consumption displaced by gas engine generator	CO_2
Grid electricity consumption by centrifugal chiller calculated from the amount of chilled water produced by *Absorption Chiller*	CO_2

Project emissions	
Emission sources	GHG types
Natural gas consumption by gas engine generator	CO_2
Electricity consumption by auxiliary equipment of *Absorption Chiller*	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated based on the net amount of electricity generated by project gas engine and the amount of chilled water produced by project *Absorption Chiller*.

Reference emissions from chilled water production are calculated from the COP of reference centrifugal chiller and the amount of electricity consumption equivalent to the heat capacity of chilled water produced by project *Absorption Chiller* which would be the same amount of chilled water as produced prior to the start of project activity.

The net emission reduction is ensured in the following manner:

1. The COP of reference centrifugal chillers is conservatively set by referring to ID_AM002 "Energy Saving by Introduction of High Efficiency Centrifugal Chiller" which set this value conservatively.
2. If different capacities of chillers are installed in the project site, the COP value of the largest capacity chiller should be applied to ensure conservativeness.

F.2. Calculation of reference emissions

$$RE_p = RE_{elec} + RE_{cool} \quad \cdots\cdots\cdots\cdots\cdots \quad \text{(Eq. 1)}$$

Where,

RE_p	Total reference emissions during a given period p	(tCO_2/p)
RE_{elec}	Reference emissions from consumption of grid electricity during a given period p	(tCO_2/p)
RE_{cool}	Reference emissions from the production of chilled water during a given period p	(tCO_2/p)

$$RE_{elec} = EG_{p,\,net} * EF_{elec} \quad \cdots\cdots\cdots\cdots\cdots \quad \text{(Eq. 2)}$$

Where,

$EG_{p, net}$	Amount of net electricity generated by gas engine generator which displaces grid electricity during a given period p	(MWh/p)
EF_{elec}	CO_2 emission factor of regional grid electricity in Indonesia	(tCO_2/MWh)

$$RE_{cool} = EC_{RE} * EF_{elec} \quad \cdots\cdots\cdots\cdots\cdots \quad \text{(Eq. 3)}$$

Where,

EC_{RE}	Amount of electricity consumption equivalent to the COP of reference centrifugal chiller and the amount of electricity consumption equivalent to the heat capacity of chilled water produced by project *Absorption Chiller*	(MWh/p)

$$EC_{RE} = \{ CG_{PJ} / (3.6 * 10^{-3}) \} / COP_{RE} \quad \cdots\cdots\cdots\cdots\cdots \quad \text{(Eq. 4)}$$

Where,

CG_{PJ}	Heat capacity of chilled water produced by *Absorption Chiller*s during a given period p	(TJ/p)
$3.6 * 10^{-3}$	Conversion factor from TJ to MWh	(TJ/MWh)
COP_{RE}	COP of reference centrifugal chiller under the standard temperature conditions	(-)

$$CG_{PJ} = \Sigma \{ CW_{PJ,l} * C * (T_{CW, PJ, in, l} - T_{CW, PJ, out,l}) \} \quad \cdots\cdots\cdots\cdots\cdots \quad \text{(Eq. 5)}$$

Where,

$CW_{PJ,l}$	Amount of chilled water produced by *Absorption Chiller* during the monitoring interval *l*	(ton)
C	Specific heat capacity of the chilled water (= 4.1868×10^{-6})	(TJ/ton)
$T_{CW, PJ, in, l}$	Average inlet temperature of the chilled water entering the *Absorption Chiller* during monitoring interval *l*	(°C)
$T_{CW, PJ, out,l}$	Average outlet temperature of the chilled water	

	leaving the *Absorption Chiller* during monitoring interval *l*	(°C)
l	Monitoring intervals for monitoring the amount and temperature of chilled water produced during a given period p	(-)

G. Calculation of project emissions

$$PE_p = PE_{gen,p} + PE_{aux,p} \quad \text{……} \quad \text{(Eq. 6)}$$

Where,

PE_p	Total project emissions during a given period p	(tCO_2/p)
$PE_{gen,p}$	Project emissions from natural gas consumed by gas engine generator during a given period p □	(tCO_2/p)
$PE_{aux,p}$	Project emissions from electricity consumed by auxiliary equipment of project *Absorption Chiller* during a given period p	(tCO_2/p)

$$PE_{gen,p} = FC_{PJ,p} * NCV_p / 10^6 * CEF * 44 / 12 \quad \text{……} \quad \text{(Eq. 7)}$$

Where,

$FC_{PJ,p}$	Amount of natural gas consumed by gas engine generator during a given period p □	(Nm^3/p)
NCV_p	Net calorific value of natural gas consumed	(MJ/m^3)
CEF	Default emission factor of natural gas	(tC/TJ)

$$PE_{aux,p} = \Sigma(EC_{aux,i,p} * EF_{elec}) \quad \text{……} \quad \text{(Eq. 8)}$$

Where,

$EC_{aux,i,p}$	Amount of electricity consumed by auxiliary equipment i of project *Absorption Chiller* during a given period p □	(MWh/p)

H. Calculation of emissions reductions

Emission reductions are calculated as the difference between the reference emissions and project emissions, as follows:

$ER_p = RE_p - PE_p$ …… (Eq. 9)

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. 0.814*[tCO_2/MWh] (Grid electricity) *The most recent value available from the source stated in this table at the time of validation	The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. The data is sourced from "Emission Factors of Electricity Interconnection Systems", National Committee on Clean Development Mechanism Indonesian DNA for CDM unless otherwise instructed by the Joint Committee.
COP_{RE}	The COP of the reference chiller. Comparing the value of the centrifugal chiller and the value of following table, higher COP value is used. Table $COP_{RE,I}$	[COP of *existing centrifugal chiller*] Manufacturer's specification [Value of Table $COP_{RE,I}$] ID_AM002 "Energy Saving by Introduction of High Efficiency Centrifugal Chiller"
CEF	Default carbon content of natural gas is 15.3tC/TJ	2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, Table1.4

Cooling capacity /unit (USRT)	**x<300**	**300≦ x<450**	**450≦ x<500**	**500≦ x<700**	**700≦ x<1,250**
COP_{RE}	4.92	5.33	5.59	5.85	5.94