Joint Crediting Mechanism Approved Methodology ID_AM010

"Introducing double-bundle modular electric heat pumps to a new building"

A. Title of the methodology

Introducing double-bundle modular electric heat pumps to a new building, version 1.0

B. Terms and definitions

Terms	Definitions
Double-bundle modular electric heat pump (modular HP)	A double-bundle water-to-water type modular heat pump is a modular heat pump system where heating/cooling energy is simultaneously generated. The modular HP is composed of one or multiple module units, which can operate individually, by having different combinations of modules, or altogether by a master control. Run by electricity, the modular HPs in this methodology are also equipped with power optimization devices (e.g. inverters) to minimize the electricity consumption of motors.
Packaged air conditioner	Packaged air conditioner is one of the types of air conditioner (A/C) system which consists of factory-assembled A/C unit. It is used for the cooling capacity in between 20 and 140 kW per unit.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	The project contributes to GHG emission reductions at a new building, by reducing electricity and oil consumption with (an) efficient modular HP(s).
Calculation of reference emissions	Reference emissions are GHG emissions from electricity and oil consumption by the reference equipment for the generation of hot and chilled water. They are calculated by the amount of hot and chilled water utilized by the project building, efficiencies of

	the reference equipment and CO_2 emission factor of fuel and electricity which are consumed by the reference equipment. Default values from CDM methodological tool and National Standard of Indonesia (SNI) are used for the efficiencies.
Calculation of project emissions	Project emissions are calculated based on the monitored electricity consumption by the modular HP(s), other chilled water generating equipment and the auxiliary equipment and the monitored oil consumption by the project.
Monitoring parameters	・ Quantity of heating energy utilized by the project building ・ Quantity of cooling energy utilized by the project building ・ Oil consumed by the project ・ Electricity consumed by the modular HP ・ Electricity consumed by auxiliary electric equipment of the modular HP ・ Electricity consumed by other chilled water generating equipment ・ Electricity consumed by auxiliary electric equipment of the other chilled water generating equipment

D. Eligibility criteria

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

Criterion 1	A project introduces (a) modular HP(s) to a new building. The total cooling capacity of the modular HP(s) is altogether less than 176 kW or 600,000 BTU/hr.
Criterion 2	The modular HP(s) introduced under the project has its technical capability to produce outgoing hot water higher than or equal to 70 degrees Celsius. The value can be checked against specifications from an equipment supplier.
Criterion 3	In addition to the modular HP(s) installed for project, oil-fired hot water generating equipment(s) and/or electric-run chilled water generating equipment(s) may be installed and operated to supply hot and/or chilled water to the project building. In such cases, the capacity of these additional equipment to generate hot and/or chilled water is less than or equal to half of the heating capacity and/or the cooling capacity of the modular HP(s), respectively.
Criterion 4	A plan for not releasing refrigerant used for the modular HP(s) is prepared, if the refrigerant contains CFCs, HFCs, or HCFCs.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Electricity consumption by chilled water generating equipment	CO_2
Oil consumption by hot water generating equipment	CO_2
Project emissions	
Emission sources	GHG types
Electricity consumption by modular HPs	CO_2
Electricity consumption by auxiliary equipment of modular HPs (e.g. air handling unit, fan coil unit, and pump)	CO_2
Electricity consumption by other chilled water generating equipment	CO_2
Electricity consumption by auxiliary electric equipment of the other chilled water generating equipment	CO_2
Oil consumption by the project	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

This methodology applies only to a new building which uses both hot and chilled water.

Reference emissions are calculated from the monitored quantity of heating and cooling energy utilized by the project building during the project multiplied by the efficiencies of the reference equipments (oil-fired boiler and packaged A/C) and the individual emission factors for electricity and oil which are consumed by the reference equipment. For the efficiencies, default values from CDM methodological tool and SNI are used.

This methodology ensures a net emission reduction by following reasons:

(i) The reference emissions use conservatively-set default efficiencies for the oil-fired boiler (90%) and the packaged A/C (COP 3.70). They are derived from CDM methodological tool and SNI respectively; and

(ii) The hot and chilled water generated by modular HP(s) is to be utilized within the project building. It can also be utilized in other buildings nearby. The methodology takes into account only the project emissions related to the amount of water supplied to other buildings and not the

reference emissions.

F.2. Calculation of reference emissions

The reference emissions are calculated using one of the approaches shown below, depending on the measurement instruments installed in the project:

Approach 1: Where heating and cooling energy is measured by a calorimeter and is expressed in terms of energy utilized by the equipments;

$$RE_p = (Q_{PJh,p} / \eta_{REh}) \times EF_{REh} + (Q_{PJc,p} / \eta_{REc} / 3.6) \times EF_{elec}$$

Where

$$Q_{PJh,p} = \sum_i \sum_t Q_{PJh,i,t}$$

$$Q_{PJc,p} = \sum_j \sum_t Q_{PJc,j,t}$$

RE_p	Reference emissions during the period p [tCO_2/p]
$Q_{PJh,p}$	Quantity of heating energy utilized by the project building during the period *p* [GJ/p]
$Q_{PJc,p}$	Quantity of cooling energy utilized by the project building during the period *p* [GJ/p]
η_{REh}	Efficiency of the reference equipment for heating energy generation [-]
η_{REc}	Efficiency of the reference equipment for cooling energy generation [-]
EF_{REh}	CO_2 emission factor for the oil consumed by the reference equipment for heating energy generation [tCO_2/GJ]
EF_{elec}	CO_2 emission factor for the electricity consumed by the project [tCO_2/MWh]
3.6	Conversion factor from GJ to MWh
$Q_{PJh,i,t}$	Quantity of heating energy utilized by equipment *i* in the project building between time *t*-1 and time *t* [GJ]
$Q_{PJc,i,t}$	Quantity of cooling energy utilized by equipment *j* in the project building between time *t*-1 and time *t* [GJ]
't'	Number of time period [-]
'i'	Number of equipment utilizing the hot water

'j'	Number of equipment utilizing the chilled water for A/C

Approach 2: Where heating and cooling energy is calculated by monitored values of temperature and quantity of hot / chilled water utilized by the equipments:

$$RE_p = (Q_{PJh,p} / \eta_{REh}) \times EF_{REh} + (Q_{PJc,p} / \eta_{REc} / 3.6) \times EF_{elec}$$

Where

$$Q_{PJh,p} = \sum_i \sum_t m_{PJh,i,t} \times (T_{h-1,i,t} - T_{h-0,i,t}) \times C_p \times \rho \times 10^{-3}$$

$$Q_{PJc,p} = \sum_j \sum_t m_{PJc,j,t} \times (T_{c-0,j,t} - T_{c-1,j,t}) \times C_p \times \rho \times 10^{-3}$$

$m_{PJh,i,t}$	Quantity of hot water utilized by the equipment *i* in the project building between time *t*-1 and time *t* [m^3]
$m_{PJc,j,t}$	Quantity of chilled water utilized by the equipment *j* in the project building between time *t*-1 and time *t* [m^3]
$T_{h-0,i,t}$	Inlet temperature of the feed water for hot water to be utilized by the equipment *i* at time *t* [degree Celsius]
$T_{h-1,i,t}$	Outlet temperature of the hot water utilized by the equipment *i* at time *t* [degree Celsius]
$T_{c-0,j,t}$	Inlet temperature of the feed water for chilled water to be utilized by the equipment *j* at time *t* [degree Celsius]
$T_{c-1,j,t}$	Outlet temperature of the chilled water utilized by the equipment *j* at time *t* [degree Celsius]
C_p	Specific heat capacity of water [MJ/tonne- degree Celsius]
ρ	Density of water [tonne /m^3]
't'	Number of time period [-]
'i'	Number of equipment utilizing the hot water
'j'	Number of equipment utilizing the chilled water for A/C

G. Calculation of project emissions

Project emissions are from the electricity consumed by modular HPs, other electric-run chilled water generating equipment and their auxiliary equipment (e.g. air handling unit, fan coil unit, pump, etc.) installed by the project, and oil consumption by oil-fired hot water generating equipment to supplement hot water demand, which can be calculated as below:

$$PE_p = (EC_{PJ,p} \times EF_{elec}) + (FC_{PJ,p} \times EF_{fuel})$$

PE_p	Project emissions during the period p [tCO_2/p]
$EC_{PJ,p}$	Electricity consumed by the project during the period p [MWh/p]
EF_{elec}	CO_2 emission factor for the electricity consumed by the project [tCO_2/MWh]
$FC_{PJ,p}$	Oil consumed by the project during the period p [kL/p]
EF_{fuel}	CO_2 emission factor for the oil consumed by the project [tCO_2/kL]

$$EC_{PJ,p} = \sum_m (EC_{HP,m,p} + EC_{HP\_aux,m,p}) + \sum_n (EC_{other,n,p} + EC_{other\_aux,n,p})$$

$EC_{HP,m,p}$	Electricity consumed by the modular HP m operated during the period p [MWh/p]
$EC_{HP\_aux,m,p}$	Electricity consumed by auxiliary electric equipment for the modular HP m during the period p [MWh/p]
$EC_{other,n,p}$	Electricity consumed by other chilled water generating equipment n operated during the period p [MWh/p]
$EC_{other\_aux,n,p}$	Electricity consumed by auxiliary electric equipment for other chilled water generating equipments n during the period p [MWh/p]
'm'	Number of modular HP
'n'	Number of other chilled water generating equipment

H. Calculation of emissions reductions

Emission reductions are calculated as below:

$$ER_p = RE_p - PE_p$$

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.

<table>
<tr><th>Parameter</th><th>Description of data</th><th>Source</th></tr>
<tr><td>η_{REh}</td><td>Efficiency of the reference equipment for heating energy generation

A default value: 90% (new oil fired boiler)</td><td>Default value in the methodology (from the CDM methodological tool "Tool to determine the baseline efficiency of thermal or electric energy generation systems", ver.01).</td></tr>
<tr><td>η_{REc}</td><td>Efficiency of the reference equipment for cooling energy generation

Default value for packaged A/C:<table><tr><td colspan="2">SNI 6390:2011</td></tr><tr><td>A/C type</td><td>COP</td></tr><tr><td>Packaged A/C</td><td>3.70</td></tr></table></td><td>Default value in the methodology (from the latest National Standard of Indonesia SNI 6390 available at the time of validation).</td></tr>
<tr><td>EF_{REh}</td><td>CO_2 emission factor for the oil which is consumed by the reference equipment for heating energy generation [tCO_2/GJ]

When a hot water generating equipment other than modular HP is installed on a premise of a new project building, the oil used in that equipment is considered to be the oil of the reference equipment.

When any hot water generating equipment other than modular HP is not installed on a premise of a new project building, the lower CO_2 emission factor for either diesel oil or MFO, commonly used in Indonesia, available from one of the sources stated in this table at the time of validation is applied in a conservative manner.</td><td>In the order of preference:
a) values provided by the fuel supplier;
b) measurement by the project participants;
c) regional or national default values;
d) IPCC default values provided in table 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied.</td></tr>
<tr><td>C_p</td><td>Specific heat capacity of water
4.186MJ/tonne-degree Celsius</td><td></td></tr>
<tr><td>ρ</td><td>Density of water
1 tonne/m^3</td><td></td></tr>
</table>

EF_{elec}	CO_2 emission factor for the electricity consumed by the project and the reference equipment. When the project equipment consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When the project equipment may consume both grid electricity and captive electricity, the project participant applies the CO_2 emission factor with lower value. [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: 0.8* [tCO_2/MWh] *The most recent value available from CDM approved small scale methodology AMS-I.A at the time of validation is applied.	[Grid Electricity] The data is sourced from "Emission Factors of Electricity Interconnection Systems", National Committee on Clean Development Mechanism (Indonesian DNA for CDM), based on data obtained by Directorate General of Electricity, Ministry of Energy and Mineral Resources, Indonesia, unless otherwise instructed by the Joint Committee. [Captive Electricity] CDM approved small scale methodology AMS-I.A
EF_{fuel}	CO_2 emission factor for the oil consumed by the project [tCO_2/kL]	In the order of preference: a) values provided by the fuel supplier; b) measurement by the project participants; c) regional or national default values; d) IPCC default values provided in table 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied.

History of the document

Version	Date	Contents revised
01.0	6 August 2015	Electronic decision by the Joint Committee Initial approval.