Joint Crediting Mechanism Approved Methodology VN_AM012
"Energy Saving by Introduction of Heat Recovery Electric Heat Pump"

A. Title of the methodology

Energy Saving by Introduction of Heat Recovery Electric Heat Pump, Version 01.0

B. Terms and definitions

Terms	Definitions
Heat Recovery Electric Heat Pump (HREHP)	A heat pump system run by electricity where heating and cooling energy are simultaneously generated and supplied.
Coefficient of Performance (COP)	A ratio of the energy produced by the equipment to the energy consumed by the equipment including chiller, heat pump and electric heater, which is calculated by using following formula: $COP = Q/W$ Where: Q: Amount of heat produced by the equipment [watts] W: Electric power consumed by the equipment [watts]
Periodical check	Periodical check is a periodical investigation of HREHP done by manufacturer or agent who is authorized by the manufacturer, in order to maintain HREHP performance.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	HREHP is introduced to save energy, which leads to GHG emission reductions.
Calculation of reference emissions	Reference emissions are GHG emissions from using reference equipment for heating energy generation (boiler or electric heater) and air-cooled chiller for cooling energy generation. Reference emissions for heating energy generation are

	calculated with power consumption of project HREHP(s), rated electricity consumption of project HREHP, rated heating capacity of project HREHP, efficiency of the reference equipment for heating energy generation and CO_2 emission factor for the reference equipment for heating energy generation. Reference emissions for cooling energy generation are calculated with power consumption of project HREHP(s), rated electricity consumption of project HREHP, rated cooling capacity of project HREHP, efficiency of the reference equipment for cooling energy generation (COP) and CO_2 emission factor for electricity consumed.
Calculation of project emissions	Project emissions are GHG emissions from using project HREHP(s), calculated with power consumption of project HREHP(s) and CO_2 emission factor for electricity consumed.
Monitoring parameters	● Power consumption of project HREHP(s) ● The amount of fuel consumption 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	A project introduces (an) heat recovery electric heat pump(s) (HREHP). In case (an) project HREHP(s) replaces existing equipment, the existing one is not (an) HREHP(s).
Criterion 2	Periodical check is planned more than one (1) time annually.
Criterion 3	Ozone Depletion Potential (ODP) of the refrigerant used for project HREHP(s) is zero.
Criterion 4	A plan for prevention of releasing refrigerant used for project HREHP(s) is prepared. In the case of replacing the existing chiller with the project HREHP(s), 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 electric heater and air-cooled chiller	CO_2
Project emissions	
Emission sources	GHG types
Power consumption by project HREHP(s)	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated by multiplying electricity consumption of the project HREHP(s) by the ratio of efficiency between a reference equipment and project HREHP(s), and emission factors of electricity and/or fuel consumed.

[The efficiency values for reference equipment for heating energy generation]
1. The efficiency value for the reference boiler (η_{REh}) is set to 0.92 as a default value in a conservative manner referred to the CDM methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems, Version 2".
2. The efficiency value for the reference electric heater (η_{REh}) is set to 1.0, theoretically the most efficient value, as a default value in a conservative manner.

[The reference COP value for air-cooled chiller]
1. The reference COP value ($COP_{RE,cool,i}$) varies by its cooling capacity.
2. The maximum values of COP in each cooling capacity range set as default values in a conservative manner as described in Section I.

F.2. Calculation of reference emissions

$$RE_p = \sum_i \left(\frac{EC_{PJ,i,p} \times 3.6}{ECR_i} \times \frac{H_{PJ,i}}{\eta_{REh}} \times EF_{REh} \right) + \sum_i \left(\frac{EC_{PJ,i,p}}{ECR_i} \times \frac{CH_{PJ,i}}{COP_{RE,cool,i}} \times EF_{elec} \right)$$

Where

RE_p	Reference emissions during the period p [tCO_2/p]
$EC_{PJ,i,p}$	Power consumption of project HREHP i during the period p [MWh/p]
ECR_i	Rated electricity consumption of project HREHP i [kW]

$H_{PJ,i}$	Rated heating capacity of project HREHP *i* [kW]
η_{REh}	Efficiency of the reference equipment for heating energy generation [-]
EF_{REh}	CO_2 emission factor for the reference equipment for heating energy generation [tCO_2/GJ]
$CH_{PJ,i}$	Rated cooling capacity of project HREHP *i* [kW]
$COP_{RE,cool,i}$	COP of reference air-cooled chiller *i* [-]
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]
i	Identification number of project HREHP

G. Calculation of project emissions

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

Where

PE_p	Project emissions during the period *p* [tCO_2/p]
$EC_{PJ,i,p}$	Power consumption of project HREHP *i* during the period *p* [MWh/p]
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]

H. Calculation of emissions reductions

$$ER_p = RE_p - PE_p$$

Where

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 of consumed electricity. When project HREHPs consume only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When project HREHPs 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, it is determined based on the following options: 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; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{elec,CG}} \times EF_{fuel,CG}$$ 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	[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 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

<table>
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<td>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.

● 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>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 the source of EF of natural gas.
CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems</td>
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<tr><td></td><td></td><td>version02.0" for the default efficiency for off-grid power plants.</td></tr>
<tr><td>EF_{REh}</td><td>CO_2 emission factor for the reference equipment for heating energy generation [tCO_2/GJ]

When an auxiliary heater exists in the project HREHP(s), a value is applied according to the instruction described in the table below depending on the type of auxiliary heater.
When an auxiliary heater does not exist in the project HREHP(s), a value of natural gas for boiler is applied.
<table><tr><th>Type of auxiliary heater</th><th>Applied value</th></tr><tr><td>Boiler</td><td>CO_2 emission factor of the fuel consumed by the auxiliary heater in the project is applied.</td></tr><tr><td>Electric heater</td><td>CO_2 emission factor in the same manner as EF_{elec} in this section divided by 3.6 ($EF_{REh} = EF_{elec}/3.6$) is applied.</td></tr></table></td><td>[Boiler]
In the order of preference:
a) value provided by fuel supplier;
b) value measured by the project participants;
c) regional or national default value; or
d) IPCC default value provided in table 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Lower value is applied.

[Electric heater]
Same source as the parameter EF_{elec} in this section</td></tr>
<tr><td>ECR_i</td><td>Rated electricity consumption of project HREHP i [kW]</td><td>Specifications of project HREHP i prepared for the quotation or factory acceptance test data by manufacturer</td></tr>
<tr><td>η_{REh}</td><td>Efficiency of the reference equipment for heating energy generation [-]

When an auxiliary heater exists in the project HREHP(s), a default value from the table below is applied depending on the type of auxiliary heater.
When an auxiliary heater does not exist in the project HREHP(s), a default value of boiler from the table below is applied.</td><td>[Boiler]
CDM Methodological tool “Determining the baseline efficiency of thermal or electric energy generation systems, Version 2”

[Electric heater]</td></tr>
</table>

<table>
<tr><td></td><td><table><tr><th>Type of auxiliary heater</th><th>Default value</th></tr><tr><td>Boiler</td><td>0.92</td></tr><tr><td>Electric heater</td><td>1.0</td></tr></table></td><td>Theoretically the most efficient value</td></tr>
<tr><td>$COP_{RE,cool,i}$</td><td>COP of reference air-cooled chiller i [-]

COP of the reference chiller is selected from the default COP values in the following table in line with cooling capacity of the project HREHP i. (“x” in the table represents cooling capacity per unit.)<table><tr><th>Cooling capacity per unit (USRt)</th><th>4≤x≤60</th><th>60<x≤140</th><th>140<x≤184</th></tr><tr><td>$COP_{RE,cool,i}$</td><td>3.08</td><td>2.96</td><td>2.71</td></tr></table>*1 USRt = 12,000 BTU/hr = 3.52 kW</td><td>The default COP values are derived from the result of survey on COP of air-cooled chillers from manufacturers with high market share. The survey should prove the use of clear methodology.
The default COP values should be revised if necessary from survey result which is conducted by JC or project participants.</td></tr>
<tr><td>$H_{PJ,i}$</td><td>Rated heating capacity of project HREHP i [kW]</td><td>Specifications of project HREHP i prepared for the quotation or factory acceptance test data by manufacturer</td></tr>
<tr><td>$CH_{PJ,i}$</td><td>Rated cooling capacity of project HREHP i [kW]</td><td>Specifications of project HREHP i prepared for the quotation or factory acceptance test data by manufacturer</td></tr>
</table>

History of the document

Version	Date	Contents revised
01.0	29 August 2018	Decision by the Joint Committee Initial approval.