# Joint Crediting Mechanism Approved Methodology Form VN_AM011
# "Energy Saving by Introduction of High Efficiency Inverter Type Centrifugal Chiller"

## A. Title of the methodology

Energy Saving by Introduction of High Efficiency Inverter Type Centrifugal Chiller, Version 01.0

## B. Terms and definitions

| Terms | Definitions |
|---|---|
| Inverter type centrifugal chiller | An inverter type centrifugal chiller is a chiller which contains inverter, an apparatus to control the speed of the compressor motor in order to maintain the ambient temperature, and includes a centrifugal compressor. |
| Cooling capacity | The capability of individual chiller to remove heat. In this methodology, "cooling capacity" is used to represent a cooling capacity per one chiller unit and not for a system with multiple chiller units. |
| Periodical check | A periodical investigation of chiller done by manufacturer or agent who is authorized by the manufacturer, in order to maintain chiller performance. |

## C. Summary of the methodology

| Items | Summary |
|---|---|
| *GHG emission reduction measures* | High efficiency centrifugal chiller with inverter technology is introduced to save energy, which leads to GHG emission reductions. |
| *Calculation of reference emissions* | Reference emissions are GHG emissions from using reference chiller, calculated with power consumption of project chiller, ratio of COPs (Coefficient Of Performance) of reference/project chillers and $CO_2$ emission factor for electricity consumed. |
| *Calculation of project* | Project emissions are GHG emissions from using project chiller, |

| | |
|---|---|
| *emissions* | calculated with power consumption of project chiller and $CO_2$ emission factor for electricity consumed. |
| *Monitoring parameters* | ● Power consumption of project chiller<br>● 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.

<table>
<tr><td>Criterion 1</td><td>Project chiller is an inverter type centrifugal chiller with a capacity which is less than or equals to 1,500 USRt.<br>*1 USRt = 12,000 BTU/hr = 3.52 kW</td></tr>
<tr><td>Criterion 2</td><td>
COP for project chiller $i$ calculated under the standardizing temperature conditions* ($COP_{PJ,tc,i}$) is more than the threshold COP values set in the tables below. (“x” in the table represents cooling capacity per unit.)
<table>
<tr><td>Cooling capacity per unit (USRt)</td><td>300≤x<450</td><td>450≤x<550</td><td>550≤x<825</td><td>825≤x≤1,500</td></tr>
<tr><td>Threshold COP value</td><td>5.59</td><td>5.69</td><td>5.85</td><td>6.06</td></tr>
</table>
$COP_{PJ,tc,i}$ is calculated by altering the temperature conditions of COP of project chiller $i$ ($COP_{PJ,i}$) from the project specific conditions to the standardizing conditions. $COP_{PJ,i}$ is derived from specifications prepared for the quotation or factory acceptance test data by manufacturer.<br>
[equation to calculate $COP_{PJ,tc,i}$]<br>
$$\mathbf{COP_{PJ,tc,i} = COP_{PJ,i} \times [(T_{cooling-out,i} - T_{chilled-out,i} + TD_{chilled} + TD_{cooling}) \div (37 - 7 + TD_{chilled} + TD_{cooling})]}$$<br>
$COP_{PJ,tc,i}$ : COP of project chiller $i$ calculated under the standardizing temperature conditions* [-]<br>
$COP_{PJ,i}$ : COP of project chiller $i$ under the project specific conditions [-]<br>
$T_{cooling-out,i}$ : Output cooling water temperature of project chiller $i$ set under the project specific conditions [degree Celsius]<br>
$T_{chilled-out,i}$ : Output chilled water temperature of project chiller $i$ set under the project specific conditions [degree Celsius]
</td></tr>
</table>

| | |
|---|---|
| | $TD_{cooling}$ : Temperature difference between condensing temperature of refrigerant and output cooling water temperature, 1.5 degree Celsius set as a default value [degree Celsius]<br>$TD_{chilled}$ : Temperature difference between evaporating temperature of refrigerant and output chilled water temperature, 1.5 degree Celsius set as a default value [degree Celsius]<br><br>*The standardizing temperature conditions to calculate $COP_{PJ,tc,i}$<br>Chilled water: output 7 degrees Celsius<br>input 12 degrees Celsius<br>Cooling water: output 37 degrees Celsius<br>input 32 degrees Celsius |
| Criterion 3 | Periodical check is planned more than one (1) time annually. |
| Criterion 4 | Ozone Depletion Potential (ODP) of the refrigerant used for project chiller is zero. |
| Criterion 5 | 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 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 chiller | $CO_2$ |
| Project emissions | |
| Emission sources | GHG types |
| Power consumption by project chiller | $CO_2$ |

## F. Establishment and calculation of reference emissions

### F.1. Establishment of reference emissions

Reference emissions are calculated by multiplying power consumption of project chiller, ratio of COPs for reference/project chillers, and $CO_2$ emission factor for electricity consumed.

The COP of reference chiller is conservatively set as a default value in the following manner to ensure the net emission reductions.

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

### F.2. Calculation of reference emissions

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

$$\boldsymbol{COP_{PJ,tc,i} = COP_{PJ,i} \times [(T_{cooling-out,i} - T_{chilled-out,i} + TD_{chilled} + TD_{cooling}) \div (37 - 7 + TD_{chilled} + TD_{cooling})]}$$

*Where*

| | |
|---|---|
| $RE_p$ | Reference emissions during the period *p* [$tCO_2$/p] |
| $EC_{PJ,i,p}$ | Power consumption of 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] |
| $COP_{PJ,i}$ | COP of project chiller *i* under the project specific conditions [-] |
| $T_{cooling-out,i}$ | Output cooling water temperature of project chiller *i* set under the project specific conditions [degree Celsius] |
| $T_{chilled-out,i}$ | Output chilled water temperature of project chiller *i* set under the project specific conditions [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] |
| $i$ | Identification number of project chiller |

## G. Calculation of project emissions

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

*Where*

| | |
|---|---|
| $PE_p$ | Project emissions during the period *p* [$tCO_2$/p] |
| $EC_{PJ,i,p}$ | Power consumption of 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

$$\mathbf{ER_p} = \mathbf{RE_p} - \mathbf{PE_p}$$

*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 for consumed electricity.<br>When project chillers consume only grid electricity or captive electricity, the project participant applies the $CO_2$ emission factor respectively.<br>When project chillers may consume both grid electricity and captive electricity, the project | [Grid electricity]<br>Ministry of Natural Resources and Environment of Vietnam (MONRE), Vietnamese DNA for CDM unless otherwise instructed by the Joint Committee.<br>[Captive electricity] |

| | | |
|---|---|---|
| | participant applies the $CO_2$ emission factor with lower value.<br>[$CO_2$ emission factor]<br>For grid electricity: The most recent value available from the source stated in this table at the time of validation<br>For captive electricity, it is determined based on the following options:<br>a) Calculated from its power generation efficiency ($\eta_{elec,CG}$ [%]) obtained from manufacturer's specification<br>The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied;<br>$\mathrm{EF_{elec}} = 3.6 \times \frac{100}{\eta_{\mathrm{elec,CG}}} \times \mathrm{EF_{fuel,CG}}$<br>b) Calculated from measured data<br>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. The measurement is conducted with the monitoring equipment to which calibration certificate is issued by an entity accredited under national/international standards;<br>$\mathrm{EF_{elec}} = \mathrm{FC_{PJ,CG,p}} \times \mathrm{NCV_{fuel,CG}} \times \mathrm{EF_{fuel,CG}} \times \frac{1}{\mathrm{EG_{PJ,CG,p}}}$<br>Where:<br>$NCV_{fuel,CG}$: Net calorific value of fuel consumed by the captive power generation system [GJ/mass or volume] | For the option a)<br>Specification of the captive power generation system provided by the manufacturer ($\eta_{elec,CG}$ [%]).<br>$CO_2$ emission factor of the fossil fuel type used in the captive power generation system ($EF_{fuel,CG}$ [$tCO_2/GJ$])<br>For the option b)<br>Generated and supplied electricity by the captive power generation system ($EG_{PJ,CG,p}$ [MWh/p]).<br>Fuel amount consumed by the captive power generation system ($FC_{PJ,CG,p}$ [mass or volume/p]).<br>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:<br>1) values provided by the fuel supplier;<br>2) measurement by the project participants;<br>3) regional or national default values;<br>4) IPCC default values provided in tables 1.2 and 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG |

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<td>Note:<br>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.<br><br>● The system is non-renewable generation system<br>● Electricity generation capacity of the system is less than or equal to 15 MW<br><br>
<table>
<tr><th>fuel type</th><th>Diesel fuel</th><th>Natural gas</th></tr>
<tr><td>$EF_{elec}$</td><td>0.8 *1</td><td>0.46 *2</td></tr>
</table>
<br>*1 The most recent value at the time of validation is applied.<br>*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>Inventories. Lower value is applied.<br><br>[Captive electricity with diesel fuel]<br>CDM approved small scale methodology: AMS-I.A.<br><br>[Captive electricity with natural gas]<br>2006 IPCC Guidelines on National GHG Inventories for the source of EF of natural gas.<br>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>$COP_{RE,i}$</td>
<td>COP of reference chiller *i* under the standardizing temperature conditions<br><br>The COP of the reference chiller *i* is selected from the default COP value in the following table in line with cooling capacity of the project chiller *i*. (“x” in the table represents cooling capacity per unit.)<br><br>
<table>
<tr><th>Cooling capacity per unit (USRt)</th><th>300≤x<450</th><th>450≤x<550</th><th>550≤x<825</th><th>825<x≤1,500</th></tr>
</table></td>
<td>Specifications of project chiller *i* prepared for the quotation or factory acceptance test data by manufacturer.<br><br>The default COP values are derived from the result of survey on COP of chillers from manufacturers that have high market share. The</td>
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</table>

<table>
<tr><td></td><td><table><tr><td>$COP_{RE,i}$</td><td>5.59</td><td>5.69</td><td>5.85</td><td>6.06</td></tr></table><br>*1 USRt = 12,000 BTU/hr = 3.52 kW</td><td>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>$\mathrm{COP}_{\mathrm{PJ,i}}$</td><td>The COP of project chiller *i* under the project specific conditions.</td><td>Specifications of project chiller *i* prepared for the quotation or factory acceptance test data by manufacturer</td></tr>
<tr><td>$\mathrm{T}_{\mathrm{cooling-out,i}}$</td><td>Output cooling water temperature of project chiller *i* set under the project specific conditions.</td><td>Specifications of project chiller *i* prepared for the quotation or factory acceptance test data by manufacturer</td></tr>
<tr><td>$\mathrm{T}_{\mathrm{chilled-out,i}}$</td><td>Output chilled water temperature of project chiller *i* set under the project specific conditions.</td><td>Specifications of project chiller *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<br>Initial approval. |
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