Joint Crediting Mechanism Approved Methodology TH_AM012

"Energy Saving by Installation of an Evaporator with Mechanical Vapor Recompression"

A. Title of the methodology

Energy Saving by Installation of an Evaporator with Mechanical Vapor Recompression, Ver.01.0

B. Terms and definitions

Terms	Definitions
Evaporator	An evaporator is a device used in a process turning liquid form in a solution into its vapor to obtain a solution with high concentration.
Mechanical vapor recompression (MVR)	Mechanical vapor recompression is an energy recovery method which boosts low pressure suction vapor generated in an evaporator with a mechanically driven compressor and uses it again as a heating source in an evaporator to heat a liquid such as an inlet solution.
Thermal vapor recompression (TVR)	Thermal vapor recompression is a process which mixes the low-pressure suction vapor generated in an evaporator with a supplied new steam and increases the pressure of the mixed vapor by an ejector to heat a liquid such as an inlet solution.
Suction ratio	Suction ratio is the indicator of the efficiency for an ejector used in TVR. It is defined as the amount of recovered vapor per the amount of new steam.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	Waste heat recovery by installing an evaporator with mechanical vapor recompression.
Calculation of reference emissions	Reference emissions are calculated by steam consumption of reference evaporator, heating value of the steam, efficiencies of the project boiler and CO_2 emission factor of fuel for the boiler.
Calculation of project	Project emissions are calculated by electricity consumption and

emissions	steam consumptions by project evaporator and CO_2 emission factors for electricity and steam consumed.
Monitoring parameters	• Total amount of inlet solution to evaporator • Total amount of evaporation from supplied solution by the project evaporator • Project steam consumption by project evaporator • Electricity consumption of project evaporator

D. Eligibility criteria

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

Criterion 1	The project installs evaporator(s) which applies mechanical vapor recompression.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Consumption of steam supplied from steam generator by reference evaporator	CO_2
Project emissions	
Emission sources	GHG types
Consumption of steam supplied from steam generator by project evaporator	CO_2
Electricity consumption of project evaporator	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated by multiplying reference steam consumption, heating value and CO_2 emission factor of fuel for the boiler. The reference steam consumption is determined by the theoretical formula for the steam consumption of reference evaporator which applies thermal vapor recompression. In order to secure net emission reductions in this methodology, the reference emissions are conservatively calculated in the following manners.

-Setting inlet water temperature for the steam generation at 38.5 degree Celsius which is derived from the highest monthly average atmospheric temperature in Thailand

-Setting the suction ratio at 1.2 by taking the highest value within the range of values applied to the existing evaporator in the market

In addition, possible emissions from auxiliary equipment which cools non-recovered vapor in the reference system are not taken into account for calculating the reference emissions.

F.2. Calculation of reference emissions

$$RE_p = \frac{\sum SC_{RE,i,p} \times (h_{steam,i} - SPH \times T_{inlet})}{1000} \times \frac{1}{\eta_{PJh}} \times EF_{fuel}$$

RE_p : *Reference emissions during the period p [tCO_2/p]*

$SC_{RE,i,p}$: *Reference steam consumption by the reference evaporator i during the period p [t/p]*

$h_{steam,i}$: *Specific enthalpy of supplied steam to the project evaporator i [MJ/t]*

SPH : *Specific heat capacity of water[1] [MJ/(t·K)]*

T_{inlet} : *Inlet water temperature for the steam generation [degree celsius]*

η_{PJh} : *Efficiency of project boiler for steam supply [-]*

EF_{fuel} : *CO_2 emission factor for the fuel consumed by the project boiler for heating energy generation [tCO_2/GJ]*

$$\sum SC_{RE,i,p} = \sum \frac{\left(EV_{tot,i,p} \times LH_{EV,i}\right) - FL_{IN,i,p} \times SPH \times (T_{LS,i} - T_{EV,i})}{LH_{HT,i} \times (SR + 1)}$$

$EV_{tot,i,p}$: *Total amount of evaporation from supplied solution by the project evaporator i during the period p [t/p]*

$LH_{EV,i}$: *Specific latent heat of the evaporation temperature of solution at the project evaporator i [MJ/t]*

SPH : *Specific heat capacity of water[1] [MJ/(t·K)]*

$T_{LS,i}$: *Temperature of the supplied solution to the project evaporator i [degree Celsius]*

$T_{EV,i}$: *Evaporation temperature of the solution at the project evaporator i [degree Celsius]*

$LH_{HT,i}$: *Specific latent heat of the heating temperature of the supplied vapor to the project evaporator i[MJ/t]*

SR	*: Suction ratio of ejector in the reference evaporator with thermal vapor recompression [-]*
$FL_{IN,i,p}$	*: Total amount of inlet solution to the evaporator i during the period p [t/p]*

[1] This methodology may apply the specific heat capacity of water instead of specific heat capacities of solution.

G. Calculation of project emissions

$$PE_p = \sum EC_{PJ,i,p} \times EF_{elec} + \frac{\sum SC_{PJ,i,p} \times (h_{steam,i} - SPH \times T_{inlet})}{1000} \times \frac{1}{\eta_{PJh}} \times EF_{fuel}$$

PE_p	*: Project emissions during the period p [tCO_2/p]*
$EC_{PJ,i,p}$	*: Electricity consumption of the project evaporator i during the period p [MWh/p]*
EF_{elec}	*: CO_2 emission factor for consumed electricity [tCO_2/MWh]*
$SC_{PJ,i,p}$	*: Project steam consumption by the project evaporator i during the period p [t/p]*
$h_{steam,i}$	*: Specific enthalpy of supplied steam to the project evaporator i [MJ/t]*
SPH	*: Specific heat capacity of water [MJ/(t·K)]*
T_{inlet}	*:Inlet water temperature for the steam generation [degree celsius]*
η_{PJh}	*: Efficiency of project boiler for steam supply [-]*
EF_{fuel}	*: CO_2 emission factor for the fuel consumed by the project boiler for heating energy generation [tCO_2/GJ]*

H. Calculation of emissions reductions

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

$$ER_p = RE_p - PE_p$$

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 [tCO_2/MWh]. When the project evaporator consumes only 1) grid electricity, 2) captive electricity or 3) electricity directly supplied from other sources (e.g. independent power producer (IPP), small power producer (SPP) and very small power producer (VSPP)) to the project site, the project participant applies the CO_2 emission factor respectively. When the project evaporator may consume electricity supplied from more than 1 electric source, the project participant applies the CO_2 emission factor with the lowest value. [CO_2 emission factor] **Case 1) Grid electricity** The most recent value available from the source stated in this table at the time of validation **Case 2) Captive electricity including cogeneration system** EF_{elec} is determined based on the following options: a) <u>Calculated from its power generation efficiency (η_{elec} [%]) obtained from manufacturer's specification.</u> The power generation efficiency based on lower heating value (LHV) of the captive power generation system from the manufacturer's specification is applied; $EF_{gen} = 3.6 \times \frac{100}{\eta_{elec}} \times EF_{fuel}$ <u>b) Calculated from measured data</u>	**Case 1)** [Grid electricity] The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter. The data is sourced from "Grid Emission Factor (GEF) of Thailand", endorsed by Thailand Greenhouse Gas Management Organization (TGO) unless otherwise instructed by the Joint Committee. **Case 2)** [Captive electricity] <u>For Option a)</u> Specification of the captive power generation system provided by the manufacturer (η_{elec} [%]). CO_2 emission factor of the fossil fuel type used in the captive power generation system (EF_{fuel} [tCO_2/GJ]) <u>For Option b)</u> Generated and supplied electricity by the captive power generation system ($EG_{PJ,p}$ [MWh/p]). Fuel amount consumed by

<table>
<tr><th>Parameter</th><th>Description of data</th><th>Source</th></tr>
<tr><td></td><td>The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{PJ,p}$) and the amount of electricity generated ($EG_{PJ,p}$) during the 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;
$$EF_{elec} = FC_{PJ,p} \times NCV_{fuel} \times EF_{fuel} \times \frac{1}{EG_{PJ,p}}$$
Where:
NCV_{fuel} : Net calorific value of consumed fuel [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 (0.0543tCO_2/GJ), and the most efficient value of default efficiency for off-grid gas turbine systems (42%) are applied.

Case 3) Electricity directly supplied from other</td><td>the captive power generation system ($FC_{PJ,p}$ [mass or volume/p]).
Net calorific value (NCV_{fuel} [GJ/mass or volume]) and CO_2 emission factor of the fuel (EF_{fuel} [tCO_2/GJ]) 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. The default 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</td></tr>
</table>

Parameter	Description of data	Source
	sources including cogeneration system EF_{elec} is determined based on the following options: a) The value provided by the electricity supplier with the evidence; b) The value calculated in the same manner for the option a) of 2) captive electricity as instructed above; c) The value calculated in the same manner for the option b) of 2) captive electricity as instructed above; When the project evaporator may consume electricity supplied from more than 1 electric source, the project participant applies the CO_2 emission factor with the lowest value.	"Determining the baseline efficiency of thermal or electric energy generation systems version 02.0" for the default efficiency for off-grid power plants. **Case 3)** [Electricity directly supplied from other sources including cogeneration system] <u>For Option a)</u> The evidence stating information relevant to the value of emission factor (e.g. data of power generation, type of power plant, type of fossil fuel, period of time).
η_{PJh}	Efficiency of the project boiler for steam supply. If multiple boilers are installed, the most efficient value is applied. In case that the efficiency cannot be identified, one of the following default values is applied according to the fuel used for the boiler. Natural gas: 0.92 [-] Oil: 0.9 [-]	Specifications of the project boiler from catalogue or prepared for the quotation. [Default value] CDM Methodological tool "Determining the baseline efficiency of thermal or electric energy generation systems version02.0" for the default efficiency of project boiler. The default values should be updated along with the revision of the CDM tool.
EF_{fuel}	CO_2 emission factor for the fuel consumed by the project boiler for heating energy generation [tCO_2/GJ] In case that the efficiency cannot be identified, one	In the order of preference: a) values provided by the fuel supplier; b) measurement by the project participants; c) national default values;

Parameter	Description of data	Source
	of the following default values is applied according to the fuel used for the boiler. Natural gas: 0.0543 [tCO_2/GJ] Oil: 0.0726 [tCO_2/GJ]	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.
$h_{steam,i}$	Specific enthalpy of supplied steam to the project evaporator *i* [MJ/t] In case that the value applied for this parameter has changed, the newly applied value and its date of occurrence is recorded and stored, then start the new monitoring period with the new value as fixed ***ex ante***.	Based on steam table using the values in operating manual or a value displayed on the control panel at factory
T_{inlet}	Inlet water temperature for the steam generation. The highest monthly average atmospheric temperature in Thailand is applied. Default value is set to 38.5 [degree Celsius].	Thai Meteorological Department (2016) "Climatological Data for the Period 1981–2010" unless otherwise instructed by the Joint Committee.
$LH_{HT,i}$	Specific latent heat of the heating temperature of the supplied vapor to the project evaporator *i* [MJ/t] In case that this parameter has changed, the newly applied value and its date of occurrence is recorded and stored, then start the new monitoring period with the new value as fixed ***ex ante***.	Based on steam table using the values in operating manual or a value displayed on the control panel at factory
SR	Suction ratio of ejector in the reference evaporator with thermal vapor recompression. Default value is set to 1.2 [-].	Value derived from the result of survey. Default value, 1.2, should be revised if necessary.
SPH	Specific heat capacity of water. Default value is set to 4.18 [MJ/(t·K)]	

Parameter	Description of data	Source
$T_{LS,i}$	Temperature of the supplied solution to the project evaporator *i* [degree Celsius]. In case that this parameter has changed, the newly applied value and its date of occurrence is recorded and stored, then start the new monitoring period with the new value as fixed ***ex ante***.	Operating manual or a value displayed on the control panel at factory
$T_{EV,i}$	Evaporation temperature of the solution at the project evaporator *i* [degree Celsius]. In case that this parameter has changed, the newly applied value and its date of occurrence is recorded and stored, then start the new monitoring period with the new value as fixed ***ex ante***.	Operating manual or a value displayed on the control panel at factory
$LH_{EV,i}$	Specific latent heat of the evaporation temperature of solution at the project evaporator *i* [MJ/t]. In case that this parameter has changed, the newly applied value and its date of occurrence is recorded and stored, then start the new monitoring period with the new value as fixed ***ex ante***.	Based on steam table using the values in operating manual or a value displayed on the control panel at factory

History of the document

Version	Date	Contents revised
01.0	20 September 2021	Electronic decision by the Joint Committee Initial approval.