JCM Proposed Methodology Form

Cover sheet of the Proposed Methodology Form

Form for submitting the proposed methodology

Host Country	The Kingdom of Thailand
Name of the methodology proponents submitting this form	Tepia Corporation Japan Co., Ltd.
Sectoral scope(s) to which the Proposed Methodology applies	1. Energy industries (renewable- / non-renewable sources)
Title of the proposed methodology, and version number	Introduction of Biomass Boiler, Ver. 01.0
List of documents to be attached to this form (please check):	☐The attached draft JCM-PDD: ☐Additional information
Date of completion	28/04/2022

History of the proposed methodology

Version	Date	Contents revised
01.0	28/04/2022	First Edition

A. Title of the methodology

Introduction of Biomass Boiler, Ver. 01.0

B. Terms and definitions

Terms	Definitions
Biomass	Biomass is non-fossilized and biodegradable organic material originating from plants, animals and microorganisms. This includes products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes.
Biomass residue	Biomass residues are defined as biomass that is a by-product, residue or waste stream from agriculture, forestry and related industries. This does not include municipal waste or other wastes that contain fossilized and/or non-biodegradable material (however, small fractions of inert inorganic material like soil or sands may be included).
Biomass boiler	A boiler which combusts biomass to heat water and produce steam.
Boiler efficiency	The ratio of the total absorption heating value of the usable heat output to the heat amount contained in fuel fired in the boiler. In other words, it means that 1 minus the fraction of the heat loss. The heat loss includes the one by blow water.
Drain recovery system	Drain recovery system is an equipment which recovers drain with some heating energy and reuses for boiler feed water.

C. Summary of the methodology

Items	Summary

GHG emission reduction measures	One or more biomass boilers are introduced and combust biomass instead of fossil fuels to generate heat and produce steam, resulting in reduction of GHG emissions from fossil fuels.
Calculation of reference emissions	Reference emissions are CO_2 emissions from heat generation by a reference boiler which combusts fossil fuel(s). They are calculated by the amount of produced steam by the project biomass boiler(s), specific enthalpies of steam and water, reference boiler efficiency and a CO_2 emission factor of fossil fuel.
Calculation of project emissions	Project emissions are CO_2 emissions from electricity consumed by the project biomass boiler(s), combustion of fossil fuel(s) by the project biomass boiler(s) and transportation of biomass. CO_2 emissions from consumed electricity are calculated by the amount of electricity consumed by the project biomass boiler(s) and its CO_2 emission factor. In case the project biomass boiler(s) combusts fossil fuel(s) as well as biomass, project emissions include CO_2 emissions from the combustion of fossil fuel(s), which are calculated by the amount of fossil fuel(s), net calorific value of fossil fuel(s) and its/their CO_2 emission factors. CO_2 emissions from biomass transportation are calculated by roundtrip distance of biomass transportation, mass of transported biomass and a CO_2 emission factor for biomass transportation.
Monitoring parameters	● Amount of steam produced by the project biomass boiler(s) ● Amount of electricity consumed by the project biomass boiler(s) and ancillary equipment ● Amount of fossil fuel consumed by the project biomass boiler(s) ● Round trip distance of biomass transportation ● Mass of transported biomass

D. Eligibility criteria

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

Criterion 1	One or more biomass boilers are newly installed or replace an existing fossil fuel-fired boiler(s).
Criterion 2	In case of utilizing biomass fuel for project biomass boiler(s), only solid biomass fuels made of biomass residues are used.
Criterion 3	Biomass residues utilized for the project are not used for energy application in absence of the project activity. This can be demonstrated by the letter from suppliers of biomass.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Fossil fuel(s) consumed for generation of heat to produce steam	CO_2
Project emissions	
Emission sources	GHG types
Electricity consumed by the project biomass boiler(s) and ancillary equipment	CO_2
Fossil fuel(s) combusted by the project biomass boiler(s)	CO_2
Fossil fuel(s) consumption by transportation of biomass between the place of biomass supplier's stockyard and the project site	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

Reference emissions are calculated based on the amount of steam produced by the project boiler(s), specific enthalpies of produced steam and feed water, reference boiler efficiency and a CO_2 emission factor of reference fossil fuel.

A default value for the reference boiler efficiency is conservatively set to 89% taking the highest value among the fossil fuel-fired boilers sold in Thailand, and specific enthalpy of feed water is conservatively calculated by setting the highest air temperature recorded in Thailand as the temperature of feed water, so as to ensure net emission reductions.

F.2. Calculation of reference emissions

$$RE_p = \frac{SP_{PJ,p} \times (h''_{steam} - h'_{water})}{10^3} \times \frac{100}{\eta_{RE}} \times EF_{fuel,RE}$$

RE_p	Reference emissions during the period p [tCO_2/p]
$SP_{PJ,p}$	The amount of steam produced by the project biomass boiler(s) during the period p [t/p]
h''_{steam}	Specific enthalpy of produced steam [kJ/kg]
h'_{water}	Specific enthalpy of feed water [kJ/kg]
η_{RE}	Reference boiler efficiency [%]
$EF_{fuel,RE}$	CO_2 emission factor for fossil fuel consumed by the reference boiler [tCO_2/GJ]

G. Calculation of project emissions

$$PE_p = PE_{elec,p} + PE_{fuel,p} + PE_{tr,p}$$

$$PE_{elec,p} = EC_{PJ,p} \times EF_{elec}$$

$$PE_{fuel,p} = \sum_i FC_{PJ,i,p} \times NCV_{fuel,PJ,i} \times EF_{fuel,PJ,i}$$

$$PE_{tr,p} = \sum_j D_{j,p} \times m_{j,p} \times EF_{tr}$$

PE_p	Project emissions during the period p [tCO_2/p]
$PE_{elec,p}$	Project emissions from consumed electricity by the project biomass boiler(s) and ancillary equipment during the period p [tCO_2/p]
$PE_{fuel,p}$	Project emissions from combustion of fossil fuel by the project boiler(s) during the period p [tCO_2/p]
$PE_{tr,p}$	Project emissions from transportation of biomass during the period p [tCO_2/p]
$EC_{PJ,p}$	The amount of electricity consumed by the project biomass boiler(s) and ancillary equipment during the period p [MWh/p]
EF_{elec}	CO_2 emission factor of consumed electricity [tCO_2/MWh]
i	Identification number of fossil fuel type [-]
$FC_{PJ,i,p}$	The amount of fossil fuel consumed by the project biomass boiler(s) for the fuel type i during the period p [mass or volume/p]
$NCV_{fuel,PJ,i}$	Net calorific value of fossil fuel used by the project biomass boiler(s) for the fuel

	type *i* [GJ/mass or volume]
$EF_{fuel,PJ,i}$	CO_2 emission factor of fossil fuel used by the project biomass boiler(s) for the fuel type *i* [tCO_2/GJ]
j	Identification number of the round trip for biomass transportation between the place of biomass supplier's stockyard and the project site [-]
$D_{j,p}$	Round trip distance of the biomass transportation *j* during the period *p* [km]
$m_{j,p}$	Mass of biomass transported in the biomass transportation *j* during the period *p* [t]
EF_{tr}	CO_2 emission factor for biomass transportation [tCO_2/(t·km)]

* If the round trip distance for biomass transportation $D_{j,p}$ is less than 200 km and the total rated thermal output of the project biomass boiler(s) is equal to or less than 45 MW, the emissions from the transportation may be neglected.

H. Calculation of emissions reductions

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

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
h''_{steam}	Specific enthalpy of produced steam [kJ/kg].	Saturated steam table based on "IAPWS Industrial Formulation" (e.g. steam table published by The Japan Society of Mechanical Engineers), using the values for setting steam pressure according to vendor specification or operation manual on the site.

h'_{water}	Specific enthalpy of feed water [kJ/kg]. Calculated based on the following equation: $h'_{water} = T_{FW} \times C_p$ Where: T_{FW} Temperature of feed water [°C] C_p Specific heat capacity of water [kJ/(kg·°C)] (= 4.184 kJ/(kg·°C))	(In case that hot water recovered by drain recovery system is not reused for feed water into project biomass boiler(s)) The highest air temperature recorded in Thailand by the Thai Meteorological Department is applied to T_{FW} for conservativeness. (In case that hot water recovered by drain recovery system is reused for feed water into project biomass boiler(s)) T_{FW} is fixed at the values taken from implementation plan or operation manual on the site for feed water into project biomass boiler(s). C_p: Theoretical value provided in table 6 of Cabinet Order No. 357 of 1992, Japan
η_{RE}	Reference boiler efficiency [%]. The default value is set to 89%.	JCM approved methodology TH_AM009. The value is derived from the survey. It is revised if deemed necessary by the Joint Committee.
$EF_{fuel,RE}$	CO_2 emission factor for fossil fuel consumed by the reference boiler [tCO_2/GJ]. CO_2 emission factor of natural gas is applied in this methodology in a conservative manner.	In the order of preference: a) regional or national default values; or b) 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.
EF_{elec}	CO_2 emission factor of consumed electricity [tCO_2/MWh]. When the biomass boiler(s) consumes	**Grid electricity:** The most recent value available at the time of validation is applied and fixed for the monitoring period thereafter.

	only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When both grid electricity and captive electricity may be consumed by the project biomass boiler(s), the project participant applies the CO_2 emission factor to higher 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)** <u>Calculated from its power generation efficiency (η_{cap} [%]) 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; $$EF_{elec} = 3.6 \times \frac{100}{\eta_{cap}} \times EF_{fuel,cap}$$ **b)** <u>Calculated from measured data</u> The power generation efficiency calculated from monitored data of the amount of fuel input for power generation ($FC_{cap,p}$) and the amount of electricity generated ($EG_{cap,p}$) during the monitoring period p is applied. The measurement is conducted with the monitoring	The data is sourced from "Grid Emission Factor (GEF) of Thailand", endorsed by Thailand Greenhouse Gas Management Organization, unless otherwise instructed by the Joint Committee. **Captive electricity:** <u>For the option **a)**</u> Specification of the captive power generation system connected to the boiler, provided by the manufacturer (η_{cap} [%]). CO_2 emission factor of the fuel consumed by the captive power generation system connected to the boiler ($EF_{fuel,cap}$ [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 table 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Upper value is applied. <u>For the option **b)**</u> Generated and supplied electricity by the captive power generation system connected to the biomass boiler(s) ($EG_{cap,p}$ [MWh/p]). Fuel amount consumed by the captive power generation system connected to the biomass boiler(s) ($FC_{cap,p}$ [mass or volume/p]).

	equipment to which calibration certificate is issued by an entity accredited under national/international standards; $EF_{elec} = FC_{cap,p} \times NCV_{fuel,cap} \times EF_{fuel,cap} \times \frac{1}{EG_{cap,p}}$ Where: $NCV_{fuel,cap}$: Net calorific value of the fuel consumed by the captive power generation system connected to the boiler [GJ/mass or volume] **c)** <u>Conservative default value:</u> A value of <u>1.3 tCO_2/MWh</u> may be applied.	Net calorific value ($NCV_{fuel,cap}$ [GJ/mass or volume]) and CO_2 emission factor of the fuel ($EF_{fuel,cap}$ [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. Upper value is applied. <u>For the option **c)**</u> CDM methodological tool "TOOL 05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation, version 03.0"
$NCV_{fuel,PJ,i}$	Net calorific value of fossil fuel used by the project biomass boiler(s) for the fuel type *i* [GJ/mass or volume]	In the order of preference: a) values provided by the fuel supplier; b) measurement by the project participants; c) regional or national default values; or d) IPCC default values provided in table 1.2 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Upper value is applied.
$EF_{fuel,PJ,i}$	CO_2 emission factor of fossil fuel used by the project biomass boiler(s) for the fuel type *i* [tCO_2/GJ]	In order of preference: a) values provided by the fuel supplier; b) measurement by the project participants;

<table>
<tr><td></td><td></td><td>c) regional or national default values; or
d) IPCC default values provided in table 1.4 of Ch.1 Vol.2 of 2006 IPCC Guidelines on National GHG Inventories. Upper value is applied.</td></tr>
<tr><td>EF_{tr}</td><td>CO_2 emission factor for biomass transportation [$tCO_2/(t \cdot km)$]

The default value in the following table is applied.
<table><tr><th>Vehicle class</th><th>EF_{tr} [$tCO_2/(t \cdot km)$]</th></tr><tr><td>Light vehicles</td><td>0.000245</td></tr><tr><td>Heavy vehicles</td><td>0.000129</td></tr></table>
Light vehicles: Vehicles with a gross vehicle mass being less or equal to 26 tonnes.
Heavy vehicles: Vehicles with a gross vehicle mass being higher than 26 tonnes.

If both vehicle classes are used in the project, the larger value (0.000245 $tCO_2/(t \cdot km)$) is applied.</td><td>CDM methodological tool “TOOL 12: Project and leakage emissions from transportation of freight, version 01.1.0”</td></tr>
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