Joint Crediting Mechanism Approved Methodology ID_AM009
"Replacement of conventional burners with regenerative burners for aluminum holding furnaces"

A. Title of the methodology

Replacement of conventional burners with regenerative burners for aluminum holding furnaces, ver. 1.0

B. Terms and definitions

Terms	Definitions
Regenerative burner	Burner systems which absorb exhaust gas heat to a reservoir and preheat combustion air using the absorbed heat in the reservoir to improve energy efficiency.
Conventional burner	Burner systems which do not have combustion air preheating facility.
Periodical check	Periodical investigation of furnace done by manufacturer or agent who is authorized by the manufacturer, in order to maintain furnace performance.

C. Summary of the methodology

Items	Summary
GHG emission reduction measures	By replacing conventional burners with regenerative burners for aluminum holding furnaces, consumption of natural gas is reduced, which leads to the reduction of GHG emissions.
Calculation of reference emissions	Reference emissions are the CO_2 emissions from the use of reference burners in an aluminum holding furnace, which are calculated based on the consumption of natural gas in the project furnace and energy efficiency of the reference and project burners.
Calculation of project emissions	Project emissions are the CO_2 emissions from the use of project burners in an aluminum holding furnace, which are calculated based on the consumption of natural gas and electricity in the project furnace.

Items	Summary
Monitoring parameters	- Consumption of natural gas by the project furnace - The number of operating days

D. Eligibility criteria

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

Criterion 1	The project replaces conventional burners with regenerative burners for aluminum holding furnaces.
Criterion 2	Holding temperature of aluminum melt, which is determined in the furnace user's specification, is within the range from 600 to 800 degrees Celsius.
Criterion 3	The regenerative burners have a structure which leads all exhaust gas to flow through the heat reservoir before discharging it into the atmosphere.
Criterion 4	Periodical check is planned at least once a year.

E. Emission Sources and GHG types

Reference emissions	
Emission sources	GHG types
Combustion of natural gas in the reference furnace	CO_2
Project emissions	
Emission sources	GHG types
Combustion of natural gas in the project furnace	CO_2
Power consumption by the project furnace	CO_2

F. Establishment and calculation of reference emissions

F.1. Establishment of reference emissions

The methodology results in conservative calculation of emission reductions and ensures net reduction of emissions by the following approaches:

1. Setting energy efficiencies of burners in a conservative manner

It can be said that the energy efficiency of burners increases as the exhaust gas temperature falls (and vice versa), since high exhaust gas temperature means that heat is released without being used. In this methodology, the energy efficiencies are set as default values by assuming the exhaust gas temperature conservatively.

For the reference burner, the exhaust gas temperature is set as 750 degrees Celsius. When the holding temperature is designed to be within the range from 600 to 800 degrees Celsius, the actual furnace atmospheric temperature is generally in the range of 750 to 950 degrees Celsius. Therefore, for the reference burner, the exhaust gas temperature is assumed to be equal to the lower end of furnace atmospheric temperature for the sake of conservativeness.

For the project burner, the exhaust gas temperature is set as 300 degrees Celsius. When the holding temperature is designed to be within the range from 600 to 800 degrees Celsius, the actual furnace atmospheric temperature is generally in the range of 750 to 950 degrees Celsius for project burner, too. In addition, for the project burner, the exhaust gas temperature is lower than the furnace atmospheric temperature due to the heat absorber; when the furnace atmospheric temperature is in the range of 750 to 950 degrees Celsius, the possible temperature of the project exhaust gas is less than 300 degrees Celsius. Therefore, for the project burner, the exhaust gas temperature is set as the upper end of the possible exhaust gas temperature for the sake of conservativeness.

Therefore, this methodology results in the conservative calculation of reference emissions by assuming the lower reference exhaust gas temperature and the higher project exhaust gas temperature in setting the burner efficiencies.

2. Omitting reference power consumption

Although electricity is used in the reference furnace, CO_2 emissions from power consumption are not included in the reference emissions for the purpose of ensuring simplicity and conservativeness.

F.2. Calculation of reference emissions

Reference emissions are calculated as follows:

$$RE_p = \sum_i \{FC_{PJ,NG,i,p} \times (\eta_{PJ,i} \div \eta_{RE,i}) \times NCV_{NG} \times EF_{NG}\}$$

Where:

RE_p	Reference emissions during the period *p* [tCO_2/p]
$FC_{PJ,NG,i,p}$	Consumption of natural gas by the project furnace *i* during the period *p* [Nm^3/p]
$\eta_{PJ,i}$	Energy efficiency of the project burner of the project furnace *i* [-]

$\eta_{RE,i}$	Energy efficiency of the reference burner of the project furnace *i* [-]
NCV_{NG}	Net calorific value of natural gas [GJ/Nm^3]
EF_{NG}	CO_2 emission factor of natural gas [tCO_2/GJ]

G. Calculation of project emissions

Project emissions are calculated as follows:

$$PE_p = PE_{NG,p} + PE_{elec,p}$$

Where:

PE_p	Project emissions during the period *p* [tCO_2/p]
$PE_{NG,p}$	Project emissions from natural gas consumption during the period *p* [tCO_2/p]
$PE_{elec,p}$	Project emissions from electricity consumption during the period *p* [tCO_2/p]

$$PE_{NG,p} = \sum_i (FC_{PJ,NG,i,p} \times NCV_{NG} \times EF_{NG})$$

Where:

$PE_{NG,p}$	Project emissions from natural gas consumption during the period *p* [tCO_2/p]
$FC_{PJ,NG,i,p}$	Consumption of natural gas by the project furnace *i* during the period *p* [Nm^3/p]
NCV_{NG}	Net calorific value of natural gas [GJ/Nm^3]
EF_{NG}	CO_2 emission factor of natural gas [tCO_2/GJ]

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

Where:

$PE_{elec,p}$	Project emissions during the period *p* (from electricity) [tCO_2/ p]
$EC_{PJ,p}$	Consumption of electricity by the project furnace during the period *p* [MWh/ p]
EF_{elec}	CO_2 emission factor for consumed electricity [tCO_2/MWh]

$$EC_{PJ,p} = \sum_i \{RC_{CAP,i} \times 10^{-6} \times 24(hours/day) \times D_{op,i,p}\}$$

Where:

$EC_{PJ,p}$	Consumption of electricity by the project furnace during the period *p* [MWh/p]
$RC_{CAP,i}$	The total maximum rated capacity of auxiliary equipment of the project furnace *i* [W]
$D_{op,i,p}$	The number of operating days of the project furnace *i* during the period *p* [day/p]

H. Calculation of emissions reductions

Emissions reductions are calculated as follows:

$$ER_p = RE_p - PE_p$$

Where:

ER_p	Emissions 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
NCV_{NG}	Net calorific value of natural gas [GJ/Nm^3] The IPCC value is converted by gas composition and molecular weight. The default value for NCV_{NG} is set as 0.036659 GJ/Nm^3.	IPCC Special Report on Carbon dioxide Capture and Storage, Annex I, Table AI.10. Lower Heating Value (LHV) is applied.
EF_{NG}	CO_2 emission factor of natural gas [tCO_2/GJ]	Country specific data or IPCC default value from "2006 IPCC Guidelines for National Greenhouse Gas Inventory". Lower limit value of the default CO_2 emission factor is applied.
$\eta_{RE,i}$	Energy efficiency of the reference burner of the project furnace *i* [-] The default value for η_{RE} is set as 0.682.	See explanatory note 1.
$\eta_{PJ,i}$	Energy efficiency of the project burner of the project furnace *i* [-] The project-specific value is calculated	See explanatory note 2.

Parameter	Description of data	Source
	by the equation in explanatory note 2 using the recommended operational value of air ratio in the manual of the project burner.	
m_p	Air ratio for the project burner The recommended operational value in the manual of the project burner.	See explanatory note 2.
EF_{elec}	CO_2 emission factor for consumed electricity. When the project furnace consumes only grid electricity or captive electricity, the project participant applies the CO_2 emission factor respectively. When the project furnace 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
RC_{CAP}	The total maximum rated capacity of auxiliary equipment of the project furnace [W]	Specification or nameplate of auxiliary equipment of the project furnace

(Explanatory note 1)

$$\eta_{RE} = \frac{NCV_{NG} - [Gw_{NG} * c_{1,r} * (T_{1,r} - T_2) + A_{0,NG} * (m_r - 1) * c_{2,r} * (T_{1,r} - T_2)]}{NCV_{NG}}$$

Where:

η_{RE}	Energy efficiency of the reference burner [-]
NCV_{NG}	Net calorific value of natural gas: the default value for NCV_{NG} is set as **36,659** [kJ/Nm^3] based on *IPCC Special Report on Carbon dioxide Capture and Storage*, Annex I, Table AI.10, and it is converted by gas composition and molecular weight.
Gw_{NG}	Theoretical volume of wet exhaust gas from combustion of natural gas: the default value for Gw_{NG} is set as **10.694** [Nm^3/Nm^3] based on the assumed natural gas composition of CH_4: 94.4%, C_2H_6: 3.1%, C_8H_8: 0.5%, and C_4H_{10}: 0.2% based on *IPCC Special Report on Carbon dioxide Capture and Storage*, Annex I, Table AI.10.
$c_{1,r}$	Average specific heat at constant pressure of wet exhaust gas of natural gas, at the reference temperature of exhaust gas: the default value for $c_{1,r}$ is set as **1.455** [kJ/ Nm^3・degree Celsius] based on the aforementioned natural gas composition and JIS G 0702, Appendix Table 2 (linear prediction is used for the estimation).
$T_{1,r}$	Reference temperature of exhaust gas: the default value for $T_{1,r}$ is set as **750** [degrees Celsius].
T_2	Ambient temperature (annual average in Jakarta): the default value for T_2 is set as **32.6** [degrees Celsius].
$A_{0,NG}$	Theoretical amount of air of the natural gas: the default value for $A_{0,NG}$ is set as **9.688** [Nm^3/Nm^3] based on the aforementioned natural gas composition.
m_r	Air ratio for the reference burner: the default value for m_r is set as **1.05** in a conservative manner**.**
$c_{2,r}$	Average specific heat at constant pressure of air, at the reference temperature of exhaust gas: the default values for $c_{2,r}$ is set as **1.380** [kJ/ Nm^3・degree Celsius] based on the aforementioned natural gas composition and JIS G 0702, Appendix Table 2 (Linear prediction is used for the estimation).

(Explanatory note 2)

$$\eta_{PJ} = \frac{NCV_{NG} - [Gw_{NG} * c_{1,p} * (T_{1,p} - T_2) + A_{0,NG} * (m_p - 1) * c_{2,p} * (T_{1,p} - T_2)]}{NCV_{NG}}$$

Where:

η_{PJ}	Energy efficiency of the reference burner [-]
NCV_{NG}	Net calorific value of natural gas: the default value for NCV_{NG} is set as **36,659** [kJ/Nm^3] based on *IPCC Special Report on Carbon dioxide Capture and Storage*, Annex I, Table AI.10, and it is converted by gas composition and molecular weight.
Gw_{NG}	Theoretical volume of wet exhaust gas from combustion of natural gas: the default value for Gw_{NG} is set as **10.694** [Nm^3/Nm^3] based on the assumed natural gas composition of CH_4: 94.4%, C_2H_6: 3.1%, C_8H_8: 0.5%, and C_4H_{10}: 0.2% based on *IPCC Special Report on Carbon dioxide Capture and Storage*, Annex I, Table AI.10.
$c_{1,p}$	Average specific heat at constant pressure of wet exhaust gas of natural gas, at the project temperature of exhaust gas: the default value for $c_{1,p}$ is set as **1.368** [kJ/ Nm^3･degree Celsius] based on the aforementioned natural gas composition and JIS G 0702, Appendix Table 2 (linear prediction is used for the estimation).
$T_{1,p}$	Project temperature of exhaust gas: the default value for $T_{1,p}$ is set as **300** [degrees Celsius].
T_2	Ambient temperature (annual average in Jakarta): the default value for T_2 is set as **32.6** [degrees Celsius].
$A_{0,NG}$	Theoretical amount of air of the natural gas: the default value for $A_{0,NG}$ is set as **9.688** [Nm^3/Nm^3] based on the aforementioned natural gas composition.
m_p	Air ratio for the project burner: the recommended operational value in the manual of the project burner**.**
$c_{2,p}$	Average specific heat at constant pressure of air, at the *project* temperature of exhaust gas: the default values for $c_{2,p}$ is set as **1.319** [GJ/Nm^3･degree Celsius] based on the aforementioned natural gas composition and JIS G 0702, Appendix Table 2 (Linear prediction is used for the estimation).

History of the document

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