T-VER-P-METH-06-02

Metal Melting Furnace Efficiency Improvement

Version 01

Scope: 03 - Energy demand

Entry into force on July 23, 2025

1. Methodology	Metal Melting Furnace Efficiency Improvement
2. Project Type	Energy Efficiency Improvement in building, factory and household
3. Sector scope	Scope: 03 - Energy demand
4. Project Outline	The project activities must aim to improve the energy efficiency of melting furnaces used in metal production processes including aluminum, steel, brass and others.
5. Applicability	1) The project activity must have one of the following activities ● Installation of new melting furnace(s) ● Upgrade existing melting furnace(s) 2) The energy efficiency improvement activity for the existing melting furnace must have one of the following technical approaches: ● Regenerative burner ● Recovery and reuse of wasted heat for preheating ● Electromagnetic stirring ● Laser-based or ultrasonic frequency-based melting 3) The energy efficiency improvement activities for existing melting furnaces may not include common housekeeping measures, such as furnace insulation or installation of temperature control systems.
6. Project Conditions	1. Utilization of wasted heat from melting furnaces for electricity generation shall not be included under the project activities of this methodology. 2. The installation of new furnace(s) or modification of an existing furnace(s) shall not increase existing production capacity or significantly alter the production process. 3. In the case of new melting furnace(s) installation as replacements, the project developer must provide the following baseline energy consumption data: 3.1 In the case of existing electric furnace, the project developer must provide collected data on electricity consumption in accordance with production output of the existing furnace for at least one year prior the operation of new equipment.

	3.2 In the case of existing fossil fuel furnace, the project developer must provide collected data on fossil fuels consumption in accordance with production output of the existing furnace for at least one year prior the operation of new equipment. 4. The replaced original melting furnace(s) must not be reinstalled for future production outside the project boundary. The project owner or developer must provide evidence of decommissioning and dismantling of the original furnace(s).
7. Project Starting Date	The date on which the project owner and the contractor jointly signed the construction or installation agreement for new equipment as the part of greenhouse gas reduction project developed as a T-VER project.
8. Definition	**Raw materials** refer to substances used in the process of manufacturing products. **Product** refers to either intermediate or final products discharged from the melting furnace that are part of the project activity. **Furnace (or Melting Furnace)** is a device that provides heat generated directly from the combustion of fuels, used in industrial processes requiring temperatures above 400°C through radiation and convection heat transfer process.

Details of voluntary emission reductions program for
Metal Melting Furnace Efficiency Improvement

1. Emission reductions activities used in the calculations

Table 1: Sources and Types of Greenhouse Gases

Greenhouse gas emission	Source	Greenhouse Gas	Details of activities that emit greenhouse gas emissions
Baseline Emission	Use of electricity	CO_2	Electricity consumption in metal melting furnaces, including auxiliary equipment
	Use of fuel fossil	CO_2	Fossil fuels consumption in metal melting furnaces, including auxiliary equipment
Project Emission	Energy consumption within the project	CO_2	Electricity consumption from national grid
			Use of fuel fossil
Leakage Emission	-	-	-

2. Scope of Project

The project involves activities aimed at improving the efficiency of metal melting furnaces through the installation of new machinery and equipment or the upgrading of existing machinery and equipment such as the installation of waste heat recovery systems for preheating metal and permanent magnetic stirring equipment. These modifications may not change the production capacity or the manufacturing process. The project boundary covers the metal melting furnace and the associated newly installed or upgraded machinery and equipment.

3. Additionality

The project must undergo further proof of operation from normal operations. (Additionality) by using the “Proof of Operations Guidelines in addition to normal operations (Additionality) under the Thailand Voluntary Emission Reduction Program (T-VER)" standard equivalent to the international standards prescribed by the TGO.

4. Baseline Scenario

Based on the baseline scenario defined as below business as usual (Below BAU), the reference scenario is the operation of the existing metal melting furnace at its highest operational efficiency (i.e., lowest specific energy consumption), using fossil fuels and/or electricity that results in the lowest greenhouse gas emissions. Therefore, the project baseline data refers to the greenhouse gas emissions resulting from the combustion of fossil fuels such as natural gas and/or from electricity generated from natural gas used in the existing metal melting furnace operated at its maximum efficiency, for the production output of the project activity.

5. Baseline Emission

Baseline scenarios consider only carbon dioxide (CO_2) emissions resulting from electricity consumption and/or the combustion of fossil fuels in the metal smelting furnace. The Baseline emission can be calculated as follow

$$\mathbf{BE_y = BFE_y + BEE_y} \qquad \text{Equation (1)}$$

Where

BE_y = Baseline emissions in year y (tCO_2e/year)

BFE_y = Baseline emissions from fossil fuels consumption in year y (tCO_2e/year)

BEE_y = Baseline emissions from electricity consumption in year y (tCO_2e/year)

5.1 Baseline emissions from fossil fuels consumption (BFE_y)

Baseline emissions from fossil fuels consumption can be calculated as follow

$$\mathbf{BFE_y = BSEC_{th,y} \times P_y \times EF_{CO2,NG}} \qquad \text{Equation (2)}$$

Where

BFE_y = Baseline emissions from fossil fuels consumption in year y (tCO_2e/year)

$BSEC_{th,y}$ = Annual baseline specific thermal energy consumption for year y (TJ/t of product)

P_y = Production output for the year y (t of product)

$EF_{CO2,NG}$ = CO2 emissions from the combustion of natural gas ($kgCO_2$/TJ)
equal 56,100 $kgCO_2$/TJ

5.1.1 Annual baseline specific thermal energy consumption ($BSEC_{th,y}$)

The baseline specific thermal energy consumption is determined as the lowest value between the annual average specific thermal energy consumption (calculated as a weighted average based on product type) and the historical specific thermal energy consumption (calculated based on total production volume), or the design-specific thermal energy consumption provided by the manufacturer for replacement projects. It can be calculated as follow

$$BSEC_{th,y} = \min (BSEC_{av,th,y} ; BSEC_{hist/design,th}) \quad \text{Equation (3)}$$

Where

$BSEC_{th,y}$ = Annual baseline specific thermal energy consumption for year y (TJ/t of product)

$BSEC_{av,th,y}$ = Average annual baseline specific thermal energy consumption for year y (TJ/t of product)

$BSEC_{hist/design,th}$ = Baseline specific thermal energy consumption established from historical data for existing facilities or from design manufacturer's specifications for greenfield project activities (TJ/t of product)

5.1.1.1 Average annual baseline specific thermal energy consumption ($BSEC_{av,th,y}$)

Average annual baseline specific thermal energy consumption can be calculated as follow

$$BSEC_{av,th,y} = \frac{R_{av,th,y} \times TFE_y}{\sum_i P_i} \quad \text{Equation (4)}$$

Where

$BSEC_{av,th,y}$ = Average annual baseline specific thermal energy consumption for year y (TJ/t of product)

$R_{av,th,y}$ = Average annual ratio for thermal specific energy consumption in year y

TFE_y = Total energy consumption from fossil fuels combustion in the furnace/kiln and auxiliary equipment in the year y (TJ)

1) Average annual ratio for thermal specific energy consumption ($R_{av,th,y}$)

Average annual ratio for thermal specific energy consumption can be calculated as follow

$$R_{av,th,y} = \frac{\sum_i R_{i,th} \times P_i}{\sum_i P_i} \quad \text{Equation (5)}$$

Where

$R_{av,th,y}$ = Average annual ratio for thermal specific energy consumption in year y

$R_{i,th}$ = Ratio for thermal specific energy consumption defined for configuration i

P_i = Amount of product produced in configuration i (t of product)

i = Types of products

1.1) Ratio for thermal specific energy consumption ($R_{i,th}$)

The proportion of specific thermal energy consumption for product manufacturing is calculated based on the specific thermal energy consumption from the baseline scenario and the specific thermal energy consumption from project implementation. It can be calculated as follow

$$R_{i,th} = BSEC_{i,th} / PSEC_{i,th} \quad \text{Equation (6)}$$

Where

$R_{i,th}$ = Ratio for thermal specific energy consumption defined for configuration i

$BSEC_{i,th}$ = Baseline specific thermal energy consumption defined for configuration i (TJ/t of product)

$PSEC_{i,th}$ = Project specific thermal energy consumption defined for configuration i (TJ/t of product)

5.1.2 Baseline specific thermal energy consumption established from historical data for existing facilities or from design manufacturer's specifications for greenfield project activities ($BSEC_{hist/design,th}$)

Baseline specific thermal energy consumption established from historical data for existing facilities or from design manufacturer's specifications for greenfield project activities can be calculated as follow

5.1.2.1 In the case of upgrading the existing melting furnace

The specific thermal energy consumption in the case of upgrading the existing melting furnace shall be determined using two methods, with the lower value to be applied, as follow

1) Baseline specific thermal energy consumption established from historical data

Baseline specific thermal energy consumption established from historical data shall be determined using the lowest average value of specific thermal energy consumption from past production data, either by monthly cycle or production cycle, with details as follow

$$\mathbf{BSEC_{hist,th} = Average\ of\ the\ 3\ lowest\ values\ of\ BSEC_{hist,monthly/batch,th,m}} \quad \text{Equation (7)}$$

Where

$BSEC_{hist,th}$	=	Baseline specific thermal energy consumption established from historical data (TJ/t of product)
$BSEC_{hist,monthly/batch,th,m}$	=	Monthly (for continuous processes) or batch wise baseline specific thermal energy consumption in month/batch m (TJ/t of product)
m	=	All months/batches considered in determination of the historical specific energy consumption

1.1) Monthly (for continuous processes) or batch wise baseline specific thermal energy consumption ($BSEC_{hist,monthly/batch,th,m}$)

Monthly (for continuous processes) or batch wise baseline specific thermal energy consumption can be calculated as follow

$$\mathbf{BSEC_{hist,monthly/batch,th,m} = TFE_{hist,m} / P_{hist,m}} \quad \text{Equation (8)}$$

Where

$BSEC_{hist,monthly/batch,th,m}$	=	Monthly (for continuous processes) or batch wise baseline specific thermal energy consumption in month/batch m (TJ/t of product)
$TFE_{hist,m}$	=	Total energy consumption from the fossil fuel combustion (in the furnace and auxiliary equipment) in month/batch m (TJ)
$P_{hist,m}$	=	Production output for month/batch m (t of product)

1.1.1) Total energy consumption from the fossil fuel combustion ($TFE_{hist,m}$)

Total energy consumption from the fossil fuel combustion based on historical production data is calculated from the quantity of fossil fuels consumed and the net calorific value (NCV) of the fossil fuels, with details as follow

$$TFE_{hist,m} = \sum_j Q_{hist,j,m} \times NCV_{hist,j} \quad \text{Equation (9)}$$

Where

$TFE_{hist,m}$ = Total energy consumption from the fossil fuel combustion (in the furnace and auxiliary equipment) in month/batch m (TJ)

$Q_{hist,m}$ = Quantity of fossil fuel j consumed in month/batch m (unit)

$NCV_{hist,j}$ = Net calorific value per mass or volume unit of fossil fuel j (TJ/unit)

Type of fossil fuel

2) Specific thermal energy consumption of the best available metal smelting furnace technology

Project developers should research the specific thermal energy consumption of the best available metal melting furnace technologies

5.1.2.2 In the case of new furnace installation

In the case of project activities involving the installation of a new metal melting furnace, project developers must use furnace specifications provided by the manufacturer used in the project activity. The value of $BSEC_{design,th}$ refers to the specific thermal energy consumption of the furnace, including all fossil fuel usage within the project boundary (TJ/t of product).

5.1.3 Calculation of specific energy consumption from the baseline case during project implementation ($R_{ini,th}$)

The specific energy consumption from the baseline case during project implementation can be calculated as follow

$$R_{ini,th} = BSEC_{ini,th}/PSEC_{ini,th} \quad \text{Equation (10)}$$

Where

$R_{ini,th}$ = Ratio for thermal specific energy consumption defined at the start of the project activity (%)

$BSEC_{ini,th}$ = Baseline specific thermal energy consumption established at the start of the project activity, (TJ/t of product)

$PSEC_{ini,th}$ = Project specific thermal energy consumption established at the start of the project activity, (TJ/t of product)

The steps are as follow

Step 1: Identification of all key parameters influencing specific energy consumption under the baseline scenario. The product of type i shall be defined as a feasible combination of fossil fuels and raw materials utilized within the facility, along with other relevant parameters that affect specific energy consumption during a defined period.

Step 2: Determination of initial values for energy consumption under the baseline scenario and the project activity, as outlined below

1) At the initial stage of the project activity, thermal energy consumption must be measured daily for a period of one week. The lowest measured value during this period shall be used as the initial baseline specific energy consumption ($BSEC_{ini,th}$). The baseline specific energy consumption must be determined using the by-pass method, which involves sending the raw material directly to the furnace.

2) Following the completion of the initial thermal energy consumption measurement over a one-week period, the project's thermal energy consumption must be measured daily for another one-week period. The average of the measured values during this period shall be used as the initial specific energy consumption of the project activity ($PSEC_{ini,th}$). In this case, the raw material shall be fed into the furnace after implementing energy efficiency improvements to the furnace.

1) Ratio for thermal specific energy consumption defined at the start of the project activity ($R_{ini,th}$)

The value of $R_{ini,th}$ will be used until the default configuration is changed as follow

(1) Daily tracking of Specific Thermal Energy Consumption (PSEC) resulting from project activities.

(2) In the case where a new product type i is introduced and the specific thermal energy consumption of the project activity increases or decreases by more than 5% compared to the previously established value ($PSEC_{ini,th}$ during the initial stage of the

project activity or $PSEC_{i,th}$ in case the product type i had previously changed), it is necessary to assess whether the change in production of the new product type i has occurred. This assessment requires monitoring the increase or decrease in specific thermal energy consumption of the project activity for at least one week. If a change in product type i is confirmed, the value of $R_{i,th}$ must be determined by measuring both BSEC and PSEC under the new product type i. The value of $BSEC_{i,th}$ must be measured for one day following the change in product type i, during which raw material shall be fed directly into the furnace.

5.2 Baseline emissions from electricity consumption (BEE_y)

Baseline emissions from electricity consumption can be calculated as follow

$$BEE_y = BSEC_{el,y} \times P_y \times EF_{el,y} \times 10^{-3} \quad \text{Equation (11)}$$

Where

BEE_y = Baseline emissions from electricity consumption in year y (tCO_2eq/year)

$BSEC_{el,y}$ = Annual baseline specific electrical energy consumption in year y (kWh/t of product)

P_y = Production output in year y (t of product)

$EF_{el,y}$ = Emission factor for electricity generation/consumption in year y (tCO_2/MWh)

5.2.1 Annual baseline specific electrical energy consumption ($BSEC_{el,y}$)

The baseline specific electricity consumption is determined based on the lowest value among the following: the annual average specific electricity consumption (calculated as a weighted average based on product types), the specific electricity consumption from historical production data (based on total product output), or the design value provided by the manufacturer for newly installed projects. The calculation can be performed as follow

$$BSEC_{el,y} = \min (BSEC_{av,el,y} ; BSEC_{hist/design,el}) \quad \text{Equation (12)}$$

Where

$BSEC_{el,y}$ = Annual baseline specific electrical energy consumption for year y (kWh/t of product)

$BSEC_{av,el,y}$ = Average annual baseline specific electrical energy consumption for year y (kWh/t of product)

$BSEC_{hist/design,el}$ = Baseline specific electrical energy consumption established from historical data for existing facilities or from design manufacturer's specifications for Greenfield project activities, (kWh/t of product)

5.2.1.1 Average annual baseline specific electrical energy consumption ($BSEC_{av,el,y}$)

Average annual baseline specific electrical energy consumption can be calculated as follow

$$BSEC_{av,el,y} = \frac{R_{av,el,y} \times TEE_y}{\sum_i P_i} \quad \text{Equation (13)}$$

Where

$BSEC_{av,el,y}$ = Average annual baseline specific electrical energy consumption in year y (kWh/t of product)

$R_{av,el,y}$ = Average annual ratio for electrical specific energy consumption in year y

TEE_y = Total electrical energy consumption in the furnace/kiln and auxiliary equipment in year y (kWh)

P_i = Amount of product produced in configuration i (t of product)

1) Average annual ratio for electrical specific energy consumption ($R_{av,el,y}$)

Average annual ratio for electrical specific energy consumption can be calculated as follow

$$R_{av,el,y} = \frac{\sum_i R_{i,el} \times P_i}{\sum_i P_i} \quad \text{Equation (14)}$$

Where

$R_{av,el,y}$ = Average annual ratio for electrical specific energy consumption in year y

$R_{i,el}$ = Ratio for electrical specific energy consumption defined for configuration i

P_i = Amount of product produced in configuration i (t of product)

i = Type of products

1.1) Ratio for electrical specific energy consumption defined for configuration i ($R_{i,el}$)

The proportion of specific electricity consumption in product manufacturing is calculated based on the specific electricity consumption from the baseline scenario and the specific electricity consumption from project operations, as follow

$$R_{i,el} = BSEC_{i,el} / PSEC_{i,el} \quad \text{Equation (15)}$$

Where

$R_{i,el}$ = Ratio for electrical specific energy consumption defined for configuration i

$BSEC_{i,el}$ = Baseline specific electrical energy consumption defined for configuration i (kWh/t of product)

$PSEC_{i,el}$ = Project specific electrical energy consumption defined for configuration i (kWh/t of product)

5.2.2 Baseline specific electrical energy consumption established from historical data for existing facilities or from design manufacturer's specifications for greenfield project activities ($BSEC_{hist/design,el}$)

The specific electricity consumption from historical data (for retrofitting existing melting furnaces) or from the manufacturer's design specifications (for installing new melting furnaces) can be calculated as follow

5.2.2.1 In the case of upgrading the existing melting furnace

The specific electricity consumption in the case of retrofitting an existing melting furnace is defined using two methods, with the lower value to be used.

1) Baseline specific electrical energy consumption established from historical data

Baseline specific electrical energy consumption established from historical data is assessed based on the specific electricity consumption recorded during past monthly periods or production cycles, with details as follow

$$BSEC_{hist,el} = \text{Average of the 3 lowest values of } BSEC_{hist,monthly/batch,el,m} \quad \text{Equation (16)}$$

Where

$BSEC_{hist,el}$ = Baseline specific electrical energy consumption established from historical data (kWh/t of product)

$BSEC_{hist,monthly/batchel,m}$ = Monthly (for continuous processes) or batch wise baseline specific electrical energy consumption in month/batch m (kWh/t of product)

m = All months/batches considered in determination of the historical specific energy consumption

1.1) Monthly (for continuous processes) or batch wise baseline specific electrical energy consumption ($BSEC_{hist,monthly/batch,el,m}$)

Monthly (for continuous processes) or batch wise baseline specific electrical energy consumption is determined based on the ratio of electricity consumption during past monthly periods or production cycles to the amount of product output during the same periods. It can be calculated as follow

$$BSEC_{hist,monthly/batch,el,m} = TEE_{hist,m} / P_{hist,m} \quad \text{Equation (17)}$$

Where

$BSEC_{hist,monthly/batch,el,m}$ = Monthly (for continuous processes) or batch wise baseline specific electrical energy consumption in month/batch m (kWh/t of product)

$TEE_{hist,m}$ = Total electrical energy consumption (in the furnace/kiln and auxiliary equipment within the project boundary) in month/batch m, (kWh)

$P_{hist,m}$ = Production output for month/batch m, (t of product)

2) Specific electricity consumption from the best available metal melting furnace technology

Project developers shall investigate specific electricity consumption data from the best available metal melting furnace technology.

5.2.2.2 In the case of a installation of a new melting furnace

In the case of project activities involving the installation of a new melting furnace, the project participant shall use the furnace specifications provided by the manufacturer for use in the project activity. The parameter $BSEC_{design,el}$ refers to the specific electricity energy consumption of the furnace (kWh/t of product).

5.2.3 CO_2 emission factor of the electrical energy source ($EF_{el,y}$)

CO_2 emission factor from electricity generation/use are calculated based on three scenarios 1) Use of electricity from a self-generated power plant 2) Use of electricity from the grid and 3) Use of electricity from both a self-generated power plant and the grid. The details are as follow

1) Use of electricity from a self-generated power plant ($EF_{el,y}$)

Use of electricity from a self-generated power plant can be calculated as follow

$$EF_{el,y} = EF_{captive,y} = \frac{EF_{CO2,captive,y}}{\eta_{captive}} \times \frac{44}{12} \times 3.6 \times 10^{-3} \quad \text{Equation (18)}$$

Where

$EF_{el,y}$	=	CO_2 emission factor of the electrical energy source (tCO_2/MWh)
$EF_{captive,y}$	=	Emissions factor for captive power generation plant in year y (tCO_2/MWh)
$EF_{CO2,captive,y}$	=	CO_2 emissions factor of fuel used in captive power generation (tC/TJ)
$\eta_{captive}$	=	Efficiency of the captive power generation plant
44/12	=	Carbon to carbon dioxide mass conversion factor
3.6×10^{-3}	=	TJ to MWh conversion factor

2) CO_2 emission factor of the electrical energy source with national grid ($EF_{el,y}$)

CO_2 emission factor of the electrical energy source can be calculated as follow

$$EF_{el,y} = EF_{Elec,y} \quad \text{Equation (19)}$$

Where

$EF_{el,y}$	=	CO_2 emission factor of the electrical energy source (tCO_2/MWh)
$EF_{Elec,y}$	=	Emission factor for electricity generation/consumption in year y (tCO_2/MWh)

3) CO_2 emission factor of the electrical energy source with national grid and captive ($EF_{el,y}$)

CO_2 emission factor of the electrical energy source can be calculated as follow

$$EF_{el,y} = S_{grid,y} \times EF_{Elec,y} + S_{captive,y} \times EF_{captive,y} \quad \text{Equation (20)}$$

Where

$EF_{el,y}$	=	CO_2 emission factor of the electrical energy source (tCO_2/MWh)
$S_{grid,y}$	=	Share of the facility electricity demand supplied by the grid in year y (%)
$EF_{Elec,y}$	=	Emission factor for electricity generation/consumption in year y (tCO_2/MWh)

$S_{captive,y}$ = Share of the facility electricity demand supplied by the captive power plant In year y (%)

$EF_{captive,y}$ = Emissions factor for captive power generation plant in year y (tCO_2/MWh)

5.2.4 Ratio for electrical specific energy consumption defined at the start of the project activity ($R_{ini,el}$)

Ratio for electrical specific energy consumption defined at the start of the project activity can be calculated as follow

$$R_{ini,el} = BSEC_{ini,el}/PSEC_{ini,el} \quad \text{Equation (21)}$$

Where

$R_{ini,el}$ = Ratio for electrical specific energy consumption defined at the start of the project activity (%)

$BSEC_{ini,el}$ = Baseline specific electrical energy consumption established at the start of the project activity, (kWh/t of product)

$PSEC_{ini,el}$ = Project specific electrical energy consumption established at the start of the project activity, (kWh/t of product)

The steps are as follow

Step 1 : Identification of all key parameters affecting specific electricity consumption in the baseline scenario. The product type i shall be defined as a feasible combination of fuels and raw materials used in the facility, along with other parameters that influence specific energy consumption over a given time period.

Step 2: Establishment of initial values for specific electricity consumption in both the baseline scenario and project operations.

1) At the beginning of the project activities, electricity consumption must be measured daily over a period of one week. The lowest measured value during this period shall be considered the initial baseline specific electricity consumption ($BSEC_{ini,el}$). The baseline specific electricity consumption must be measured under conditions where raw materials are fed directly into the melting furnace.

2) After completing the one-week measurement of the initial baseline electricity consumption, the project's electricity consumption must be measured daily over another one-week period. The average of the measured values during this period shall be

considered the initial specific electricity consumption for project operations ($PSEC_{ini,th}$). In this case, the raw material shall be fed into the furnace after implementing energy efficiency improvements to the furnace.

1) Ratio for electrical specific energy consumption defined at the start of the project activity ($R_{ini,el}$)

The value of $R_{ini,el}$ shall be used until the initial value is revised as follow

(1) Daily tracking of electricity usage attributable solely to project activities (PSEC)

(2) In the case of producing a new product type i, where the specific electricity consumption from project operation increases or decreases by more than 5 % compared to the previously established value ($PSEC_{ini,el}$ during the initial stage of project activity, or $PSEC_{i,el}$ in the case where product type i has previously changed), it is necessary to assess whether the production of product type i has changed. This assessment requires monitoring the increase or decrease in specific electricity consumption from project operation for a minimum period of one week. If product type i has indeed changed, the value of $R_{i,el}$ must be determined by measuring both BSEC and PSEC under the new product type i configuration. The measurement of $BSEC_{i,el}$ must be conducted for one day following the change in product type i, during which raw materials are fed directly into the melting furnace.

6. Project Emission

Project emission are determined based on the amount of emissions from the use of fossil fuels and from electricity consumption can be calculated as follow

$$\mathbf{PE_y = PE_{FF,y} + PE_{EC,y}} \qquad \text{Equation (22)}$$

Where

PE_y = Project emissions in year y (tCO2eq/year)

$PE_{FF,y}$ = Project emissions from fossil fuel combustion in the furnace in year y (tCO_2eq/year)

$PE_{EC,y}$ = Project emissions from electricity consumption in project implementation in year y (tCO_2eq/year)

6.1 Project emissions from fossil fuel combustion in the furnace ($PE_{FF,y}$)

Calculation of greenhouse gas emissions from fossil fuel use due to project implementation shall include the use of fossil fuels in existing furnaces used as backup systems (if any). Such calculations shall be carried out using the latest version of the calculation tool T-VER-P-TOOL-02-01: Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion.

6.2 Project emissions from electricity consumption in project implementation ($PE_{EC,y}$)

Project emissions from electricity consumption in project implementation can be calculated based on electricity consumption, the emission factor from electricity generation, and power losses in the electricity grid, can be calculated as follow

$$PE_{EC,y} = EC_{PJ,y} \times EF_{Elec,y} \times (1 + TDL_y) \quad \text{Equation (23)}$$

Where

$PE_{EC,y}$ = Project emissions from electricity consumption in project implementation in year y (tCO_2eq/year)

$EC_{PJ,y}$ = Electricity consumption from project implementation in year y (MWh/year)

$EF_{Elec,y}$ = Emission factor for electricity generation/consumption in year y (tCO_2/MWh)

TDL_y = Average technical transmission and distribution losses for providing electricity in year y

7. Leakage Emission

Not Applicable

8. Emission Reduction

Emission reductions are calculated as follow

$$ER_y = (BE_y - PE_y - LE_y) \times (P_{y,min} / P_y) \quad \text{Equation (24)}$$

Where

ER_y = Emission reductions in year y (tCO_2e/year)

BE_y = Baseline emissions in year y (tCO_2e/year)

PE_y = Project emissions in year y (tCO_2e/year)

LE_y = Leakage emission in year y (tCO_2e/year)

$P_{y,min}$ = The minimum total quantity of products produced for the year y (t of product)

P_y = Production output for the year y (t of product)

8.1 The minimum total quantity of products produced ($P_{y,min}$)

The minimum total quantity of products produced ($P_{y,min}$) can be calculated in two cases: Case 1) The minimum total product quantity based on historical data, and Case 2) The minimum total product quantity for newly installed projects.

1) The minimum total quantity of products produced based on historical data ($P_{y,min}$)

The minimum total quantity of products produced based on historical data is determined by the lower value between the maximum historical production quantity and the current total production quantity. It can be calculated as follow

$$P_{y,min} = Min (P_{hist,max} , P_y) \quad \text{Equation (25)}$$

Where

$P_{y,min}$ = The minimum total quantity of products produced for the year y (t of product)

$P_{hist,max}$ = Maximum annual production in the historic production data vintage (t of product)

P_y = Production output for the year y (t of product)

2) Minimum total product quantity for newly installed projects

Minimum total product quantity for newly installed projects shall be determined based on the lower value between (1) the expected production output according to the manufacturer's design specifications, excluding energy efficiency enhancement equipment for the furnace, and (2) the actual current production output. This minimum output can be calculated as follow

$$P_{y,min} = Min (P_{opt} , P_y) \quad \text{Equation (26)}$$

Where

$P_{y,min}$ = The minimum total quantity of products produced for the year y (t of product)

P_{opt} = Capacity of production of the product per year as per design specification of the furnace (t of product)

P_y = Production output for the year y (t of product)

9. Monitoring Plan

9.1 Monitoring approach

1) The project developer shall explain and specify the steps for monitoring the project activity data (Activity data) or verify all measurement results in the project proposal document. including the type of measuring instruments used Person responsible for monitoring results and verifying information Calibration of measuring instruments (if any) and procedures for warranty and quality control Where methods have different options, such as using default values or on-site measurements The project developer must specify which option to use. In addition, the installation, maintenance and calibration of measuring instruments should be carried out in accordance with the instructions of the equipment manufacturer and in accordance with national standards. or international standards such as IEC, ISO etc.

2) All data collected as part of the greenhouse gas reduction monitoring shall be stored in electronic files format with the storage period aligned with the guidelines by the the organization administrative or quality system in accordance with TGO guidelines. The list of monitoring parameters are presented in Table 9.2.

9.2 Data and parameters monitored

Parameter	$EC_{PJ,y}$
unit	MWh/year
Description	Electricity consumption from project implementation in year y
Source of data	Report or data record
Measurement procedures	Measurement from the project's electricity meter
Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$EF_{Elec,y}$
unit	tCO_2/MWh
Description	Emission factor for electricity generation/consumption in year y
Source of data	Report on greenhouse gas emissions (Emission Factor) from electricity generation/consumption for projects and activities of greenhouse gas reduction published by TGO.
Measurement procedures	**For the preparation of project proposal documents** Use the latest $EF_{Elec,y}$ announced by TGO

	For monitoring the results of reducing greenhouse gas emissions Use the $EF_{Elec,y}$ values announced by TGO according to the year of the crediting period. However, in the case that the year of the crediting period does not have $EF_{Elec,y}$ values announced by TGO, use the latest $EF_{Elec,y}$ values announced by TGO in that year instead.
Monitoring frequency	-

Parameter	TDL_y
unit	-
Description	Average technical transmission and distribution losses for providing electricity in year y
Source of data	**Option 1:** Report based on monitoring data in cases where information is available on the amount of electricity supplied by the producer and the amount of electricity received by the user **Option 2:** Use the most recent value announced by TGO (value = 0.0596), which is based on data from the Thailand Energy Balance Report for the year 2023, by the Department of Alternative Energy Development and Efficiency
Measurement procedures	If Option 1 is chosen, the project developer must monitor the specified value annually throughout the monitoring period of greenhouse gas emission reductions If Option 2 is chosen, the project developer must use this value consistently throughout the monitoring period of greenhouse gas emission reduction
Monitoring frequency	To be determined once in the first year of the carbon crediting period

Parameter	P_i
unit	t of product
Description	Amount of product produced in configuration i
Source of data	Record of product production volume
Measurement procedures	-
Monitoring frequency	Measure daily and consolidate each time the specific energy consumption ($PSEC_{i,th}$) of the project varies by more than 5%

Parameter	$P_{y,min}$
unit	t of product
Description	The minimum total quantity of products produced for the year y
Source of data	Records from the project
Measurement procedures	Report on the total quantity of products produced

Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$\eta_{captive}$
unit	%
Description	Efficiency of the captive power generation plant
Source of data	Document the observed performance metrics and manufacturer-provided specifications of the generator.
Measurement procedures	Use the maximum value between: 1. The performance measured in year y; or 2. The performance specifications provided by the generator manufacturer.
Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$S_{grid,y}$
unit	%
Description	Share of the facility electricity demand supplied by the grid in year y
Source of data	Records from the project
Measurement procedures	Measurement from the project's electricity meter
Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$S_{captive,y}$
unit	%
Description	Share of the facility electricity demand supplied by the captive power plant in year y
Source of data	Records from the project
Measurement procedures	Measurement from the project's electricity meter
Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$BSEC_{ini,th}$
unit	TJ/t of product
Description	Baseline specific thermal energy consumption established at the start of the project activity
Source of data	Records from the project
Measurement procedures	-
Monitoring frequency	Measurement shall be conducted once in the first year of the carbon crediting period

Parameter	$PSEC_{ini,th}$
unit	TJ/t of product

Description	Project specific thermal energy consumption established at the start of the project activity,
Source of data	Records from the project
Measurement procedures	-
Monitoring frequency	Measurement shall be conducted once in the first year of the carbon crediting period

Parameter	$BSEC_{ini,el}$
unit	kWh/t of product
Description	Baseline specific electrical energy consumption established at the start of the project activity
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Measurement shall be conducted once in the first year of the carbon crediting period

Parameter	$PSEC_{ini,el}$
unit	kWh/t of product
Description	Project specific electrical energy consumption established at the start of the project activity
Source of data	Records from the project
Measurement procedures	-
Monitoring frequency	Measurement shall be conducted once in the first year of the carbon crediting period

Parameter	$BSEC_{i,th}$
unit	TJ/t of product
Description	Baseline specific thermal energy consumption defined for configuration i
Source of data	Records from the project
Measurement procedures	Report on the specific thermal energy consumption
Monitoring frequency	Measurements shall be conducted each time the specific thermal energy consumption from the project operation ($PSEC_{i,th}$) differs by more than 5%

Parameter	$PSEC_{i,th}$
unit	TJ/t of product
Description	Project specific thermal energy consumption defined for configuration i
Source of data	Records from the project

Measurement procedures	
Monitoring frequency	Daily or per production cycle

Parameter	$BSEC_{i,el}$
unit	kWh/t of product
Description	Baseline specific electrical energy consumption defined for configuration i
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Measurements shall be conducted each time the specific electricity consumption from the project operation ($PSEC_{i.el}$) differs by more than 5%

Parameter	$PSEC_{i,el}$
unit	kWh/t of product
Description	Project specific electrical energy consumption defined for configuration i
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Daily or per production cycle

Parameter	$R_{i,th}$
unit	%
Description	Ratio for thermal specific energy consumption defined for configuration i
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Measurements shall be conducted each time the specific thermal energy consumption of the project ($PSEC_{i.th}$) differs by more than 5%.

Parameter	$R_{i,el}$
unit	%
Description	Ratio for electrical specific energy consumption defined for configuration i
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Measurements shall be conducted each time the specific power energy consumption of the project ($PSEC_{i.el}$) differs by more than 5%

Parameter	$BSEC_{th,y}$
unit	TJ/t of product
Description	Annual baseline specific thermal energy consumption for year y
Source of data	Records from the project
Measurement procedures	-
Monitoring frequency	Continuous monitoring and at least monthly recording

Parameter	$PSEC_{th,y}$
unit	TJ/t of product
Description	Specific thermal energy consumption from project activities in year y
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Annually

Parameter	$BSEC_{el,y}$
unit	kWh/t of product
Description	Specific electricity consumption from the baseline scenario in year y
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Annually

Parameter	$PSEC_{y,el}$
unit	kWh/t of product
Description	Specific electricity consumption from project activities in year y
Source of data	Records from the project
Measurement procedures	
Monitoring frequency	Annually

9.3 Data and parameters not monitored

Parameter	$BSEC_{design,th}$
Unit	TJ/t of product
Description	the specific thermal energy consumption of the furnace, including all fossil fuel usage within the project boundary
Source of data	Design specification values from the furnace manufacturer
Applicable value	

Parameter	$BSEC_{design,el}$
unit	kWh/t of product
Description	the specific power energy consumption of the furnace
Source of data	Design specification values from the furnace manufacturer
Applicable value	-

Parameter	$P_{hist,m}$
unit	t of product/month (Monthly or per production cycle)
Description	Production output for month/batch m
Source of data	Record of measured production output
Applicable value	-

Parameter	$Q_{hist,j,m}$
unit	t or m^3
Description	Quantity of fossil fuel j consumed in month/batch m
Source of data	Record of fossil fuel consumption measurement based on historical production data
Applicable value	-

Parameter	$NCV_{hist,j}$
unit	TJ/unit
Description	Net calorific value per mass or volume unit of fossil fuel j
Source of data	**Option 1:** Net calorific value of fossil fuel as specified in the invoice from the fuel supplier **Option 2:** Based on direct measurement **Option 3:** Energy statistics report of Thailand by the Department of Alternative Energy Development and Efficiency, Ministry of Energy **Option 4:** Reference values from the IPCC Table 1.2 in Chapter 1 of Volume 2 (Energy) of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories
Applicable value	-

Parameter	$TEE_{hist,m}$
unit	kWh
Description	Total electrical energy consumption in month/batch m
Source of data	Electricity meter reading record of the project
Applicable value	-

Parameter	P_{opt}
unit	t of product/year

Description	Capacity of production of the product per year as per design specification of the furnace
Source of data	Design specification values from the furnace manufacturer
Applicable value	
Note	This value is used to define the acceptable deviation range (±5%) for specific energy consumption

Parameter	$BSEC_{hist,th}$
unit	TJ/t of product
Description	Baseline specific thermal energy consumption established from historical data
Source of data	Record of specific fossil fuel consumption measurements
Applicable value	-

Parameter	$BSEC_{hist,el}$
unit	kWh/t of product
Description	Baseline specific electrical energy consumption established from historical data
Source of data	Record of specific electricity consumption
Applicable value	

10. Reference

Clean Development Mechanism (CDM)

AM0066 GHG emission reductions through waste heat utilization for pre-heating of raw materials in sponge iron manufacturing process Version 02

Document information T-VER-P-METH-06-02

Version	Amendment	Entry into force	Description
01	-	23 July 2025	Initial adoption