T-VER-P-METH-01-04

Thermal Energy Generation from Renewable Energy

Version 01

Scope: 01 - Energy industries

and 03 - Energy demand

Entry into force on 22 June 2024

1. Methodology title	Thermal Energy Generation from Renewable Energy
2. Project type	Renewable energy or alternative energy to fossil fuels
3. Sector and scope	01 - Energy industries 03 - Energy demand
4. Project outline	The project activity is to install a thermal energy generation system for application which uses one of the following energy sources: ● Fully renewable energy ● A combination of renewable energy and fossil fuels
5. Applicability	1. The thermal energy generation system using renewable energy must be in one of the following activities: ● Installation of a new thermal energy generation system (Greenfield) or ● Replacement of an existing thermal energy generation system 2. Eligible renewable energy sources include solar energy, biomass, biogas, compressed bio-methane gas (CBG) and hydrogen. 3. Eligible thermal energy generation systems include: ● Systems that water, steam, or other liquids are used as heat-transfer medium for application, such as boilers, thermal oil boilers. ● Systems that air is used as heat-transfer medium for application such as furnaces.
6. Project conditions	1. The thermal energy generated by the installed or replaced system must not be utilized for electricity generation. 2. The installation of a thermal energy generation system as a replacement must not be intended for expanding production capacity or changing production processes.

	3. In cases where the system replaces an existing heat generation system, the project proponent must provide the historical data on fossil fuel consumption, thermal energy output, or production output associated with the existing system for a minimum of three years prior to the implementation of the project activity. This data is required to account baseline emission. In addition, the existing system must use high carbon intensity of fossil fuels compared to natural gas. 4. The thermal energy generation system is not be applicable to a cook stove. 5. Biomass used as a renewable energy source for thermal energy generation must not be stored within the project boundary for more than one year.
7. Project starting date	The date is that the project owner (client) and the contractor have signed to construct the project of greenhouse gas emission reduction which will be developed to the T-VER project.
8. Definition	**Compressed Bio-methane Gas (CBG)** refers to gas derived from upgrading biogas by reducing the concentrations of CO_2 and H_2S and removing moisture, resulting in a higher purity of methane in the biogas. **Green Hydrogen** refers to hydrogen produced through the electrolysis of water, using electricity generated from renewable energy sources, such as solar and wind power. **Blue Hydrogen** refers to hydrogen production through chemical processes involving the use of fossil fuels, such as Steam Methane Reforming (SMR), combined with the Carbon dioxide Capture and Storage (CCS) instead of releasing it into the atmosphere. **Furnace** refers to equipment that generates thermal energy by direct fuel combustion for industrial processes requiring temperatures above 400°C. Heat transfer in a furnace occurs through two mechanisms: radiation and convection.

	Biomass residue refers to leftover materials from agricultural harvesting or processing, including rice husks, sugarcane bagasse, rice straw, and corn cobs, as well as wood and woodchips, that are eligible for use as fuel.
Remark	

Details of T-VER methodology for
Thermal Energy Generation from Renewable Energy

1. Greenhouse gas (GHG) emission reduction activities applied in calculation.

Table 1: Sources and types of GHGs

GHG emissions	Sources of GHG emission	Types of GHGs	Details of activities involving GHG emissions
Baseline emission	Thermal energy production	CO_2	Production of thermal energy from fossil fuel combustion
Project emission	Energy use within the project boundary	CO_2	Purchasing electricity from the national grid
			• Utilization of fossil fuels, e.g., biomass loaders, biomass transport vehicles, etc. • Generation of thermal energy from fossil fuel combustion (in cases of partial use of renewable energy or as a backup to the existing thermal generation system)
	Utilization of biomass and biomass residues	CO_2 and CH_4	• Cultivation of biomass in dedicated crop land • Transportation of biomass • Processing of biomass • Transportation of biomass residues (if applicable) • Processing of biomass residues (if applicable)
Leakage emission	Land change to dedicated crop land/biomass residue utilization	CO_2 and CH_4	• Land-use change activities prior to the cultivation of biomass in dedicated crop land • Utilization of biomass residues for other purposes

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GHG emissions	Sources of GHG emission	Types of GHGs	Details of activities involving GHG emissions
			• Increased processing of biomass residues • Transportation of biomass residues
	Utilization of hydrogen	CO_2	• Production of hydrogen from fossil fuel
		CO_2	• Transportation of hydrogen by vehicle or piping
	Utilization of biogas or CBG	CH_4	• Biogas leakage from anaerobic wastewater treatment including biogas storage • Incomplete combustion of biogas

2. Scope of Project

Projects activities is to install the new machinery and equipment to produce thermal energy using renewable energy sources for either utilization at the point of use or distribution to end-users outside the project boundary. These project activities must to be either the installation of a new thermal energy generation system (greenfield) or the installation of a replacement existing system, without the change of production capacity or production processes.

The project boundary refers to the installation area of the project's renewable energy-based thermal energy generation system and all activities related to thermal energy generation within the project. In cases where the project operates an existing thermal energy generation system as a backup, the installation area of that existing system must also be included as part of the project boundary.

Remark: In the case of project activities involving thermal energy generation using biogas generated from the decomposition of organic matter in waste or from wastewater treatment, project developers should apply other relevant methodologies for accounting emission reductions from methane avoidance through utilization. This methodology should be applied specifically for accounting emission reductions from the use of methane in thermal energy production.

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3. Additionality

The project must demonstrate additionality by following the "Guidelines for Demonstrating Additionality under the Thailand Voluntary Emission Reduction Program (T-VER)" as stipulated by the Thailand Greenhouse Gas Management Organization (TGO). These guidelines specify the process for proving that project activities exceed business-as-usual operations to qualify for voluntary GHG reductions in accordance with Thailand's standards.

4. Baseline scenario

In accordance with the guidelines for determining a baseline scenario below business-as-usual (Below BAU), the lowest GHG emissions from thermal energy production using fossil fuels is achieved through the use of natural gas. Therefore, the baseline scenario for this project activity is defined as the GHG emissions from thermal energy generation using natural gas.

5. Baseline Emission

Baseline GHG emissions consider only carbon dioxide (CO_2) emissions from thermal energy production using natural gas, which is displaced by the thermal energy generated by the project. The baseline emission is calculated using the following formula:

$$BE_y = BE_{CO2,y} \qquad \text{Equation (1)}$$

Where

BE_y = GHG emissions from the baseline scenario in year y (tCO_2/year)

$BE_{CO2,y}$ = GHG emissions from fossil fuel use displaced by the renewable energy-based thermal energy generation system in year y (tCO_2/year)

5.1 GHG emissions from fossil fuel use displaced by the renewable energy-based thermal energy generation system

The GHG emissions from fossil fuel use displaced by the renewable energy-based thermal energy generation system is calculated based on the characteristics of the thermal energy generation system as follows:

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5.1.1 GHG emissions from fossil fuel use in the project's thermal energy generation system using water/steam or other fluids as heat-transfer medium

$$BE_{CO2,y} = \left[HG_{PJ,y} / \eta_{BL} \right] \times EF_{CO2,NG} \times 10^{-3} \qquad \text{Equation (2)}$$

Where

$HG_{PJ,y}$ = Net thermal energy generated by the project's thermal energy generation system in year y (TJ/year)

$EF_{CO2,NG}$ = CO_2 emission factor for natural gas combustion ($kgCO_2$/TJ) equal to 56,100 $kgCO_2$/TJ

η_{BL} = Efficiency of the baseline thermal energy generation system

In the case of installing a replacement thermal energy generation system, project developers must provide data on fossil fuel consumption and amount of thermal energy from the existing system for at least three years prior to the operating of the project activity. The data must be calculated based on average, excluding years when the thermal energy system was not in normal operation. The baseline value η_{BL} is calculated using the following formula:

$$\eta_{BL} = \left[HG_{BL} \right] / \left[FC_{i,BL} \times NCV_{i,BL} \right] \times 10^{-6} \qquad \text{Equation (3)}$$

Where

HG_{BL} = Net thermal energy output from the baseline thermal energy generation system (TJ/year)

$FC_{i,BL}$ = Quantity of fossil fuel type i consumed in the baseline thermal energy generation system (unit/year)

$NCV_{i,BL}$ = Net Calorific Value (NCV) of fossil fuel type i used in the baseline thermal energy generation system (MJ/unit)

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5.1.2 Guidelines for determining the efficiency of the baseline thermal energy generation system using fossil fuels for new installations

Determination of the efficiency of the baseline thermal energy generation system shall follow one of the following options:

Option 1: Apply the highest efficiency measured across all operating conditions for comparable thermal energy generation systems that utilize natural gas as fuel. Efficiency testing must be conducted in accordance with recognized standards such as the American Society of Mechanical Engineers (ASME).

Option 2: Use the maximum efficiency specified by at least two manufacturers for comparable thermal energy generation systems that use natural gas as fuel.

Option 3: Assume an initial efficiency of 100 percent.

5.1.3 GHG emissions from fossil fuel use in the thermal energy generation system using air as heat-transfer medium

In the case of installing a replacement thermal energy generation system, project developers must provide data on fossil fuel consumption and the production output from the existing thermal energy system for at least three years prior to the operation of the new system. The data must be averaged, excluding years when the thermal energy system experienced abnormal operation.

$$BE_{CO2,y} = P_{Prod,y} \times SFC_{BL} \times EF_{CO2,NG} \times 10^{-3} \qquad \text{Equation (4)}$$

Where

$P_{Prod,y}$ = Quantity of products entering the thermal energy generation system of project activity in year y (kg/year or m^3/year)

SFC_{BL} = Specific fuel consumption for the baseline thermal energy generation system (TJ/kg or TJ/m^3)

$EF_{CO2,NG}$ = CO_2 emissions from natural gas combustion (kgCO$_2$/TJ) equal to 56,100 kgCO$_2$/TJ

The SFC_{BL} value is calculated from:

$$SFC_{BL} = \sum_i \left[FC_{i,BL} \times NCV_{i,BL} \right] / P_{Prod,BL} \times 10^{-6}$$ Equation (5)

Where

$FC_{i,BL}$ =   Quantity of fossil fuel type i consumed in the baseline thermal energy generation system (unit/year)

$NCV_{i,BL}$ =   Net calorific value of fossil fuel type i used in the baseline thermal energy generation system (MJ/unit)

$P_{Prod,BL}$ =   Quantity of products entering the baseline thermal energy generation system (kg/year or m^3/year)

Remark: For newly installed thermal energy generation systems using air as the heat-transfer medium, it is specified that $P_{Prod,BL} = P_{Prod,y}$

6. Project Emission

Project emissions from the operation of the renewable energy-based thermal energy generation system are categorized and calculated according to the following equations:

$$PE_y = PE_{FF,y} + PE_{EC,y} + PE_{Biomass,y}$$ Equation (6)

Where

PE_y =   Total GHG emissions from project activity in year y (tCO$_2$/year)

$PE_{FF,y}$ =   GHG emissions from fossil fuel use in project activity in year y (tCO$_2$/year)

$PE_{EC,y}$ =   GHG emissions from electricity consumption in project activity in year y (tCO$_2$/year)

$PE_{Biomass,y}$ =   GHG emissions from biomass and biomass residues in year y (tCO$_2$/year)

6.1 GHG emissions from fossil fuel use

The calculation of GHG emissions from fossil fuel use in project activity must account for fossil fuel consumption in the existing thermal energy system as a backup (if applicable). This calculation should follow the latest version of T-VER-P-TOOL-02-01, "Tool to Calculate Project or Leakage CO_2 Emissions from Fossil Fuel Combustion". In addition, if fossil fuels are used in machinery and equipment associated with biomass processing, storage, and transportation such as biomass preparation, conveyor systems, drying, pelletizing, and briquetting. These emissions must also be included under GHG emissions from biomass and biomass residues ($PE_{Biomass,y}$).

6.2 GHG emissions from electricity consumption

GHG emissions from electricity consumption in project activity can be calculated based on electricity consumption, the emission factor for electricity generation, and transmission and distribution losses in the electricity grid, as follows:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{Elec,y} \times (1 + TDL_y) \qquad \text{Equation (7)}$$

Where

$PE_{EC,y}$ = GHG emissions from electricity consumption in project activity in year y (tCO_2/year)

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

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

TDL_y = Proportion of losses in the electricity grid for electricity distribution in year y

Accordingly, electricity consumption for the operation of machinery and equipment related to biomass preparation, processing, and storage, such as conveyor systems, drying machines, pelletizers, and briquetting machines, must also be accounted for under the parameter $PE_{EC,y}$.

6.3 GHG emissions from biomass

In cases where the project activity utilizes biomass or biomass residues as fuel, project developers must calculate GHG emissions from project activity using the latest version of T-VER-P-TOOL-02-02, "Tool to Calculation for Project Emission and Leakage Emissions from Biomass" in accordance with the relevant activities:

1) Cultivation of biomass in dedicated crop land.

2) Transportation of biomass.

3) Processing of biomass.

4) Transportation of biomass residues (if applicable).

5) Processing of biomass residues (if applicable).

7. Leakage Emission

7.1 Utilization of biomass and/or biomass residues

Project developers must account GHG emissions outside the project boundary using the latest version of T-VER-P-TOOL-02-02, "Tool to Calculation for Project Emission and Leakage Emissions from Biomass" based on the following aspects:

1) Changes in pre-existing activities to biomass cultivation in dedicated crop land.

2) Utilization of biomass residues from project activity for other purposes outside the project boundary.

3) Increased processing of surplus biomass resulting from project activities.

4) Transportation of biomass residues.

7.2 Utilization of biogas or CBG

In cases where the thermal energy generation system utilizes biogas produced from a newly constructed anaerobic wastewater treatment system and the project developer does not account for emission reductions from methane avoidance, the project developer must account GHG emissions outside the project boundary. This includes emissions from biogas release in the

newly constructed anaerobic wastewater treatment system and the incomplete combustion for biogas from the methane flaring system installed alongside the anaerobic wastewater treatment system. The project developer applies the equation for project emissions from methane release in capture systems (Section 6.6) in T-VER-P-METH-12-01, "Methane Capture from Anaerobic Wastewater Treatment for Utilization or Flaring" and the calculation tool T-VER-P-TOOL-02-04, "Tool to Calculate Project Emissions from Flaring". Additionally, the calculation must include biogas-based thermal energy generation from existing anaerobic wastewater treatment systems if the project activity increases biogas production from these systems.

Accordingly, the project developers are not required to account GHG emissions outside the project boundary from biogas release from newly constructed anaerobic wastewater treatment systems or from the flaring of biogas in methane flaring systems installed alongside these treatment systems. This exemption applies to project activities that apply the methodology T-VER-P-METH-12-01, "Methane Capture from Anaerobic Wastewater Treatment for Utilization or Flaring" and the calculation tool T-VER-P-TOOL-02-04, "Tool to Calculate Project Emissions from Flaring" to determine emission reductions from methane avoidance in conjunction with this methodology.

Furthermore, project developers must account leakage emissions caused to the transportation of biogas or CBG via pipelines or vehicles from the production site to the project activity.

7.3 Utilization of hydrogen

In cases where the hydrogen source is not green hydrogen or blue hydrogen, project developers must account leakage emission, specifically carbon dioxide (CO_2) emissions caused to the hydrogen production process. This assessment must be conducted using engineering-based theoretical approaches, such as stoichiometry, apart from assessing GHG emissions from the transportation of hydrogen via pipelines or vehicles from the production site to the project activity.

8. Emission Reduction

Emission reduction from the project activity can be calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \qquad \text{Equation (8)}$$

Where

ER_y = Emission reduction in year y (tCO$_2$e/year)

BE_y = GHG emissions from the baseline scenario in year y (tCO$_2$e/year)

PE_y = GHG emissions from project activity in year y (tCO$_2$e/year)

LE_y = GHG emissions outside the project boundary in year y (tCO$_2$e/year)

9. Monitoring Plan

9.1 Monitoring procedures

1) Project developers must describe and specify the procedures for monitoring project activity data (activity data) or verifying all measurement results in the project proposal document. This must include details on the types of measurement instruments used, the personnel responsible for monitoring and data verification, calibration of measurement instruments (if applicable), and quality assurance and control procedures. In cases where different methodological options are available, such as the use of default values or on-site measurements, the project developer must specify the selected option. <u>Additionally, the installation, maintenance, and calibration of measurement instruments should be conducted in accordance with the equipment manufacturer's guidelines and must comply with national or international standards, such as IEC or ISO.</u>

2) All collected data must be incorporated as part of the monitoring of GHG emission reductions. The data should be stored in electronic file formats and retained in accordance with the guidelines established by the TGO or the organization's quality management system, ensuring that the retention period is not shorter than the duration specified by TGO. The data must be verified for accuracy in accordance with the monitoring procedures outlined in the parameters to be monitored, as specified in Table 9.2.

9.2 Parameters to be monitored

Parameter	$HG_{PJ,y}$
Unit	TJ/year
Definition	Net thermal energy generated by the thermal energy generation system from project operations in year y
Data source	Measurement report
Monitoring method	The calculation is based on the enthalpy difference of the heated fluid (steam, liquid, or gas) generated by the thermal energy generation system. Accordingly, the enthalpy value must be calculated from the flow rate (mass-based or volume-based) and the temperature of the heated fluid, or the pressure in the case of superheated steam. These values can be obtained from thermodynamic property tables or calculated using thermodynamic equations.
Monitoring frequency	Continuous monitoring and data recording at least on a monthly basis.
Remark	Project developers must not calculate the amount of thermal energy generated in the baseline scenario or from project operations using calorific values (net calorific value, lower heating value, or higher heating value) and fuel consumption.

Parameter	$P_{Prod,y}$
Unit	kg/year or m^3 /year
Definition	Quantity of products entering the thermal energy generation system of project activity in year y
Data source	Reports or recorded data
Monitoring method	Measured using instruments or equipment, with verification against other relevant records to ensure accuracy such as production records, sales documents, or reports.
Monitoring frequency	Continuous monitoring and data recording at least on a monthly basis.

Parameter	$EC_{PJ,y}$
Unit	MWh/year
Definition	Electricity consumption of the project in year y
Data source	Reports or recorded data
Monitoring method	Measured using the project's electricity meter
Monitoring frequency	Continuous monitoring and data recording at least on a monthly basis

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Parameter	$EF_{Elec,y}$
Unit	tCO_2/MWh
Definition	Emission factor for electricity generation/consumption in year y
Data source	GHG emission factor reports for electricity generation in the national grid and thermal energy generation for the project and GHG mitigation activities, as published by the TGO.
Monitoring method	**For preparation of project design documentation** The lasted value of $EF_{Elec,y}$ value published by the TGO must be used. **For monitoring emission reduction** The $EF_{Elec,y}$ value published by TGO for the calendar year (B.E.) corresponding to the carbon crediting period must be used. If the $EF_{Elec,y}$ value for the B.E. year of the carbon crediting period has not yet been published, the most recent $EF_{Elec,y}$ value announced by TGO shall be used for that year.
Monitoring frequency	-

Parameter	TDL_y
Unit	-
Definition	Proportion of losses in the electricity grid for electricity distribution in year y
Data source	Option 1: Measurement report, applicable when data on the amount of electricity supplied by the producer and the amount received by the electricity users is available. Option 2: Use the lasted value published by the TGO.
Monitoring method	1) If option 1 is selected, project developers must monitor this value annually throughout the crediting period. 2) If option 2 is selected, project developers must apply this value consistently throughout the crediting period.
Monitoring frequency	Determined once in the first year of the crediting period.

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9.3 Parameters not required for monitoring

Parameter	$P_{Prod,BL}$
Unit	kg/year or m³/year
Definition	Quantity of products entering the baseline thermal energy generation system
Data source	Measurement records for the quantity of products entering the baseline thermal energy generation system.
Utilization factor	The measurement period shall be set to align with the measurement period for fossil fuel type i consumption in the existing thermal energy generation system.

Parameter	HG_{BL}
Unit	TJ/year
Definition	Net thermal energy generated by the baseline thermal energy generation system.
Data source	Measurement records of thermal energy calculations must cover a period of at least three years prior to the operation of the new thermal energy generation system. These calculations must be based on measured data, including the mass/volumetric flow rate, temperature, or pressure of the input and output fluids in the thermal energy generation system.
Utilization factor	The calculation period must align with the measurement period for fossil fuel type i consumption in the existing thermal energy generation system. Data from years in which the existing thermal energy generation system with abnormal operation must be excluded.

Parameter	$FC_{i,BL}$
Unit	unit/year
Definition	Quantity of fossil fuel type i consumed in the baseline thermal energy generation system.
Data source	Measurement records of fossil fuel type i consumption in the existing thermal energy generation system must be maintained.
Utilization factor	The measurement period must align with the measurement period for the quantity of products entering the existing thermal energy generation system or with the calculation period for the net thermal energy generated by the existing thermal energy generation system.

Parameter	$NCV_{i,BL}$
Unit	MJ/Unit
Definition	Net Calorific Value (NCV) of fossil fuel type i used in the baseline thermal energy generation system.

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Data source	Option 1: Net calorific value of the fossil fuel as specified in the invoice from the fuel supplier.
	Option 2: Direct measurement
	Option 3: Thailand Energy Statistics Report, Department of Alternative Energy Development and Efficiency (DEDE), Ministry of Energy
	Option 4: Reference values from IPCC Table 1.2. of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories
Utilization factor	-

10. References

Clean Development Mechanism (CDM)

1) AMS-III.AN.: Fossil fuel switch in existing manufacturing industries. Version 02

2) AMS-I.C.: Thermal energy production with or without electricity. Version 22.0

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Document information T-VER-P-METH-01-04

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Version	Amendment	Entry into force	Description
01	-	22 June 2024	Initial adoption

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