T-VER-P-METH-01-05

Electricity Generation from Hydrogen for Internal Usage or Grid Reselling

Version 01

Scope: 01 Energy industries

Entry into force on 25 September 2024

1. Methodology	Electricity Generation from Hydrogen for Internal Usage or Grid Reselling
2. Project Type	Renewable energy or energy used to replace fossil fuels.
3. Scope	01 – Energy industries
4. Project Outline	Project activity is to install the electricity generation using hydrogen for distribution to the national grid or for personal use or for direct sale to consumers with private power purchase agreement (Private PPA).
5. Applicability	Project activity is to generate electricity using hydrogen with one of following conditions: 1) New installation (Greenfield) or 2) Improving the existing electricity generation system to support the use of hydrogen fuel as a co-fuel.
6. Project Conditions	1. It replaces the electricity generation from fossil fuels with: • Grid Reselling • Production for own use or production for sale in Private PPA 2. It is the electricity generation from hydrogen through a fuel cell or the mixed fuel between natural gas and hydrogen (Co-Firing). 3. The project activity is applied the waste heat utilization into the new installation of electricity generation, or the improvement of existing electricity or heat generation systems is not eligible.
7. Project Starting Date	The date the project owner (employer) and contractor have jointly signed a contract for construction or installation of a greenhouse gas reduction project that will be developed into the T-VER project.
8. Definition	**A type of power plant that can use two or more types of fuel. (Co-firing Powerplant):** A type of power plant that can use two or more types of fuel, such as a mixture of natural gas and hydrogen, etc. **Fuel Cell**: A type of electrochemical cell similar to a battery that creates energy using electrochemical principles that transform the chemical energy of fuel into electricity without having to go through the combustion process. And the combined heat energy is obtained from the process of the inputs for the fuel cell being hydrogen (H_2) and oxygen (O_2).

	Green Hydrogen: The production of hydrogen through the electrolysis of water (Electrolysis), which uses electricity produced from renewable energy such as sunlight, wind, etc. **Blue Hydrogen:** The production of hydrogen from various chemical reactions. that involves the use of fossil fuels such as Steam Methane Reforming (SMR), etc. together with the process of capturing and storing carbon dioxide (CCS: Carbon dioxide Capture and Storage) instead of releasing it into the atmosphere. **Gray Hydrogen:** Hydrogen produced from the steam reforming process using natural gas as a raw material.
9. Note	-

Details of T-VER methodology for Electricity Generation from Hydrogen for Internal Usage or Grid Reselling

1. Greenhouse gas emission reduction activities used in the calculations

Table 1 Sources and types of greenhouse gases

Greenhouse gas emission	Source	Types of greenhouse gas	Details of activities that emit greenhouse gas emissions
Baseline Emission	Electricity generation of the national grid	CO_2	The burning of fossil fuels to generate electricity of the country's electric power generation structure. which is replaced by electricity generated from renewable energy and sold into the electricity grid, including MEA, PEA, EGAT
Project Emission	Using fossil fuels mixed with hydrogen (Co-Firing)	CO_2	• Combustion of fossil fuels mixed with hydrogen (Co-Firing) to generate electricity. • Combustion of fossil fuels in backup electricity generator and purchasing electricity from the national grid to project activity.
	Fuel cell system	CO_2	• Purchasing electricity from the national grid supplying to supporting equipment in the fuel cell system. • Combustion of fossil fuels in supporting equipment in a fuel cell system.
Leakage	Using Hydrogen	CO_2	• Process of hydrogen production using fossil fuels as feed. • Transportation of hydrogen by vehicle or through pipelines.

2. Applicability and Scope of Project

Project activity includes the installation of new machinery and equipment or the improvement of existing machinery and equipment to use hydrogen in the electricity generation for sale to the electrical grid, or for use at the point of use, or for sale to consumers that located at the out of boundary. Project activity must be the new installation of electricity generation system (Greenfield) or the improvement of the existing electricity generation system to use hydrogen fuel without changing the electricity production capacity or the electricity generation process.

Project scope covers the installation area of the electricity generation system using hydrogen and supporting facilities related to the project's electricity production. That does not include the hydrogen production process.

3. Additionality

The project activity must be proven the additionality using “Guidelines to Additionality Demonstration under the Thailand Voluntary Emission Reduction Program: T-VER” published by the TGO. In addition, project owners or project developers applying BEV electric buses gaining subsidies of electric vehicle promotion from government agencies must create guidelines to prove additional financial operations including amount of all direct and indirect support, such as direct subsidies and various tax deductions, etc.

4. Baseline Scenario

Considering the guidelines for determining the baseline data based on the concept of Below Business as Usual (Below BAU), the baseline data for greenhouse gas emissions from fossil fuel combustion for electricity generation of the national grid or private PPA powerplant substituting with hydrogen fuel is the greenhouse gas emissions from electricity generation based on natural gas.

5. Baseline Emission

The baseline emissions only consider CO_2 emissions from electricity generation using natural gas that is replaced by electricity generation from project activities.

Baseline emissions can be calculated in two cases as follows:

5.1 Case 1: Installation of a new electricity generation system (Greenfield)

Baseline emissions for new installation of electricity generation system (Greenfield) can be calculated as follows.

$$BE_y = EG_{PJ,y} \times EF_{grid,y} \quad \text{Equation (1)}$$

Where:

BE_y = Baseline emissions in year y (tCO_2/year)

$EG_{PJ,y}$ = Quantity of net electricity generation that is fed into the national grid/own use/direct sale in year y (MWh)

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

5.2 Case 2: Improving the existing power generation system to support the use of hydrogen

Bassline emissions for improving the existing power generation system to support the use of hydrogen fuel can be calculated as follows:

$$BE_y = \frac{EG_{PJ,y} \times SFC_{BL} \times NCV_{BL} \times EF_{CO2,NG}}{\eta_{BL}} \quad \text{Equation (2)}$$

Where:

BE_y = Baseline Emissions in year y (tCO_2/year)

$EG_{PJ,y}$ = Quantity of net electricity generation that is fed into the national grid/own use/direct sale in year y (MWh)

SFC_{BL} = Specific fuel consumption of the generator in the baseline activity (unit/MWh)

η_{BL} = The efficiency of the generator in the baseline activity

NCV_{BL} = Net Calorific Value of baseline fuel type (GJ/unit)

$EF_{CO2,NG}$ = CO_2 emissions from the combustion of natural gas (tCO_2/GJ) equaled to 56,100 tCO_2/GJ

6. Project Emission

Project emission only considers CO_2 emissions from electricity generation using hydrogen through a fuel cell system and/or using a mixture of natural gas and hydrogen.

Project emissions are calculated as follows:

$$PE_y = PE_{Cofire,y} + PE_{FuelCell,y} \quad \text{Equation (3)}$$

Where:

PE_y = Project emissions in year y (tCO_2/year)

$PE_{Cofire,y}$ = Emissions from the use of mixed fuels (natural gas and hydrogen) from the project activity in year y (tCO_2/year)

$PE_{FuelCell,y}$ = Emissions from the use of fuel in fuel cell systems from project activity in year y (tCO_2/year)

6.1 Project emissions from the use of mixed fuels (natural gas and hydrogen) ($PE_{Cofire,y}$)

$PE_{Cofire,y}$ is calculated as follows:

$$PE_{Cofire,y} = m \times EC_{PJ,Cofire,y} \times \frac{\eta_{PJ}}{\eta_{BL}} \times EF_{grid,y} \quad \text{Equation (4)}$$

Where:

$PE_{Cofire,y}$ = Project emissions from the use of mixed fuels (natural gas and hydrogen) year y (tCO_2/year)

m = Proportion of natural gas in the fuel mixture (%)

$EC_{PJ,Cofire,y}$ = Electricity produced using mixed fuels (natural gas and hydrogen) from project case in year y (MWh/year)

η_{PJ} = The efficiency of the generator in the project activity

η_{BL} = The efficiency of the generator in the baseline activity

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

6.1.1 Proportion of natural gas in the fuel mixture (m)

Proportion of natural gas in the fuel mixture are calculated as follows:

$$m = \frac{FC_{NG,y} \times NCV_{NG}}{(FC_{NG,y} \times NCV_{NG}) + (FC_{H2,y} \times NCV_{H2})} \quad \text{Equation (5)}$$

Where:

m = Proportion of natural gas in the fuel mixture (%)

$FC_{NG,y}$ = Natural gas consumption in year y (unit)

NCV_{NG} = Net Calorific Value of natural gas (GJ/unit)

$FC_{H2,y}$ = Hydrogen fuel consumption in year y (unit)

NCV_{H2} = Net Calorific Value of hydrogen fuel (GJ/unit)

6.2 Emissions from the use of fuel in fuel cell systems from project case ($PE_{FuelCell,y}$)

$PE_{FuelCell,y}$ is calculated as follows:

$$PE_{Fuelcell,y} = PE_{EC,y} + PE_{FF,y} \quad \text{Equation (6)}$$

Where:

$PE_{Fuelcell,y}$ = Emissions from the use of fuel in the fuel cell system in year y (tCO_2/year)

$PE_{EC,y}$ = Emissions from the use of electricity in supporting equipment in the fuel cell system in year y (tCO_2/year)

$PE_{FF,y}$ = Emissions from the use of fossil fuels in supporting equipment in the fuel cell system in year y (tCO_2/year)

6.2.1 Emissions from the use of electricity in supporting equipment in the fuel cell system ($PE_{EC,y}$)

$PE_{EC,y}$ can be calculated using electricity consumption, emission factor for electricity use and loss of power in the national grid as follows:

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

Where:

$PE_{EC,y}$ = Emissions from the use of electricity in supporting equipment in the fuel cell system in year y (tCO_2/year)

$EC_{PJ,FuelCell,y}$ = Electricity consumption in supporting equipment in the fuel cell system in year y (MWh/year)

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

TDL_y = Proportion of power loss in the national grid for transmission in year y

6.2.2 Emissions from the use of fossil fuels in supporting equipment in the fuel cell system from the project case ($PE_{FF,y}$)

$PE_{FF,y}$ is calculated using the calculation tool of T-VER-P-TOOL-02-01 "Calculating CO_2 emissions from fossil fuel combustion from project emission or leakage emission" latest edition

7. Leakage Emission

In the case of not using green hydrogen or blue Hydrogen, the project developer must calculate leakage emissions (CO_2) from the hydrogen production process using engineering theory for example, stoichiometry etc., in addition to leakage emissions hydrogen transportation by piping or vehicle from the production site to project activities.

8. Emission Reduction

Emission reductions are calculated as follows:

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

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 emissions in year y (tCO_2e/year)

9. Monitoring Plan

9.1 Measurement Procedures

1) The project developer explains and specifies the steps for monitoring the project activity data (Activity data) or verifying 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 and ISO.**

2) All data collected as part of the greenhouse gas reduction monitoring. The data should be stored in electronic file format and the retention period is in accordance with the guidelines set by the Administrative Organization or the organization's quality system, but the period of time is not less than that specified by the TGO. Must follow the follow-up methods specified in the follow-up parameters specified in Table 9.3.

9.2 Data and parameters not monitored

Data / Parameter:	NCV_{BL} NCV_{NG} and NCV_{H2}
Data unit:	GJ/unit
Description:	Net Calorific Value of baseline fuel type
Source of data:	**Option 1** Net calorific value of fossil fuels specified in the invoice from the fuel supplier **Option 2** Real measurement

	Option 3 Report on Thailand's energy statistics such as Department of Alternative Energy Development and Energy Efficiency 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

Data / Parameter:	η_{BL}
Data unit:	%
Description:	The efficiency of the generator in the baseline activity
Source of data:	Use the maximum efficiency values given by two or more manufacturers of generators that use natural gas as fuel.

Data / Parameter:	SFC_{BL}
Data unit:	unit/MWh
Description:	Specific fuel consumption of the generator in baseline activity
Source of data:	**Option 1** Actual measurement. **Option 2** Manufacturer's information of that device.

9.3 Data and parameters monitored

Data / Parameter:	$FC_{NG,y}$
Data unit:	unit
Description:	Natural gas consumption in year y
Source of data:	Report on measurement of natural gas consumption
Measurement Procedures:	Summary of annual natural gas usage data
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$FC_{H2,y}$
Data unit:	unit
Description:	Hydrogen fuel consumption in year y
Source of data:	Hydrogen consumption measurement report.
Measurement Procedures:	Summary of annual hydrogen use data.
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$EG_{PJ,y}$
Data unit:	MWh/year
Description:	Quantity of net electricity generation that is fed into the national grid/own use/direct sale in year y (MWh)
Source of data:	Report on measurement of electricity consumption from electricity meter

Measurement Procedures:	Summary of annual electricity production data
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	η_{PJ}
Data unit:	%
Description:	The efficiency of the generator in the project activity
Source of data:	**Option 1** Use the highest measured efficiency value during all operating conditions of a generator with the same characteristics and using a mixture of natural gas and hydrogen as fuel. However, performance testing must be carried out according to specified guidelines such as ASME (American Society of Mechanical Engineer) etc. **Option 2** Use the maximum efficiency values of two or more generator manufacturers for generators with the same characteristics. It uses a mixture of natural gas and hydrogen as fuel.
Measurement Procedures:	Summary of generator efficiency data on an annual basis
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$EC_{PJ,Cofire,y}$
Data unit:	MWh/year
Description:	Electricity produced using mixed fuels (natural gas and hydrogen) from project case in year y
Source of data:	Report on measurement of electricity consumption from electricity meter
Measurement Procedures:	Summary of annual electricity consumption data
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	$EC_{PJ,FuelCell,y}$
Data unit:	MWh/year
Description:	Electricity consumption in supporting equipment in the fuel cell system in year y
Source of data:	Report on measurement of electricity consumption from electricity meter
Measurement Procedures:	Summary of annual electricity consumption data.
Monitoring frequency:	Continuous monitoring and monthly recording at least

Data / Parameter:	TDL_y
Data unit:	-
Description:	Proportion of power loss in the national grid for transmission in year y

Source of data:	**Option 1** Measurement report in the case where there is information on the amount of electricity issued by the producer and the amount of electricity that the electricity consumer receives **Option 2** Use the latest value announced by the TGO.
Measurement Procedures:	1) If using option 1, the project developer must monitor the said value every year throughout the monitoring. Results of reducing greenhouse gas emissions 2) If using option 2, the project developer must use this value throughout the monitoring of greenhouse gas emissions reduction results.
Monitoring frequency:	Set once in the first year of the carbon credit calculation period.

Data / Parameter:	$EF_{grid,y}$
Data 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 production in national grid and from heat production for greenhouse gas reduction projects and activities announced by the TGO.
Measurement Procedures:	**For preparing project proposal documents** Use the latest $EF_{grid,y}$ value announced by the TGO. **For following up on the results of reducing greenhouse gas emissions.** Use the $EF_{grid,y}$ value announced by the TGO according to the year of the period for which carbon credit certification is requested. In the case that the year of the period for which carbon credit certification is requested does not yet have the $EF_{grid,y}$ value announced by the TGO, use the latest $EF_{grid,y}$ value announced by the TGO instead in that year.

Reference documents

1. AMS-III.AC.: Electricity and/or heat generation using fuel cell Version 1.1
2. AM0124: Large-scale Methodology: Hydrogen production from electrolysis of water Version 1.1

Document information T-VER-P-METH-01-05

Version	Amendment	Entry into force	Description
01	-	25 September 2024	Initial adoption.