

T-VER-P-METH-01-08
Green Hydrogen Production

Version 01

Scope: 01 - Energy industries

Scope: 05 - Chemical Industry

Effective from 24 September 2026

1. Methodology	Green Hydrogen Production
2. Project Type	Renewable energy or fossil fuel replacement
3. Scope	01 - Energy industries 05 - Chemical industry
4. Project Outline	This project is intended to reduce emissions through the production of green hydrogen as a substitute for hydrogen derived from fossil fuels.
5. Applicability	1. Green hydrogen production to replace conventional methods, such as hydrogen derived from fossil fuels, in the following forms: • Installation of new green hydrogen production systems (Greenfield), or • Production of green hydrogen to substitute existing systems (Replacement). 2. Eligible green hydrogen production systems include: • Electrolysis of water powered by renewable energy sources such as solar and/or wind energy. • Hydrogen production from biomethane, for example through reforming processes.
6. Project Conditions	1. In the case where the project developer produces green hydrogen from electrolysis, electricity consumed in the hydrogen production facility is only produced by renewable-energy sources. The ratio between electricity consumption from non-renewable sources and total energy consumption in the hydrogen production facility remains below 0.1 monitored annually. If this ratio exceeds the threshold, the project developer shall not be eligible to claim greenhouse gas emission reductions for the relevant crediting period. 2. In the case where the project developer produces green hydrogen from biomethane, renewable energy shall be the main energy source of the process. The ratio between electricity consumption from non-renewable sources and total energy consumption in the hydrogen production facility must remain below 0.1 monitored annually. If this ratio exceeds the threshold, the project developer

	shall not be eligible to claim greenhouse gas emission reductions for the relevant crediting period. 3. The project developer shall demonstrate that the biomethane used for green hydrogen production originates from sustainable waste sources, such as anaerobic wastewater treatment systems or municipal solid waste landfills with biogas capture. 4. In cases where the project activity involves the installation of a biogas upgrading system, the project developer shall account for project emissions and leakage emissions. 5. The project developer shall ensure that water use does not significantly affect community drinking water consumption, thereby guaranteeing that water used in the electrolysis process does not displace other essential uses. Verification shall be conducted during validation and at each crediting period renewal, based on project activity data and official sources. 6. Hydrogen consumption demands planned to be replaced or displaced by green hydrogen from the project activity shall be stated in the Project Design Document (PDD) prior to project implementation. 7. In cases of replacement installations, the baseline hydrogen production system shall not be relocated or reused outside the project boundary.
7. Project Starting Date	The date on which the project developer (employer) and the contractor jointly signed the purchase and installation contract for the green hydrogen production system to be developed as a T-VER project.
8. Definition	Green Hydrogen refers to low-carbon hydrogen production, generated either through electrolysis of water using electricity from renewable energy sources, or from biomethane. Electrolysis means the process of passing direct current through water to separate water molecules into hydrogen gas and oxygen gas, based on electrochemical principles applied via electrodes.

	Reforming refers to a chemical process that uses catalysts under heat and pressure to restructure hydrocarbons, such as methane, to produce syngas or subsequent fuels, including hydrogen gas.
	Biomethane refers to biogas produced from the anaerobic digestion of organic matter (e.g., food waste, animal manure, wastewater, or municipal solid waste), which is then upgraded through a biogas upgrading process to achieve properties comparable to natural gas.
	Renewable Energy refers to a type of alternative energy derived from sources that can be naturally replenished and reused.
Note	1) In the event that a project developer installs a new green hydrogen production system (Greenfield) or implements green hydrogen production to replace an existing system (Replacement) and also utilizes the produced green hydrogen for purposes such as electricity or heat generation, the project developer may apply for both the green hydrogen production component and the utilization component. 2) Non-renewable energy power plants include those utilizing fossil fuel combustion and hydrogen produced from fossil fuels.

**Details of the voluntary emission reduction methodology
for green hydrogen production**

1. Emission reduction activities

Table 1: Sources and Types of Greenhouse Gases

Greenhouse Gas Emissions	Sources of Greenhouse Gases	Types of Greenhouse Gases	Description of Activities Associated with Greenhouse Gas Emissions
Baseline Emissions	Use of fossil fuels	CO ₂	Hydrogen production from fossil fuels (natural gas) replaced by green hydrogen
Project Emissions	Use of electricity	CO ₂	Purchase of electricity from the grid for use in the supporting systems of green hydrogen production
	Use of fossil fuels	CO ₂	Combustion of fossil fuels, including: - Heat generation for use in green hydrogen production processes - Electricity generation from backup generators
	Hydrogen transportation	CO ₂	Transportation of hydrogen to end-users, considering only additional transportation, categorized as follows: - Use of fossil fuels for road transportation - Use of electricity for pipeline transportation
	Physical leakage of hydrogen	H ₂	Hydrogen leakage during transportation to end-users, which triggers indirect chain reactions and contributes to global warming.
Leakage Emissions	Biomethane production or biogas production	CO ₂ and CH ₄	Purchasing or carrying biomethane/ biogas from producer located outside boundary

2. Applicability and Scope of Project

Project activity involving the installation of new green hydrogen production systems (Greenfield) or the replacement of existing systems (Replacement), utilizing either electrolysis powered by renewable energy or hydrogen production from biomethane (e.g., through reforming processes), to substitute hydrogen derived from fossil fuels.

The project boundary covers the site of the green hydrogen production system and all related activities associated with hydrogen production, including biogas upgrading systems (if applicable) and hydrogen transportation for utilization.

3. Additionality

The project must demonstrate additionality beyond common practice by applying the 'Criteria for Demonstration of Additionality under Premium Thailand Voluntary Emission Reduction (Premium T-VER) Program' as prescribed by TGO.

4. Baseline Scenario

When considering the determination of baseline data below business as usual (Below BAU), in accordance with the Guideline for the Development of Premium T-VER Methodology (Version 02), the baseline shall take into account greenhouse gas emissions from hydrogen production using fossil fuels, which are replaced by green hydrogen generated under the project. For year 1 baseline data, existing actual or historical emissions shall be applied. From year 2 onwards during the crediting period, the downward adjusted baseline approach shall be adopted. Details are as follows.

4.1 Installation of new green hydrogen production systems (Greenfield),

For year 1 baseline data, emissions from hydrogen production using fossil fuels, which are replaced by green hydrogen, shall be determined using existing actual data with downward adjusted. For year 2 onwards during the crediting period, the downward adjusted baseline approach shall be applied.

4.2 Production of green hydrogen to substitute existing systems (Replacement).

For year 1 baseline data, greenhouse gas emissions from hydrogen production using fossil fuels, which are replaced by green hydrogen under the project, shall be determined using historical

emissions together with the Adjusted Downward principle. From year 2 onwards during the crediting period, the downward adjusted baseline method shall be applied.

5. Baseline Emission

Baseline greenhouse gas emissions comprise the methodology for calculating baseline emissions, the calculation of greenhouse gas emissions reduced from the baseline, and the calculation of greenhouse gas emissions under business-as-usual operations, with details as follows.

5.1 Baseline Emission Equation

Baseline emissions are calculated based on the amount of green hydrogen produced under the project and the emission factor of hydrogen produced from fossil fuels. The calculation can be expressed as follows:

$$BE_y = M_{H_2,PJ,y} \times EF_{H_2,i,y} \quad \text{Equation (1)}$$

Where

BE_y = Baseline emission in year y. (tCO₂/year)

$M_{H_2,PJ,y}$ = The amount of green hydrogen produced and transported for utilization under the project in year y. (tH₂)

$EF_{H_2,i,y}$ = Emission factor of hydrogen produced from fossil fuel type i. (tCO₂e/H₂)

The amount of green hydrogen produced and transported for utilization under the project activity shall be calculated according to the following equation:

$$M_{H_2,PJ,y} = \sum_{t=1}^y V_{0,t} \times v_{H_2,t} \times (2/22.4) \times 10^{-3} \quad \text{Equation (2)}$$

Where

$M_{H_2,PJ,y}$ = The amount of green hydrogen produced and transported for utilization under the project in year y. (tH₂)

$V_{0,t}$ = Volumetric flow rate of gas under standard temperature and pressure (STP) during time interval t. (Sm³)

$v_{H_2,t}$ = Volumetric fraction of hydrogen gas during time interval t. (m³ H₂/m³ gas)

2 = Molar mass of hydrogen (kg/kmol)

22.4 = Gas volume under standard conditions (Sm³/kmol)

The volume of hydrogen under STP conditions, the project developer shall convert the values using the following equation:

$$V_{0,t} = \frac{V_{H_2,t} \times P_{H_2,t} \times 273.15}{101,325 \times (273.15 + T_{H_2,t})} \quad \text{Equation (3)}$$

Where

- $V_{0,t}$ = Volumetric flow rate of gas under standard temperature and pressure (STP) during time interval t (Sm^3)
- $V_{H_2,t}$ = Volumetric flow rate of hydrogen under operational conditions during time interval t (m^3)
- $P_{H_2,t}$ = Pressure of compressed hydrogen during time interval t (Pa)
- $T_{H_2,t}$ = Temperature of compressed hydrogen during time interval t ($^{\circ}\text{C}$)

5.2 Baseline emissions for year 1

5.2.1 Installation of new green hydrogen production systems (Greenfield)

The project developer shall calculate baseline emissions from the installation of new green hydrogen production systems (Greenfield) according to the following steps:

- 1) For year 1 of the crediting period, the calculation shall apply existing actual data (Existing Actual) using Equation (1), together with the adjusted downwards approach specified in Section 5.2.2.
- 2) From year 2 onwards during the crediting period, the calculation shall apply the adjusted downwards approach specified in Section 5.3.

The application of the equation shall follow the guidelines as outlined below:

1) Emission factor of hydrogen produced from fossil fuel ($\text{EF}_{H_2,i,y}$)

Emission factor of hydrogen produced from fossil fuels for the installation of new green hydrogen production systems (Greenfield) shall be determined based on the emission factor of hydrogen produced from natural gas in the existing production system, using the Ambitious Benchmark Approach. The calculation can be expressed as follows:

$$EF_{H2,i,y} = EF_{H2,NG} \quad \text{Equation (4)}$$

Where

$EF_{H2,i,y}$ = Emission factor of hydrogen produced from fossil fuel type i (tCO₂e/ tH₂)

$EF_{H2,NG}$ = Emission factor of hydrogen produced from natural gas (tCO₂e/ tH₂)

5.2.2 Production of green hydrogen to substitute existing systems (Replacement).

The project developer shall calculate baseline emissions for the case of replacing the existing system with green hydrogen production, using historical emissions together with equation (1) and the Adjusted Downward principle. From year 2 onwards during the crediting period, the downward adjusted baseline method specified in Section 5.3 shall be applied. Under the adjusted downward approach, the calculation shall consider the minimum value between the downward-adjusted baseline and the baseline adjusted for uncertainty, following the steps below:

$$BE_{adj,y1} = \min (BE_{adj,min,y1} : BE_{adj,UNC,y1}) \quad \text{Equation (5)}$$

Where

$$BE_{adj,min,y1} = BE_{y1} - 0.1 \times (BE_{y1} - PE_{y1}) \quad \text{Equation (6)}$$

$$BE_{adj,UNC,y1} = BE_{y1} \times (1 - UNC_{BE,y1}) \quad \text{Equation (7)}$$

$BE_{adj,y1}$ = Adjusted baseline emissions in year 1 of the crediting period (tCO₂e/year)

$BE_{adj,min,y1}$ = Minimum adjusted baseline emissions in year 1 of the crediting period (tCO₂e/year)

$BE_{adj,UNC,y1}$ = Adjusted baseline emissions for uncertainty in year 1 of the crediting period (tCO₂e/year)

BE_{y1} = Baseline emissions in year 1 of the crediting period (tCO₂e/year)

PE_{y1} = Project emissions in year 1 of the crediting period (tCO₂e/year)

$UNC_{BE,y1}$ = Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval compared to the mean baseline emissions (unadjusted) in year 1 of the crediting period (% represented as a value between 0–1).

1) Baseline emissions in year 1 of the crediting period (BE_{y1})

For the calculation of baseline emissions in year 1 of the crediting period, project developers are required to apply equation (1). The application of the equation shall follow these guidelines:

1.1) Emission factor of hydrogen produced from fossil fuel ($EF_{H2,i,y}$)

For the replacement of the existing system with green hydrogen production, the emission factor of hydrogen produced from fossil fuels shall be determined based on historical data from the past three years, including electricity consumption, fossil fuel consumption, and hydrogen output. The calculation shall be carried out using the following equation:

$$EF_{H2,i,y} = EF_{H2,BL} = \frac{\sum_{t=3}^{t-1} (EC_{H2,BL,t} \times EF_{EF,BL,t}) + (\sum_i FC_{i,BL,t} \times NCV_i \times EF_{CO2,i})}{M_{H2,BL,t}} \quad \text{Equation (8)}$$

Where

$EF_{H2,i,y}$ = Emission factor of hydrogen produced from fossil fuel type i. (tCO₂e/ tH₂)

$EF_{H2,BL}$ = Emission factor of the baseline hydrogen produced from fossil fuels (tCO₂e/ tH₂)

$EC_{H2,BL,t}$ = Electricity consumption of the baseline hydrogen production system in year t (MWh)

$EF_{EF,BL,t}$ = Emission factor of the electricity source supplying the baseline hydrogen production system in year t (tCO₂e/ MWh)

$FC_{i,BL,t}$ = Consumption of fossil fuel type i in the baseline hydrogen production system in year t (Unit)

NCV_i = Net Calorific Value of fossil fuel type i (GJ/Unit)

$EF_{CO2,i}$ = Emission factor of fossil fuel combustion type i (tCO₂e/ GJ)

$M_{H2,BL,t}$ = Hydrogen output from the baseline hydrogen production system in year t (tH₂)

2) Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval compared to the mean baseline emissions (unadjusted) in year 1 of the crediting period (UNC_{BEy1})

Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval compared to the mean baseline emissions (unadjusted) in year 1 of the crediting period, shall be calculated using the latest version of T-VER-P-TOOL-02-06 'Tool to Uncertainty Analysis for the Equation Calculating Greenhouse Gas Emission Reductions,' with details as follows.

Calculation of combined uncertainty from multiplication or division

The calculation of uncertainty from multiplication or division can be performed as follows:

$$UNC_{total} = \sqrt{UNC_1^2 + \dots + UNC_i^2 + \dots + UNC_n^2} \quad \text{Equation (9)}$$

Where

UNC_{total} = The percentage uncertainty in the product of the quantities

UNC_i = The percentage uncertainties associated with each of the quantities

Calculation of combined uncertainty from addition or subtraction

Calculation of combined uncertainty from addition or subtraction can be performed as follows:

$$UNC_{total} = \frac{\sqrt{(UNC_1 * x_1)^2 + \dots + (UNC_i * x_i)^2 + \dots + (UNC_n * x_n)^2}}{|x_1 + x_i + \dots + x_n|} \quad \text{Equation (10)}$$

Where

UNC_{total} = The percentage uncertainty in the sum of the quantities

UNC_i = The percentage uncertainties associated with them.

x_i = The uncertain quantities associated with them.

5.3 Adjusted Downwards for baseline emissions from year 2 onwards

5.3.1 Adjusted Downwards for baseline emissions: DA_{y1}

The calculation of the adjusted downwards value to be applied for determining the baseline from year 2 onwards shall consider the maximum value between the two results, as expressed in the following equation.

$$DA_{y1} = \text{MAX} \left\{ \begin{array}{l} 0.1 \times (BE_{y1} - PE_{y1}) \\ BE_{y1} \times UNC_{BE,y1} \end{array} \right. \quad \text{Equation (11)}$$

Where

- DA_{y1} = Adjusted downwards for baseline emissions in year 1 (tCO₂e/year)
- BE_{y1} = Baseline emissions in year 1 of the crediting period (tCO₂e/year)
- PE_{y1} = Project emissions in year 1 of the crediting period (tCO₂e/year)
- $UNC_{BE,y1}$ = Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval compared to the mean baseline emissions. (Unadjusted) in year 1 of the crediting period (% represented as a value between 0–1)

5.3.2 Emissions under business-as-usual operations and the principle of conservativeness. ($BAU_{cons,y}$)

Emissions under business-as-usual operations and the principle of conservativeness shall be determined by considering the minimum value between the lowest adjusted baseline and the uncertainty-adjusted baseline, according to the following steps.

$$BAU_{cons,y} = \min (BAU_{cons,min,y} : BAU_{cons,UNC,y}) \quad \text{Equation (12)}$$

Where

$$BAU_{cons,min,y} = BAU_y - 0.1 \times (BAU_y - PE_y) \quad \text{Equation (13)}$$

$$BAU_{cons,UNC,y} = BAU_y \times (1 - UNC_{BAU,y}) \quad \text{Equation (14)}$$

$BAU_{cons,min,y}$	=	Emissions under business-as-usual operations and the principle of conservativeness in year y (tCO ₂ e/year)
$BAU_{cons,UNC,y}$	=	Emissions under business-as-usual operations, incorporating the principle of conservativeness and uncertainty, in year y. (tCO ₂ e/year)
BAU_y	=	Emissions under business-as-usual operations in year y. (tCO ₂ e/year)
PE_y	=	Project emissions in year y of the crediting period (tCO ₂ e/year)
$UNC_{BAU,y}$	=	Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval, compared to the mean business-as-usual (unadjusted) emissions in year y of the crediting period. (% represented as a value between 0–1).

1) Emissions under business-as-usual operations (BAU_y)

Emissions under business-as-usual operations can be calculated as follows:

$$BAU_y = M_{H_2,PJ,y} \times EF_{H_2,BAU,y} \quad \text{Equation (15)}$$

Where

BAU_y	=	Emissions under business-as-usual operations in year y. (tCO ₂ e/year)
$M_{H_2,PJ,y}$	=	The amount of green hydrogen produced and transported for utilization under the project in year y. (tH ₂)
$EF_{H_2,BAU,y}$	=	Emission factor of hydrogen produced from fossil fuels under business-as-usual operations in year y (tCO ₂ e/tH ₂)

2) Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval, compared to the mean business-as-usual (Unadjusted) emissions in year y of the crediting period. ($UNC_{BAU,cp1,y}$)

Uncertainty value of greenhouse gas emissions at the lower bound of the 95% confidence interval, compared to the mean business-as-usual (unadjusted) emissions in year y of the crediting period, shall be calculated using the latest version of T-VER-P-TOOL-02-06 'Tool to Uncertainty Analysis for the Equation Calculating Greenhouse Gas Emission Reductions,' with details provided in Equation (9) and Equation (10).

5.3.3 Adjusted baseline value for year y (from year 2 onwards), $BE_{adj,y}$

The calculation of the adjusted baseline value for year y (from year 2 onwards) can be performed as follows:

$$BE_{adj,y} = BE_y - (DA_{y1} + BE_{y1} \times 0.01 \times (y - y_1)) \quad \text{Equation (16)}$$

Where

$BE_{adj,y}$ = Adjusted baseline emissions in year y of the crediting period (tCO₂e/year)

BE_{y1} = Baseline emissions in year 1 of the crediting period (tCO₂e/year)

DA_{y1} = Adjusted downwards value for baseline emissions in year 1 (tCO₂e/year)

y = Year y

y₁ = Year 1

Consider comparing the values of $BE_{adj,y}$ and $BAU_{cons,y}$ calculated from Section 5.3.2, and proceed according to the following conditions:

- If $BE_{adj,y} < BAU_{cons,y}$, $BE_{adj,y}$ can be readily applied
- If $BE_{adj,y} > BAU_{cons,y}$ recalculate $BE_{adj,y}$ according to Section 5.3.3 by adding a constant adjustment so that $BE_{adj,y}$ becomes lower than $BAU_{cons,y}$

Accordingly, repeat the procedures in Sections 5.3.2 and 5.3.3 for the calculation of baseline values for years 3, 4, and 5, until the completion of the carbon crediting period.

6. Project Emission

Project emissions shall be based on emissions from electricity consumption, fossil fuel consumption, hydrogen transportation for utilization, and physical leakage of hydrogen, with details as follows:

$$PE_y = PE_{EC,y} + PE_{FF,y} + PE_{transport,y} + PE_{H2-leaks,y} \quad \text{Equation (17)}$$

Where

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

$PE_{EC,y}$ = Project emission from electricity consumption in year y (tCO₂/year)

$PE_{FF,y}$ = Project emission from fossil fuel consumption in year y (tCO₂/year)

$PE_{transport,y}$ = Project emission from hydrogen transportation for additional utilization in year y (tCO₂/year)

$PE_{H2-leaks,y}$ = Project emission from physical leakage of hydrogen in year y (tCO₂eq/year)

6.1 Project emission from electricity consumption ($PE_{EC,y}$)

Project emission from electricity consumption can be calculated based on electricity consumption, the emission factor of electricity generation, and transmission losses in the grid, as follows:

$$PE_{EC,y} = EC_{PJ,y} \times EF_{Elec,y} \times (1 + TDL_y) \quad \text{Equation (18)}$$

Where

$PE_{EC,y}$ = Project emission from electricity consumption in year y (tCO₂/year)

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

$EF_{Elec,y}$ = Emission factor for electricity generation/use in year y (tCO₂/MWh)

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

6.2 Project emission from fossil fuel consumption ($PE_{FF,y}$)

Project emission from fossil fuel consumption shall be calculated using the latest version of T-VER-P-TOOL-02-01 'Calculate Project or Leakage CO₂ Emissions from Fossil Fuel Combustion'

6.3 Project emission from hydrogen transportation for additional utilization ($PE_{transport,y}$)

Project emissions from hydrogen transportation for additional utilization shall be determined based on the sum of emissions from road transportation of hydrogen and emissions from pipeline transportation of hydrogen. The calculation shall be applied only in cases where hydrogen is transported to new consumers or where the transportation distance is increased and can be calculated as follows.

$$PE_{transport,y} = PE_{Road,y} + PE_{Pipeline,y} \quad \text{Equation (19)}$$

Where

$PE_{transport,y}$ = Project emission from hydrogen transportation for additional utilization in year y (tCO₂/year)

$PE_{Road,y}$ = Project emission from road transport of hydrogen in year y (tCO₂/year)

$PE_{Pipeline,y}$ = Project emission from pipeline transport of hydrogen in year y (tCO₂/year)

6.3.1 Project emission from road transport of hydrogen ($PE_{Road,y}$)

Project emission from road transport of hydrogen shall be calculated based on the round-trip distance between origin and destination of hydrogen transport, the quantity of hydrogen transport, and the emission factor of fossil fuel consumption for hydrogen transport, as follows:

$$PE_{Road,y} = D_y \times Q_y \times EF_{CO_2,TR,i} \times 10^{-6} \quad \text{Equation (20)}$$

Where

$PE_{Road,y}$ = Project emission from road transport of hydrogen in year y (tCO₂/year)

D_y = Round-trip distance between origin and destination of hydrogen road transport activity for utilization of the project activity in year y (km)

Q_y = Quantity of hydrogen transported in year y (t H₂)

$EF_{CO_2,TR,i}$ = Emission factor of fossil fuel type i used for hydrogen transport for utilization (gCO₂/t-km)

i = Type of fossil fuel

6.3.2 Project emission from pipeline transport of hydrogen ($PE_{Pipeline,y}$)

Project emission from pipeline transport of hydrogen shall be calculated based on electricity consumption for pipeline transport, the emission factor of electricity generation/use, and the proportion of grid transmission losses, as follows:

$$PE_{Pipeline,y} = EC_{H_2,Pipeline,y} \times EF_{Elec,y} \times (1 + TDL_y) \quad \text{Equation (21)}$$

Where

$PE_{Pipeline,y}$ = Project emission from pipeline transport of hydrogen in year y (tCO₂/year)

$EC_{H_2,Pipeline,y}$ = Electricity consumption for pipeline transport of hydrogen of the project activity in year y (MWh/year)

$EF_{Elec,y}$ = Emission factor for electricity generation/consumption in year y (tCO₂/MWh)

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

6.4 Project emission from physical leakage of hydrogen ($PE_{H_2\text{-leaks},y}$)

Project emission from physical leakage of hydrogen shall be calculated based on the quantity of green hydrogen produced and the proportion of physical hydrogen leakage from the project activity, as follows:

$$PE_{H_2\text{-leaks},y} = M_{H_2,PJ,y} \times PL_{H_2} \times GWP_{H_2} \quad \text{Equation (22)}$$

Where

- $PE_{H_2\text{-leaks},y}$ = Project emission from physical leakage of hydrogen in year y (tCO₂eq/year)
- $M_{H_2,PJ,y}$ = The amount of green hydrogen produced and transported for utilization under the project in year y. (tH₂)
- PL_{H_2} = Proportion of physical hydrogen leakage from the project activity (%)
- GWP_{H_2} = Global Warming Potential (GWP) of hydrogen (tCO₂eq/tH₂)

7. Leakage Emission

None

8. Emission Reduction

Emission reductions can be calculated as follows.

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (23)}$$

Where

- ER_y = Emission reductions in year y (tCO₂e/year)
- BE_y = Baseline emissions in year y (tCO₂e/year)
- PE_y = Project emissions in year y (tCO₂e/year)
- LE_y = Leakage emissions in year y (tCO₂e/year)

8.1 The calculation of emission reductions from the adjusted baseline during the crediting period.

The calculation of emission reductions from the adjusted baseline during the crediting period can be calculated as follows.

$$ER_y = BE_{adj,y} - PE_y - LE_y \quad \text{Equation (24)}$$

Where

- ER_y = Emission reductions in year y (tCO₂e/year)
- $BE_{adj,y}$ = Adjusted baseline emissions in year y of the crediting period (tCO₂e/year)
- PE_y = Project emissions in year y (tCO₂e/year)
- LE_y = Leakage emissions in year y (tCO₂e/year)

9. Monitoring Plan

9.1 Monitoring procedure

1) The project developer shall describe and specify the monitoring steps for project activity data or verification of all measurement results in the project proposal document, including the type of measuring instruments used, the responsible personnel for monitoring and data verification, instrument calibration (if applicable), and the procedures for quality assurance and quality control. In cases where alternative methods are available, such as using default values or on-site measurements, the project developer must indicate which option will be applied. Furthermore, the installation, maintenance, and calibration of measuring instruments shall be carried out in accordance with the manufacturer's instructions and in compliance with national or international standards, such as IEC and ISO, and as specified in Table 9.2.

2) All data collected as part of the monitoring of greenhouse gas emission reductions shall be stored in electronic file format and retained for a period consistent with the guidelines specified by TGO or in accordance with the organization's quality system, but not less than the period required by TGO. The data shall also be verified for accuracy in line with the monitoring methods specified for the data/parameters to be monitored, as indicated in Table 9.2.

9.2 Data and parameters monitored

Data/parameter	$M_{H_2,P,J,y}$	
Description	The amount of green hydrogen produced and transported for utilization under the project in year y	
Unit	tH ₂	
Equations referred	(1) (2) (15) and (22)	
Purpose of data	☒ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	Continuous monitoring and recording of data at least monthly.	
Measurement methods and procedures	Measurements shall be taken using the hydrogen flow meter.	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	Flow meter
	Accuracy class	Flow meters under supervision shall comply with the specifications of the measuring instrument supplier.
	Calibration requirements	Flow meters shall comply with either the specifications of the measuring instrument supplier or national requirements. If no applicable standard exists and the supplier does not specify requirements, the meter shall be calibrated every three years.
	Location	Flow meters must comply with national standards or the requirements specified by the measuring instrument supplier.
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$V_{0,t}$	
Description	Volumetric flow rate of gas under standard temperature and pressure (STP) during time interval t	
Unit	Sm ³	
Equations referred	(2) and (3)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Measurement methods and procedures	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	

Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$V_{H_2,t}$	
Description	Volumetric fraction of hydrogen gas during time interval t.	
Unit	$m^3 H_2/m^3$ gas	
Equations referred	(2) and (3)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Measurement methods and procedures	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$V_{H_2,t}$	
Description	Volumetric flow rate of hydrogen under operational conditions during time interval t.	
Unit	m^3	
Equations referred	(2) and (3)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	

Monitoring frequency	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Measurement methods and procedures	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$P_{H_2,t}$	
Description	Pressure of compressed hydrogen during time interval t.	
Unit	Pa	
Equations referred	(3)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Measurement methods and procedures	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$T_{H_2,t}$	
Description	Temperature of compressed hydrogen during time interval t.	
Unit	°C	

Equations referred	(3)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Measurement methods and procedures	Reference: T-VER-P-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	EG _{H₂,y}	
Description	Electricity supplied to the green hydrogen production system in year y	
Unit	MWh/year	
Equations referred	-	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Daily data recording	
Measurement methods and procedures	Measurements shall be taken using a bidirectional kWh meter	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	Bidirectional kWh meter
	Accuracy class	1) Electricity meters under regulatory supervision shall comply with the requirements of the meter supplier and/or the requirements specified by the transmission system operator, or national requirements. 2) Electricity meters not under regulatory supervision shall comply with the requirements of the meter supplier or national requirements. In cases where no applicable standard exists and the meter supplier has not specified

		requirements, the meter shall be calibrated every three years and shall have an accuracy class of at least 0.5.
	Calibration requirements	1) Electricity meters under regulatory supervision shall comply with national standards, or the requirements specified by the meter supplier, or those specified by the transmission system operator. 2) Electricity meters not under regulatory supervision shall comply with national standards or the requirements specified by the meter supplier.
	Location	Install measuring instruments at the connection point with the green hydrogen production system.
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	$EF_{H_2,BAU,y}$	
Description	Emission factor of hydrogen produced from fossil fuels under business-as-usual operations in year y	
Unit	tCO ₂ e/ tH ₂	
Equations referred	(15)	
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission	
Monitoring frequency	Once per year	
Measurement methods and procedures	<u>For the preparation of the project proposal document</u> The latest $EF_{H_2,BAU,y}$ value announced by TGO shall be used. <u>For the monitoring of greenhouse gas emission reductions</u> The $EF_{H_2,BAU,y}$ value announced by TGO for the calendar year corresponding to the crediting period shall be used. In cases where the $EF_{H_2,BAU,y}$ value for that calendar year has not yet been announced by TGO, the latest $EF_{H_2,BAU,y}$ value announced by TGO shall be applied for that year.	
Entity/person responsible for the measurement	TGO	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	

Treatment of uncertainties	-
Additional comment	-

Data/parameter	$EF_{Elec,y}$	
Description	Emission factor for electricity generation/use in year y	
Unit	tCO ₂ /MWh	
Equations referred	(18) and (21)	
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	Once per year	
Measurement methods and procedures	<u>For the preparation of the project proposal document</u> The latest $EF_{Elec,y}$ value announced by TGO shall be used. <u>For the monitoring of greenhouse gas emission reductions</u> The $EF_{Elec,y}$ value announced by TGO for the calendar year corresponding to the crediting period shall be used. In cases where the $EF_{Elec,y}$ value for that calendar year has not yet been announced by TGO, the latest $EF_{Elec,y}$ value announced by TGO shall be applied for that year.	
Entity/person responsible for the measurement	TGO	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	-	

Data/parameter	$EC_{PJ,y}$	
Description	Electricity consumption of the project activity in year y	
Unit	MWh/year	
Equations referred	(18)	
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	Electricity consumption shall be recorded at least on a monthly basis.	
Measurement methods and procedures	Measurements shall be taken using a bidirectional kWh meter	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	Bidirectional kWh meter

	Accuracy class	1) Electricity meters under regulatory supervision shall comply with the requirements of the meter supplier and/or the requirements specified by the transmission system operator, or national requirements. 2) Electricity meters not under regulatory supervision shall comply with the requirements of the meter supplier or national requirements. In cases where no applicable standard exists and the meter supplier has not specified requirements, the meter shall be calibrated every three years and shall have an accuracy class of at least 0.5.
	Calibration requirements	1) Electricity meters under regulatory supervision shall comply with national standards, or the requirements specified by the meter supplier, or those specified by the transmission system operator. 2) Electricity meters not under regulatory supervision shall comply with national standards or the requirements specified by the meter supplier.
	Location	1) In the case of electricity from renewable energy, measuring instruments shall be installed at the connection point with the renewable energy generation system. 2) In the case of electricity from the grid, measuring instruments shall be installed at the connection point with the electricity grid.
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	TDL _y
Description	Proportion of electricity transmission losses in the grid for electricity supply in year y
Data unit	-
Equations referred	(18) and (21)
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission
Monitoring frequency	■ If Option 1 is chosen, the project developer shall monitor the value annually throughout the monitoring of greenhouse gas emission reductions.

	■ If Option 2 is chosen, the project developer shall apply this value consistently throughout the monitoring of greenhouse gas emission reductions.	
Measurement methods and procedures	Option 1: Report measurement results in cases where data on the amount of electricity supplied by the producer and the amount of electricity received by the consumer are available. Option 2: Use the latest value announced by TGO (equal to 0.0596), which is referenced from the Thailand Energy Balance Report 2023 by the Department of Alternative Energy Development and Efficiency. For rural low-voltage grids, a value of 0.2 shall be used.	
Entity/person responsible for the measurement	In the case of Option 1, the project developer shall be the reporting entity. In the case of Option 2, TGO shall be the reporting entity.	
Measuring instrument	Type of instrument	-
	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	-	
Additional comment	In cases where the measurement results differ significantly from previous measurements or other relevant data sources, additional measurements shall be conducted.	

Data/parameter	D_y	
Description	Round-trip distance between origin and destination of hydrogen road transport activity for utilization of the project activity in year y	
Unit	km	
Equations referred	(21)	
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	Round-trip distance shall be recorded at least monthly.	
Measurement methods and procedures	Round-trip distance shall be recorded from vehicles transporting hydrogen by road.	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	-

	Accuracy class	-
	Calibration requirements	-
	Location	-
QA/QC procedures	-	
Treatment of uncertainties	-	
Additional comment	-	

Data/parameter	EC _{H2,Pipeline,y}	
Description	Electricity consumption for pipeline transport of hydrogen of the project activity in year y	
Unit	MWh/year	
Equations referred	(22)	
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	Electricity consumption shall be recorded at least on a monthly basis.	
Measurement methods and procedures	Measurements shall be taken using a bidirectional kWh meter	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	Bidirectional kWh meter
	Accuracy class	1) Electricity meters under regulatory supervision shall comply with the requirements of the meter supplier and/or the requirements specified by the transmission system operator, or national requirements. 2) Electricity meters not under regulatory supervision shall comply with the requirements of the meter supplier or national requirements. In cases where no applicable standard exists and the meter supplier has not specified requirements, the meter shall be calibrated every three years and shall have an accuracy class of at least 0.5.
	Calibration requirements	1) Electricity meters under regulatory supervision shall comply with national standards, or the requirements specified by the meter supplier, or those specified by the transmission system operator.

		2) Electricity meters not under regulatory supervision shall comply with national standards or the requirements specified by the meter supplier.
	Location	Install measuring instruments at the hydrogen pipeline inlet.
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

Data/parameter	Q_y	
Description	Quantity of hydrogen transported in year y	
Unit	tH_2	
Equations referred	(21)	
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission	
Monitoring frequency	The quantity of hydrogen transported shall be recorded at least monthly.	
Measurement methods and procedures	Measurements shall be taken using a flow meter	
Entity/person responsible for the measurement	Project developer	
Measuring instrument	Type of instrument	Flow meter
	Accuracy class	Flow meters under supervision shall comply with the specifications of the measuring instrument supplier.
	Calibration requirements	Flow meters shall comply with either the specifications of the measuring instrument supplier or national requirements. If no applicable standard exists and the supplier does not specify requirements, the meter shall be calibrated every three years.
	Location	Install measuring instruments within the project area.
QA/QC procedures	-	
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.	
Additional comment	-	

9.3 Data and parameters not monitored

Data/parameter	$EF_{H_2,NG}$
Description	Emission factor of hydrogen produced from natural gas
Unit	$tCO_2e/ \text{ ton } H_2$
Equations referred	(4)

Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	9 tCO ₂ e/tH ₂
Source of Data	☐ Measured ☒ Other sources
Measurement methods and procedures	Reference: CDM AM0124 Hydrogen production from electrolysis of water
Treatment of uncertainties	Reference from value(s) applied
Additional comment	-

Data/parameter	FC _{i,BL,t}
Description	Consumption of fossil fuel type i in the baseline hydrogen production system in year t
Unit	unit
Equations referred	(8)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☒ Measured ☐ Other sources
Measurement methods and procedures	Record the quantity of fossil fuel consumed by the baseline hydrogen production.
Treatment of uncertainties	Reference from value(s) applied
Additional comment	

Data/parameter	NCV _i
Description	Net Calorific Value of fossil fuel type i.
Unit	GJ/Unit
Equations referred	(8)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☒ Measured ☒ Other sources
Measurement methods and procedures	Option 1 Data from the fuel supplier: The density of the fuel shall be recorded for each fuel delivery, and the values obtained shall then be used to calculate the annual weighted average. Option 2 Measurements by the project developer: In cases where the fuel supplier does not provide the fuel values, measurements shall be conducted in accordance with national or international fuel standards. The NCV of the fuel shall be determined for each fuel delivery, and the annual weighted average shall be calculated from the obtained values.

	Option 3 Regional or national standard values (applicable only to liquid fuels, in cases where data from the fuel supplier is not available). Such values shall be reviewed annually. Option 4 Reference to Table 1.2 in Chapter 1 of Volume 2 of the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories: The upper bound of the 95% confidence interval shall be used as the default value in cases where data from the fuel supplier is not available.
Treatment of uncertainties	Verify whether the uncertainty values specified under Option 1, Option 2, and Option 3 fall within the uncertainty ranges of the IPCC default values as indicated in Table 1.2 of Volume 2 of the 2019 Refinement to the 2006 IPCC Guidelines. In cases where the values are lower than this range, additional data shall be collected from the relevant laboratories to explain the cause of the results or further measurements shall be conducted. Laboratories for Option 1, Option 2, and Option 3 must be accredited under ISO standards or other equivalent standards.
Additional comment	-

Data/parameter	$EC_{H_2,BL,t}$
Description	Electricity consumption of the baseline hydrogen production system in year t
Unit	MWh
Equations referred	(8)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☒ Measured ☐ Other sources
Measurement methods and procedures	Record the quantity of fossil fuel consumed by the baseline hydrogen production.
Treatment of uncertainties	Reference from value(s) applied
Additional comment	

Data/parameter	$EF_{EF,BL,t}$
Description	Emission factor of the electricity source supplying the baseline hydrogen production system in year t
Unit	tCO ₂ e/MWh
Equations referred	(8)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☐ Measured ☒ Other sources

Measurement methods and procedures	Reference shall be made to the emission factor announcement for electricity generation/use (Emission factor) for projects and greenhouse gas reduction activities issued by TGO.
Treatment of uncertainties	Reference from value(s) applied
Additional comment	

Data/parameter	$EF_{CO_2,i}$
Description	Emission factor of fossil fuel combustion type i
Unit	tCO ₂ e/ GJ
Equations referred	(8) and (19)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☐ Measured ☒ Other sources
Measurement methods and procedures	Table 1.4 of Volume 2, Chapter 1 of the IPCC (2006)
Treatment of uncertainties	Reference from value(s) applied
Additional comment	

Data/parameter	$EF_{CO_2,TR,i}$
Description	Emission factor of fossil fuel type i used for hydrogen transport for utilization
Unit	gCO ₂ /t-km
Equations referred	(21)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-
Source of Data	☒ Measured ☒ Other sources
Measurement methods and procedures	In cases where alternative data sources are selected, the following values shall be applied: 1) For transportation by small vehicles, use 245 (gCO ₂ /t km). 2) For transportation by large vehicles, use 129 (gCO ₂ /t km).
Treatment of uncertainties	-
Additional comment	-

Data/parameter	$M_{H_2,BL,t}$
Description	Hydrogen output from the baseline hydrogen production system in year t
Unit	tH ₂
Equations referred	(8)
Purpose of data	☒ Baseline emission ☐ Project emission ☐ Leakage emission
Value(s) applied	-

Source of Data	☒ Measured ☐ Other sources
Measurement methods and procedures	-
Treatment of uncertainties	Uncertainty values shall be referenced from the measuring instruments.
Additional comment	-

Data/parameter	PL_{H_2}
Description	Proportion of physical hydrogen leakage from the project activity
Unit	%
Equations referred	(23)
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission
Value(s) applied	5
Source of Data	☐ Measured ☒ Other sources
Measurement methods and procedures	Reference: CDM AM0124 Hydrogen production from electrolysis of water
Treatment of uncertainties	-
Additional comment	-

Data/parameter	GWP_{H_2}
Description	Global Warming Potential (GWP) of hydrogen
Unit	tCO ₂ eq/tH ₂
Equations referred	(23)
Purpose of data	☐ Baseline emission ☒ Project emission ☐ Leakage emission
Value(s) applied	5.8
Source of Data	☐ Measured ☒ Other sources
Measurement methods and procedures	IPCC AR4 WG1 as under chapter 2.10.3.6
Treatment of uncertainties	-
Additional comment	-

10. References

- 1) CDM: AM0124 Hydrogen production from electrolysis of water version 01.1
- 2) Article 6.4 Mechanism: A6.4-AMM-001 Flaring or use of landfill gas.

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Version	Amendment	Entry into force	Description
01	-	24 September 2026	Initial issue