T-VER-P-METH-01-01

Grid Connected Renewable Electricity Generation

Version 01

Scope: 01 - Energy industries

Entry into force on 1 March 2023

1. Methodology Title	Grid Connected Renewable Electricity Generation
2. Project Type	Renewable energy or alternative energy substituted to fossil fuel
3. Scope	01 - Energy industries
4. Project Outline	Emission reduction by grid connected electricity generation from renewable sources.
5. Applicability	Projects with primary objective are to generate electricity from renewable sources for selling to national electricity network after internal usage[1] including the following activities: 1) Greenfield power plant establishment 2) Retrofit of an existing power plant 3) Rehabilitation of an existing power plant 4) Replacement of an existing power plant
6. Project Conditions	1. Electricity production from one or combination of any types of renewable sources. 2. Primary project objective is to sell electricity to national grid network with internal usage. 3. Requires additional proof of Additionality by TGO T-VER criteria.
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	**Renewable Energy** refers to a type of alternative energy produced from renewable resources such as solar, wind, hydro, biomass etc.
	Greenfield power plant refers to a new renewable power plant that is built and operated in an area where there is no renewable power plant prior to project activities.
	Retrofit of an existing power plant refer to investments in repairing or renovating existing power plants. To be able to produce more electricity or better efficiency without installing additional power generation systems This does not include regular maintenance.
	Rehabilitation of an existing power plant refers to investments in the restoration of existing power plants. but cannot be used due to severe damage or destruction due to natural disasters which may lead to optimization or the power generation capacity of the power

	plant without installing additional power generation systems This does not include regular maintenance.
	Replacement of an existing power plant refers to the investment to replace the power generation system
	National Grid means the electricity generation and distribution network in Thailand operated by Electricity Generating Authority of Thailand (EGAT), Provincial Electricity Authority (PEA) and Metropolitan Electricity Authority (MEA).
	Reservoir refers to a large basin created in a valley to store water. which is commonly used to build dams.
	Biomass residue means waste material from harvesting or processing agricultural commodities such as rice husks, sugarcane residue, rice straw, corncobs, etc., or wood and wood chips. that can be used to produce fuel
Notes	[1] Generating electricity from renewable energy for distribution into the power grid with internal use refers to, for example, the project has an installed capacity of the electricity generating system from renewable energy of 8 MW, with 7 MW being sold into the power grid with 1 MW power plant parasitic loads and other internal consumptions. In such case, the project developer can apply this methodology to the 7 MW portion sold back to the electricity grid.

Details of T-VER methodology for

Grid Connected Renewable Electricity Generation

1. Greenhouse gas emission reduction activities used in the calculations

Table 1. Sources and types of greenhouse gases

Greenhouse gas emission	Source	Greenhouse Gas	Details of activities that emit greenhouse gas emissions
Baseline Emission	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	Energy use within the project plant	CO_2	Purchasing electricity from the National Grid
			The use of fossil fuels such as backup generators, biomass loaders, etc.
	Hydroelectric power generation with large reservoirs	CH_4	The decomposition of plants and organic matter under the reservoir.
	The use of biomass from dedicated plantations	CO_2, CH_4	• Cultivation of biomass in a dedicated plantation • Transportation of biomass /biomass residues • Processing of biomass /biomass residues
Leakage	Transportation of Biomass	CO_2	The burning of fossil fuels in the transport of biomass

2. Applicability and Scope of Project

The nature of the activity must be a project that generates electricity from renewable energy such as solar energy, wind energy, hydropower, and biomass energy, etc., by generating electricity for distribution into the electricity grid. or to sell to the electricity grid and use it yourself However, more than one technology can be used together to produce electricity.

Project scope is electricity generation system from the project's renewable energy including various activities related to the Electricity generation of the project

There are characteristics of activities that fall into the additional scope. The details are as follows.

1) Hydroelectric power generation with a reservoir that meets at least one of the following conditions:

(a) Project activities are carried out on existing reservoirs without changing the volume of the reservoir.

(b) Project activities carried out in existing reservoirs; The volume of the reservoir increases and the power density of the project activities. According to the conditions set for greenhouse gas emissions from project implementation more than 4 W/m^2

(c) Project activities result in a new reservoir and power density of the power plant meeting the conditions set for project implementation GHG emissions greater than 4 W/m^2

2) Project activities with the installation of new power generating units with components that use renewable energy and non-renewable (e.g., generating electricity from wind power coupled with diesel fuel). Project activities including renovation, rehabilitation, or replacement of the power generation system to replace the old one can be used.

3) Electricity generation using cogeneration systems cannot use this method.

4) Projects related to capacity increase cannot use this methodology.

5) In the case of project activities that are generating electricity from gas from landfills Biogas from decomposing organic matter from waste and biogas from wastewater treatment Reducing greenhouse gas emissions from methane emissions avoided by recycling, use another methodology for calculations. But if the project developer has an activity that uses methane to produce electricity to sell to the electricity grid, this methodology can be used.

6) In the event that the project activity uses electricity generated from the project to be used by itself in a factory or business establishment that is the same juristic person as the project owner, this methodology can be used. However, the reduction from this activity is calculated using T-VER-P-METH-01-02 together with this methodology.

3. Additionality

The project must undergo further proof of operation from normal operations. (Additionality) by using the "Guidelines to prove operations in addition to normal operations. (Additionality) under the Thailand Voluntary Emission Reduction Program (T-VER)" as prescribed by the TGO.

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 substituting with renewable energy is the greenhouse gas emissions from electricity generation using natural gas in the national grid.

4.1 Baseline Scenario for Greenfield power plants.

Baseline scenario for the installation of new power plants is the generation of electricity from project activities for selling through the national grid, which increases capacity from new sources to the grid.

4.2 Baseline Scenario for Retrofit, Rehabilitation or Replacement)

For project activities related to the improvement, restoration, or replacement of the existing power generation system, the base case is the situation of continuous operation of the existing power plant using historical power generation data to determine the amount of power generation of the original power plant in the base case. By assuming that the situation in the past before the implementation of the project activities. The power generation system will continue to be able to supply electricity to the grid at historical average levels until the time the power plant is likely to be renovated, restored, or replace the old one. and after that time onwards. The base case is the project activity, and that portion of the electricity generation will be equal to the net electricity quantity of the project. This will not be considered a reduction in greenhouse gas emissions.

5. Baseline Emission

Baseline emission consider only carbon dioxide (CO_2) emissions from natural gas-fired power generation of the national grid's power generation system that has been replaced by the electricity generated by the project. only which can calculate greenhouse gas emissions as follows:

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

Where

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

$EG_{PJ.y}$ = Quantity of net electricity generation that is produced and fed into the grid in year y (MWh)

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

5.1 Calculation of $EG_{PJ.y}$

$EG_{PJ.y}$ is the amount of net power generation distributed to the grid from project activities. The calculations can be divided according to the nature of the activities as follows:

5.1.1 Greenfield power plants

$$EG_{PJ.y} = EG_{PJ,facility,y} \quad \text{Equation (2)}$$

Where

$EG_{PJ,facility,y}$ = Quantity of net electricity generation supplied by the project plants/units to the grid in year y (MWh/year)

Note: The amount of net power generation sold to the electricity grid ($EG_{PJ,facility,y}$) in this case refers to the amount of electricity produced minus the amount of electricity generated for self-consumption in project activities. and the amount of electricity purchased from the electricity grid for project activities.

5.1.2 Retrofit , rehabilitation and replacement of an existing power for the generation of electricity from hydro, solar and wind power.

In the case of improvement, restoration, or replacement of the existing power generation system for hydro, solar and wind power generation, the power generation can vary greatly from

year to year due to natural variations such as water availability. different rain, wind speed, or solar radiation The power generation data in this case must take into account such uncertainty, so the method of determining such uncertainty requires a statistical process to improve historical power generation by standard deviations. The $EG_{PJ.y}$ value can be found as the equation below.

$$EG_{PJ.y} = \begin{cases} \max(EG_{PJ,facility.y} - (EG_{historical} + \sigma_{historical}), 0), \text{ until } DATE_{BaselineRetrofit} \\ 0, \text{ after } DATE_{BaselineRetrofit} \end{cases} \quad \text{Equation (3)}$$

Where

$EG_{historical}$ = Annual average historical net electricity generation from pre-existing power generation systems (MWh). See 5.2 for how to determine this parameter.

$\sigma_{historical}$ = Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy power plants/units that was operated at the project site prior to the implementation of the project activity (MWh)

$DATE_{BaselineRetrofit}$ = The amount of time required to replace existing equipment in the absence of project activity (date). This parameter does not apply to restoration projects. (Rehabilitation)

5.1.3 Retrofit , rehabilitation and replacement of an existing power for the generation of electricity from biomass

$EG_{PJ.y}$ can be calculated using this equation.

$$EG_{PJ.y} = \begin{cases} EG_{PJ,facility.y} - EG_{BL,retrofit,y}), \text{ until } DATE_{BaselineRetrofit} \\ 0, \text{ after } DATE_{BaselineRetrofit} \end{cases} \quad \text{Equation (4)}$$

Where

$$EG_{BL,retrofit,y} = \max(EG_{historicaly}, EG_{estimated,y}) \quad \text{Equation (5)}$$

$EG_{BL,retrofit,y}$ = The net amount of electricity sold into the grid in the absence of project activity requires a higher value between $EG_{actual,y}$ and $EG_{estimated,y.}$ in year y (MWh)

5.2 Calculation of $EG_{historical}$

1) The average historical net power generation level transmitted by the existing network and equipment covering all data from the most recent available year or month, week, or other time period. until the time it was updated or modified in a manner that has a significant impact (5% or more) must be applied.

2) the project developer may choose between two retrospective periods. Using longer intervals may result in lower standard deviations. And using a shorter timeframe may allow it to reflect a more current (technical) situation.

3) The project developer may select the following two historical data ranges for $EG_{historical}$

   (a) the past 3 years (5 years for hydroelectric power generation)[1] before the project activities.

   (b) The time period from the calendar year following $DATE_{hist}$, up to the last calendar year prior to the implementation of the project, as long as this time span includes at least five calendar years, where $DATE_{hist}$ is latest point in time between:

      (i) The commissioning of the plant/unit; or

      (ii) If applicable: the last capacity addition to the plant/unit; or

      (iii) If applicable: the last retrofit or rehabilitation of the plant/unit.

4) In case of rehabilitation where the power plant/unit did not operate for last five calendar years before the rehabilitation starts, $EG_{historical}$ is equal to zero.

5.3 Calculation of $DATE_{BaselineRetrofit}$

1) Estimated date to be replaced with existing equipment/additional installations in the event of no project activity ($DATE_{BaselineRetrofit}$). Participants may take into account the typical average technical life of that type of equipment. which must be specified and documented according to the manual to determine the remaining life of the equipment.

[1] In the event that there is no historical data for 3 years due to the latest revision or unusual circumstances such as natural disasters, conflicts and restrictions on transmission. to propose a new method or amendment

2) The point in time when the existing equipment would need to be replaced/retrofitted in the absence of the project activity should be chosen in a conservative manner that is, if a range is identified, the earliest date should be chosen.

6. Project Emission

6.1 Electricity generation from renewable energy such as solar, wind, wave, tidal and hydro.

For electricity generation activities from renewable energy such as solar, wind, wave, tidal and hydro (which does not fall under clause 6.2), greenhouse gas emissions from project implementation or PE_y will be zero. Except for projects that use fossil fuels, T-VER-P-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition is applied to determine PE_y.

6.2 Electricity generation from hydro power with a large reservoir hydro plant

Calculation of greenhouse gas emissions from large-scale hydropower projects Use this equation to calculate.

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

Where

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

$PE_{FF,j,y}$ = Project emissions from fossil fuel consumption in year y (tCO_2e/year)

$PE_{HP,y}$ = Project emissions from water reservoirs of hydropower plants in year y (tCO_2e/year)

The amount of greenhouse gas emissions from the use of fossil fuels ($PE_{FF,j,y}$) shall be calculated using the calculation tool. T-VER-P-TOOL-02-01 lasted edition of the "Calculation of CO_2 emissions from project emission or leakage emission from fossil fuel combustion" and the large reservoir emissions of hydroelectric power generation ($PE_{HP,y}$) shall be calculated accordingly. The steps are as follows:

(1) The power density (*PD*) of the project activity is calculated as follows:

$$PD = \frac{Cap_{PJ} - Cap_{BL}}{A_{PJ} - A_{BL}} \quad \text{Equation (7)}$$

Where

PD = Power density of the project activity (W/m^2)

Cap_{PJ} = Installed capacity of the hydropower plant after the implementation of the project activity (W)

Cap_{BL} = Installed capacity of the hydropower plant before the implementation of the project activity (W). For new hydropower plants, this value is zero

A_{PJ} = Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full (m^2)

A_{BL} = Area of the single or multiple reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero

(2) For hydropower project activities that result in new single or multiple reservoirs and hydropower project activities that result in the increase of single or multiple existing reservoirs, project proponents shall account for CH_4 and CO_2 emissions from the reservoirs, estimated as follows:

a. For integrated hydropower project PD of the entire project is calculated as follows:

$$PD = \frac{\sum Cap_{PJ,i}}{\sum A_{PJ,j}} \quad \text{Equation (8)}$$

Where

i = Individual power plants included in integrated hydropower project

j = Individual reservoirs included in integrated hydropower project

b. If the power density of the project activity using equation (7) or in case of integrated hydropower project using equation (8) is greater than 4 W/m^2 and less than or equal to 10 W/m^2

$$PE_{HP,y} = \frac{EF_{Res} \times TEG_y}{1000}$$ Equation (9)

Where

$PE_{HP,y}$ = Project emissions from water reservoirs (tCO$_2$e/y)

EF_{Res} = Default emission factor for emissions from reservoirs of hydropower plants (kgCO$_2$e/MWh)

TEG_y = Total electricity produced by the project activity, including the electricity supplied to the grid and the electricity supplied to internal loads, in year y (MWh)

c. If the power density of the project activity is greater than 10 W/m^2:

$$PE_{HP,y} = 0$$ Equation (10)

6.3 Electricity generation from biomass

6.3.1 In case of using fossil fuels due to project implementation

To calculate greenhouse gas emissions from fossil fuel, T-VER-P-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition is applied.

6.3.2 In the case of biomass from dedicated plantations

In the case of biomass from a specific plantation area, greenhouse gas emissions from project implementation, use T-VER-P-TOOL-02-02 "Calculation of Greenhouse Gas Emissions from Project Emission and Leakage Emission for Biomass", latest edition.

7. Leakage Emission

7.1 In the case of electricity generation from renewable energy from hydro, solar, wind, tidal and tidal energy

Not Applicable

7.2 In the case of electricity generation from biomass

For the generation of electricity from biomass and/or biomass residue, project developers must estimate greenhouse gas emissions outside the project scope using T-VER-P-TOOL-02-02 "Calculation of Greenhouse Gas Emissions from Project Emission and Leakage Emission for Biomass", latest edition.

8. Emission Reduction

Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y \quad \text{Equation (11)}$$

Where

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

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

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

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

9. Monitoring methodology procedure

9.1 Monitoring procedures

1) The project developer explains and specify the steps for monitoring the project activity data (Activity data) or verify all measurement results in the project proposal document. including the type of measuring instruments used Person responsible for monitoring results and verifying information Calibration of measuring instruments (if any) and procedures for warranty and quality control Where methods have different options, such as using default values or on-site

measurements The project developer must specify which option to use. In addition, the installation, maintenance, and calibration of measuring instruments should be carried out in accordance with the instructions of the equipment manufacturer and in accordance with national standards, or international standards such as IEC 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 9.2.

9.2 Parameters monitored

Parameter	$EF_{Elec,y}$
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 generation/consumption for projects and activities of greenhouse gas reduction published by TGO.
Measurement procedures	**For the preparation of project design documents** Use the latest $EF_{Elec,y}$ published by TGO **For carbon credit issuance** Use the $EF_{Elec,y}$ values announced by TGO according to the year of the carbon credit issuance. However, in the case that the year of the carbon credit issuance does not have $EF_{Elec,y}$ values published by TGO, use the latest $EF_{Elec,y}$ values published by TGO in that year instead.

Parameter	$EG_{PJ,facility,y}$
Data unit	MWh/year
Description	Quantity of net electricity generation supplied by the project plants/units to the grid in year y (MWh/year)
Source of data	Electricity meter (kWh meter)
Measurement procedures	This parameter should be measured using a bidirectional kWh meter or using a unidirectional kWh meter and calculated as the difference between: (a) the amount of electricity supplied by the project's electricity generation to the grid; and (b) the amount of electricity of the project power plants purchased from the grid.
Monitoring frequency	Continuous monitoring and at least monthly recording.

Parameter	TEG_y
Data unit	MWh/year
Description	Total electricity produced by the project activity, including the electricity supplied to the grid and the electricity supplied to internal loads, in year y
Source of data	Project activity site
Measurement procedures	Electricity meters
Monitoring frequency	Continuous measurement and at least monthly recording
Any comment	Applicable to hydro power project activities with a power density greater than 4 W/m^2 and less than or equal to 10 W/m^2

Parameter	Cap_{PJ}
Data unit	W
Description	Installed capacity of the hydro power plant after the implementation of the project activity
Source of data	Project site
Measurement procedures	Determine the installed capacity based on manufacturer's specifications or commissioning data or recognized standards
Monitoring frequency	Once at the beginning of each crediting period

Parameter	A_{PJ}
Data unit	m^2
Description	Area of the single or multiple reservoirs measured in the surface of the water, after the implementation of the project activity, when the reservoir is full
Source of data	Project site
Measurement procedures	Measured from topographical surveys, maps, satellite pictures, etc
Monitoring frequency	Once at the beginning of each crediting period

9.3 Parameters not monitored

Parameter	$EG_{historical}$
Data unit	MWh/year
Description	Annual average historical net electricity generation delivered to the grid by the existing renewable energy power plant that was operated at the project site prior to the implementation of the project activity
Source of data	Project activity site
Value to be applied	Electricity meters

Parameter	$\sigma_{historical}$
Data unit	MWh/year
Description	Standard deviation of the annual average historical net electricity generation delivered to the grid by the existing renewable energy power plant that was operated at the project site prior to the implementation of the project activity
Source of data	Calculated from data used to establish $EG_{historical}$
Value to be applied	Parameter to be calculated as the standard deviation of the annual generation data used to calculate $EG_{historical}$ for retrofit, or rehabilitation or replacement project activities

Parameter	$DATE_{BaselineRetrofit}$
Data unit	date
Description	Point in time when the existing equipment would need to be replaced in the absence of the project activity
Source of data	Project activity site
Value to be applied	As per provisions in the methodology above

Parameter	$DATE_{hist}$
Data unit	date
Description	Point in time from which the time span of historical date for retrofit, rehabilitation or replacement project activities may start
Source of data	Project activity site
Value to be applied	$DATE_{hist}$ is the latest point in time between: (a) The commercial commissioning of the plant/unit; (b) If applicable: the last capacity addition to the plant/unit; or (c) If applicable: the last retrofit or rehabilitation of the plant/unit

Parameter	EF_{Res}
Data unit	$kgCO_2e/MWh$

Description	Default emission factor for emissions from reservoirs
Source of data	CDM Methodology: ACM0002: Consolidated baseline methodology for grid-connected electricity generation from renewable sources. Version 20
Value to be applied:	90 $kgCO_2e/MWh$

Parameter	Cap_{BL}
Data unit	W
Description	Installed capacity of the hydropower plant before the implementation of the project activity. For new hydropower plants, this value is zero
Source of data	Project site
Value to be applied	Determine the installed capacity based on manufacturer's specifications or recognized standards

Parameter	A_{BL}
Data unit	m^2
Description	Area of the single or multiple reservoirs measured in the surface of the water, before the implementation of the project activity, when the reservoir is full (m^2). For new reservoirs, this value is zero
Source of data	Project site
Value to be applied	Measured from topographical surveys, maps, satellite pictures, etc.

10. References

Clean Development Mechanism (CDM)

1) AMS-I.D.: Grid connected renewable electricity generation. Version 18
2) ACM0002: Consolidated baseline methodology for grid-connected electricity generation from renewable sources. Version 20
3) TOOL01: Tool for the demonstration and assessment of additionality. Version 07
4) TOOL03: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion. Version 03
5) TOOL16: Project emissions from cultivation of biomass. Version 05

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

Version	Amendment	Entry into force	Description
01	-	1 March 2023	- Change document code from TVER-METH-01-01 Version 01. - Add the definition of project starting date. - Change the sign and the meaning for parameter of $EF_{grid,y}$ and revise the data sources.
01	-	24 August 2022	Initial adoption.