T-VER-P-TOOL-02-06

Tool to Uncertainty Analysis for the Equation Calculating Greenhouse Gas Emission Reductions

Version 01

Effective from July 23, 2026

1. Introduction

This document serves as a tool for estimating and analyzing uncertainty (Uncertainty Analysis) in the equations used to calculate the reduction, absorption, and storage of greenhouse gases, as well as the emissions of greenhouse gases and the trends of their reduction, absorption, and storage in subsequent years. It provides methodologies for project developers and examples of how to combine uncertainty calculations across categories in order to derive the overall uncertainty value of greenhouse gas emissions

2. Definitions

- **Uncertainty** refers to the lack of information about the true value of a variable, which can be described by a Probability Density Function (PDF) that represents the range and likelihood of possible values. Uncertainty depends on the analyst's data, which in turn relies on the quality and quantity of the information used, as well as the knowledge of the underlying processes and estimation methods.
- **Absolute uncertainty** refers to an uncertainty of a measured value, expressed as a single numerical quantity and has the same units as measured quantity and represents the magnitude of the margin of error deviated from the true value.
- **Percentage uncertainty** refers to the ratio of the expanded uncertainty to the actual measured value, expressed as a percentage to indicate the level of reliability of the measurement.
- **Standard deviation** refers to a measure of the dispersion of a dataset. It can be applied to probability distributions, random variables, populations, or multisets.
- **Mean** refers to the statistical central value obtained by summing all data points and dividing by the total number of data points. It represents the central tendency or the representative value of a dataset.
- **The 95% confidence interval** refers to the range of values calculated from a sample, within which there is 95% statistical confidence that the true population mean or parameter lies. For example, if sampling were repeated 100 times, in 95 of those cases the confidence interval would cover the true value, while in about 5% (5 cases) it may not.

3. Scope and Applicability

This tool applies to all methodologies for activities involving the reduction, absorption, and storage of greenhouse gases under Thailand's Voluntary Emission Reduction Program (T-VER), specifically for Premium T-VER. The tool may be revised in the future to cover methodologies related to emission reduction activities at other levels.

4. Uncertainty Analysis

The approach to uncertainty analysis is divided into multiple calculations. When uncertainties arise from different terms used in the calculations, they can be combined as follows

4.1 Combined Uncertainty Calculation

The calculation of combined uncertainty is divided into two cases: (1) calculation of combined uncertainty from multiplication or division, and (2) calculation of combined uncertainty from addition or subtraction, with details as follows:

4.1.1 Calculation of combined uncertainty from multiplication or division

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

$$\mathrm{UNC_{total}} = \sqrt{\mathrm{UNC_1^2} + \ldots + \mathrm{UNC_i^2} + \ldots + \mathrm{UNC_n^2}} \qquad \textbf{Equation (1)}$$

Where

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

$\mathrm{UNC_i}$ = The percentage uncertainties associated with each of the quantities

4.1.2 Calculation of combined uncertainty from addition or subtraction

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

$$\mathrm{UNC_{total}} = \frac{\sqrt{(UNC_1 * x_1)^2 + \ldots + (UNC_i * x_i)^2 + \ldots + (UNC_n * x_n)^2}}{\left| x_1 + x_i + \ldots + x_n \right|} \qquad \textbf{Equation (2)}$$

Where

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

$\mathrm{UNC_i}$ = The percentage uncertainties associated with the data point

x_i = The uncertain quantities associated with them

4.2 Calculation of uncertainty from a dataset

The calculation of uncertainty from a dataset involves determining the uncertainty of the sample mean using either the z-score or the t-score, depending on the desired confidence level and the number of data points. The guidelines are as follows:

1) When the number of data points (n) is greater than or equal to 30, apply the z-score distribution.
2) When the number of data points (n) is less than 30, apply the t-score distribution.

Note: Other uncertainty related calculation not stated in this document shall comply with the latest IPCC guidelines.

4.2.1 Applying z-score distribution

Use the z-score distribution when the population standard deviation (σ) is known or the sample size is equal or larger than 30. For a 95% confidence level, the z-score equals 1.96, and it does not depend on the sample size since σ is known. The uncertainty of the sample mean for a dataset with n observations can be calculated as follows:

$$\text{UNC}(\bar{x}) = \pm z \frac{\sigma}{\sqrt{n}} \qquad \textbf{Equation (3)}$$

where

$\text{UNC}(\bar{x})$	=	Uncertainty of the mean (unit)
σ	=	Population Standard Deviation (unit)
z	=	1.96 at the 95% confidence level
n	=	Sample size

This applies to a normal distribution (bell curve). If the distribution differs from normal, other relevant statistical theories should be referenced. To verify whether a dataset follows a normal distribution, at least three methods can be applied:

1) Observe the histogram of the data to see if it resembles a bell curve.
2) Consider statistical measures, which can be done in several ways. For example, if the dataset is normally distributed, the mean, median, and mode should be equal (Mean = Median = Mode). Alternatively, check whether the skewness is zero (Skewness = 0) and the kurtosis is three (Kurtosis = 3).
3) Perform hypothesis testing.

Whether a dataset follows a normal distribution does not require a minimum number of data points to be strictly specified. However, in practice, when testing for normality, the dataset should generally contain no fewer than 20–30 data points in order to reduce sampling error.

Calculation of the population standard deviation

The population standard deviation can be calculated as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n}} \qquad \textbf{Equation (4)}$$

Where

σ = Population Standard Deviation (unit)

x = Data set values (unit)

$\bar{x}$ = Mean of the dataset (unit)

n = Sample size

Calculation of the dataset mean

Calculation of the dataset mean can be calculated as follows:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \textbf{Equation (5)}$$

Where

$\bar{x}$ = Mean of the dataset (unit)

x_i = Data set values (unit)

n = Sample size

4.2.2 Applying t-score distribution

Use the t-score when the population standard deviation (σ) is unknown and sample size is smaller than 30. For a 95% confidence level, the t-score varies depending on the number of data points collected (see Appendix Table 1). The uncertainty of the sample mean for a dataset with n observations can be calculated as follows:

$$\text{UNC}(\bar{x}) = \pm t\frac{s}{\sqrt{n}} \quad \text{Equation (6)}$$

Where

UNC ($\bar{x}$)	=	Uncertainty of the mean (unit)
s	=	Standard deviation of the dataset (unit)
t	=	t-score at the 95% confidence level
n	=	Sample size

Calculation of the sample standard deviation

Calculation of the sample standard deviation can be calculated as follows:

$$s = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})^2}{n-1}} \quad \text{Equation (7)}$$

Where

s	=	Standard deviation of the dataset (unit)
x	=	Data set values (unit)
$\bar{x}$	=	Mean of the dataset (unit)
n	=	Sample size

Calculation of the dataset mean

The calculation of the dataset mean shall be performed using Equation (5).

5. References

1) IPCC 2006, *2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme*, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan. Volume 1, Chapter 3: Uncertainties.
2) IPCC 2019, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Calvo Buendia, E., et al. (eds). Published: IPCC, Switzerland.
3) Hughes, I., & Hase, T. (2010). *Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis*. Oxford University Press.

4) Pishro-Nik, H. *Introduction to Probability, Statistics, and Random Processes*; Kappa Research LLC: Montgomery, PA, USA, 2014; Available online: **https://www.probabilitycourse.com** (accessed on 1 April 2026)

5) Walpole, Myers, Myers & Ye. Probability and Statistics for Engineers and Scientists. 9th ed. Boston: Pearson, 2012.

Appendix 1

t-score calculation table

t-distribution

	Confidence Level									
	60%	70%	80%	85%	90%	95%	98%	99%	99.8%	99.9%
	Level of Significance									
2 Tailed	0.40	0.30	0.20	0.15	0.10	0.05	0.02	0.01	0.002	0.001
1 Tailed	0.20	0.15	0.10	0.075	0.05	0.025	0.01	0.005	0.001	0.0005
df										
1	1.376	1.963	3.133	4.195	6.320	12.69	31.81	63.67	—	—
2	1.060	1.385	1.883	2.278	2.912	4.271	6.816	9.520	19.65	26.30
3	0.978	1.250	1.637	1.924	2.352	3.179	4.525	5.797	9.937	12.39
4	0.941	1.190	1.533	1.778	2.132	2.776	3.744	4.596	7.115	8.499
5	0.919	1.156	1.476	1.699	2.015	2.570	3.365	4.030	5.876	6.835
6	0.906	1.134	1.440	1.650	1.943	2.447	3.143	3.707	5.201	5.946
7	0.896	1.119	1.415	1.617	1.895	2.365	2.999	3.500	4.783	5.403
8	0.889	1.108	1.397	1.592	1.860	2.306	2.897	3.356	4.500	5.039
9	0.883	1.100	1.383	1.574	1.833	2.262	2.822	3.250	4.297	4.780
10	0.879	1.093	1.372	1.559	1.813	2.228	2.764	3.170	4.144	4.586
11	0.875	1.088	1.363	1.548	1.796	2.201	2.719	3.106	4.025	4.437
12	0.873	1.083	1.356	1.538	1.782	2.179	2.682	3.055	3.930	4.318
13	0.870	1.079	1.350	1.530	1.771	2.160	2.651	3.013	3.852	4.221
14	0.868	1.076	1.345	1.523	1.761	2.145	2.625	2.977	3.788	4.141
15	0.866	1.074	1.341	1.517	1.753	2.131	2.603	2.947	3.733	4.073
16	0.865	1.071	1.337	1.512	1.746	2.120	2.584	2.921	3.687	4.015
17	0.863	1.069	1.333	1.508	1.740	2.110	2.567	2.899	3.646	3.965
18	0.862	1.067	1.330	1.504	1.734	2.101	2.553	2.879	3.611	3.922
19	0.861	1.066	1.328	1.500	1.729	2.093	2.540	2.861	3.580	3.884
20	0.860	1.064	1.325	1.497	1.725	2.086	2.529	2.846	3.552	3.850
21	0.859	1.063	1.323	1.494	1.721	2.080	2.518	2.832	3.528	3.820
22	0.858	1.061	1.321	1.492	1.717	2.074	2.509	2.819	3.505	3.792
23	0.857	1.060	1.319	1.489	1.714	2.069	2.500	2.808	3.485	3.768
24	0.857	1.059	1.318	1.487	1.711	2.064	2.493	2.797	3.467	3.746
25	0.856	1.058	1.316	1.485	1.708	2.060	2.486	2.788	3.451	3.725
26	0.856	1.058	1.315	1.483	1.706	2.056	2.479	2.779	3.435	3.707
27	0.855	1.057	1.314	1.482	1.703	2.052	2.473	2.771	3.421	3.690
28	0.855	1.056	1.313	1.480	1.701	2.048	2.468	2.764	3.409	3.674
29	0.854	1.055	1.311	1.479	1.699	2.045	2.463	2.757	3.397	3.660
30	0.854	1.055	1.310	1.477	1.697	2.042	2.458	2.750	3.386	3.646
40	0.851	1.050	1.303	1.468	1.684	2.021	2.424	2.705	3.307	3.551
50	0.849	1.047	1.299	1.462	1.676	2.009	2.404	2.678	3.262	3.496
60	0.848	1.045	1.296	1.458	1.671	2.000	2.391	2.661	3.232	3.460
70	0.847	1.044	1.294	1.456	1.667	1.994	2.381	2.648	3.211	3.435
80	0.846	1.043	1.292	1.453	1.664	1.990	2.374	2.639	3.196	3.417
90	0.846	1.042	1.291	1.452	1.662	1.987	2.369	2.632	3.184	3.402
100	0.845	1.042	1.290	1.451	1.660	1.984	2.365	2.626	3.174	3.391
∞	0.842	1.036	1.282	1.440	1.645	1.960	2.327	2.576	3.091	3.291

Appendix 2

Example of uncertainty calculation

1. Example of uncertainty calculation from statistical operation

In various calculations, when uncertainties arise from different terms involved, the combined uncertainty can be obtained as follows:

1.1 An example of uncertainty calculation from multiplication or division is as follows:

For multiplication

1) Specification of the dataset

(1.0 ± 0.1%) x (2.0 ± 0.2%)

2) Calculate the combined uncertainty

$$UNC_{total} = \sqrt{(0.1)^2 + (0.2)^2} = 0.22\%$$

3) Summary of the calculation

(1.0 x 2.0) ± UNC_{total} = 2.0 ± 0.22%

For division

1) Specification of the dataset

(1.0 ± 0.1%) / (2.0 ± 0.2%)

2) Calculate the combined uncertainty

$$UNC_{total} = \sqrt{(0.1)^2 + (0.2)^2} = 0.22\%$$

3) Summary of the calculation

(1.0 / 2.0) ± UNC_{total} = 0.5 ± 0.22%

1.2 An example of uncertainty calculation from addition or subtraction is as follows:

For addition

1) Specification of the dataset

(1.0 ± 1%) + (2.0 ± 2%)

2) Calculate the combined uncertainty

$$UNC_{total} = \frac{\sqrt{(1 * 1.0)^2 + (2 * 2.0)^2}}{\left| 1.0 + 2.0 \right|} = 1.37\%$$

3) Summary of the calculation

(1.0 + 2.0) $\pm$ UNC_{total} = 3.0 $\pm$ 1.37%

For subtraction

1) Specification of the dataset

(2.0 $\pm$ 1%) - (1.0 $\pm$ 2%)

2) Calculate the combined uncertainty

$$UNC_{total} = \frac{\sqrt{(2 * 1.0)^2 + (1 * 2.0)^2}}{\left| 2.0 - 1.0 \right|} = 2.82\%$$

3) Summary of the calculation

(2.0 – 1.0) $\pm$ UNC_{total} = 1.0 $\pm$ 2.82%

2. Example of uncertainty calculation from a dataset

2.1 Calculation of uncertainty from z-score

1) Specification of the dataset
   - Number of data points (N) = 50
   - Population standard deviation (σ) = 20
   - Sample mean ($\bar{x}$) = 100
2) Calculate the uncertainty of the dataset mean

$$\text{UNC } (\bar{x}) = \pm 1.96 \frac{20}{\sqrt{50}}$$

$$= \pm 5.543$$

3) Summary of the calculation

$$\bar{x} = 100 \pm 5.543$$

2.2 Calculation of uncertainty from t-score

1) Specification of the dataset
   - Number of data points (N) = 10
   - Standard deviation of the dataset (s) = 6
   - Sample mean ($\bar{x}$) = 50
2) Calculate the t-score
   - From a dataset of 10 samples, the degree of freedom (df) from the table in Appendix 1 is 9, which gives a t-score of 2.262, for example.
3) Calculate the uncertainty of the dataset mean

$$\text{UNC } (\bar{x}) = \pm 2.262 \frac{6}{\sqrt{10}}$$

$$= \pm 4.295$$

4) Summary of the calculation

$$\bar{x} = 50 \pm 4.295$$

Appendix 3

Uncertainty Analysis of emissions from the baseline case under the methodology T-VER-P-METH-01-01: Grid Connected Renewable Electricity Generation.

1. Baseline emissions

Baseline emissions consider only carbon dioxide (CO_2) emissions from electricity generation using natural gas in the national grid system, which are replaced by the electricity generated from the project. The calculation of baseline emissions is as follows:

$BE_y = EG_{PJ,y} \times EF_{Elec,y}$

Where

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

$EG_{PJ,y}$ = Net electricity generation supplied to the grid from the project activity in year y (MWh)

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

2. Specification of dataset parameters for baseline emissions calculation

Specification of dataset parameters for baseline emissions calculation are as follows:

NO.	Parameter	Value	Sources of Uncertainty
1	$EG_{PJ,y}$	1,000,000 ± 0.2% MWh/year	Measuring instrument
2	$EF_{Elec,y}$	0.4004 ± 0.2% tCO_2/MWh	TGO

3. Determination of baseline emissions calculation

By substituting the dataset into the equation for baseline emissions calculation, the results can be computed as follows:

$$UNC_{total} \sqrt{(0.2)^2 + (0.2)^2} = 0.28\%$$

BE_y = (1,000,000 ± 0.2%) x (0.4004 ± 0.2%)

= 400,400 ± 0.28% tCO_2eq/year

4. Calculation summary

The baseline emissions amount to 400,400 ± 0.28% tCO_2eq/year.

Appendix 4

Uncertainty Analysis of baseline emissions under the methodology T-VER-P-METH-12-01: Methane Capture from Anaerobic Wastewater Treatment for Utilization or Flaring.

1. Baseline emissions

The calculation of baseline emissions is as follows:

$$BE_y = BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{S,final,y}$$

Where

BE_y = Baseline emissions in year y (tCO_2eq/year)

$BE_{power,y}$ = Baseline emissions from electricity or fossil fuel consumption in year y (tCO_2eq/year)

$BE_{ww,treatment,y}$ = Baseline emissions from wastewater treatment processes in year y (tCO_2eq/year)

$BE_{s,treatment,y}$ = Baseline emissions from sludge treatment processes in year y (tCO_2eq/year)

$BE_{ww,discharge,y}$ = Baseline emissions from degradable organic matter in treated wastewater discharged into water in year y (tCO_2eq/year)

$BE_{S,final,y}$ = Baseline emissions from anaerobic decomposition of final sludge in year y (tCO_2eq/year)

2. Dataset parameter specification for baseline emissions calculation

2.1 Baseline emissions from electricity or fossil fuel consumption

Baseline emissions from energy use must cover all equipment in the baseline wastewater and sludge treatment system. If the baseline operation utilizes biogas for energy supply to auxiliary equipment, this should be considered with an emission factor equal to zero. Baseline emissions from electricity or fossil fuel consumption can be calculated as follows:

$$BE_{power,y} = BE_{EC,y} + BE_{FF,y}$$

Where

$BE_{power,y}$ = Baseline emissions from electricity or fossil fuel consumption in year y (tCO_2eq/year)

$BE_{EC,y}$ = Baseline emissions from electricity consumption in year y (tCO_2eq/year)

$BE_{FF,y}$ = Baseline emissions from fossil fuel consumption in year y (tCO_2eq/year)

2.1.1 Baseline emissions from electricity consumption

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

$$BE_{EC,y} = \sum_{j} EC_{PJ,j,y} \times EF_{EF,j,y} \times (1+ TDL_{j,y})$$

Where

$BE_{EC,y}$ = Baseline emissions from electricity consumption in year y (tCO_2eq/year)

$EC_{BL,j,y}$ = Electricity consumption of the project at electricity source type j in year (MWh/year)

$EF_{Elec,y}$ = Baseline emissions factor for electricity generation/use in year y (tCO_2/MWh)

$TDL_{j,y}$ = Proportion of electricity transmission losses in the grid for supply to source j in year y

j = Sources of electricity consumption from the project activity

NO.	Parameter	Value	Sources of Uncertainty
1	$EC_{BL,j,y}$	1,000,000 ± 0.2% MWh/year	Measuring instrument
2	$EF_{Elec,y}$	0.4004 ± 0.2% tCO_2/MWh	TGO
3	$TDL_{j,y}$	6.09	-

2.1.2 Baseline emissions from fossil fuel consumption

Baseline emissions from fossil fuel consumption can be calculated as follows:

$$BE_{FF,y} = FC_{i,BL} \times NCV_i \times EF_{CO2,i} \times 10^{-6}$$

Where

$BE_{FF,y}$ = Baseline emissions from fossil fuel consumption in year y (tCO_2eq/year)

$FC_{i,BL}$ = Baseline diesel fuel consumption (unit)

NCV_i = Net calorific value of diesel fuel (GJ/unit)

$EF_{CO2,i}$ = CO_2 emissions from diesel fuel combustion ($kgCO_2$/TJ)

NO.	Parameter	Value	Sources of Uncertainty
1	$FC_{i,BL}$	1,000 ± 0.3% litre	Measuring instrument
2	NCV_i	0.03642 ± 0.2% GJ/litre	Measuring instrument
3	$EF_{CO2,i}$	0.0741 tCO_2/GJ	-

2.2 Baseline emissions from wastewater treatment processes

Baseline emissions from wastewater treatment systems, considering the COD removal efficiency of the baseline plant.

$$BE_{ww,treatment,y} = \sum_i (Q_{ww,i,y} \times COD_{inflow,i,y} \times \eta_{COD,BL,i} \times MCF_{ww,treatment,BL,i}) \times B_{o,ww} \times UF_{BL} \times GWP_{CH4}$$

Where

$BE_{ww,treatment,y}$ = Baseline emissions from wastewater treatment processes in year y (tCO_2eq/year)

$Q_{ww,i,y}$ = Wastewater volume of the project entering wastewater treatment system type i in year y (m^3/year)

$COD_{inflow,i,y}$ = Average COD of wastewater entering baseline wastewater treatment system type i in year y (t COD/m^3), with sampling possibly applied at 90/10 confidence/precision level

$\eta_{COD,BL,i}$ = COD removal efficiency of baseline wastewater treatment system type i

$MCF_{ww,treatment,BL,i}$ = Methane correction factor (MCF) for baseline wastewater treatment system type i

$B_{o,ww}$ = Methane generation rate of wastewater treatment process ($kgCH_4$/kgCOD removed)

UF_{BL} = Model correction factor for baseline model uncertainty

GWP_{CH4} = Global Warming Potential (GWP) of methane (tCO_2eq/tCH_4)

i = Type of baseline wastewater treatment system

NO.	Parameter	Value	Sources of Uncertainty
1	$Q_{ww,i,y}$	1,000 m^3 ± 0.3%	Measuring instrument
2	$COD_{inflow,i,y}$	20,000 t COD/m^3 ± 0.3%	Measuring instrument
3	$\eta_{COD,BL,i}$	60 %	-
4	$MCF_{ww,treatment,BL,i}$	0.8 ± 20%	A6.4-AMM-001
5	$B_{o,ww}$	0.25 $kgCH_4/kgCOD_{removal}$	CDM AMS-III.H
6	UF_{BL}	0.89	CDM AMS-III.H
7	GWP_{CH4}	28 tCO_2eq/tCH_4	-

2.3 Baseline emissions from sludge treatment processes

$$BE_{s,treatment,y} = \sum_{j} S_{j,BL,y} \times MCF_{s,treatment,BL,j} \times DOC_s \times UF_{BL} \times DOC_F \times F \times 16/12 \times GWP_{CH4}$$

Where

$BE_{s,treatment,y}$ = Baseline emissions from sludge treatment processes in year y (tCO_2eq/year)

$S_{j,BL,y}$ = Dry weight of sludge entering baseline sludge treatment process type j in year y (t)

j = Type of baseline sludge treatment process

$MCF_{s,treatment,BL,j}$ = Methane correction factor (MCF) for baseline sludge treatment process type j

DOC_s = Fraction of degradable organic matter in untreated sludge in year y (dry basis)

UF_{BL} = Model correction factor for baseline model uncertainty

DOC_F = Fraction of degradable organic matter in sludge converted to biogas

F = Methane fraction in biogas

NO.	Parameter	Value	Sources of Uncertainty
1	$S_{j,BL,y}$	100 ± 0.2% ton	Measuring instrument
2	$MCF_{ww,treatment,BL,i}$	0.8 ± 20%	A6.4-AMM-001
3	DOC_s	0.257	CDM AMS-III.H
4	UF_{BL}	0.89	CDM AMS-III.H
5	DOC_F	0.5	CDM AMS-III.H
6	F	0.5	CDM AMS-III.H
7	GWP_{CH4}	28 tCO_2eq/tCH_4	-

2.4 Baseline emissions from degradable organic matter in treated wastewater discharged into water

$$BE_{ww,discharge,y} = Q_{ww,y} \times GWP_{CH4} \times B_{o,ww} \times UF_{BL} \times COD_{ww,discharge,BL,y} \times MCF_{ww,BL,discharge}$$

Where

$BE_{ww,discharge,y}$ = Baseline emissions from degradable organic matter in treated wastewater discharged into water in year y (tCO_2eq/year)

$Q_{ww,y}$ = Wastewater volume discharged from the treatment process in year y (m^3)

UF_{BL} = Model correction factor for baseline model uncertainty

$COD_{ww,discharge,BL,y}$ = Average COD of treated wastewater discharged into water (tCOD/m³). If the baseline scenario is direct discharge without treatment, then the COD value of untreated wastewater shall be used.

$MCF_{ww,BL,discharge}$ = Methane correction factor (MCF) for baseline wastewater discharge

NO.	Parameter	Value	Sources of Uncertainty
1	$Q_{ww,y}$	1,000 m^3 ± 0.3%	Measuring instrument
2	GWP_{CH4}	28 tCO_2eq/tCH_4	-
3	$B_{o,ww}$	0.25 $kgCH_4/kgCOD_{removal}$	CDM AMS-III.H
4	UF_{BL}	0.89	CDM AMS-III.H
5	$COD_{ww,discharge,BL,y}$	1,000 t COD/m^3 ± 0.3%	Measuring instrument
6	$MCF_{ww,BL,discharge}$	0.3 ± 20%	A6.4-AMM-001

2.5 Baseline emissions from anaerobic decomposition of final sludge

If the sludge is subject to controlled combustion, disposal in landfills with biogas capture, or application as soil conditioner under aerobic conditions, then $BE_{S,final,y}$ is equal to zero.

3. Determination of baseline emissions calculation

3.1 Baseline emissions from electricity or fossil fuel consumption

$BE_{power,y}$ = 424,784.36 ± 0.28% + 2.70 ± 0.36%

$$= (424{,}784.36 + 2.70) \pm \frac{\sqrt{(0.28 * 424{,}784.36)^2 + (0.36 * 2.7)^2}}{(424{,}787.06 + 2.7)}$$

= 424,787.06 ± 0.28% tCO_2eq/year

3.1.1 Baseline emissions from electricity consumption

$BE_{EC,y}$ = (1,000,000 ± 0.2%) × (0.4004 ± 0.2%) × (1+0.0609)

$$= (1{,}000{,}000 \times 0.4004 \times 1.0609) \pm \sqrt{(0.2)^2 + (0.2)^2}$$

= 424,784.36 ± 0.28% tCO_2eq/year

3.1.2 Baseline emissions from fossil fuel consumption

$BE_{FF,y}$ = (1,000 ± 0.3%) × (0.03642 ± 0.2%) × 0.0741

= (1,000 × 0.03642 × 0.0741) $\pm\sqrt{(0.3)^2 + (0.2)^2}$

= 2.70 ± 0.36% tCO_2eq/year

3.2 Baseline emissions from wastewater treatment processes

Baseline emissions from wastewater treatment processes can be calculated as follows:

$BE_{ww,treatment,y}$ = (1,000 ± 0.3%) x (20,000 ± 0.3%) x 0.6 x (0.8 ± 20%) x 0.25 x 0.89 x 28

= (1,000 x 20,000 x 0.6 x 0.8 x 0.25 x 0.89 x 28) $\pm\sqrt{(0.3)^2 + (0.3)^2 + (20)^2}$

= 59,808,000 ± 20.00% tCO_2eq/year

3.3 Baseline emissions from sludge treatment processes

$BE_{s,treatment,y}$ = (100 ± 0.2%) x (0.8 ± 20%) x 0.257 x 0.89 x 0.5 x 0.5 x 16/12 x 28

= (100 x 0.8 x 0.257 x 0.89 x 0.5 x 0.5 x 16/12 x 28) $\pm\sqrt{(0.2)^2 + (20)^2}$

= 170.79 ± 20.00 % tCO_2eq/year

3.4 Baseline emissions from degradable organic matter in treated wastewater discharged into water

$BE_{ww,discharge,y}$ = (1,000 ± 0.3%) x 28 x 0.25 x 0.89 x (1,000 ± 0.3%) x (0.3 ± 20%)

= (1,000 x 28 x 0.25 x 0.89 x 1,000 x 0.3) $\pm\sqrt{(0.3)^2 + (0.3)^2 + (20)^2}$

= 1,869,000 ± 20.00 % tCO_2eq/year

3.5 Baseline emissions from anaerobic decomposition of final sludge

If the sludge is subject to controlled combustion, disposal in landfills with biogas capture, or application as soil conditioner under aerobic conditions, then $BE_{S,final,y}$ is equal to zero.

3.6 Determination of baseline emissions

$$BE_y = BE_{power,y} + BE_{ww,treatment,y} + BE_{s,treatment,y} + BE_{ww,discharge,y} + BE_{S,final,y}$$

$$= 424{,}787.06 \pm 0.28\% + 59{,}808{,}000 \pm 20.00\% + 170.79 \pm 20.00\ \% + 1{,}869{,}000 \pm 20.00\ \%$$

$$= (424{,}787.06+59{,}808{,}000+170.79+1{,}869{,}000)$$

$$\pm \frac{\sqrt{(0.28 * 424{,}787.06\ )^2 + (20 * 59{,}808{,}000)^2 + (20 * 170.79\ )^2 + (20 * 1{,}869{,}000)^2}}{(424{,}787.06 + 59{,}808{,}000 + 170.79 + 1{,}869{,}000)}$$

$$= 62{,}101{,}957.85 \pm 19.27\ \%\ tCO_2eq/year$$

4. Calculation summary

Baseline emissions from methane capture in anaerobic wastewater treatment for utilization or flaring amount to 62,101,957.85 ± 19.27 % $tCO_2eq/year$.

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

Version	Amendment	Entry into force	Description
01	-	23 July 2026	Initial issue