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METHODOLOGY

BM EN01.00XX

Production for Compressed Bio-gas (CBG)

INDIAN Carbon MARKET

Publication Date: DD MM YYYY

Version 1.0

Sectoral scope(s): Energy, Industries and Waste Handling and Disposal

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1. Introduction

1. This methodology is adopted and refers to the latest approved version of the following UNFCCC Clean Development Mechanism Methodologies:

    a. ACM0022 (valid from 09 September 2021)

    b. AMS-III.Q (valid from 16 April 2015)

    c. Gold Standard Soil Organic Carbon Framework Methodology (Valid from January 2020)

2. It shall be the responsibility of the non-obligated entity and Accredited Carbon Verification Agency (ACVA) to note of any subsequent changes or revisions in the above-mentioned methodologies while developing projects and performing validation and/or verification activity respectively.

3. The following table describes the key elements of the methodology:

Table 1. Methodology key elements

Typical project(s)	Project activities involve the installation and operation of new plants that use anaerobic digestion and associated processes to produce compressed biogas and its use in various applications; The produced gas may be utilized for cogeneration, generation of electricity, direct use as process heat, generation of heat in an element process or generation of mechanical energy, such as for use in transport application **Feedstock categories: Both 1G and 2G** feedstocks may be used for production of compressed biogas. Examples of 1G feedstocks include Napier grass, while 2G feedstocks include agri residues and waste, press mud, waste from agri-product manufacturing industries, animal waste, MSW, etc.
Type of GHG emissions mitigation action	• Greenhouse gas (GHG) emissions avoidance CH_4 emissions due to anaerobic decay of organic waste are avoided by alternative waste treatment processes. • Renewable energy Waste is used as renewable source of energy. • Energy efficiency Reduction of GHG emissions by energy recovery

2. Scope & Applicability

2.1. Scope

4. This methodology covers project activities implementing and operating new plants for the anaerobic treatment of waste that would otherwise be disposed in a solid waste disposal site (SWDS) or left to decay or burnt in aerobic conditions.
5. The methodology is for project activities implemented in an existing or greenfield waste energy generation (WEG) facility converting waste energy carried in the identified waste energy carrying medium (WECM) stream(s) into useful energy (i.e. electricity, mechanical or thermal) that is consumed in an existing and/or greenfield recipient facility(ies) through the production of compressed biogas. The WEG facility may be one of the recipient facilities. In the case of electricity generation, grid may be one of the recipient facilities.

6. The useful energy generated from the utilization of waste energy carried in the WECM stream(s) may be one or a combination of the below:

    a) Cogeneration;

    b) Generation of electricity;

    c) Direct use as process heat;

    d) Generation of heat in an element process; or

    e) Direct use as fuel in vehicles

2.2. Applicability

7. The methodology applies to project activities that install and operate new plants for the treatment of waste through any combination of the following processes:

    a) Anaerobic digestion process leading to the production of compressed biogas;

    b) Co-composting of wastewater in combination with waste;

    c) Anaerobic co-treatment of wastewater in combination with waste leading to the production of compressed biogas;

    d) The following conditions apply to all project activities using this methodology:

        a. The project plant only treats waste/wastewater for which emission reductions are claimed.

        b. Neither the waste nor the products from the project plant are stored on-site under anaerobic conditions;

        c. Any wastewater discharge resulting from the project activity is treated in accordance with applicable regulations;

        d. The project activity does not reduce the amount of waste that would be recycled in the absence of the project activity. This shall be justified and documented in the Indian Carbon Market project design document (ICM-PDD);

        e. When applicable regulations mandate any waste treatment process implemented under the project activity, the rate of compliance with such regulations for the treatment process is below 50 per cent[1];

    e) Hazardous wastes/wastewater are not eligible under this methodology.

8. The methodology is only applicable if the baseline scenario is:

    a) The disposal of the waste in a SWDS with or without a partial LFG capture system (M2 or M3)[2];

[1] Supporting evidence may include official studies, reports and certification from municipal authorities.

[2] Non-Obligated Entities shall demonstrate that sufficient landfill capacity would be available to dispose waste at a SWDS with a comparable annual waste acceptance rate and with the same operating lifetime as the project activity.

b) In the case of co-composting or co-treatment of wastewater in an anaerobic digester, the treatment of organic wastewater in either an existing or new anaerobic lagoon or sludge pit without methane recovery ;

c) In the case of electricity generation, the electricity is generated in an existing/new captive fossil fuel fired power-only plant, captive cogeneration plant and/or the grid (P2, P4 or P6);

d) In the case of heat generation, the heat is generated in an existing/new fossil fuel fired cogeneration plant, boiler or air heater.[3]

Table 2: Scope and Applicability Criteria

Type of Facility	Activity Scenario
Dedicated Plantation	Biogenic waste from plantations where the plant material and waste are used as feedstock for CBG.
Open Air Decomposition	Biomass waste earlier being openly dumped is diverted to CBG production
CBG by-product-Fermented Organic Manure	The primary by-product of Compressed Biogas (CBG) production is bio-manure, also known as fermented organic manure (FOM). Additionally, CBG plants can also recover Carbon Dioxide (CO_2)

1. The methodology is applicable under the following conditions:

(a) The recovery of waste energy shall be a new initiative (i.e. WECM was flared, vented or released into the atmosphere in the absence of the project activity).[4] The ACVAs during on-site visit as part of their validation activities shall confirm that no equipment for waste energy recovery and utilisation had been installed on the specific WECM stream(s) (that is recovered under the project activity) prior to the implementation of the project activity by using one of the following options:

i. By **direct measurements** of energy content and amount of the waste energy for at least three years prior to the start of the project activity;

ii. **Energy balance** of relevant sections of the plant to prove that the waste energy was not a source of energy before the implementation of the project activity. For the energy balance representative process parameters are required. The energy balance shall demonstrate that the waste energy was not used and also provide conservative estimations of the energy content and amount of waste energy released;

iii. **Energy bills** (electricity, fossil fuel) to demonstrate that all the energy required for the process (e.g. based on specific energy consumption specified by the manufacturer) has been procured commercially. Non-Obligated Entities are

[3] When heat is generated with a product or by-product from the project activity and used in the cement industry, Non-Obligated Entities should refer to specific methodologies applicable to the cement sector.

[4] Project activities that recover a small amount of waste energy in the baseline may apply this methodology provided that the current practice of recovering small amount of waste energy continues during the crediting period and there is no diversion of the baseline waste energy use, i.e. only energy that was otherwise flared, vented or released to atmosphere is utilized in the project activity.

required to demonstrate through the financial documents (e.g. balance sheets, profit and loss statement) that no energy was generated by waste energy and sold to other facilities and/or the grid. The bills and financial statements should be audited by competent authorities;

iv. **Process plant** manufacturer's original specification/information, schemes and diagrams from the construction of the facility could be used as an estimate of quantity and energy content of waste energy produced for rated plant capacity per unit of product produced;

(b) Regulations do not require the WEG facility to recover and/or utilize the waste energy prior to the implementation of the project activity;

(c) A WECM stream that is released under abnormal operations (for example: emergencies, shutdown etc.) of the WEG facility shall not be included in the emission reduction calculations;

(d) Energy (i.e. electricity or thermal heat) produced in the project activity may be exported to a grid or other industrial facilities (included in the project boundary), a contractual agreement exists between the owners of the WEG facility and the recipient facility(ies) to avoid the potential double counting of emission reductions. These procedures shall be described in the ICM Project Design Document;

(e) For project activities that use waste pressure to generate electricity the electricity generated from waste pressure shall be measurable.

2. Emission reductions cannot be claimed at and beyond the end of the lifetime of the equipment at the WEG facility or on-site captive unit at the recipient facility. The end of the lifetime of the equipment shall be determined as per the requirements mentioned in BM-T-015.

3. The date of adoption of this document shall be effective from DD MM YYYY.

2.3. Applicability of sectoral scopes

4. For validation and verification of ICM projects by a designated ACVA using this methodology application of sectoral scope *"03: Waste Handling and Disposal"* are mandatory.

2.4. Applicability of approved adopted tools

5. This methodology also refers to the latest approved versions of the following adopted ICM tools:

a) "BM-T-001: Combined tool to identify the baseline scenario and demonstrate additionality" (hereinafter referred as "BM-T-001");

b) "BM-T-002: Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" (hereinafter referred as "BM-T-002");

c) "BM-T-003: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation" (hereinafter referred as "BM-T-003");

d) "BM-T-004: Project emissions from flaring" (hereinafter referred as "BM-T-004");

e) "BM-T-005: Tool to determine the mass flow of a greenhouse gas in a gaseous stream" (hereinafter referred as "BM-T-005");

f) "BM-T-006: Determining the baseline efficiency of thermal or electric energy generation systems" (hereinafter "BM-T-006").

g) "BM-T-008: Project and leakage emissions from anaerobic digesters" (hereinafter referred as "BM-T-008");

h) "BM-T-011: Emissions from solid waste disposal sites" (hereinafter referred as "BM-T-011");

i) "BM-T-013: Project and leakage emissions from composting" (hereinafter referred as "BM-T-013");

j) "BM-T-015: Tool to determine remaining lifetime of equipment" (hereinafter referred as "BM-T-015").

3. Definitions

6. The definitions contained in the Detail Procedure for Offset Mechanism shall apply.

7. For the purpose of this methodology, the following definitions apply:

a) **By-products** - By-products from the waste treatment plant(s) established under the project activity. This includes, for example, aluminium or glass collected from the sorting of waste prior to subsequent treatment;

b) **Co-composting** - a type of composting where solid wastes and wastewater containing solid biodegradable organic material are composted together;

c) **Cogeneration** - the simultaneous production of electricity and useful thermal energy from a common fuel source;

d) **Compressed Biogas (CBG)**- is produced from waste/biomass sources (e.g agricultural residue, cattle dung, sugarcane press mud, municipal solid waste, and se wage treatment plant waste) through the process of anaerobic decomposition followed by compression. Typically, the composition of the gas is 50 to 70 per cent CH_4 and 30 to 50 per cent CO_2, with traces of H_2S and NH_3 (1 to 5 per cent);

e) **Composting** - a process of biodegradation of waste under aerobic (oxygen-rich) conditions. Waste that can be composted must contain solid biodegradable organic material. Composting converts biodegradable organic carbon to mostly carbon dioxide (CO_2) and a residue (compost) that can be used as a fertilizer. Other outputs from composting can include, inter alia, methane (CH_4), nitrous oxide (N_2O), and wastewater discharge (in case of co-composting);

f) **Digestate** - spent contents of an anaerobic digester. Digestate may be liquid, semi-solid or solid. Digestate may be further stabilized aerobically (e.g. composted), applied to land, sent to a solid waste disposal site (SWDS), or kept in a storage or evaporation pond;

g) **Elemental process** - the process of generation of thermal energy through fuel combustion or transfer of heat in equipment. Examples of an element process are steam generation by a boiler and hot air generation by a furnace. Each element process should generate a single output (such as steam or hot air or hot oil) by using single or multiple energy sources. For each element process, energy efficiency is defined as the ratio of the useful energy (the enthalpy of the steam multiplied with the steam quantity) and the supplied energy to the element process (the net calorific value of the fuel multiplied with the respective fuel quantity);

h) **Existing facility** (includes the WEG facility and the recipient facility) - existing facility is a facility that has been in operation for at least three years immediately prior to the start date of the project activity;

i) **Gasification** - the process of thermal decomposition of organic compounds at high temperatures, typically more than 800˚C. Gasification converts organic compounds, of biogenic, into combustible gas i.e compressed biogas;

j) **Greenfield facility** (includes the WEG facility and the recipient facility) – Greenfield facility is either a new facility constructed and operated at a site where no facility was operated prior to the implementation of the project activity or a facility which has less than three years of operational history immediately prior to the start date of the project activity. In case of capacity expansion or replacement, the increased or replaced capacity shall be treated as a greenfield facility;

k) **Recipient facility** - the facility that receives useful energy generated using waste energy under the project activity in the waste energy generation facility. It may be the same waste energy generation facility;

l) **Sludge pits** - a pit or tank where untreated liquid sludge is pumped and stored for at least one year. Anaerobic bacteria decompose the liquid sludge and decrease the organic matter content, resulting in emissions of CO_2, CH_4, hydrogen sulphide (H_2S) and ammonia. Once the pits are dried out and the sludge is stable, the solids are removed and used, e.g. as fertiliser for non-food crops;

m) **Solid waste disposal site (SWDS) -** designated areas intended as the final storage place for solid waste. Stockpiles are considered a SWDS if: (a) their volume to surface area ratio is 1.5 or larger; and if (b) a visual inspection by the accredited carbon verification agency (ACVA) confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist);

n) **Stockpile -** a pile of solid waste (not buried below ground). Anaerobic conditions are not assured in a stockpile with low volume to surface area ratios (less than 1.5) because the waste may be exposed to higher aeration;

o) **Waste-** is any unwanted or unusable material that is discarded after primary use or processing, mainly biogenic in nature. It can include Municipal solid waste (MSW) that contains household, garden/park, and commercial/institutional waste. Waste disposed of in solid waste disposal sites (SWDS) is also included under this definition. Waste also includes solid waste intended for disposal in an SWDS but not yet disposed of, typically comprising MSW and excluding hazardous waste. Hazardous waste, often generated by industries or hospitals and may pose potential risks due to its hazardous or infectious nature, is not considered waste under this methodology.

p) **Waste energy -** Energy contained in residual streams from industrial processes in the form of heat or pressure, for which it can be demonstrated that it would not have been recovered in the absence of the project activity. Examples of waste energy include the energy contained in gases flared, vented or released into the atmosphere, the heat or pressure from a residual stream is not recovered and therefore is wasted. Gases that have an intrinsic value in a spot market as an energy carrier or chemical (e.g. natural gas, hydrogen, liquefied petroleum gas, or their substitutes) are not eligible under this category;

q) **Waste energy carrying medium (WECM) -** the medium carrying the waste energy in the form of heat or pressure. Examples of WECM include gas, air or steam;

r) **Waste energy generation facility ("WEG facility") -** the facility where the waste energy which is utilized by the ICM project activity is available. The project activity can be implemented by the owner of the facility or by a third party (e.g. ESCO). If the waste energy is recovered by another facility, i.e. a third party in a separate facility, the "WEG facility" will encompass both the waste energy generation facility and the waste energy recovery facility. In a situation where waste gas is exported instead of supplying useful energy to a recipient plant, then the WEG facility shall include the recipient facility.

s) **Wastewater discharge -** Wastewater that is generated as a by-product from a waste treatment plant established under the project activity.

4. Methodology: Baseline Component

4.1. Project boundary

8. The spatial extent of the project boundary is the SWDS where the waste is disposed of in the baseline,[5] anaerobic lagoons or sludge pits treating organic wastewater in the baseline, sites of open burning of waste/residues, and the site of the alternative waste treatment process(es). The boundary also includes on-site electricity and/or heat generation and use, on-site fuel use and the wastewater treatment plant used to treat the wastewater by-products of the alternative waste treatment process(es).
9. In the case that the project provides electricity to a grid, then the spatial extent of the project boundary will also include those plants connected to the energy system to which the plant is connected. If upgraded biogas is fed to a natural gas distribution system, then the natural gas distribution system is also included in the boundary.
10. The GHG emission sources included in or excluded from the project boundary are listed in Table 3.

Table 2. Emission sources included in or excluded from the project boundary

	Source	Gas	Included	Justification/explanation
Baseline	Emissions from heat generation	CO_2	Yes	Major emission source if heat generation is included in the project activity and displaces more carbon intensive heat generation in the baseline
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small

[5] If supressed demand is considered for the baseline identified, SWDS need not be identified or included in the project boundary.

Source		Gas	Included	Justification/explanation
	Emissions at the SWDS	CH_4	Yes	The major source of emissions in the baseline
		N_2O	No	N_2O emissions are small compared to CH_4 emissions from landfills. Exclusion of this gas is conservative
		CO_2	No	CO_2 emissions from the decomposition of fresh waste are not accounted for[a]
	Emissions from anaerobic lagoons or sludge pits	CO_2	No	CO_2 emissions from biomass source are considered GHG neutral
		CH_4	Yes	Methane emission from anaerobic process
		N_2O	No	Not significant. Excluded for simplification and conservativeness
	Emissions from electricity generation	CO_2	Yes/No	Major source if electricity generation is included in the project activity and is sent to the grid or displaces fossil fuel fired electricity generation in the baseline
		CH_4	No	Excluded for simplification. This is conservative
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from use of natural gas	CO_2	No	Excluded for simplification. This is conservative
		CH_4	Yes/No	Major emission source if supply of upgraded biogas through a natural gas distribution network is included in the project activity
		N_2O	No	Excluded for simplification. This is conservative
	Emissions from on-site electricity use	CO_2	Yes	May be an important emission source
		CH_4	No	Excluded for simplification. This emission source is assumed to be very small
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small
	Emissions from the waste treatment processes	N_2O	Yes	N_2O may be emitted from composting
		CO_2	Yes	CO_2 emissions from incineration, gasification or combustion of fossil-based waste shall be included. CO_2 emissions from the decomposition or combustion of fresh waste are not accounted[a]
		CH_4	Yes	CH_4 leakage from the anaerobic digester and incomplete combustion in the flaring process are potential sources of project emissions. CH_4 may be emitted from, gasification, composting

Source		Gas	Included	Justification/explanation
	Emissions from wastewater treatment	CO_2	No	CO_2 emissions from the decomposition of fresh waste are not accounted[a]
		CH_4	Yes	CH_4 emissions from anaerobic treatment of wastewater are accounted for. Aerobic treatment of wastewater shall not result in CH_4 emissions
		N_2O	No	Excluded for simplification. This emission source is assumed to be very small

(a) CO_2 emissions from the combustion or decomposition of biomass (see definition by the Board in annex 8 of the CDM Executive Board's 20th meeting report) are not accounted as GHG emissions. Where the combustion or decomposition of biomass under a ICM project activity results in a decrease of carbon pools, such stock changes should be considered in the calculation of emission reductions. This is not the case for waste treatment projects.

11. The geographical extent of the project boundary shall also include the relevant WECM stream(s), equipment and energy distribution system in following facilities:

    a) WEG facility;
    b) Recipient facility(ies), which may be the same as the "WEG facility".

12. The spatial extent of the grid is as defined in the latest approved version of the CEA Database as applicable.

13. The relevant equipment and energy distribution system covers:

    a) In a WEG facility, the WECM stream(s), waste energy recovery and useful energy generation equipment, and distribution system(s) for useful energy;
    b) In a recipient facility, the equipment which receives useful energy supplied by the project and distribution system(s) for useful energy.

14. Where multiple waste gas streams are available in the WEG facility, and can be used interchangeably for various applications as part of energy sources in the facility, the guidance provided in Annexture 8 shall be followed to establish the project boundary.

15. The fossil fuel fired power unit(s), introduced in the project scenario shall be considered as part of project activity.

4.2. Additionality

4.2.1. Procedure for the selection of the most plausible baseline scenario and demonstration of additionality

16. Identify the baseline scenario and demonstrate additionality using BM-T-001.

17. For the treatment of the waste, the following alternatives or combinations of these alternatives shall, inter alia, be considered:

    M1: The project activity without being registered as a ICM project activity;

M2: Disposal of the waste in a SWDS with a partial capture of the LFG and flaring of the captured LFG;

M3: Disposal of the waste in a SWDS without an LFG capture system;

M4: Part of the fraction of the waste is recycled and not disposed in the SWDS;

M5: Part of the fraction of the waste is treated aerobically and not disposed in the SWDS;

M6: Part of the organic fraction of the feedstock is burnt in open fields

M7: Part of the organic fraction of the waste is treated in an anaerobic digester and not disposed in the SWDS;

18. For the treatment of the wastewater, the following alternatives or combinations of these alternatives shall, inter alia, be considered:

W1: Continuation of current practice of using anaerobic lagoons or sludge pits without methane recovery;

W2: Anaerobic lagoons or sludge pits with methane recovery and flaring of the recovered methane;

W3: Anaerobic lagoons or sludge pits with methane recovery and utilization of the recovered methane for electricity and/or heat generation;

W4: Construction of a new anaerobic lagoon or sludge pits without methane recovery;

W5: Construction of a new anaerobic lagoon or sludge pits with methane recovery and flaring of the recovered methane;

W6: Using the wastewater for co-composting (the project activity implemented without being registered as a ICM project activity);

19. For electricity generation the following alternatives or combinations of these alternatives, inter alia, shall be considered:

P1: Electricity generated as an output of one of the waste treatment processes listed in Table 1, not undertaken as a ICM project activity;

P2: Use of an existing or construction of a new on-site or off-site fossil fuel fired cogeneration plant;

P3: Existing or new construction of an on-site or off-site renewable based cogeneration plant;

P4: Existing or new construction of an on-site or off-site fossil fuel fired electricity plant;

P5: Existing or new construction of an on-site or off-site renewable based electricity plant;

P6: Electricity generation in existing and/or new grid-connected electricity plants.

20. For heat generation, one or a combination of the following alternatives, inter alia, shall be considered:

H1: Heat generated as a by-product from one of the processes for waste treatment listed in Table 1, not undertaken as a ICM project activity;

H2: Use of (an) existing or construction of (a) new on-site or off-site fossil fuel fired cogeneration plant(s);[6]

H3: Use of (an) existing or construction of (a) new on-site or off-site renewable based cogeneration plant(s);[7]

H4: Use of (an) existing or construction of (a) new on-site or off-site fossil fuel-based boiler(s) or air heater(s);

H5: Use of (an) existing or construction of (a) new on-site or off-site renewable energy-based boiler(s) or air heater(s);

H7: Other heat generation technologies (e.g. heat pumps or solar energy).

H8: Use of an existing fossil fuel-based transportation system

21. Non-Obligated Entity shall demonstrate that the identified baseline fuel used for generation of heat is available in abundance in India and there is no supply constraint. In case of supply constraints (e.g. partial or seasonal supply), non-obligated entities shall consider the period when there is availability.

22. Detailed justifications shall be provided and documented in the ICM-PDD for the selected baseline fuel. As a conservative approach, the lowest carbon-intensive fuel, such as natural gas, may be used throughout all periods of the year.

23. For the supply of upgraded biogas to a natural gas distribution network, the baseline is assumed to be the continued supply with natural gas.

24. Mandatory applicable legal and regulatory requirements regarding CBG production to be adhered to. Other policies could include local policies promoting productive use of CBG, such as those for the production of renewable energy, or those that promote the processing of waste.

25. If the products or by-products are used by another ICM project activity and if the non-obligated entities of both ICM projects are the same, then the following provision shall be followed:

    a) The by-products shall be considered to have market value when assessing additionality of the project activity applying this methodology;

    b) The by-products shall be considered to have no value when assessing additionality of the second project activity.

26. For project activities that are deemed automatically additional above, the baseline scenario is assumed to be the continued disposal of the waste in the nearest SWDS. If condition (d) applies, it shall also be demonstrated that 80 per cent of the collected MSW of the

6 Scenarios P2 and H2 are related to the same fossil fuel cogeneration plant.
7 Scenarios P3 and H3 are related to the same renewable energy-based cogeneration plant.

municipality (or the region from where the MSW treated by the project activity is sourced)[8] are treated in SWDS or stockpiles.

27. The collection coverage of MSW may be estimated as: (1) the quantity of waste collected divided by the total waste generation, or (2) the population covered by waste collection service divided by the total population. The quantity of waste collected may be (1) obtained from the municipal waste authority, (2) based on local statistics, or (3) based on the MSW accepted by all waste processing facilities, including open dump sites. Total waste generation may be calculated using data on population and/or waste generation per capita.

28. The investment related to fossil fuel fired power unit(s), introduced in the project scenario shall be considered in investment analysis for demonstrating additionality.

For existing WEG facilities

29. For the use of waste energy at the WEG facility the plausible baseline scenario shall be WECM was flared, vented or released into the atmosphere in the absence of the project activity.

For existing recipient facilities

30. In case of project activities involving existing recipient facilities the baseline scenario shall be based on relevant operational data from immediately prior three years to the start date of the project activity (or the start date of validation with due justification). For existing facilities, which has three years of operation history but do not have sufficient operational data for the purpose of determining baseline, all historic information shall be available (a minimum of one year operational data is required).

31. All options for demonstrating the use of waste energy in the absence of a ICM project activity shall be based on historic information and not on a hypothetical scenario.

For Greenfield WEG facilities

32. In case of project activities involving greenfield WEG facilities the baseline scenario shall be determined by applying investment comparison analysis to each of the design options that are realistic alternatives to the proposed greenfield project.

For Greenfield recipient facilities

33. The baseline for greenfield recipient facilities shall be determined:

    A. Using reference plant approach - In cases where the baseline scenario consists of the installation of new systems and/or the utilization of new energy sources, a Reference Plant shall be defined as the baseline scenario. The Reference Plant shall be based on common practice for similar industrial, residential, commercial, and institutional energy generation systems and sources in the same sector and in the same region as the project. The identification of the reference plant should exclude plants implemented as ICM project activities. In cases where no such plant exists within the region, the economically most attractive technology and fuel type should be identified among those which provide the

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[8] The applicable geographical region may be India, the region or the municipality where the project activity is located.

same service, that are technologically available, and that are in compliance with relevant regulations. The efficiency of the technology should be selected in a conservative manner, i.e. where several technologies could be used and are similarly economically attractive, the most efficient technology with the lowest baseline emissions should be defined as the baseline scenario. In addition, the least carbon intensive fuel type should be chosen in case of multiple fuels being possible choices; or

B. The baseline scenarios shall be:

   a. For electricity generation:

      i. Electricity is imported from a grid;

      ii. Electricity is produced in an on-site captive power plant using fossil fuel; or

      iii. Combination of both;

   b. For cogeneration:

      i. Electricity is imported from a grid and thermal energy is produced using fossil fuel;

      ii. Electricity is produced in an on-site captive power plant using fossil fuel and thermal energy is produced using fossil fuel;

      iii. Combination of both; or

      iv. Electricity and thermal energy are produced in a cogeneration unit using fossil fuel.

4.3. Baseline

34. Baseline emissions are determined as follows:

Equation (1)

$$BE_y = \sum_t \left(BE_{CH4,t,y} + BE_{WW,t,y} + BE_{EN,t,y} + BE_{NG,t,y}\right) \times (1 - RATE_{compliance,t})$$

Where:

BE_y	=	Baseline emissions in year *y* (t CO_2e)
$BE_{CH4,t,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e)
$BE_{WW,t,y}$	=	Baseline methane emissions from anaerobic treatment of the wastewater in open anaerobic lagoons or of sludge in sludge pits in the absence of the project activity in year *y* (t CO_2e)
$BE_{EN,t,y}$	=	Baseline emissions associated with energy generation in year *y* (t CO_2)
$BE_{NG,t,y}$	=	Baseline emissions associated with natural gas use in year *y* (t CO_2)

$RATE_{compliance,t}$	=	Discount factor to account for the rate of compliance of a regulatory requirement that mandates the use of alternative waste treatment process t [9]
t	=	Type of alternative waste treatment process

4.3.1.1. Baseline emissions of methane from the SWDS (***BE*** $_{CH4,t,y}$)

35. Baseline methane emissions from the SWDS are determined using BM-T-011. The following requirements shall be complied with when applying the tool:

 a) $W_{j,x}$ in the tool is the amount of waste prevented from disposal in the baseline SWDS due to its treatment in any (combination) alternative waste treatment process[10];

 b) Emission amounts are calculated using Application B in the tool ;

 c) Sampling to determine the fractions of different waste types is necessary (note that for the case that the waste is combusted in the project activity, then the parameter $Q_{j,c,y}$ in this methodology is equivalent to the variable $W_{j,x}$ in the tool);

 d) The tool instructs that f_y shall be determined based on historic data or contract or regulation requirements specifying the amount of methane that must be destroyed/used (if available). The following additional instruction applies:

  i. If the regulation requirements specify a percentage of the LFG that is required to be flared, the amount shall equal $f_{y.}$;

  ii. If the regulation requirements do not specify the amount or percentage of LFG that should be destroyed but require the installation of a capture system, without requiring the captured LFG to be flared then $f_y = 0$; and

  iii. If the requirement does not specify any amount or percentage of LFG that should be destroyed but require the installation of a system to capture and flare the LFG, then it is assumed $f_y = 0.2$.[11]

4.3.1.1.1. Suppressed demand scenario

36. When applying the tool, a default MCF of 0.4[12] for baseline emissions may be used to account for the scenario of a suppressed demand as described in the "Detailed Procedure for Offset Mechanism" when all the following conditions apply:

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9 Determined once for each crediting period, based on the most recent data available at the time of submission of the ICM-PDD to the ACVA for validation.

10 In case a <u>combination</u> of treatment processes is implemented <u>in parallel</u>, $W_{j,x}$ is determined for each process.

11 Non-Obligated Entities may propose and justify an alternative default value as a request for revision to this methodology.

12 Shallow landfill (<5m) is a realistic and conservative technology for disposing MSW, and it is also the least cost alternative for providing comparable level of service to alternative waste treatment technologies applicable in the methodology. The MCF value is chosen from the definition provided in 2006 IPCC Guideline applicable to unmanaged shallow landfills that do not have controlled placement of waste (i.e. waste directed to specific deposition areas, a degree of control of scavenging and a degree of control of fires) and do not include any cover material, mechanical compacting and levelling of the waste. The non-obligated entities can choose to select and justify a different baseline scenario expected under a suppressed demand scenario. If they choose to do so, the alternatives considered shall include inter alia alternatives M1 through M8 discussed in the procedure for the selection of the most plausible baseline scenario and demonstration of additionality.

a) It can be demonstrated that waste is being dumped in an uncontrolled manner in human settlement areas under the current practice due to a lack of organized waste collection and disposal system;

b) It can be demonstrated that only the municipal solid waste is being treated under the project activity and wastes from other sources such as agricultural or agro-industrial wastes are not being treated under the project activity;

c) It can be demonstrated that entire portion of the waste treated under the project activity would comply with the above two conditions.

4.3.1.2. Baseline emissions from wastewater ($BE_{WW,t,y}$)

37. Baseline emissions are determined as the minimum between the amount of methane produced after the implementation of the project activity and the amount of methane calculated using the methane conversion factor method for the estimation of methane emissions from anaerobic lagoons or sludge pits, as follows:

Equation (2)

$$BE_{WW,t,y} = min\{Q_{CH4,y}; BE_{CH4,MCF,y}\}$$

Where:

$BE_{WW,t,y}$	=	Baseline methane emissions from anaerobic treatment of the wastewater[13] in open anaerobic lagoons or of sludge in sludge pits in the absence of the project activity in year *y* (t CO_2e)
$Q_{CH4,y}$	=	Amount of methane produced from wastewater in year *y* after the implementation of the project activity (t CO_2e)
$BE_{CH4,MCF,y}$	=	Baseline methane emissions determined using the Methane Conversion Factor (t CO_2e)

4.3.1.2.1. Methane produced ($Q_{CH4,y}$)

38. Non-Obligated Entities shall use Step 1 “Determination of the quantity of methane produced in the digester ($Q_{CH4,y}$)” of the latest version of BM-T-014 to determine the amount of methane produced from wastewater after the implementation of the project activity ($Q_{CH4,y}$).

4.3.1.2.2. Baseline methane emissions determined using the methane conversion factor ($BE_{CH4,MCF,y}$)

39. $BE_{CH4,MCF,y}$ is determined based on the chemical oxygen demand (*COD*) of the wastewater that would enter the lagoon in the absence of the project activity ($COD_{BL,y}$), the maximum methane producing capacity (B_o) and a methane conversion factor ($MCF_{BL,y}$) which expresses the proportion of the wastewater that would decay to methane, as follows:

Equation (3)

$$BE_{CH4,MCF,y} = GWP_{CH4} \times MCF_{BL,y} \times B_o \times COD_{BL,y}$$

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[13] The quantity of wastewater treated in the baseline shall include only fresh wastewater and exclude any wastewater discharge.

Where:

$BE_{CH4,MCF,y}$	=	Baseline methane emissions determined using the Methane Conversion Factor (t CO_2e)
GWP_{CH4}	=	Global Warming Potential of methane valid for the commitment period (t CO_2e/t CH_4)
B_o	=	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (t CH_4/tCOD)
$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{BL,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in anaerobic lagoons or sludge pits in the absence of the project activity in year *y* (tCOD)

4.3.1.2.2.1. Determination of $COD_{BL,y}$

40. In principle, the baseline chemical oxygen demand ($COD_{BL,y}$) corresponds to the chemical oxygen demand that is treated under the project activity ($COD_{PJ,y}$). But, if there would be effluent from the lagoons or the sludge pit in the baseline, COD_{BL} should be adjusted by an adjustment factor which relates the *COD* supplied to the lagoon or sludge pit with the *COD* in the effluent.

Equation (4)

$$COD_{BL,y} = \rho\left(1 - \frac{COD_{out,x}}{COD_{in,x}}\right) \times COD_{PJ,y}$$

Where:

$COD_{BL,y}$	=	Quantity of chemical oxygen demand that would be treated in anaerobic lagoons or sludge pits in the absence of the project activity in year *y* (tCOD)
$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year *y* (tCOD)
$COD_{out,x}$	=	COD of the effluent in the period *x* (tCOD)
$COD_{in,x}$	=	COD directed to the anaerobic lagoons or sludge pits in the period *x* (tCOD)
x	=	Representative historical reference period
ρ	=	Discount factor to account for the uncertainty of the use of historical data to determine $COD_{BL,y}$

41. $COD_{PJ,y}$ is determined as follows:

Equation (5)

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,AD,m} \times COD_{AD,m}$$

Where:

$COD_{PJ,y}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in year *y* (tCOD)
$F_{PJ,AD,m}$	=	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m^3)
$COD_{AD,m}$	=	Chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* ($tCOD/m^3$)
m	=	Months of year *y* of the crediting period

4.3.1.2.2.2. Determination of $MCF_{BL,y}$

42. The quantity of methane generated from COD disposed of in the baseline in open anaerobic lagoons or sludge pits depends mainly on the temperature and the depth of the lagoon or sludge pit. Accordingly, the methane conversion factor is calculated based on a factor f_d, expressing the influence of the depth of the lagoon or sludge pit on methane generation, and a factor $f_{T,y}$ expressing the influence of the temperature on the methane generation. In addition, a conservativeness factor of 0.89 is applied to account for the uncertainty associated with this approach. $MCF_{BL,y}$ is calculated as follows:

Equation (6)

$$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89$$

Where:

$MCF_{BL,y}$	=	Average baseline methane conversion factor (fraction) in year *y*, representing the fraction of ($COD_{BL,y}$ x B_o) that would be degraded to CH_4 in the absence of the project activity
f_d	=	Factor expressing the influence of the depth of the anaerobic lagoon or sludge pit on methane generation
$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
0.89	=	Conservativeness factor

4.3.1.2.2.2.1. Determination of f_d

43. f_d represents the influence of the average depth of the anaerobic lagoons or sludge pits on methane generation.

Equation (7)

$$f_d = \begin{cases} 0; & if\ D < 1m \\ 0.5; & if\ 1\,m \le D < 2\,m \\ 0.7; & if\ D \ge 2\,m \end{cases}$$

Where:

f_d	=	Factor expressing the influence of the depth of the anaerobic lagoon or sludge pit on methane generation

D	=	Average depth of the anaerobic lagoons or sludge pits used in the baseline scenario (m)

4.3.1.2.2.2.2. Determination of $f_{T,y}$

44. The factor $f_{T,y}$ is calculated based on a monthly stock change model as follows:

$$COD_{available,m} = COD_{BL,m} + \left(1 - f_{T,m-1}\right) \times COD_{available,m-1}$$ Equation (8)

with

$$COD_{BL,m} = \left(1 - \frac{COD_{out,x}}{COD_{in,x}}\right) \times COD_{PJ,m}$$ Equation (9)

and

$$COD_{PJ,m} = F_{PJ,AD,m} \times COD_{AD,m}$$ Equation (10)

Where:

$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the anaerobic lagoon or sludge pit in month *m* (tCOD)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in anaerobic lagoons or sludge pits in the absence of the project activity in month *m* (tCOD)
$COD_{PJ,m}$	=	Quantity of chemical oxygen demand that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (tCOD)
$F_{PJ,AD,m}$	=	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m^3)
$COD_{AD,m}$	=	Chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* ($tCOD/m^3$)
$f_{T,m-1}$	=	Factor expressing the influence of the temperature on the methane generation in month *m-1*
m	=	Months of year *y* of the crediting period
$COD_{out,x}$	=	COD of the effluent in the period *x* (t COD)
$COD_{in,x}$	=	COD directed to the open lagoons or in sludge pits in the period *x* (t COD)
x	=	Representative historical reference period

45. In case of emptying the anaerobic lagoon or sludge pit, the accumulation of organic matter restarts with the next inflow and the COD available from the previous month should be set to zero.

46. The monthly factor to account for the influence of the temperature on methane generation is calculated based on the following "van't Hoff-Arrhenius" approach:

$$f_{T,m} = \begin{cases} 0.104 & if \quad T_{2,m} < 278K \\ e^{\left(\frac{E \ x \ (T_{2,m} - T_1)}{R \ x \ T_1 \ x \ T_{2,m}}\right)} & if \quad 278K \leq T_{2,m} \leq 302.5K \\ 0.95 & if \quad T_{2,m} > 302.5K \end{cases}$$ Equation (11)

Where:

$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
E	=	Activation energy constant (15,175 cal/mol)
$T_{2,m}$	=	Average temperature at the project site in month *m* (K)
T_1	=	303.15 K (273.15 K + 30 K)
R	=	Ideal gas constant (1.986 cal/K mol)
m	=	Months of year *y* of the crediting period

47. The annual value $f_{T,y}$ is calculated as follows:

$$f_{T,y} = \frac{\sum_{m=1}^{12} f_{T,m} \times COD_{available,m}}{\sum_{m=1}^{12} COD_{BL,m}}$$ Equation (12)

Where:

$f_{T,y}$	=	Factor expressing the influence of the temperature on the methane generation in year *y*
$f_{T,m}$	=	Factor expressing the influence of the temperature on the methane generation in month *m*
$COD_{available,m}$	=	Quantity of chemical oxygen demand available for degradation in the anearobic lagoon or sludge pit in month *m* (tCOD)
$COD_{BL,m}$	=	Quantity of chemical oxygen demand that would be treated in anaerobic lagoons or sludge pits in the absence of the project activity in month *m* (tCOD)
m	=	Months of year *y* of the crediting period

4.3.1.3. Baseline emissions from generation of energy ($BE_{EN,t,y}$)

48. This procedure is distinguished depending on whether the baseline is the separate generation of electricity and heat or the combined generation of heat and electricity by cogeneration.

4.3.1.3.1. Separate generation of electricity and heat

Equation (13)

$$BE_{EN,y} = BE_{EC,y} + BE_{HG,y}$$

Where:

$BE_{EN,y}$	=	Baseline emissions associated with energy generation in year *y* (t CO_2)
$BE_{EC,y}$	=	Baseline emissions associated with electricity generation in year *y* (t CO_2)
$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2)

4.3.1.3.1.1. Baseline emissions from separate generation of electricity ($BE_{EC,y}$)

49. The baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) shall be calculated using BM-T-003 When applying the tool:

    a) The electricity sources *k* in the tool correspond to the sources of electricity generated identified in the selection of the most plausible baseline scenario; and

    b) $EC_{BL,k,y}$ in the tool is equivalent to the net amount of electricity generated by the alternative waste treatment process *t* and exported to the grid or displacing fossil fuel fired captive energy plant in year *y* ($EG_{t,y}$).

4.3.1.3.1.2. Baseline emissions associated with separate generation of heat ($BE_{HG,y}$)

50. For use of heat in other facilities where the baseline heat generation was a fossil fuel fired boiler or air heater, and if the facilities are included in the project boundary, the baseline emissions associated with heat generation in year *y* ($BE_{HG,y}$) are determined based on the heat generation in the project activity, as follows:

Equation (14)

$$BE_{HG,y} = \frac{HG_{PJ,y} \times EF_{CO2,BL,HG}}{\eta_{HG,BL}}$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (t CO_2)
$\eta_{HG,BL}$	=	Efficiency of the boiler or air heater used for heat generation in the baseline (ratio)
$HG_{PJ,y}$	=	Quantity of heat supplied by the project activity displacing baseline heat generation by a fossil fuel boiler or air heater in year *y* (TJ)
$EF_{CO2,BL,HG}$	=	CO_2 emission factor of the fossil fuel type used for heat generation by the boiler or air heater in the baseline (t CO_2/TJ)

51. To estimate the baseline energy efficiency of the boiler or air heater in the baseline ($\eta_{HG,BL}$) non-obligated entities shall apply BM-T-006.

4.3.1.3.2. Cogeneration of electricity and heat

52. Baseline emissions from electricity and heat cogeneration are calculated by multiplying electricity generation ($EG_{t,y}$) and the quantity of heat supplied ($HG_{PJ,y}$) with the CO_2 emission factor of the fuel used by the cogeneration plant, as follows:

Equation (15)

$$BE_{EN,y} = \frac{(EG_{t,y} \times 3.6) \times 10^{-3} + HG_{PJ,y}}{\eta_{cogen}} \times EF_{CO2,BL,CG}$$

Where:

$BE_{EN,y}$	=	Baseline emissions associated with energy generation in year *y* (t CO_2)
$EF_{CO2,BL,CG}$	=	CO_2 emission factor of the fossil fuel type used for energy generation by the cogeneration plant in the baseline (t CO_2/TJ)
$HG_{PJ,y}$	=	Quantity of heat supplied by the project activity displacing baseline heat generation by a fossil fuel cogeneration plant in year *y* (TJ)
$EG_{t,y}$	=	Electricity generated by the alternative waste treatment process *t* and exported to the grid or displacing fossil fuel fired power-only and/or cogeneration captive energy generation in year *y* (MWh)
η_{cogen}	=	Efficiency of the cogeneration plant that would have been used in the absence of the project activity (ratio)

4.3.1.4. Baseline emissions associated with natural gas use (*$BE_{NG,y}$*)

53. $BE_{NG,y}$ is estimated as follows:

Equation (16)

$$BE_{NG,y} = BIOGAS_{NG,y} \times NCV_{BIOGAS,NG,y} \times EF_{CO2,NG,y}$$

Where:

$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (t CO_2)
$BIOGAS_{NG,y}$	=	Quantity upgraded biogas sent to the natural gas network due to the project activity in year *y* (Nm^3)
$NCV_{BIOGAS,NG,y}$	=	Net calorific value of the upgraded biogas sent to the natural gas network due to the project activity in year *y* (TJ/Nm^3)
$EF_{CO2,NG,y}$	=	Average CO_2 emission factor of natural gas in the natural gas network in year *y* (t CO_2/TJ)

54. $EF_{CO2,NG,y}$ is determined using the relevant provisions in BM-T-002.

4.3.1.5. Baseline Emissions for electricity from an existing plant/the grid

55. Electricity is obtained from an identified existing plant or from the grid. The baseline emissions can be calculated as follows:

$$BE_{elec,y} = f_{cap} \times f_{wcm} \times \sum_{j}\sum_{i}(EG_{i,j,y} \times EF_{Elec,i,j,y})$$

Equation (17)

Where:

$BE_{elec,y}$	=	Baseline emissions due to displacement of electricity during the year *y* in tons of CO_2
f_{cap}	=	The ratio of waste energy generated at a historical level, expressed as a fraction of the total waste energy used in the project activity for producing useful energy in year *y*. The ratio is 1 if the waste energy generated in project year *y* is the same or less than that generated at a historical level. Capping factor is to exclude increased waste energy utilization in the project year *y* due to increased level of activity of the plant, relative to the level of activity in the base years before project start. The value of f_{cap} shall be estimated using one of the applicable methods that applies to the situation of the project activity prescribed in the Annexture 4. Where the method requires historical data, the non-obligated entities shall follow the requirement stipulated in paragraph 45 above
f_{wcm}	=	Fraction of total electricity generated by the project activity using waste energy. This fraction is 1 if the electricity generation is purely from use of waste energy. The value of f_{wcm} shall be estimated using applicable procedures that apply to the situation of the project activity prescribed in the Annexture 5. Where the method requires historical information, the non-obligated entities shall follow the requirement stipulated in paragraph 45 above. In cases where auxiliary fossil fuel is used to supplement the waste energy directly in the waste heat recovery combustion systems and the energy output cannot be demonstrably apportioned due to technical constraints (e.g. waste gas measurement and its quality) between fossil fuels and the waste energy, a value of 1 for f_{wcm} can be used and consider the emissions resulting from the combustion of fossil fuel as project emissions using BM-T-002. Note: for a project activity using waste pressure to generate electricity this fraction is 1
$EG_{i,j,y}$	=	The quantity of electricity supplied to the recipient *j* by generator, that in the absence of the project activity would have been sourced from i^{th} source (*i* can be either grid or identified existing source) during the year *y* in MWh.
$EF_{Elec,i,j,y}$	=	The CO_2 emission factor for the electricity source *i* (grid or identified existing source), displaced due to the project activity, during the year *y* in tons CO_2/MWh.

4.3.1.5.1. Determination of $EF_{elec,i,j,y}$

56. In the case where the recipient of the electricity produced by the project activity is solely the grid or if the displaced electricity for the recipient facility is solely supplied by a connected grid system, and the grid is demonstrated to be the electricity baseline; then, the CO_2 emission factor $EF_{elec,gr,j,y}$ shall be determined as per the latest approved version of the CEA Database; otherwise, if the baseline generation source is an identified existing power plant, the CO_2 emission factor shall be determined as follows:

Equation (18)

$$EF_{Elec,i,j,y} = \frac{EF_{CO2,i,j}}{\eta_{Plant,j}} \times 3.6 \times 10^{-3}$$

Where:

$EF_{CO2,i,j}$	=	The CO_2 emission factor per unit of energy of the fossil fuel used in the baseline generation source *i* in (tCO_2/TJ).
$\eta_{Plant,j}$	=	The overall efficiency of the identified existing plant that would be used by j^{th} recipient in the absence of the project activity.
$3.6*10^{-3}$	=	Conversion factor, expressed as TJ/MWh.

57. For project activities that displace both imported grid electricity and identified existing power plant the baseline emission factor should reflect the emissions intensity of the grid and identified existing source in the baseline scenario i.e. the weighted average emission factor for the displaced electricity is calculated using values in accordance with requirements of paragraph 45 above for historical information. In cases where historical information is deemed not suitable to determine the relative proportion of these two sources used in the baseline (e.g. the available data is not reliable due to various factors such as the use of imprecise or non-calibrated measuring equipment) then the most conservative emission factor for the two energy sources shall be used.

58. If in the baseline situation, more than one type of fossil fuel is used in the identified existing power plant, the relative contribution to the total output of each fossil fuel shall be considered and the formulas for baseline emissions shall be adjusted accordingly. The relative contribution shall be determined based on the historical data as indicated in the paragraph 45 above.

59. Efficiency of the identified existing power plant ($\eta_{Plant,j}$) shall be determined in accordance with the latest approved version of BM-T-006.

4.3.1.6. Baseline emissions for mechanical energy

60. Mechanical energy is obtained by electric motors that displace mechanical energy generated by a steam turbine in the project activity. The baseline emissions can be calculated as follows:

Equation (19)

$$BE_{Elec,y} = f_{cap} \times f_{wcm} \times \sum_{j}\sum_{i}\left(\frac{\mathrm{MG}_{\mathrm{i,j,y,mot}}}{\eta_{\mathrm{mech,mot,i,j}}} \times EF_{Elec,i,j,y}\right)$$

Where:

$BE_{elec,y}$	=	Baseline emissions due to displacement of electricity during the year *y* (t CO_2).
$\mathrm{MG}_{\mathrm{i,j,y,mot}}$	=	Mechanical energy generated by a steam turbine in the project activity and supplied to the mechanical equipment (e.g. pump, compressor) of recipient *j*, which in the absence of the project activity would be driven by electric motor *i* (MWh).

$\eta_{mech,mot,i,j}$ = The efficiency of the baseline electric motor *i* that would provide mechanical power to recipient *j* in the absence of the project activity.

$EF_{Elec,i,j,y}$ = The CO_2 emission factor for the electricity source *i* (grid or identified source), displaced due to the project activity, during the year *y* in tons CO_2/MWh.

4.3.1.7. Baseline emissions for thermal energy and steam-generated mechanical energy

61. Thermal energy is obtained from a fossil fuel-based element process (e.g. steam boiler, hot water generator, hot air generator, hot oil generator, fossil fuel direct combustion in a process). The baseline emissions can be calculated as follows:

$$BE_{Ther,y} = f_{cap} \times f_{wcm} \times \sum_i \sum_j (HG_{j,y} + \mathrm{MG}_{i,j,y,tur} / \eta_{mech,tur}) \times EF_{heat,j,y}$$ Equation (20)

Where:

$BE_{Ther,y}$ = Baseline emissions from thermal energy (as steam) during the year *y* in tons of CO_2.

$HG_{j,y}$ = Net quantity of thermal energy (enthalpy) supplied to the recipient plant *j* by the project activity during the year *y* in TJ.

$\mathrm{MG}_{i,j,y,tur}$ = Mechanical energy generated and supplied to the recipient *j*, which in the absence of the project activity would receive power from a steam turbine *i,* driven by steam generated in a fossil fuel boiler (TJ).

$\eta_{mech,tur}$ = The efficiency of the baseline equipment (steam turbine) that would provide mechanical power in the absence of the project activity.

$EF_{heat,j,y}$ = The CO_2 emission factor of the element process supplying heat that would have supplied the recipient plant *j* in the absence of the project activity, expressed in t CO_2/TJ and calculated as per equation (21) below.

4.3.1.7.1. Determination of $EF_{heat,j,y}$

$$EF_{heat,j,y} = \sum_i ws_{i,j} \frac{EF_{CO2,i,j}}{\eta_{EP,i,j}}$$ Equation (21)

Where:

$EF_{CO2,i,j}$ = The CO_2 emission factor per unit of energy of the baseline fuel used in i^{th} element process used by recipient *j*, (t CO_2/TJ), in absence of the project activity.

$\eta_{EP,i,j}$ = Efficiency of the i^{th} element process that would have been supplied heat to j^{th} recipient in the absence of the project activity.

$ws_{i,j}$	=	Fraction of total heat that is used by the recipient *j* in the project that in the absence of the project activity would have been supplied by the *i*[th] element process.
i	=	Identified existing source.

62. Efficiency of the element process ($\eta_{EP,i,j}$) shall be one of the following:

a) Determine the efficiency of the element process in accordance with the latest approved version of BM-T-006;

b) Assume a constant efficiency of the element process and determine the efficiency, as a conservative approach, for optimal operation conditions i.e. design fuel, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (temperature, viscosity, moisture, size/mesh etc.), representative or favorable ambient conditions (ambient temperature and humidity); or

4.3.1.8. Baseline emissions from co-generated electricity and heat of a cogeneration plant

63. In the situation where: (i) the electricity and/or heat would be generated by an existing fossil fuel based cogeneration plant; (ii) the mechanical energy would be generated by existing electrical motors or steam turbine; (iii) all the recipient plant(s) are supplied energy from a common fuel based cogeneration source in absence of the project activity, the baseline emissions from co-generated electricity and heat of a cogeneration plant are calculated as:

a) Electricity ($EG_{j,y}$), thermal energy (steam) ($HG_{j,y}$) and if applicable, mechanical energy ($MG_{j,y,mot}$ or $MG_{j,y,tur}$) supplied to the recipient facility(ies); and

b) CO_2 emission factor of the fuel used by the cogeneration plant that would have supplied the energy to the recipient facility(ies) *j* in the absence of the project activity, as follows:

$$BE_{En,y} = f_{cap} \times f_{wcm} \times \sum_j \left[\frac{HG_{j,y} + (MG_{j,y,tur}/\eta_{mech,tur}) + (EG_{j,y} + MG_{j,y,mot}/\eta_{mech,mot}) \times 3.6 \times 10^{-3}}{\eta_{Cogen}} \right] \times EF_{CO2,COGEN} \quad \text{Equation (22}$$

Where:

$BE_{En,y}$	=	The baseline emissions from energy that is displaced by the project activity during the year *y* in tons of CO_2.
$EG_{j,y}$	=	The quantity of electricity supplied to the recipient plant *j* by the project activity during the year *y* in MWh.
$3.6*10^{-3}$	=	Conversion factor, expressed as TJ/MWh.
$HG_{j,y}$	=	Net quantity of thermal energy supplied to the recipient plant *j* by the project activity during the year *y* (TJ).
$EF_{CO2,COGEN}$	=	CO_2 emission factor per unit of energy of the fuel that would have been used in the baseline cogeneration plant in (t CO_2/TJ), obtained from reliable local or national data if available, otherwise, taken from the country specific IPCC default emission factors.

η_{Cogen}	=	Efficiency of the cogeneration plant (combined heat and power generation efficiency) using fossil fuel that would have been used in the absence of the project activity.
$MG_{j,y,mot}$	=	Mechanical energy generated by steam turbine in the project activity and supplied to the mechanical equipment (e.g. pump, compressor) of recipient *j*, which in the absence of the project activity would be driven by electric motor (MWh).
$\eta_{mech,mot}$	=	The efficiency of the baseline electric motor that would provide mechanical power in the absence of the project activity.
$MG_{j,y,tur}$	=	Mechanical energy generated by steam turbine in project activity and supplied to the mechanical equipment (e.g. pump, compressor) of recipient *j*, which in the absence of the project activity would be driven by a steam turbine, operating from steam generated in a fossil fuel boiler (TJ).
$\eta_{mech,tur}$	=	The efficiency of the baseline steam turbine that would provide mechanical power in the absence of the project activity.

64. Efficiency of the cogeneration plant (η_{Cogen}) shall be one of the following:

a) Assume a constant efficiency of the cogeneration plant and determine the efficiency, as a conservative approach, for optimal operational conditions i.e. designed fuel, designed steam extractions, optimal load, optimal oxygen content in flue gases, adequate fuel conditioning (viscosity, temperature, moisture, size/mesh etc.), representative or favorable ambient conditions (temperature, humidity); or

b) Highest of the efficiency values provided by two or more manufacturers for similar plants as used in the project activity; or

c) Maximum efficiency of 90 per cent, based on net calorific values (irrespective of type of cogeneration system and type of heat generated).

4.4. Project Emissions

65. The project emissions in year *y* are calculated for each alternative waste treatment process implemented in the project activity as follows:

Equation (23)

$$PE_y = PE_{COMP,y} + PE_{AD,y}$$

Where:

PE_y	=	Project emissions in year *y* (t CO_2e)
$PE_{COMP,y}$	=	Project emissions from composting or co-composting in year *y* (t CO_2e)
$PE_{AD,y}$	=	Project emissions from anaerobic digestion and biogas combustion in year *y* (t CO_2e)

4.4.1.1. Project emissions from composting or co-composting ($PE_{COMP,y}$)

66. Project emissions associated with composting or co-composting ($PE_{COMP,y}$) are calculated according to BM-T-013.

4.4.1.2. Project emissions from anaerobic digestion ($PE_{AD,y}$)

67. $PE_{AD,y}$ is calculated according to BM-T-008. When estimating the parameters $PE_{EC,y}$ and $PE_{FC,y}$ in the tool, the sources of electricity and fossil fuel consumption shall include processing, upgrading and compressing the biogas into the natural gas network (if this is part of the project activity).

4.4.1.3. Project emissions from electricity use ($PE_{EC,t,y}$)

68. The project emissions from electricity consumption due to waste treatment process *t* implemented under the project activity ($PE_{EC,t,y}$) shall be calculated using BM-T-003. When applying the tool:

    a) Project emissions shall be calculated for the sources of electricity consumed due to the alternative waste treatment process *t*, excluding consumption of electricity that was generated by the project activity ($EC_{t,y}$);

    b) If the project activity consists of more than one alternative waste treatment process, then non-obligated entities may choose to monitor electricity consumption for the entire site and then allocate this consumption to one of the different alternative waste treatment processes (e.g. apportionment based on sub-metering data is not required).

4.4.1.4. Project emissions from combustion within the project boundary ($PE_{COM,c,y}$)

69. This procedure estimates emissions from gasifiers ($PE_{COM,c,y}$). The procedure is not relevant for flares or biogas combustors. Emissions consist of carbon dioxide, and small amounts of methane and nitrous oxide, as follows:

Equation (24)

$$PE_{COM,C,y} = PE_{COM,CO2,c,y} + PE_{COM,CH4,N2O,c,y}$$

Where:

$PE_{COM,C,y}$	=	Project emissions from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2e)
$PE_{COM,CO2,c,y}$	=	Project emissions of CO_2 from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2)
$PE_{COM,CH4,N2O,c,y}$	=	Project emissions of CH_4 and N_2O from combustion within the project boundary associated with combustor *c* in year *y* (t CO_2)
c	=	Combustor used in the project activity: gasifier

4.4.1.5. Emissions from wastewater discharge management ($PE_{ww,t,y}$)

70. If the wastewater discharge generated by the project activity is treated using an aerobic treatment process, such as by co-composting, then project emissions from wastewater treatment are assumed to be zero.

71. If the wastewater discharge is treated in an anaerobic digester, then the associated emissions are calculated according to the section above, “Project emissions from anaerobic digestion”.

72. If the project activity generates wastewater discharge that is treated anaerobically (through other than in an anaerobic digester that is part of the project activity), stored anaerobically

or released without further treatment in accordance with applicable regulations, then non-obligated entities shall determine $PE_{ww,t,y}$ as follows:

a) For cases without flaring/combustion of the methane generated by the wastewater discharge:

$$PE_{ww,t,y} = Q_{ww,y} \times P_{COD,y} \times B_0 \times MCF_{ww} \times GWP_{CH4}$$ Equation (25)

b) For cases with partial flaring/combustion of the methane generated by the wastewater discharge:

$$PE_{ww,t,y} = Q_{ww,y} \times P_{COD,y} \times B_0 \times MCF_{ww} \times GWP_{CH4} + (\frac{PE_{flare,ww,y}}{GWP_{CH4}} - F_{CH4,flare,y})$$ Equation (26)

73. BM-T-004 shall be used to estimate the resulting methane emissions from flaring ($PE_{flare,ww,y}$ is estimated as parameter $PE_{flare,y}$ in the tool). If the methane is combusted in an incinerator, rather than flared, then for the case that non-obligated entities have selected Option 1 to use monitored data to determine "Project emissions of CH_4 and N_2O from combustion within the project boundary" these emissions are already accounted for. If Option 2 to use default values was selected instead, then assume a 90 per cent destruction efficiency of the methane contained in the gas, with $PE_{flare,ww,y}$ = $PE_{com,ww,y}$ and emissions calculated as follows:

Equation (27)

$$PE_{com,ww,y} = F_{CH4,flare,y} \times 0.1$$

Where:

$PE_{com,ww,y}$	=	Emissions from combustion of methane generated from wastewater treatment in year *y* (t CO_2e)
$F_{CH4,flare,y}$	=	Amount of methane in the wastewater treatment gas that is sent to the flare/combustor in year *y* (t CO_2e)

74. $F_{CH4,flare,y}$ is determined using BM-T-015:

a) The gaseous stream the tool shall be applied to is the wastewater treatment emissions delivery pipeline to the flare(s);

b) CH_4 is the greenhouse gases for which the mass flow shall be determined;

c) The flow of the gaseous stream shall be measured on continuous basis;

d) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations (3) or (23) in the tool); and

e) The mass flow shall be calculated for an hourly time interval *t* (as per the tool) and then summed for the year *y* (t CH_4).

75. If the wastewater treated is sourced from more than one alternative waste treatment process implemented on-site, then the emissions may be estimated for the entire site and then allocated to any of the treatment processes.

76. Project emissions due to the project activity (PE_y) include emissions due to: (i) combustion of auxiliary fuel to supplement waste gas/heat ($PE_{AF,y}$); and (ii) emissions due to consumption of electricity for cleaning of gas before being used for generation of electricity or other supplementary electricity consumption by the project activity ($PE_{EL,y}$).

$$PE_y = PE_{AF,y} + PE_{EL,y}$$ Equation (28)

PE_y	=	Project emissions due to the project activity (t CO_2)
$PE_{AF,y}$	=	Project activity emissions from on-site consumption of fossil fuels by the unit process(es) and/or co-generation plant(s) if they are used as supplementary fuels due to non-availability of waste energy to the project activity or due to any other reason (t CO_2)
$PE_{EL,y}$	=	Project activity emissions from on-site consumption of electricity for gas cleaning equipment or other supplementary electricity consumption (tCO_2) (as per Table 2: Summary of gases and sources included in the project boundary)

Note: If the electricity was consumed in gas cleaning equipment in the baseline as well, project emissions due to electricity consumption for gas cleaning can be ignored.

4.4.1.6. Project emissions due to electricity consumption of gas cleaning equipment or other supplementary electricity consumption

77. These project emissions are calculated by using latest approved tool BM-T-003.

78. Project emissions on account of use of auxiliary fossil fuel and electricity use shall be calculated in accordance with the BM-T-002 and the BM-T-003 respectively.

79. If the waste gas contains carbon monoxide or hydrocarbons, other than methane, and the waste gas is vented or released into the atmosphere in the baseline situation, project emissions have to include CO_2 emissions due to the combustion of the waste gas.

4.5. Leakage

80. Leakage emissions are associated with composting/co-composting and anaerobic digestion that is exported outside the project boundary. For the case that waste by-products of the alternative waste treatment process are:

    a. Used for soil application, these emissions shall be neglected;

    b. Composted or co-composted, then these shall be treated as fresh waste with emissions estimated according to the procedure project emissions from composting ($PE_{COMP,y}$).

81. Leakage emissions are determined as follows:

Equation (29)

$$LE_y = LE_{COMP,y} + LE_{AD,y}$$

Where:

LE_y	=	Leakage emissions in the year *y* (t CO_2e)
$LE_{COMP,y}$	=	Leakage emissions from composting or co-composting in year *y* (t CO_2e)

$LE_{AD,y}$ = Leakage emissions from anaerobic digester in year *y* (t CO_2e)

4.5.1.1. Leakage emissions from composting ($LE_{COMP,y}$)

82. Leakage emissions associated with composting ($LE_{COMP,y}$) are calculated according to BM-T-013.

4.5.1.2. Leakage emissions from anaerobic digestion ($LE_{AD,y}$)

83. Leakage emissions associated with anaerobic digestion of waste ($LE_{AD,y}$) are calculated according to BM-T-008.

84. If the energy generating equipment introduced by the project activity is transferred from outside the boundary of the project activity, leakage is to be considered.

4.5.2. Calculation of Carbon Pool

4.5.2.1. Carbon Pools

85. This methodology focuses entirely on benefits from increase of soil carbon. Benefits accounting is thus limited to the soil organic carbon pool as shown in Table 4.

Table 4: Carbon pools to be included

Pools	Includes	Project	Baseline	Leakage
Above ground	Stem, branches, bark, grass, herbs, etc.	No	No	Yes*
Below ground	Roots of grass, trees, herbs	No	No	Yes*
Deadwood	Standing and lying deadwood	No	No	No
Litter	Leaves, small fallen branches	No	No	No
Soil organic carbon	Organic material	Yes	Yes	Yes
Wood products	Furniture, construction material, etc.	No	No	No

* Change in biomass carbon stocks in leakage area to be accounted for in case of activity shift.

4.5.2.2. Baseline Calculation

86. For all of the eligible project area, baseline SOC stocks are calculated as the sum of stocks in each stratum multiplied by the stratum area as shown in Equation 30:

$$SOC_{BL}=\sum_{y=1}^{n}(SOC_{BL,y} * A_y) \quad \text{Equation (30)}$$

Where:

SOC_{BL} = soil organic carbon in the eligible project area before project start [tC]

$SOC_{BL,y}$ = soil organic carbon in stratum y before project start [tC ha-1]

A_y = area of stratum y before project start [ha]

87. For each stratum in the eligible project area, baseline SOC stocks shall be quantified using any of the three general approaches. Different approaches may be used for different strata.

• **Approach *1***: $SOC_{BL,y}$ is measured in an adequate number of soil profiles to meet ICM uncertainty requirements in each stratum. Measurement of SOC shall follow accepted sampling and analysis protocols. As these protocols require a certain measure of field and laboratory technology, alternate protocols may be proposed in Activity Modules or at project level. Deviations from the protocols listed in the methodology or activity module (or use of alternate protocols) are subject to review and decision by ICM.

• **Approach *2***: $SOC_{BL,y}$ is derived from data or models published in peer-reviewed literature. Evidence for applicability of the literature values to the project site must be provided and validated as described in section 16.2. Specifically, applicability shall be demonstrated with respect to:

- Climate factors (e.g. precipitation levels and seasonal distribution)
- Soil and vegetation types
- Current and historic management systems (land use category, crops, tillage techniques, fertilization)

Direct application of literature values is only permitted if the source conditions are comparable to the project environment, evidence of which shall be provided as described in section 16. Furthermore, literature values shall only be applied within the spatial and temporal dimensions analysed in the original source (e.g. SOC depth, timespan for which changes are documented). If a range of parameter values is given in a source or data is aggregated across various factor levels (e.g. average SOC in a region, across a range of soil types), the most conservative value shall be applied. 15

Alternatively, SOC values from literature may be verified by comparing them to measurements in a set of sample sites within the respective project stratum to indicate conservativeness of the parameter values applied. Such measurements are required if evidence for applicability (as listed above) of literature values is deemed insufficient by the ACVA.

• **Approach *3***: If no data for $SOC_{BL,y}$ is available, it may be modelled using Equation 4 (below). The calculation follows the approach documented in IPCC 2019[14] but allows for baseline management practices to be in place less than the estimated time to equilibrium (i.e., in case of IPCC default factors, less than 20 years). Note that the current IPCC Guidelines only provide stock change factors for tillage change and generic inputs (fertilizing) for croplands and grassland. Approach 3 is thus not applicable for activities increasing SOC in other manners (e.g. through biological soil agents) unless additional factors are available for the project area (e.g. Tier 2 factors from national GHG inventory).

$$SOC_{BL,y} = SOC_{REF,y} \times (1 + (F_{LU,y} \times F_{MG,BL,y} \times F_{I,BL,y} - 1) \times T_{BL}/D_{BL}) \quad \text{Equation (31)}$$

Where:

$SOC_{BL,y}$ = Soil Organic Carbon before project start in stratum y [tCha-1]

$SOC_{REF,y}$ = reference soil organic carbon stock under natural vegetation in stratum y [tC ha-1]

$F_{LU,y}$ = land use factor in stratum y [dimensionless]

$F_{MG,BL,y}$ = tillage factor before project start in stratum y [dimensionless]

$F_{I,BL,y}$ = input factor before project start in stratum y [dimensionless]

D_{BL} = time dependency of $F_{MG,BL}$ and $F_{I,BL}$ factors[15] [yr]

T_{BL} = number of years since introduction of baseline practice; maximum T_{BL} = D [yr]

88. In this approach, $SOC_{REF,y}$ shall be selected from an appropriate scientific source[16] **or** measurements, applicability of which in the project stratum shall be documented. This must include evidence that the SOC_{REF} value stems from a comparable climatic, soil and vegetation environment, as described in section 16. If evidence provided for applicability of SOC_{REF} is deemed insufficient by ACVAq, appropriate measurements are required.

89. For $F_{LU,BL,y}$, $F_{MG,BL,y}$ and $F_{I,BL,y}$ factors, default values from the IPCC 2019 guidelines may be applied within a given temperature and moisture regime (see Table 3 and Table 4 below), referring to the management before project start. If national or regional factors are available (IPCC Tier 2 or Tier 3 data) these should be used instead.

Table 5: Relative stock change factors (F_{LU}, F_{MG}, F_I) for grassland management (IPCC 2019)[17]

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) FOR GRASSLAND MANAGEMENT					
Factor Value Type	**Level**	**Temperature Regime**	**IPCC Defaults**	**Error$_{1,2}$**	**Description**
Land use (F_{LU})	All	All	1.0	N/A	All native and/or permanent grassland in a nominal condition is assigned a land-use factor of 1.
Management (F_{MG})	Nominally managed (non-degraded)	All	1.0	N/A	Represents low or medium intensity grazing regimes, in addition to periodic cutting and removal of above-ground vegetation, without significant management improvements.
Management **(F_{MG})**	High Intensity Grazing	All	0.90	±8%	Represents high intensity grazing systems (or cutting and removal of vegetation) with shifts in vegetation composition and possibly productivity but is not severely degraded.
Management (F_{MG})	Improved grassland	Temperate/ Boreal Tropical	1.14 1.17	±11% ±9%	Represents grassland which is sustainably managed with light to moderate grazing

[14] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4 Agriculture, Forestry and Other Land Use (https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html)

[15] For IPCC 2019 and IPCC 2006 default factors, *D* equals 20 years

[16] Publications, verifiable local research results, soil databases e.g. ISRIC (https://www.isric.org/explore), Hengl et al., (2014), or the European Soil Portal (http://eusoils.jrc.ec.europa.eu/; also provides information on non-European soils).

IPCC default SOC reference values (SOC_{REF}) may only be applied if within Gold Standard Uncertainty Requirements.

[17] IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use, Chapter 6 Grassland, table 6.2 (Updated). https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

					pressure (or cutting and removal of vegetation) and that receive at least one improvement (e.g., fertilization, species improvement, irrigation).
		Tropical Montane	1.16	±40%	
Input (applied only to improved grassland) (F_I)	Medium	All	1.0	NA	Applies to improved grassland where no additional management inputs have been used.
Input (applied only to improved grassland) (F_I)	High	All	1.11	±7%	Applies to improved grassland where one or more additional management inputs/improvements have been used (beyond that required to be classified as improved grassland).

Table 6: Relative stock change factors (FLU, FMG, FI) for different management activities on cropland (IPCC 2019[18])

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) (OVER 20 YEARS) FOR DIFFERENT MANAGEMENT ACTIVITIES ON CROPLAND						
Factor value type	**Level**	**Temperature regime**	**Moisture regime**	**IPCC defaults**	**Error**	**Description**
Land use (F_{LU})	Long-term cultivated	Cool Temperate/ Boreal Warm Temperate	Dry	0.77	±14%	Represents area that has been converted from native conditions and continuously managed for predominantly annual crops over 50 yrs. Land-use factor has been

[18] IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use, Chapter 5 Cropland, table 5.5 (Updated). https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

			Moist Dry Moist	0.70 0.76 0.69	±12% ±12% ±16%	estimated under a baseline condition of full tillage and nominal ("medium") carbon input levels. Input and tillage factors are also applied to estimate carbon stock changes, which includes changes from full tillage and medium input.
		Tropical	Dry Moist/Wet	0.92 0.83	±13% ±11%	
Land use (F_{LU})	Paddy rice	All	Dry and Moist/ Wet	1.35	±4%	Long-term (> 20 year) annual cropping of wetlands (paddy rice). Can include double-cropping with non-flooded crops. For paddy rice, tillage and input factors are not used.
Land use (F_{LU})	Perennial/ Tree Crop	Temperate/ Boreal	Dry and Moist	0.72	±22%	Long-term perennial tree crops such as fruit and nut trees, coffee and cacao.
		Tropical	Dry and Moist/ Wet	1.01	±25%	
Land use (F_{LU})	Set aside (< 20 yrs)	Temperate/ Boreal and Tropical	Dry	0.93	±11%	Represents temporary set aside of annually cropland (e.g., conservation reserves) or other idle cropland that has been revegetated with perennial grasses.
			Moist/Wet	0.82	±17%	
		Tropical montane	n/a	0.88	±50%	
Tillage (F_{MG})	Full	All	Dry and Moist/ Wet	1.00	n/a	Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g., <30%) of the surface is covered by residues.
Tillage (F_{MG})	Reduced		Dry	0.98	±5%	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30% coverage by residues at planting.
		Cool Temperate/ Boreal Warm Temperate	Moist Dry	1.04 0.99	±4% ±3%	

			Moist	1.05	±4%	
		Tropical	Dry	0.99	±7%	
			Moist/Wet	1.04	±7%	
			n/a	n/a	n/a	
Input (F_I)	Low	Temperate/ Boreal	Dry	0.95	±13%	Low residue return occurs when there is removal of residues (via collection or burning), frequent bare-fallowing, production of crops yielding low residues (e.g., vegetables, tobacco, cotton), no mineral fertilization or N-fixing crops.
			Moist	0.92	±14%	
		Tropical	Dry	0.95	±13%	
			Moist/Wet	0.92	±14%	
		Tropical montane	n/a	0.94	±50%	
Input (F_I)	Medium	All	Dry and Moist/ Wet	1.00	n/a	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires mineral fertilization or N-fixing crop in rotation.
Input (F_I)	High - without manure	Temperate/ Boreal and Tropical	Dry	1.04	±13%	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see row below).
			Moist/ Wet	1.11	±10%	
		Tropical montane	n/a	1.08	±50%	
Input (F_I)	High - with manure	Temperate/ Boreal and Tropical	Dry	1.37	±12%	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure.
			Moist/ Wet	1.44	±13%	
		Tropical montane	n/a	1.41	±50%	

4.5.2.3. Project Calculations

Project Scenario

90. Under the project scenario, SOC relevant practices are applied in the project area. As with the baseline, the eligible project area shall be stratified into modelling units (MU) according to:

- Soil type
- Climate zone
- Land management / cropping system
- Input levels (e.g. fertilization)
- As applicable (to be defined in SOC Activity Modules):
  Tillage practices
  Soil properties (e.g. nutrient status or soil health)
  Hydrology
  Risk of carbon loss (e.g. fire risk)

91. For each stratum (MU), SOC measurements have to be performed (*Approach 1*) and/or model parameters identified and verified (*Approach 2 or 3*).

Project Scenario Calculations

92. For all of the eligible project area, SOC stocks at time *t* are calculated as the sum of stocks in each stratum multiplied by the stratum area:

$$\boldsymbol{SOC_t} = \sum_{\boldsymbol{y=1}}^{\boldsymbol{n}} (\boldsymbol{SOC_{t,y}} * \boldsymbol{A_y})$$ Equation (32)

Where,

SOC_t	=	soil organic carbon in the eligible project area at time t [tC]
$SOC_{t,y}$	=	soil organic carbon in stratum y at time t [tC ha-1]
A_y	=	area of stratum y at time t [ha]

93. For each stratum in the eligible project area, SOC stocks are quantified using any of the three approaches. If a different approach is used for baseline and project scenarios in a stratum, conservativeness and comparability have to be ensured.

   - **Approach *1***: $SOC_{t,y}$ is measured in an adequate number of soil profiles to meet Gold Standard uncertainty requirements in each stratum (compare section 16.2). Currently accepted protocols are the ICRAF protocol[19] and the VCS SOC Module[20]. As these protocols require a certain measure of field and laboratory technology, alternate protocols may be proposed in SOC Activity Modules or on project level. Deviations from the protocols listed in the framework methodology or activity module (or use of alternate protocols) are subject to review and decision by The ICM.

94. For ex-ante calculations, literature references or an accepted soil carbon model shall be used, following Approach 2 below.

[19] Aynekulu, E. Vagen, T-G., Shephard, K., Winowiecki, L. 2011. A protocol for modeling, measurement and monitoring soil carbon stocks in agricultural landscapes. Version 1.1. World Agroforestry Centre (ICRAF), Nairobi. (http://old.worldagroforestry.org/downloads/Publications/PDFS/TM11192.pdf)

[20] Verified Carbon Standard (VCS) 2012. Module VMD0021 Estimation of Stock in The Soil Carbon Pool (Version 1.0). (https://verra.org/methodology/vmd0021-estimation-of-stocks-in-the-soil-carbon-pool-v1-0/)

• **Approach *2***: $SOC_{t,y}$ is derived from data published in peer-reviewed literature or accepted soil carbon models[21]. Evidence for applicability of the literature values and model parameters to the project site must be provided and validated as described in section 16.2. Specifically, applicability shall be shown with respect to:

• Climate factors (e.g. precipitation levels and seasonal distribution)
• Soil and vegetation types
• Current and historic management systems (land use category, crops, tillage techniques, fertilization)

95. Direct application of literature values is only permitted if the source conditions are comparable to the project environment, evidence of which shall be provided as described in section 16. Furthermore, literature values shall only be applied within the spatial and temporal dimensions analysed in the original source (e.g. SOC depth, timespan for which changes are documented). If a range of parameter values is given in a source or data is aggregated across various factor levels (e.g. average SOC in a region, across a range of soil types), the most conservative value shall be applied.

96. Alternatively, the SOC values from literature may be verified by comparing them to measurements in a set of sample sites within the respective project stratum to indicate conservativeness of the parameter values applied. Such measurements are required if evidence for applicability (as listed above) of literature values or model parameters is deemed insufficient by the ACVA.

• **Approach *3***: If no data for $SOC_{t,y}$ is available, it may be modelled using the approach documented in IPCC 2019. The land use factors F_{LU}, F_{MG} and F_I used in this approach have a time dependency based on the estimated time to reach an equilibrium state after a management change (for IPCC 2019 and IPCC 2006 defaults factors, this is 20 years). Equation 33 (below) provides an approach to account for shorter crediting periods and shall thus be applied.

$$\boldsymbol{SOC_{t,y} = SOC_{BL,y} + SOC_{t,y}}$$

$$\Delta \boldsymbol{SOC_{t,y} = SOC_{REF,y} * F_{LU,y} * \left(F_{MG,PR,y} * F_{I,PR,y} - F_{MG,BL,y} * F_{I,BL,y}\right) * \frac{T_{PR}}{T_{DR}}} \qquad \text{Equation (33)}$$

[21] such as RothC (https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc) or Century (http://www.nrel.colostate.edu/projects/century/) soil carbon models

$SOC_{t,y}$	=	soil organic carbon in stratum y at time t [tC ha-1]
$SOC_{BL,y}$	=	soil organic carbon in stratum y before project start [tC ha-1]
$\Delta SOC_{t,y}$	=	change in soil organic carbon since project start in stratum y at time t [tC ha-1]
$SOC_{REF,y}$	=	reference soil organic carbon stock under natural vegetation in stratum y [tC ha-1]
$F_{LU,y}$	=	land use factor in stratum y [dimensionless]
$F_{MG,BL,y}$	=	tillage factor before project start in stratum y [dimensionless]
$F_{I,BL,y}$	=	input factor before project start in stratum y [dimensionless]
$F_{MG,PR,y}$	=	tillage factor under the project scenario in stratum y [dimensionless]
$F_{I,PR,y}$	=	input factor under the project scenario in stratum y [dimensionless]
D_{PR}	=	time dependency of $F_{MG,PR}$ and $F_{I,PR}$ factors[22] [yr]
T_{PR}	=	number of years since project start at time t; maximum T_{PR} = D [yr]

97. Under the applicability conditions of this Methodology, no land use change is taking place and thus the $SOC_{REF,y}$ and $F_{LU,y}$ values are identical to the respective baseline values.

98. For $\mathbf{F_{MG,PR,y}}$ and $\mathbf{F_{I,PR,y}}$ factors, default values from the IPCC 2019 guidelines may be applied within a given temperature and moisture regime as in the baseline scenario (see Table 3 and Table 4), but now referring to the management and input levels under the project scenario. Note that the same climate zone and soil type as for baseline calculations shall be used. If national or regional factors are available (IPCC Tier 2 or Tier 3 data) these should be used instead. In such cases, time dependency D also has to be matched to the respective source.

Procedure for Approach Change

99. Any approach change between baseline and project scenario calculations shall meet the following conditions and procedures:

[22] For IPCC 2019 and IPCC 2006 default factors, *D* equals 20 years

1. If approach 1 or 2 are used for quantification, change to approach 3 is not allowed.

2. At project start, calculations result from both approaches shall be compared. Differences shall be assessed and procedures below applied:

a. Neutral change: If SOC stocks calculated (Approach 2) or measured (Approach 1) at project start do not differ by more than 5% of the stocks calculated and verified with the previous approach for the baseline scenario (see section 16.2), the transition can be considered neutral and may be permitted. The result of the new Approach shall be applied for stock change calculations. Exception: If the baseline stock was measured under Approach 1 and this baseline SOC value is higher than the new Approach 2 resu t, the measured baseline value shall remain to ensure conservativeness.

b. SOC change (modelled): If SOC stocks calculated with a new Approach 2 method differ by more than 5% from the stocks calculated and verified with the previous approach for the baseline scenario, the applicability of the selected dataset or model and parametrization shall be reviewed at project validation. If the model and data is deemed applicable upon review by the ACVA, the baseline value shall be corrected accordingly. Exception: If the baseline stock was measured under Approach 1 and this baseline SOC value is higher than the new Approach 2 result, the measured baseline value shall remain to ensure conservativeness.

c. SOC change (measured): If SOC stocks measured with a new Approach 1 sample differ by more than 5% from the stocks calculated and verified with the previous approach for the baseline scenario, the baseline value shall be corrected accordingly.

Table 7: illustrative examples for approach change, change assessment and outcome.

Baseline Scenario Approach		**Project Scenario Approach**		**Change Assessment**			**Change Outcome**	
Approach	**SOC Stock**	**Approach**	**SOC Stock**	**Change Rationale**	**Change Rule**	**Review Result (if applicable)**	**Baseline Value**	**Approach for Project Scenario**
Appr. 3	55 ± 8%	Appr. 2	54 ± 4%	The project owner applies a specific SOC model for the practices under project scenario. This model is not applicable under the baseline scenario due to lack of historic data. A simpler model is used for the	Rule 2a): Difference is less than 5% change is neutral	n/a	54	Appr. 2
Appr. 3	143 ± 30%[23]	Appr. 2	126 ± 6%		Rule 2b): Difference is more than 5% Review needed	Model confirmed	126	Appr. 2
Appr. 2	37 ± 12%	Appr. 2	39 ± 5%		Rule 2a): Difference is less than 5% change is neutral	n/a	39	Appr. 2 (new model)

[23] Applying a parameter with a high uncertainty will likely result in an uncertainty deduction off the benefits (see Section 9). In the assessment of the approach change, this does not have an impact.

				baseline calculations.				
Appr. 1	45 ± 2%	Appr. 2	47 ± 8%	Data collected in the baseline period has been expanded with regional soil data and a regional SOC model has been created ad published. The project owner wants to use the high-accuracy measured baseline data but use a model approach going forward.	Rule 2a): Difference is less than 5% change is neutral	n/a	47	Appr. 2
Appr. 1	68 ± 2%	Appr. 2	65 ± 8%		Rule 2a): Difference is less than 5% special case: higher measured value to be kept as baseline	n/a	68	Appr. 2
Appr. 1	93 ± 4%	Appr. 3	93 ± 4%	Previous SOC measurement is discontinued at project start. The project owner wants to apply the (measured) start value in an Approach 3 model.	Rule 1): Not allowed	n/a	To be revised	To be revised
Appr. 3	82 ± 14%	Appr. 1	69 ± 9%	The project owner intends to perform measurements in the project area throughout the crediting period. However, such measurements are not available for the baseline period.	Rule 2c): Measurements take precedence (even if difference is >5%)	n/a	69	Appr. 1

				Instead, a simple Approach 3 model was used for baseline calculations.				

4.5.2.4. Leakage Calculations

100. Leakage is defined as an increase in GHG emissions outside the project area as a result of project activities. Activity Modules shall provide leakage calculations if applicable.

In the context of this Methodology and respective Activity Modules, leakage could occur inter alia in relation to shift of crop production to other lands to compensate for yield reductions or to emissions from increased C runoff.

101. Under this Framework Methodology's applicability conditions, projects are not allowed on wetlands, where C runoff could be an issue. Leakage from C runoff is thus considered 0.

And, concerning yield-related leakage, project sites are normally actively maintained for commodity production during the project crediting period and thus yield-related leakage risks are relatively small. Crop producers are commonly risk averse and are unlikely to intentionally suffer reduced crop yields. Moreover, under this Framework Methodology's applicability conditions and the LUF Activity Requirements, projects shall not lead to a decrease in agricultural productivity, thus all projects shall be set up to maintain or increase yield. Accordingly, this Framework Methodology's applicability conditions do not allow yield reduction.

102. For initial project calculations, LK_{t-0} is thus considered equal 0.

103. Nevertheless, if a reduction in yield is detected in a performance certification, it is assumed that the lost production capacity will have to be made up for on land outside the project area. Emissions caused by such a shift must be accounted for as leakage, unless the project owner provides evidence that yield reductions are caused by factors unrelated to the project activity, e.g. regional yield reduction due to weather.

104. Equation 34 is applied to calculate the carbon losses resulting from a reduction in crop yield (CY) and activity shift to a non-project land (leakage area) in a specific calculation period. In order to avoid undue accounting for leakage after temporary yield increases (i.e. no additional losses compared to the baseline yield), reduction in crop yield is always calculated against the lowest yield in the project area since project start. Note that under these conditions, leakage shall only be calculated with Equation 34 if yield CY_t is lower than the minimal yield CY_{min}. Accounting of positive leakage is not allowed.

$$LK_{t-0} = \frac{CY_{min} - CY_t}{CY_{BL}} * A * (\Delta BC_{LA} + \Delta SOC_{LA,t-0} + \Delta FE_{LA,t-0} + \Delta FU_{LA,t-0})$$ Equation (34)

LK_{t-0}	=	emissions due to shift of production to non-project lands (leakage area) [tCO_{2e}]
CY_{min}	=	crop yield in the project area at time t (5-year average) [kg ha-1]
CY_t	=	lowest crop yield in the project area in any calculation period since project start (5-year average) [kg ha-1]
CY_{BL}	=	crop yield in the project area under the baseline scenario (5-year average) [kg ha-1]
A	=	total eligible project area [ha]
ΔBC_{LA}	=	change in biomass carbon stocks in leakage area [tCO_{2e} ha-1]
$\Delta SOC_{LA,t-0}$	=	change in soil organic carbon stocks in leakage area [tCO_{2e} ha-1]
$\Delta FE_{LA,t-0}$	=	change in emissions from use of fertilizer in leakage area [tCO_{2e} ha-1]
$\Delta FU_{LA,t-0}$	=	change in emissions from fuel use in leakage area [tCO_{2e} ha-1]

105. CY_t, CY_{min} and CY_{BL} are based on project owner's documentation. For each point in time, the previous five years' average is used as yield quantity. Note that for the first calculation period CY_{min} equals CY_{BL}.

106. ΔBC_{LA}, ΔSOC_{LA}, ΔFE_{LA}, ΔFU_{LA} are calculated as the difference between respective carbon stocks on the land to which the activity would most likely be shifted (i.e. the pre-shift vegetation cover and land use) and the long-term biomass carbon stock under the baseline cropping system.

107. For ΔBC_{LA} biomass carbon stocks according to IPCC (2019) or applicable local literature values are compared to the respective stocks under the baseline cropping system. All other parameters are calculated according to the approaches described in this methodology, taking into account the situation in the leakage area (i.e. use of appropriate parameters for different soils or management practices).

4.5.2.5. Project Buffer

108. According to GHG Emissions Reduction & Sequestration Product Requirements, a fixed percentage of the validated and verified CCCs must be transferred into the ICM Compliance Buffer if the SOC activity results in sequestration (buffer is not required for emission reduction activities). The buffer is non-refundable, though the project owner may transfer CCCs from other ICM certified projects to the ICM Compliance Buffer in lieu of the CCCs from the project.

4.5.2.6. Emission Reduction Quantification Approaches

109. Greenhouse gas benefits from activities are calculated as the net changes in the soil organic carbon pool as defined below by Equation **35** (below). Consequently, the CO_2 equivalent to the increase in SOC minus project emissions and potential emissions leakage effects is considered the greenhouse gas benefit attributable to the project activity. Projects shall transfer a fixed percentage of the issued CCCs attributable to SOC sequestration activities into ICM Compliance Buffer according to the GHG Emissions Reductions & Sequestration Product Requirements. A contribution to **ICM** Compliance Buffer is not required from activities involving SOC emission reductions (i.e. BUF = 0%).

$$\boldsymbol{ER_{t-0}} = \left[\left(\Delta \boldsymbol{C_{SOC,t-0}} * \frac{\mathbf{44}}{\mathbf{12}}\right) - \boldsymbol{PE_{t-0}} - \boldsymbol{LK_{t-0}}\right] * (\mathbf{1} - \boldsymbol{BUF}) \quad \text{Equation (35)}$$

ER_{t-0}	=	emissions reductions to be issued for the calculation period [tCO_{2e}]
$\Delta C_{SOC,t-0}$	=	*change in carbon stocks in mineral soils in the calculation period [tC]*
44/12	=	*CO_2 to C molecular mass ratio [tCO_{2e} tC-1]*
PE_{t-0}	=	*additional emissions due to project activity in the calculation period [tCO_{2e}]*
LK_{t-0}	=	*leakage of emissions due to project activity in the calculation period [tCO_{2e}]*
BUF	=	*compliance buffer fraction[24] [dimensionless]*

110. Changes in SOC between two points in time (calculation period) are determined as the difference between SOC stocks at each point as defined by Equation **36**:

$$\Delta \boldsymbol{C_{SOC,t-0}} = (\boldsymbol{SOC_t} - \boldsymbol{SOC_0}) * (\mathbf{1} - \boldsymbol{UD}) \quad \text{Equation (36)}$$

$\Delta C_{SOC,t-0}$	=	change in soil organic carbon stocks in the calculation period [tC]
SOC_t	=	soil organic carbon stock at the beginning of the calculation period [tC]
SOC0	=	soil organic carbon stock at the end of the calculation period [tC]
UD	=	uncertainty deduction [dimensionless]

4.6. Emission reductions

111. Emission reductions are calculated as follows:

$$ER_y = BE_y - PE_y - LE_y + ER_{t-0} \quad \text{Equation (37)}$$

Where:

ER_y	=	Emissions reductions in year *y* (t CO_2)
BE_y	=	Baseline emissions in year *y* (t CO_2)
PE_y	=	Project emissions in year *y* (t CO_2)
LE_y	=	Leakage emissions in year *y* (t CO_2)

4.7. Data and Parameters not monitored

Data / Parameter table 1.

Data / Parameter:	$RATE_{COMPLIANCE,t}$
Data unit:	Fraction
Description:	Rate of compliance with a regulatory requirement to implement the alternative waste treatment *t* implemented in the project activity
Source of data:	Official studies, reports and certification from municipal authorities
Measurement procedures (if any):	-

[24] *Ibid.*

Any comment:	Calculated based on the number of instances of compliance identified at the time of the investment decision

Data / Parameter table 2.

Data / Parameter:	***FFC_j***
Data unit:	%
Description:	Fraction of fossil carbon in total carbon content of waste type *j*
Source of data:	Table 2.4, chapter 2, volume 5 of IPCC 2006 guidelines
Valued to be applied	For MSW the following values for the different waste types *j* may be applied: **Table 3: Default values for $FFC_{j,y}$** **Waste type *j*** | Paper/cardboard | 5 Textiles | 50 Food waste | - Wood | - Garden and Park waste | 0 Nappies | 10 Rubber and Leather | 20 Plastics | 100 Metal* | NA Glass* | NA Other, inert waste | 100 Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common. If a waste type is not comparable to a type listed in Table 4, or cannot clearly be described as a combination of types in this table above, or if the non-obligated entity wish to measure $FFC_{j,}$ then non-obligated entity shall measure $FFC_{j,y}$ using the following standards, or similar national or international standards: ASTM D6866: "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis"; ASTM D7459: "Standard Practice for Collection of Integrated Samples for the Speciation of Biomass (Biogenic) and Fossil Carbon Dioxide Emitted from Stationary Emissions Sources". The frequency of measurement shall be as a minimum four times in year *y* with the mean value valid for year *y* The non-obligated entity also have the option to apply the balance method (**Error! Reference source not found.**) to measure $FFC_{j,y}$
Measurement procedures (if any):	-
Any comment:	Data and parameters to be monitored in respect of the balance method are shown in the **Error! Reference source not found.** additionally

Data / Parameter table 3.

Data / Parameter:	***FCC_j***
Data unit:	%
Description:	Fraction of total carbon content in waste type *j*
Source of data:	Table 2.4, chapter 2, volume 5 of IPCC 2006 guidelines
Value to be applied	For MSW the following values for the different waste types *j* may be applied: **Table 4: Default values for $FCC_{j,y}$** Waste type *j* / – ; Paper/cardboard 50; Textiles 50; Food waste 50; Wood 54; Garden and Park waste 55; Nappies 90; Rubber and Leather 67; Plastics 85; Metal* NA; Glass* NA; Other, inert waste 5 *Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common The non-obligated entity also have the option to apply the balance method (**Error! Reference source not found.**) to measure $FCC_{j,y}$
Measurement procedures (if any):	-
Any comment:	Data and parameters to be monitored in respect of the balance method are shown in the **Error! Reference source not found.** additionally

Table 4: Default values for $FCC_{j,y}$

Waste type *j*	
Paper/cardboard	50
Textiles	50
Food waste	50
Wood	54
Garden and Park waste	55
Nappies	90
Rubber and Leather	67
Plastics	85
Metal*	NA
Glass*	NA
Other, inert waste	5

Data / Parameter table 4.

Data / Parameter:	***GWP_{CH4}***
Data unit:	t CO_2e/t CH_4
Description:	Global Warming Potential of methane valid for the commitment period (t CO_2e/t CH_4)
Source of data:	IPCC
Values to be applied	Default value of 29.8 from IPCC Fourth Assessment Report (AR6). Shall be updated according to any future COP/MOP decisions
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 5.

Data / Parameter:	***GWP_{N2O}***
Data unit:	t CO_2e/t N_2O

Description:	Global Warming Potential of N_2O
Source of data:	IPCC
Values to be applied	Default value of 273 from IPCC Fourth Assessment Report (AR6). Shall be updated according to any future COP/MOP decisions
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 6.

Data / Parameter:	B_O
Data unit:	t CH_4/tCOD
Description:	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (t CH_4/tCOD)
Source of data:	Section 6.2.3.2, chapter 6, volume 5 of IPCC 2006 guidelines
Values to be applied	0.25
Measurement procedures (if any):	-
Any comment:	Applicable to the “Procedure to calculate project emissions from wastewater treatment”

Data / Parameter table 7.

Data / Parameter:	MCF_{ww}
Data unit:	Fraction
Description:	Methane conversion factor
Source of data:	The source of data shall be the following, in order of preference: 1. Project specific data; 2. Country specific data; or 3. IPCC default values (table 6.3, chapter 6, volume 5 of IPCC 2006 guidelines)
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 8.

Data / Parameter:	$EF_{CH4,t}$
Data unit:	t CH_4/t waste (wet basis)
Description:	Emission factor for CH_4 associated with waste treatment process *t*
Source of data:	Table 5.3, chapter 5, volume 5 of IPCC 2006 guidelines

<table>
<tr><td>Values to be applied:</td><td>If country-specific data is available, then this shall be applied and the method used to derive the value as well as the data sources need to be documented in the ICM-PDD. If country-specific data are not available, then apply the default values listed in Table 5. For continuous incineration of industrial waste, apply the CH_4 emission factors provided in Volume 2, Chapter 2, Stationary Combustion of IPCC 2006 Guidelines.

Table 5. CH_4 emission factors for combustion
<table>
<tr><th>Waste type</th><th colspan="2">Type of incineration/technology</th><th>CH_4 emission factors
($t\ CH_4$ / t waste) wet basis</th></tr>
<tr><td rowspan="6">MSW</td><td rowspan="2">Continuous incineration</td><td>stoker</td><td>$1.21 \times 0.2 \times 10^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>~0</td></tr>
<tr><td rowspan="2">Semi-continuous incineration</td><td>stoker</td><td>$1.21 \times 6 \times 10^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>$1.21 \times 188 \times 10^{-6}$</td></tr>
<tr><td rowspan="2">Batch type incineration</td><td>stoker</td><td>$1.21 \times 60 \times 10^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>$1.21 \times 237 \times 10^{-6}$</td></tr>
<tr><td colspan="3">Sludge (semi-continuous or batch type incineration)</td><td>$1.21 \times 9\,700 \times 10^{-6}$</td></tr>
<tr><td colspan="3">Waste oil (semi-continuous or batch type incineration)</td><td>$1.21 \times 560 \times 10^{-6}$</td></tr>
</table>

A conservativeness factor of 1.21 has been applied to account for the uncertainty of the IPCC default values</td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Any comment:</td><td>Applicable to Option 2 of procedure to estimate $PE_{COM,c,y}$</td></tr>
</table>

Data / Parameter table 9.

Data / Parameter:	$EF_{N2O,t}$
Data unit:	$t\ N_2O$/t waste (wet basis)
Description:	Emission factor for N_2O associated with treatment process *t*
Source of data:	Table 5.6, chapter 5, volume 5 of IPCC 2006 guidelines

<table>
<tr><td>Values to be applied:</td><td>If country-specific data is available, then this shall be applied, and the method used to derive the value as well as the data sources need to be documented in the ICM-PDD. If country-specific data are not available, then apply the default values listed in Table 7.

Table 6. N_2O emission factors for combustion

<table>
<tr><th>Type of waste</th><th>Technology / Management practice</th><th>Emission factor (t N_2O/t waste wet basis)</th></tr>
<tr><td>MSW</td><td>Continuous and semi-continuous incinerators</td><td>$1.21x\ 50x10^{-3}$</td></tr>
<tr><td>MSW</td><td>Batch-type incinerators</td><td>$1.21x\ 60x10^{-3}$</td></tr>
<tr><td>Industrial waste</td><td>All types of incineration</td><td>$1.21x\ 100x10^{-3}$</td></tr>
<tr><td>Sludge (except sewage sludge)</td><td>All types of incineration</td><td>$1.21x\ 450x10^{-3}$</td></tr>
<tr><td>Sewage sludge</td><td>Incineration</td><td>$1.21x\ 900x10^{-3}$</td></tr>
</table>

A conservativeness factor of 1.21 has been applied to account for the uncertainty of the IPCC default values</td></tr>
<tr><td>Measurement procedures (if any):</td><td>-</td></tr>
<tr><td>Any comment:</td><td>Applicable to Option 2, of procedure to estimate $PE_{COM,c,y}$</td></tr>
</table>

Data / Parameter table 10.

Data / Parameter:	$EF_{CO2,BL,HG}$
Data unit:	t CO_2/TJ
Description:	CO_2 emission factor of the fossil fuel type used for heat generation by the boiler or air heater in the baseline
Source of data:	The source of data shall be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values shall be used only when country or project specific data are not available or difficult to obtain
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 11.

Data / Parameter:	η_{cogen}
Data unit:	ratio
Description:	Efficiency of the cogeneration plant that would have been used in the absence of the project activity

Source of data:	Non-Obligated Entities can choose one of the following approaches: Highest of the measured efficiencies of similar plants; Highest of the efficiency values provided by two or more manufacturers for similar plants; or Maximum efficiency of 90 per cent, based on net calorific values
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 12.

Data / Parameter:	$\boldsymbol{EF_{CO2,BL,CG}}$
Data unit:	t CO_2/MJ
Description:	Emission factor of baseline fossil fuel used in the cogeneration plant, as identified in the baseline scenario identification
Source of data:	The source of data shall be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values shall be used only when country or project specific data are not available or difficult to obtain
Values to be applied	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 13.

Data / Parameter:	$\boldsymbol{COD_{out,x}}$
Data unit:	tCOD
Description:	COD of the effluent in the period *x*.
Source of data:	For existing plants: If there is no effluent: $COD_{out,x} = 0$; If there is effluent: One year of historical data should be used, or If one year data is not available then *x* represents a measurement campaign of at least 10 days to the COD inflow ($COD_{in,x}$) and COD outflow ($COD_{out,x}$) from the lagoon or sludge pit. For Greenfield projects: Use the design COD inflow for COD in and the design effluent COD flow for COD out corresponding to the design features of the lagoon system identified in the procedure for the selection of the baseline scenario
Values to be applied:	-

Measurement procedures (if any):	For the measurement campaign of at least 10 days: The measurements should be undertaken during a period that is representative for the typical operation conditions of the plant and ambient conditions of the site (temperature)
Any comment:	-

Data / Parameter table 14.

Data / Parameter:	***$COD_{in,x}$***
Data unit:	tCOD
Description:	COD directed to the anaerobic lagoons or sludge pits in the period *x* (tCOD)
Source of data:	For existing plants: If there is no effluent: $COD_{out,x} = 0$; If there is effluent: One year of historical data should be used, or If one year data is not available then *x* represents a measurement campaign of at least 10 days to the COD inflow ($COD_{in,x}$) and COD outflow ($COD_{out,x}$) from the lagoon or sludge pit. For Greenfield projects: Use the design COD inflow for COD in and the design effluent COD flow for COD out corresponding to the design features of the lagoon system identified in the procedure for the selection of the baseline scenario
Values to be applied:	-
Measurement procedures (if any):	For the measurement campaign of at least 10 days: The measurements should be undertaken during a period that is representative for the typical operation conditions of the plant and ambient conditions of the site (temperature)
Any comment:	-

Data / Parameter table 15.

Data / Parameter:	***x***
Data unit:	Time
Description:	Representative historical reference period
Source of data:	For existing plants: *x* should represent one year of historical data; If one-year data is not available then *x* represents a measurement campaign of at least 10 days. For Greenfield projects this parameter is not relevant
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 16.

Data / Parameter:	*ρ*
Data unit:	-
Description:	Discount factor to account for the uncertainty of the use of historical data to determine $COD_{BL,y}$
Source of data:	For existing plants: 1. If one year of historical data is available ρ=1; 2. If a measurement campaign of at least 10 days is available ρ=0.89. For Greenfield projects: ρ=1
Values to be applied:	-
Measurement procedures (if any):	The value of 0.89 for the case where there is no one year historical data is to account for the uncertainty range (of 30 per cent to 50 per cent) associated with this approach as compared to one-year historical data
Any comment:	-

Data / Parameter table 17.

Data / Parameter:	***B_o***
Data unit:	t CH_4/tCOD
Description:	Maximum methane producing capacity, expressing the maximum amount of CH_4 that can be produced from a given quantity of chemical oxygen demand (COD)
Source of data:	2006 IPCC Guidelines
Values to be applied:	The default IPCC value for B_o is 0.25 kg CH_4/kg COD shall be used. Unless the methodology is used for wastewater containing materials not akin to simple sugars, a CH_4 emissions factor different from 0.21 t CH_4/tCOD has to be applied.
Measurement procedures (if any):	No measurement procedures.
Any comment:	Taking into account the uncertainty of this estimate, non-obligated entities should use a value of 0.21 kg CH_4/kg COD as a conservative assumption for B_o

Data / Parameter table 18.

Data / Parameter:	***D***
Data unit:	M
Description:	Average depth of the lagoons or sludge pits
Source of data:	For existing plants: conduct measurements. For project activities implemented in Greenfield facilities: As per the baseline lagoon design as identified in Step 1 of the section "Procedure for the identification of the most plausible baseline scenario Identification of alternative scenarios"
Values to be applied:	-
Measurement procedures (if any):	Determine the average depths of the whole lagoon/sludge pit under normal operating conditions
Any comment:	-

Data / Parameter table 19.

Data / Parameter:	$\eta_{mech,mot,i,j}$
Data unit:	-
Description:	The efficiency of the baseline equipment that would provide mechanical power to recipient *j* which in the absence of the project activity
Source of data:	Manufacturers data or data from similar plant operators or Non-Obligated Entities data
Values to be applied:	-
Measurement procedures (if any):	For mechanical energy conversion equipment, apart from the options available in the baseline emission section (electrical motor or steam turbine in the baseline which is replaced by a mechanical turbine in the ICM project), use the equipment efficiency vs. the load characteristic curve from the supplier
Any comment:	-

Data / Parameter table 20.

Data / Parameter:	$\eta_{mech,tur,k}$
Data unit:	-
Description:	The efficiency of the baseline equipment that would provide mechanical power to recipient *j* which in the absence of the project activity
Source of data:	Manufacturers data or data from similar plant operators or Non-Obligated Entities data
Values to be applied:	-
Measurement procedures (if any):	For mechanical energy conversion equipment, apart from the options available in the baseline emission section (electrical motor or steam turbine in the baseline which is replaced by a mechanical turbine in the ICM project), use the equipment efficiency vs. the load characteristic curve from the supplier
Any comment:	-

Data / Parameter table 21.

Data / Parameter:	A
Data unit:	Ha
Description:	Total Project Area
Source of data:	Project Owner Records
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 22.

Data / Parameter:	A_y
Data unit:	Ha
Description:	Area per stratum y

Source of data:	Project Owner Records
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 23.

Data / Parameter:	$AQ_{BL,ET,a}$
Data unit:	Kg
Description:	Agrochemical quantity applied by emitter type for baseline activities
Source of data:	Project owner records (5year pre-project average current)
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 24.

Data / Parameter:	CY_{BL}
Data unit:	Kg/ha
Description:	Average annual crop yield per ha in the project area during the baseline period (5 year average)
Source of data:	Project owner records (self-reporting e.g. sale receipts, contracts, etc.)
Values to be applied:	-
Measurement procedures (if any):	Yield is recorded annually and an average annual yield calculated across the 5-year baseline period
Any comment:	-

Data / Parameter table 25.

Data / Parameter:	$SOC_{BL,y}$
Data unit:	tC/ha
Description:	Soil organic carbon density at equilibrium per stratum y
Source of data:	Project owner records (approach 1), from literature (approach 2) or modelled (approach 3)
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 26.

Data / Parameter:	$SOC_{REF,y}$
Data unit:	tC/ha
Description:	Soil organic carbon reference density (under natural vegetation) at equilibrium per stratum y

Source of data:	values from literature / local studies
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	Used in Approach 3 Only

Data / Parameter table 27.

Data / Parameter:	***EF_{LE}***
Data unit:	[tCO_2e kgN^{-1}]
Description:	Conversion factor for emissions from N fertilizer
Source of data:	IPCC defaults
Values to be applied:	Aggregated default value for EF_{FE} is 0.01. Disaggregated default values in IPCC 2019 Table 11.1 may be used if fertilizer inputs are known per fertilizer type.
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 28.

Data / Parameter:	**$F_{LU,y}$**
Data unit:	[dimensionless]
Description:	land use factor in stratum y
Source of data:	IPCC defaults or national / local studies (preferred)
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 29.

Data / Parameter:	**$F_{I,BL,y}$**
Data unit:	[dimensionless]
Description:	input factor before project start in stratum y
Source of data:	IPCC defaults or national / local studies (preferred)
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 30.

Data / Parameter:	**$FE_{BL,MT}$**
Data unit:	litres
Description:	Fossil fuel consumed recorded by vehicle and fuel type for baseline activities
Source of data:	Project owner records or modelling (5year pre-project average)

Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

Data / Parameter table 31.

Data / Parameter:	**$EUW_{BL,SE}$**
Data unit:	kWh
Description:	Electricity consumed by source for baseline activities
Source of data:	Project owner records (5year pre-project average)
Values to be applied:	-
Measurement procedures (if any):	-
Any comment:	-

5. Methodology: Monitoring Component

5.1. Monitoring procedures

112. The monitoring procedures are described in the tables below. As applicable, all the monitoring provisions contained in the tools referred to in this methodology shall be followed.

113. Describe and specify in the ICM-PDD all monitoring procedures, including the type of measurement instrumentation used, the responsibilities for monitoring and QA/QC procedures that will be applied. Where the methodology provides different options (e.g. use of default values or on-site measurements), specify which option will be used. All meters and instruments should be calibrated regularly as per industry practices.

5.2. Data and Parameters monitored

Data / Parameter table 32.

Data / Parameter:	**$NCV_{BIOGAS,NG,y}$**
Data unit:	TJ/Nm^3
Description:	Net calorific value of the upgraded biogas sent to the natural gas network due to the project activity in year *y*
Source of data:	Non-Obligated Entities
Measurement procedures (if any):	Measured directly using an online Heating Value Meter from the gas stream. The measurement must be in volume basis and adjusted to reference conditions
Monitoring frequency	Continuous
QA/QC Procedure	Calibration shall be according to manufacturer's specifications
Any comment:	Applicable to baseline emissions procedure (D)

Data / Parameter table 33.

Data / Parameter:	***$BIOGAS_{NG,y}$***
Data unit:	Nm^3/yr
Description:	Quantity upgraded biogas sent to the natural gas network due to the project activity in year *y* (Nm^3)
Source of data:	Non-Obligated Entities
Measurement procedures (if any):	Measured by a flow meter and adjusted to reference conditions. Data to be aggregated monthly and yearly
Monitoring frequency	Continuous (average value in a time interval not greater than an hour shall be used in the calculations of emission reductions)
QA/QC Procedure	Flow meters shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications
Any comment:	Applicable to procedure (D)

Data / Parameter table 34.

Data / Parameter:	***$EFF_{COM,c,y}$***
Data unit:	Fraction
Description:	Combustion efficiency of combustor *c* in year *y*
Source of data:	The source of data shall be the following, in order of preference: 1. Project specific data; 2. Country specific data; or 3. IPCC default values
Measurement procedures (if any):	-
Monitoring frequency	Annually
QA/QC Procedure	-
Any comment:	As per guidance from the Board, IPCC default values shall be used only when country or project specific data are not available or difficult to obtain

Data / Parameter table 35.

Data / Parameter:	***$SG_{c,y}$***
Data unit:	m^3/yr
Description:	Volume of stack gas from combustor *c* in year *y*
Source of data:	Non-Obligated Entities
Measurement procedures (if any):	The stack gas flow rate is either directly measured or calculated from other variables where direct monitoring is not feasible. Where there are multiple stacks of the same type, then it is sufficient to monitor one stack of each type. For the case that biogas is combusted, then the stack gas volume flow rate may be estimated by summing the inlet biogas and air flow rates and adjusting for stack temperature. Direct measurement of the air inlet flow rate shall be made using a flow meter
Monitoring frequency	Continuous or periodic (at least quarterly)

QA/QC Procedure	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures. Where laboratory work is outsourced, one which follows rigorous standards shall be selected
Any comment:	-

Data / Parameter table 36.

Data / Parameter:	$C_{N2O,SG,c,y}$
Data unit:	t N_2O/Nm^3
Description:	Concentration of N_2O in stack gas from combustor *c* in year *y*
Source of data:	Non-obligated entities
Measurement procedures (if any):	-
Monitoring frequency	At least every three months
QA/QC Procedure	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures. Where laboratory work is outsourced, one which follows rigorous standards shall be selected
Any comment:	More frequent sampling is encouraged

Data / Parameter table 37.

Data / Parameter:	$C_{CH4,SG,c,y}$
Data unit:	t CH_4/Nm^3
Description:	Concentration of CH_4 in stack gas from combustor *c* in year *y*
Source of data:	Non-obligated entities
Measurement procedures (if any):	-
Monitoring frequency	At least every three months
QA/QC Procedure	Maintenance and calibration of equipment will be carried out according to internationally recognised procedures. Where laboratory work is outsourced, one which follows rigorous standards shall be selected
Any comment:	More frequent sampling is encouraged

Data / Parameter table 38.

Data / Parameter:	$Q_{waste,c,y}$
Data unit:	T
Description:	Quantity of fresh waste or RDF/SB fed into combustor *c* in year *y*
Source of data:	Non-Obligated Entities
Measurement procedures (if any):	Measured with calibrated scales or load cells
Monitoring frequency	Continuously, aggregated at least annually
QA/QC Procedure	-
Any comment:	Parameter required for procedure to calculate project emissions from combustion within the project boundary

Data / Parameter table 39.

Data / Parameter:	$p_{n,j,y}$
Data unit:	Weight fraction
Description:	Fraction of waste type *j* in the sample *n* collected during the year *y*
Source of data:	Sample measurements by Non-Obligated Entities
Measurement procedures (if any):	-
Monitoring frequency	A minimum of three samples shall be undertaken every three months with the mean value valid for year *y*
QA/QC Procedure	-
Any comment:	-

Data / Parameter table 40.

Data / Parameter:	z_y
Data unit:	-
Description:	Number of samples collected during the year *y*
Source of data:	Non-Obligated Entities
Measurement procedures (if any):	-
Monitoring frequency	Continuously, aggregated annually
QA/QC Procedure	-
Any comment:	-

Data / Parameter table 41.

Data / Parameter:	$EC_{t,y}$
Data unit:	MWh
Description:	Electricity consumption of electricity generated in an on-site fossil fuel fired power plant or from the grid as a result of the alternative waste treatment process *t* in year *y*
Source of data:	Electricity meter
Measurement procedures (if any):	Sources of consumption shall include the operation of the alternative waste treatment process, on-site processing or management of the feedstock or products associated with the treatment process and on-site combustion activity. Electricity consumption shall be monitored for all activities included in the project boundary, associated with the treatment process, as illustrated in **Error! Reference source not found.**
Monitoring frequency	Continuous
QA/QC Procedure	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy. The readings will be double checked against invoices when available

Any comment:	This parameter is required for calculating project emissions from electricity consumption due to waste treatment under the project activity process *t* ($PE_{EC,t,y}$) using the BM-T-003 $EC_{t,y}$ excludes consumption of any electricity generated by the project activity. In case of consumption of electricity generated by the project by RDF/SB combustion or incineration, then emissions associated with combustion of fossil carbon content of the waste are accounted for in the procedure “Project emissions from combustion”, and do not need to be accounted for again in the procedure “Project emissions from electricity use”

Data / Parameter table 42.

Data / Parameter:	$EG_{t,y}$
Data unit:	MWh
Description:	Electricity generated by the alternative waste treatment process *t* and exported to the grid or displacing fossil fuel fired power-only and/or cogeneration captive energy generation in year *y*
Source of data:	Electricity meter
Measurement procedures (if any):	-
Monitoring frequency	Continuous
QA/QC Procedure	Electricity meter will be subject to regular (in accordance with stipulation of the meter supplier) maintenance and testing to ensure accuracy
Any comment:	-

Data / Parameter table 43.

Data / Parameter:	$HG_{PJ,y}$
Data unit:	TJ
Description:	Quantity of heat supplied by the project activity displacing baseline heat generation by a fossil fuel boiler or air heater in year *y* (TJ)
Source of data:	Steam meter
Measurement procedures (if any):	In case of steam meter: the enthalpy of steam and feed water will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by steam meter. In case of hot air: the temperature, pressure and mass flow rate will be measured
Monitoring frequency	Monthly, aggregated yearly
QA/QC Procedure	In case of monitoring of steam, it will be calibrated for pressure and temperature of steam at regular intervals. The meter shall be subject to regular maintenance and testing to ensure accuracy
Any comment:	The dedicated quantity of thermal energy generated for heat supply or cogeneration by the project activity if included

Data / Parameter table 44.

Data / Parameter:	**Temperature of the thermal treatment process**
Data unit:	degrees Celsius
Description:	The thermal treatment process (dehydration) occurs under controlled conditions (up to 300 degrees Celsius)
Source of data:	Project site
Measurement procedures (if any):	-
Monitoring frequency	-
QA/QC Procedure	-
Any comment:	-

Data / Parameter table 45.

Data / Parameter:	$Q_{ww,y}$
Data unit:	m^3
Description:	Amount of wastewater discharge generated by the project activity and treated anaerobically or released untreated from the project activity in year *y*
Source of data:	Measured value by flow meter
Measurement procedures (if any):	-
Monitoring frequency	Monthly, aggregated annually
QA/QC Procedure	The monitoring instruments will be subject to regular maintenance and testing to ensure accuracy
Any comment:	If the wastewater is treated aerobically, emissions are assumed to be zero, and hence this parameter does not need to be monitored

Data / Parameter table 46.

Data / Parameter:	$P_{COD,y}$
Data unit:	$tCOD/m^3$
Description:	COD of the wastewater discharge generated by the project activity in year *y*
Source of data:	Measured value by purity meter or COD meter
Measurement procedures (if any):	-
Monitoring frequency	Monthly and averaged annually
QA/QC Procedure	The monitoring instruments will be subject to regular maintenance and testing to ensure accuracy
Any comment:	If the wastewater discharge is treated aerobically, emissions are assumed to be zero, and hence this parameter does not need to be monitored

Data / Parameter table 47.

Data / Parameter:	$F_{PJ,AD,m}$
Data unit:	m^3
Description:	Quantity of wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m* (m^3)
Source of data:	Measured
Measurement procedures (if any):	-
Monitoring frequency	Parameter monitored continuously but aggregated monthly and annually for calculations
QA/QC Procedure	-
Any comment:	In case of Scenario 1, if the solid materials are also treated in the baseline and project scenario, the $F_{PJ,dig,m}$ does not account the amount of solid materials treated or separated from the wastewater stream in the anaerobic digester, if applicable

Data / Parameter table 48.

Data / Parameter:	$COD_{AD,m}$
Data unit:	t COD/m^3
Description:	Chemical oxygen demand in the wastewater or sludge that is treated in the anaerobic digester or under clearly aerobic conditions in the project activity in month *m*
Source of data:	Measurements
Measurement procedures (if any):	Measure the COD according to national or international standards. If COD is measured more than once per month, the average value of the measurements should be used
Monitoring frequency	Regularly, calculate average monthly and annual values
QA/QC Procedure	-
Any comment:	In case of Scenario 1, if the solid materials are also treated in the baseline and project scenario, the $w_{COD,dig,m}$ is not calculated for the solid materials treated or separated from the wastewater stream in the anaerobic digester, if applicable

Data / Parameter table 49.

Data / Parameter:	$T_{2,m}$
Data unit:	K
Description:	Average temperature at the project site in month *m*
Source of data:	Measurement in the project site, or national or regional weather statistics
Measurement procedures (if any):	In case that Non-Obligated Entities decide to measure temperature in the project site: The temperature sensor must be housed in a ventilated radiation shield to protect the sensor from thermal radiation
Monitoring frequency	Continuously, aggregated in monthly average values

QA/QC Procedure	In case that Non-Obligated Entities decide to measure temperature in the project site: Uncertainty of the measurements provided by temperature sensor supplier should be discounted from the readings
Any comment:	-

Data / Parameter table 50.

Data / Parameter:	**$EG_{i,j,y}$**
Data unit:	MWh
Description:	Quantity of electricity supplied to the recipient *j* by the generator, which in the absence of the project activity would have sourced from i^{th} source (*i* can be either grid or identified source) during the year *y*
Source of data:	Recipient facility(ies) and generation plant measurement records
Measurement procedures (if any):	-
Monitoring frequency	Monthly
QA/QC Procedure	The energy meters will undergo maintenance/calibration to the industry standards. Sales records for sold/purchased electricity/steam (e.g. invoices/receipts) and purchase receipts are used to ensure the consistency
Any comment:	Data shall be measured at the recipient facility(ies) and at the project facility for cross check. Sales receipts shall be used for verification. ACVAs shall verify that total energy supplied by the generator is equal to total electricity received by recipient facility(ies). For electricity exported to a grid, the net electricity delivered shall be monitored.

Data / Parameter table 51.

Data / Parameter:	**$EG_{j,y}$**
Data unit:	MWh
Description:	Quantity of electricity supplied to the recipient *j* by the generator, which in the absence of the project activity would have sourced from i^{th} source (*i* can be either grid or identified source) during the year *y*
Source of data:	Recipient facility(ies) and generation plant measurement records
Measurement procedures (if any):	-
Monitoring frequency	Monthly
QA/QC Procedure	The energy meters will undergo maintenance/calibration to the industry standards. Sales records for sold/purchased electricity/steam (e.g. invoices/receipts) and purchase receipts are used to ensure the consistency
Any comment:	Data shall be measured at the recipient facility(ies) and at the project facility for cross check. Sales receipts shall be used for verification. ACVAs shall verify that total energy supplied by the generator is equal to total electricity received by recipient facility(ies). For electricity exported to a grid, the net electricity delivered shall be monitored.

Data / Parameter table 52.

Data / Parameter:	**$HG_{j,y}$**
Data unit:	TJ
Description:	Net quantity of thermal energy supplied to the recipient facility *j* by the project activity during the year *y* in TJ.
Source of data:	Recipient facility(ies) actual measurement records
Measurement procedures (if any):	For the element process, thermal energy generation is determined as the difference of the enthalpy of the steam or hot water generated by the boiler(s) minus the enthalpy of the feed-water. The enthalpy of feed water to the boiler takes into account the enthalpy of condensate returned to the boiler (if any) and any other waste heat recovery (including economiser, blow down heat recovery etc.). Steam tables or appropriate thermodynamic equations may be used to calculate the enthalpy as a function of temperature and pressure. In the typical cases of waste heat recovery boilers generating steam and supplying to a turbine having extraction-cum-condensing configuration, the extraction steam of the steam turbine is sent to the recipient facility *j* and its condensate directly returns to waste heat recovery boiler. For such cases the condensate return (flow and temperature) is measured at a point before it is mixed with fresh water (or other condensate of the system e.g. that is returning from the outlet of the turbine condensing stage) to be supplied to the boiler. The difference between the enthalpy of extraction steam supplied to recipient facility *j* (e.g. turbine in this case) and the heat of condensate recovered represents $HG_{j,y}$
Monitoring frequency	Continuously, aggregated annually or for each time interval *t*
QA/QC Procedure	This data item is a calculated value using other data items. No QA/QC required
Any comment:	For element process like boilers, net quantity of thermal energy is expressed as the difference of energy content between the steam supplied to the recipient facility and feed water to the boiler. The enthalpy of feed water to the boiler takes into account the enthalpy of condensate returned to the boiler (if any) and any other waste heat recovery (including economiser, blow down heat recovery etc.). Data shall be measured at the recipient facility(ies) and at the project facility for cross check.

Data / Parameter table 53.

Data / Parameter:	**$ws_{i,j}$**
Data unit:	%
Description:	Fraction of total heat that is used by the recipient *j* in the project that in absence of the project activity would have been supplied by the i^{th} element process
Source of data:	Non-obligated entities
Measurement procedures (if any):	-
Monitoring frequency	Yearly
QA/QC Procedure	-
Any comment:	-

Data / Parameter table 54.

Data / Parameter:	**$EF_{CO2,COGEN}$**
Data unit:	Tonnes CO_2/TJ
Description:	CO_2 emission factor per unit of energy of the fuel that would have been used in the baseline cogeneration plant
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	-
Monitoring frequency	Yearly
QA/QC Procedure	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available

Data / Parameter table 55.

Data / Parameter:	**$EF_{heat,j,y}$**
Data unit:	Tonnes CO_2/TJ
Description:	CO_2 emission factor of the heat source that would have supplied the recipient facility *j* in absence of the project activity, expressed in t CO_2/TJ
Source of data:	The source of data should be the following, in order of preference: project specific data, country specific data or IPCC default values. As per guidance from the Board, IPCC default values should be used only when country or project specific data are not available or difficult to obtain
Measurement procedures (if any):	-
Monitoring frequency	Yearly
QA/QC Procedure	No QA/QC necessary for this data item
Any comment:	IPCC guidelines/Good practice guidance provide for default values where local data is not available

Data / Parameter table 56.

Data / Parameter:	**Abnormal operation of the project facility including emergencies and shut down**
Data unit:	Hours
Description:	The hours of abnormal operation of parts of project facility that can have an impact on waste energy generation and recovery
Source of data:	Operation of project facility
Measurement procedures (if any):	-
Monitoring frequency	Daily, aggregated annually
QA/QC Procedure	-

Any comment:	This parameter has to be monitored to demonstrate that no emission reduction is claimed for the hours during the abnormal operation of the part of project facility which have impact on waste energy generation and recovery. The abnormality can be in terms of violation of operational parameters, poor quality product, emergencies or shutdown

Data/Parameter table 57.

Data / Parameter:	***A***
Data unit:	Ha
Description:	Total Project Area
Source of data:	Project Owner Records
Measurement procedures (if any):	-
Monitoring frequency	Project Start
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 58.

Data / Parameter:	A_y
Data unit:	ha
Description:	Area per stratum y
Source of data:	Project Owners Record
Measurement procedures (if any):	-
Monitoring frequency	Annually
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 59.

Data / Parameter:	$AQ_{PR,ER,a}$
Data unit:	Kg
Description:	Agrochemical quantity by emitter type applied in year a
Source of data:	Project owner records (current)
Measurement procedures (if any):	-
Monitoring frequency	Annually
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 60.

Data / Parameter:	CY_t
Data unit:	Kg/ha
Description:	Average annual crop yield per ha in the project area (5 year average)
Source of data:	Project owner records (current)
Measurement procedures (if any):	Yield is recorded annually and an average annual yield calculated at the end of each 5-year reporting period
Monitoring frequency	Annually
QA/QC Procedure	-
Any comment:	This value shall be reported as evidence that no yield reduction is taking place. The lowest annual yield is considered CY_{min} and serve as threshold to assess yield reduction (see Equation 19)

Data/Parameter table 61.

Data / Parameter:	$SOC_{t,y}$
Data unit:	tC/ha
Description:	Soil organic carbon density at equilibrium per stratum y
Source of data:	Project owner records (approach 1), from literature (approach 2) or modelled (approach 3)
Measurement procedures (if any):	-
Monitoring frequency	At each performance certification
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 62.

Data / Parameter:	$SOC_{REF,y}$
Data unit:	tC/ha
Description:	Soil organic carbon reference density (under natural vegetation) at equilibrium per stratum y
Source of data:	Same as in baseline
Measurement procedures (if any):	-
Monitoring frequency	Project Start
QA/QC Procedure	-
Any comment:	Used Approach 3 Only

Data/Parameter table 63.

Data / Parameter:	$F_{LU,y}$
Data unit:	[dimensionless]
Description:	land use factor in stratum y
Source of data:	Same as in baseline
Measurement procedures (if any):	-
Monitoring frequency	Project Start
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 64.

Data / Parameter:	$F_{I,PR,y}$
Data unit:	[dimensionless]
Description:	input factor before project start in stratum y
Source of data:	IPCC defaults or national / local studies (preferred)
Measurement procedures (if any):	-
Monitoring frequency	Annually
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 65.

Data / Parameter:	$FE_{PR,a}$
Data unit:	Kg
Description:	N fertilizer input under the project scenario in year a
Source of data:	Project owner records (current)
Measurement procedures (if any):	-
Monitoring frequency	Annually, if applicable
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 66.

Data / Parameter:	$FUL_{PR,MT,a}$
Data unit:	litres

Description:	Fossil fuel consumed recorded by vehicle and fuel type in year a
Source of data:	Project owner records (current)
Measurement procedures (if any):	-
Monitoring frequency	Annually, if applicable
QA/QC Procedure	-
Any comment:	-

Data/Parameter table 67.

Data / Parameter:	$EUW_{PR,SE,a}$
Data unit:	kWh
Description:	Electricity consumed by source in year a
Source of data:	Project Owner Records (Current)
Measurement procedures (if any):	-
Monitoring frequency	Annually, if applicable
QA/QC Procedure	-
Any comment:	-

- - - - -

6. Annexure 1: Typical Boundary Layouts of What is Included in the Project Boundary

Figure 1: Composting

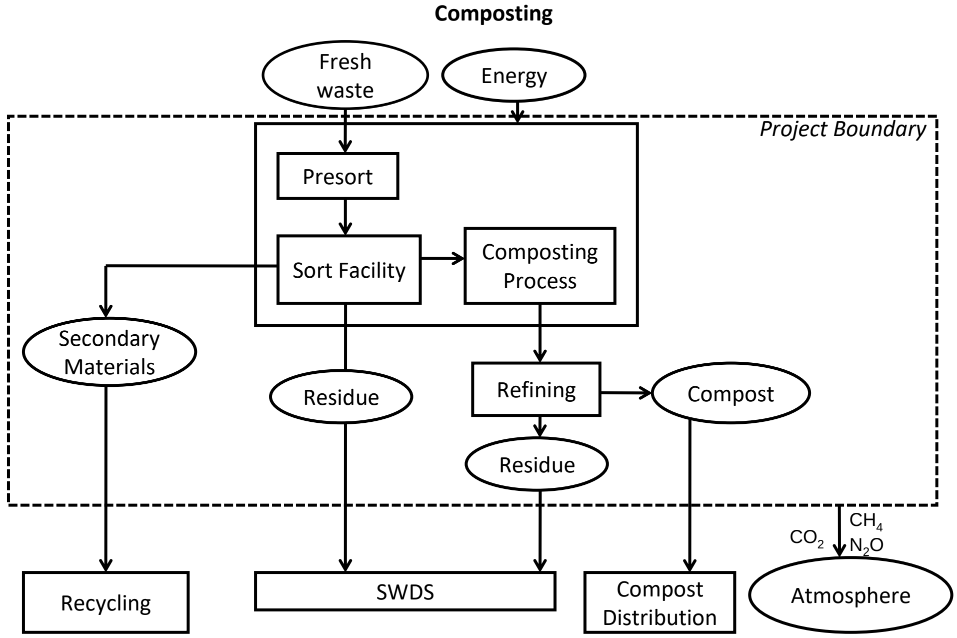


Figure 2. Co-composting

Co-composting

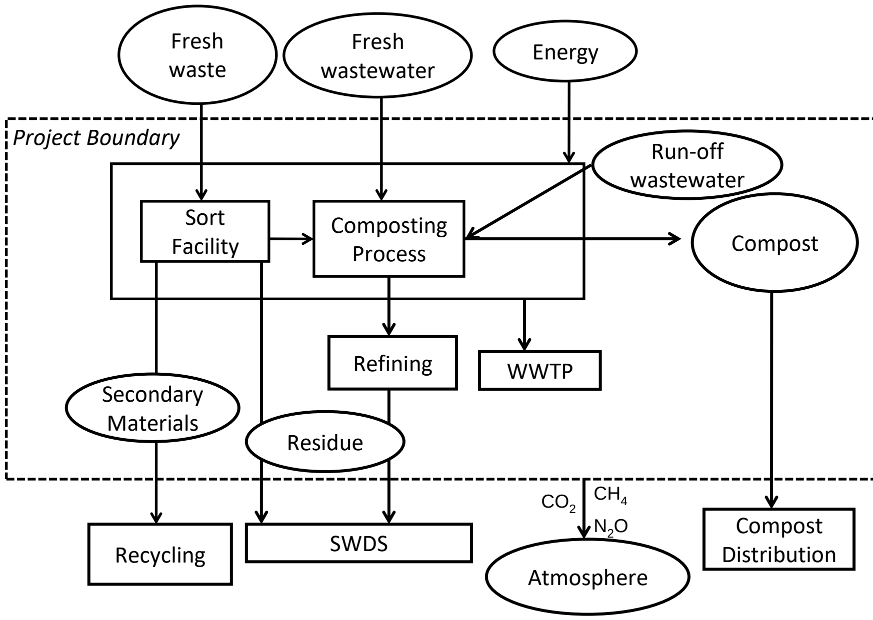
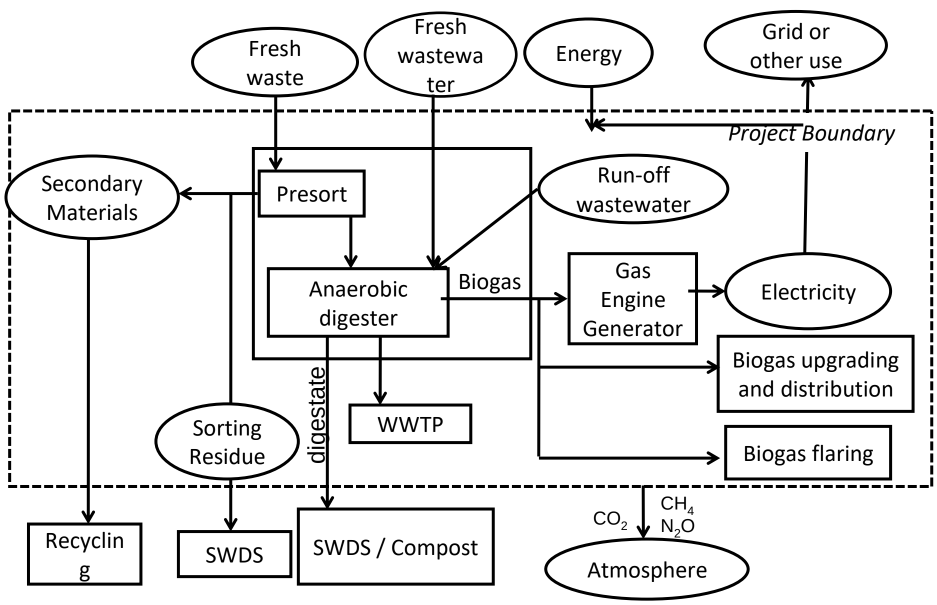


Figure 3. Anaerobic digestion with biogas collection and flaring and/or its use

Anaerobic Digestion with biogas collection and flaring and/or its use



7. Annexure 2: The Measurement of $FFC_{j,y}$ by Balance Method

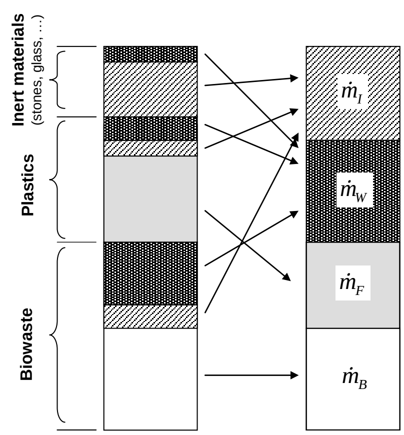
1. Balance method in the conventional waste combustion using ambient air

1. The balance method is based on five mass balances and one energy balance (see below)[25] and the standard data on the chemical composition of biogenic and fossil organic matter. In particular, the result of each balance, which describes a certain waste characteristic (e.g. content of organic carbon, heating value, ash content …) is attuned to physical or chemical waste characteristics derived from routinely measured operating data at the waste incineration plant ('WtE plant').

a) **Mass balance -** the mass fractions (m_I, m_B, m_F**,** m_W) are the four unknowns of a nonlinear set of six equations, which represent the mass fraction of each material group as shown in Figure 1 below. The four indices are I: inert (inorganic); B: biogenic; F: fossil, W: water. Inert materials include all incombustible solid residues like glass, stones, ashes or other inorganic matter from biowastes and plastics (e.g. kaolin in paper). Biogenic and fossil organic material groups refer only to the moisture- and ash-free organic matter;

$$m_I + m_B + m_F + m_w = 1 \qquad \text{Equation (1)}$$

Figure 1. Split-up of waste fractions into the four material groups mI, mB, mF and mW



b) **Ash balance -** the mass fraction of the inert (inorganic) material (the ash content of the waste a_{waste}) corresponds approximately to the quotient of the measured mass flow of solid residues $\sum M_{solidresidues}$ and the waste input M_{waste} of the plant;

$$m_I = a_{waste} = \frac{\sum M_{solidresidues}}{M_{waste}} \qquad \text{Equation (2)}$$

Where:

M_{waste}	=	Mass of waste feed into the WtE plant within a defined period hour *h* [tons]

[25] Johann Fellner, Oliver Cencic, and Helmut Rechberger. "A new method to determine the ratio of electricity production from fossil and biogenic sources in waste-to-energy plants." *Environ. Sic. Technol* 41(2007): 2579-2586.

$\sum M_{solidresidues}$	=	Solid residues (dry substance) of the WtE plant within a defined period hour *h* [tons]
a_{waste}	=	Average ash content of the waste feed within a defined period [tons ash/tons waste]

c) **Carbon balance -** the average content of carbon $C_{C_{waste}}$ of the waste feed derived from the operating data of the plant (i.e. volume flow of flue gas $V_{flue\ gas}$, the CO_2 concentration in the flue gas $C_{CO2,fg}$, and in the combustion air $C_{CO2,air}$, and the mass flow of the waste input M_{waste} as well as the mass flow of auxiliary fuels $FC_{i,h}$ and their respective carbon contents $C_{FCi,h}$), equals the product of the organic mass fractions (biomass m_B and fossil matter m_F) and their carbon contents (C_{CB} and C_{CF}), see equation (3) below. The mass flow of carbon connected to emissions of CO and hydrocarbons is neglected. The elaborate term $-\frac{100-C_{O_{2,fg}}-C_{CO_{2,fg}}}{100-C_{O_{2,air}}-C_{CO_{2,air}}}\times C_{CO_{2,air}}$ is required to consider the atmospheric content of CO_2 in the combustion air;

Equation (3)

$$(m_B \times C_{CB} + m_F \times C_{CF}) \times 10^3 = C_{Cwaste} = \frac{\left[V_{fluegas}\times\left(C_{CO2_{fg}} - \frac{100-C_{O2_{fg}}-C_{CO2_{fg}}}{100-C_{O2_{air}}-C_{CO2_{air}}}\times C_{CO2_{air}}\right)\times\frac{M_C}{100\times V_m}\right]-FC_{i,h}\times C_{FC_{i,h}}}{M_{waste}}$$

Where:

C_{CB}	=	Concentration of carbon of the combustible fraction of the biogenic matter [kg/kg$_{ash\ and\ moisture\text{-}free}$]
C_{CF}	=	Concentration of carbon of the combustible fraction of the fossil matter [kg/kg$_{ash\ and\ moisture\text{-}free}$]
C_{Cwaste}	=	Average carbon content of the waste feed within a defined period hour *h* [kg/kg]]
$V_{fluegas}$	=	Flue gas volume of the WtE plant within a defined period hour *h* [Nm^3]
$C_{O2_{fg}}$, $C_{CO2_{fg}}$	=	Average O_2 and CO_2 content in the flue gas of the WtE plant within a defined period hour *h* [vol %]
$C_{O2_{air}}$, $C_{CO2_{air}}$	=	Average O_2 and CO_2 content of combustion air of the WtE plant within a defined period [vol %]
M_c	=	Molecular weight of carbon (12.0107g/mol)
V_m	=	Molar volume of ideal gas under standard temperature and pressure (22.414Ndm^3/mol)
$FC_{i,h}$	=	The quantity of auxiliary fuel *i* (e.g. fuel oil or natural gas, if exists) combusted during hour *h* [tons/h]
$C_{FC_{i,h}}$	=	Carbon contents of the auxiliary fuel *i* (g C/kg auxiliary fuel, referring to the default values provided in Table 1.3 in Volume 2 of IPCC 2006)

d) **Energy balance** - The low calorific value of the waste HV_{waste} that is determined by using the elementary content of C, H, O, N, S, and Cl corresponds to the calorific value derived from operating data (steam production S, the net enthalpy of steam cycle Δh, the mass flow of the waste input M_{waste}, the mass flow of auxiliary fuels $FC_{i,h}$ and their respective calorific value $HVFC_{i,h}$, and the energy efficiency of the boiler η) of the plant;

$$m_B \times (34.8 \times C_{CB} + 93.9 \times C_{HB} - 10.8 \times C_{OB} + 6.3 \times C_{NB} + 10.5 \times C_{SB}) + m_F \times \left(34.8 \times C_{CF} + 93.9 \times \left(C_{HF} - \frac{C_{CIF}}{M_{CI}}\right) - 10.8 \times C_{OF} + 6.3 \times C_{NF} + 10.5 \times C_{SF}\right) + m_W \times (-2.45) = HV_{waste} = \frac{S \times \Delta h - FC_{i,h} \times HV_{FC_{i,h}}}{M_{waste} \times \eta} \quad \text{Equation (4)}$$

Where:

$C_{HB}, C_{OB}, C_{NB}, C_{SB}$	=	Concentration of hydrogen, oxygen, nitrogen and sulphur of the combustible fraction of the biogenic matter [kg/kg ash and moisture-free]
$C_{HF}, C_{OF}, C_{NF}, C_{SF}, C_{SIF}$	=	Concentration of hydrogen, oxygen, nitrogen, sulphur and chlorine of the combustible fraction of the fossil organic matter [kg/kg ash- and moisture-free]
HV_{waste}	=	Average lower calorific value of the waste feed within a defined period hour *h* [MJ/kg]
$HV_{FC_{i,h}}$	=	Lower calorific value of the auxiliary fuel [MJ/ton auxiliary fuel, referring to the default values provided in Table 1.2, Volume 2 of IPCC 2006]
S	=	Steam production of the WtE plant within a defined period hour *h* [kg]
Δh	=	Net enthalpy of steam cycle of the WtE plant [MJ/kg]
η	=	Energy efficiency of the steam boiler of the WtE plant [-]

e) **O_2 consumption -** the combustion of the organic matter consumes oxygen. The information about the chemical composition of the fuel (in particular the concentration of carbon C_C, hydrogen C_H, oxygen C_O, nitrogen C_N, sulphur C_S, and chlorine C_{Cl} of the biogenic [B] and the fossil [F] material) allows quantification of the consumption of oxygen $O_{2,consum}$ in the combustion air. This amount has to match with the oxygen depletion observable in the flue gas using operating data about the volume flow of flue gas $V_{flue\ gas}$, the O_2 and CO_2 concentration in the flue gas ($C_{O2,fg}$, $C_{CO2,fg}$) and in the combustion air ($C_{O2,air}$, $C_{CO2,air}$), and the mass flow of the waste input $M_{waste,}$ as well as the mass flow of auxiliary fuels $FC_{i,h}$ and their respective carbon and hydrogen contents $C_{FCi,h}$ and $H_{FCi,h}$. The term $\frac{100 - C_{O_{2,fg}} - C_{CO_{2,fg}}}{100 - C_{O_{2,air}} - C_{CO_{2,air}}}$ is derived from the difference in volume between the flue gas and the combustion air;

$$m_B \times \left(\frac{C_{CB}}{M_C} + \frac{C_{HB}}{4 \times M_H} - \frac{C_{OB}}{2 \times M_O} + \frac{C_{NB}}{2 \times M_N} + \frac{C_{SB}}{M_S}\right) \times 10^3 + m_F \times \left(\frac{C_{CF}}{M_C} + \frac{C_{HF} - \frac{C_{CIF}}{M_{CI}}}{4 \times M_H} - \frac{C_{OF}}{2 \times M_O} + \frac{C_{NF}}{2 \times M_N} + \frac{C_{SF}}{M_S}\right) \times 10^3 = O_{2,consum} = \frac{V_{fluegas} \times \left(C_{O2,air} - \frac{100 - C_{O2_{fg}} - C_{CO2_{fg}}}{100 - C_{O2_{air}} - C_{CO2_{air}}} \times C_{O2_{fg}}\right) \times \frac{1}{100 \times V_m}}{M_{waste}} - \frac{FC_{i,h} \times \left(\frac{C_{FC,i,h}}{M_C} + \frac{H_{FC,i,h}}{4 \times M_H}\right)}{M_{waste}} \quad \text{Equation (5)}$$

Where:

M_H	=	Molecular weight of hydrogen (1.00794 g/mol)
M_O	=	Molecular weight of oxygen (15.9994 g/mol)

M_N	=	Molecular weight of nitrogen (14.0067 g/mol)
M_S	=	Molecular weight of sulfur (32.065 g/mol)
M_{CI}	=	Molecular weight of chlorine (35.4527g/mol)
$C_{FC,i,h}$	=	Carbon contents of the auxiliary fuel *i* (g C/kg auxiliary fuel, referring to the default values provided in Table 1.2, Volume 2 of IPCC 2006)
$H_{FC,i,h}$	=	Hydrogen contents of the auxiliary *fuel i* (g H/kg auxiliary fuel, referring to the default values provided in Table 8.2 in *Applied Thermodynamics*[26])
$O_{2,consum}$	=	Average O_2 consumption during the combustion of the waste within a defined period [moles O_2/kg of waste]

f) **Difference between O_2 consumption and CO_2 production -** during the combustion of solid fuel O_2 is consumed and CO_2 is simultaneously produced. Due to the difference in the chemical composition of biogenic and fossil organic matter (in particular concerning the ratio of hydrogen and oxygen content) both materials show strong distinction in their behaviour regarding O_2 consumption and CO_2 production. The difference between O_2 consumption and CO_2 production $d_{O2\text{-}CO2}$ can be assessed using information about the chemical composition of the fuel (concentration of hydrogen C_H, oxygen C_O, nitrogen C_N, sulfur C_S, and chlorine C_{Cl} of the biogenic [B] and the fossil [F] material). This result is equated to the flue gas data obtained at the plant;

Equation (6)

$$m_B \times \left(\frac{C_{HB}}{4\times M_H} - \frac{C_{OB}}{2\times M_O} + \frac{C_{NB}}{2\times M_N} + \frac{C_{SB}}{M_S}\right) \times 10^3 + m_F \times \left(\frac{C_{HF} - \frac{C_{ClF}}{M_{Cl}}}{4\times M_H} - \frac{C_{OF}}{2\times M_O} + \frac{C_{NF}}{2\times M_N} + \frac{C_{SF}}{M_S}\right) \times 10^3 = d_{o2-CO2} = \frac{V_{fluegas}}{M_{waste}} \times \left[\left(C_{O2,air} + C_{CO2,air}\right) \times \left(\frac{100 - C_{O2_{fg}} - C_{CO2_{fg}}}{100 - C_{O2_{air}} - C_{CO2_{air}}}\right) - \left(C_{O2,fg} + C_{CO2,fg}\right)\right] \times \frac{1}{100\times V_m} - \frac{FC_{i,h} \times \frac{H_{FC,i,h}}{4\times M_H}}{M_{waste}}$$

Where:

d_{o2-CO2}	=	Average difference between O_2 consumption and CO_2 production during the combustion of the waste within a defined period hour *h* [moles O_2-CO_2/kg of waste]

2. By solving the set of above equations[27] (applying non-linear data reconciliation and utilizing operating data obtained from the incineration plant as well as data about the chemical composition of moisture-and-ash free biogenic and fossil organic matter – see for example Table 1) the unknowns m_I, m_B, m_F, m_W are determined. The *Fraction of fossil carbon in*

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[26] Onkar Singh. *Applied Thermodynamics* (2003): 279-280, available in Google book. ISBN: 81-224-1496-6.

[27] When a software following the balance method is applied in the calculation, the non-obligated entities have to demonstrate the applicability and the reliability of the software to ACVA.

total content of waste Fraction type j (FFC_j), shall subsequently be calculated by converting the carbon balance above into the following equation:

$$FFC_j = \frac{m_F \times C_{CF}}{m_B \times C_{CB} + m_F \times C_{CF}} \quad \text{Equation (7)}$$

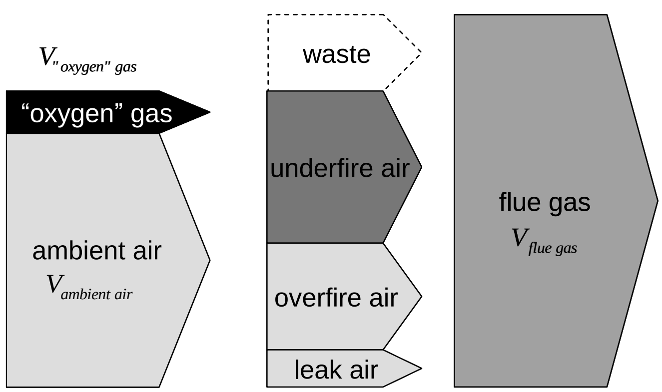
3. In addition, this method allows determining the Fraction of total carbon content in waste type *j* (FCC_j) by applying the carbon balance above:

$$FCC_j = (m_B \times C_{CB} + m_F \times C_{CF}) \times 10^3 = C_{Cwaste} = \frac{V_{fluegas} \times \left(C_{CO2,fg} - \frac{100 - C_{O2_{fg}} - C_{CO2_{fg}}}{100 - C_{O2_{air}} - C_{CO2_{air}}} \times C_{CO2_{air}} \right) \times \frac{M_C}{100 \times V_m} - FC_{i,h} \times C_{FCi,h}}{M_{waste}} \quad \text{Equation (8)}$$

2. Balance method in the oxygen-enriched combustion

4. Above equations are applied to the conventional combustion process fed with the ambient air. In equation (3), (5) & (6), the O_2 and CO_2 content of the combustion air ($C_{O2,comb,air}$ and $C_{CO2,comb,air}$) equal to those of the ambient air ($C_{O2,air}$ and $C_{CO2,air}$). However, when the oxygen-enriched combustion air is fed into the combustion process, the composition of the combustion air with oxygen enrichment at WtE plant is not known a priori. Although volumetric flow measurements of the underfire and overfire air are usually accomplished, and the information about the volume of the 'oxygen' gas and its O_2 content is available, these data do not allow a direct determination of the O_2 balance of the plant because of the unknown amount of leak air entering the system (Figure 2).

Figure 2. Air flows through a WtE plant (schematic illustration)



5. Thus, it is necessary to balance the inert gases nitrogen and argon (*N* can be considered as almost inert within the system) and to use the outcomes of this balance for calculation the amount of combustion air and its O_2 and CO_2 content, respectively.

a) **Balance for nitrogen gas and argon -** Equation (9) is established with the volumetric flow of 'oxygen' gas $V_{'oxygen'gas}$, of ambient air $V_{ambient\ air}$, and flue gas $V_{flue\ gas}$, and the contents of O_2 and CO_2 in the respective gas flows ($C_{O2,'oxgeny'gas}$, $C_{O2,amb,air}$, $C_{CO2,amb,air}$,

$C_{O2,fg}$, $C_{CO2,fg}$). The *N* input through the waste can be neglected considering the nitrogen content of the waste, which is less than 10 gN/kg waste.[28]

$$V_{'oxygen'gas} \times \frac{(100 - C_{O2,'oxygen'gas})}{100} + V_{ambientair} \times \frac{(100 - C_{O2,amb,air} - C_{CO2,amb,air})}{100} \approx V_{fluegas} \times \frac{(100 - C_{O2,fg} - C_{CO2,fg})}{100}$$ Equation (9)

Where:

$C_{O2,amb,air}$	=	Default O_2 concentration of ambient air [Vol-% dry basis]
$C_{CO2,amb,air}$	=	Default CO_2 concentration of ambient air [Vol-% dry basis]
$V_{ambientair}$	=	The volume of ambient air during hour *h* [Nm^3/h on a dry basis]
$C_{O2,'oxygen'gas}$	=	Average O_2 concentration of the 'oxygen' enriched gas of the WtE plant during hour *h* [Vol-% dry basis]
$V_{'oxygen'gas}$	=	The volume of 'oxygen' enriched gas during hour *h*[Nm^3/h on a dry basis]

6. Since $V_{ambient\ air}$ is the only unknown in equation (9), it can be calculated by converting equation (9) into the equation as follows:

$$V_{ambientair} \approx \frac{100 \times \left(V_{fluegas} \times \frac{(100 - C_{O2,fg} - C_{CO2,fg})}{100}\right) - V_{'oxygen'gas} \times \left(\frac{100 - C_{O2,'oxygen'gas}}{100}\right)}{100 - C_{O2,air} - C_{CO2,air}}$$ Equation (10)

7. Together with the monitored parameter of $V_{'oxygen'\ gas}$, the average oxygen content of the total 'combustion' air $C_{O2,comb,air}$, including underfire, overfire and leak air, can further be determined as follows:

$$C_{O2,comb,air} = \frac{(V_{ambientair} - C_{O2,amb,air} + V_{'oxygen'gas} \times C_{O2,'oxygen'gas})}{V_{ambientair} + V_{'oxygen'gas}}$$ Equation (11)

Where:

$C_{O2,comb,air}$	=	O_2 concentration of the total 'combustion' air, including underfire, overfire and leak air, of the WtE plant during hour *h* [Vol-% dry basis]

[28] David H.E. Liu and Béla G. Lipták, *Hazardous Waste and Solid* (1999): 171, Table 8.1.4. Available in Google book. ISBN 1-56670-512-6.

8. Considering that the decrease in CO_2 content of the ambient air $C_{CO2,amb,air}$ during the oxygen enrichment process (e.g. air separation by vacuum pressure swing adsorption) is alike to that for nitrogen gas, the CO_2 content of the 'oxygen' gas $C_{CO2,'oxygen'gas}$ shall be determined as follows:

$$C_{CO2,\prime oxygen\prime gas} \approx \frac{(100 - C_{O2,\prime oxygen\prime gas})}{(100 - C_{CO2,amb,air - C_{O2,amb,air}}) \times C_{CO2,amb,air}}$$ Equation (12)

Where:

$C_{CO2,\prime oxygen\prime gas}$ = CO_2 concentration of the 'oxygen' enriched gas used in the WtE plant during hour *h* [Vol-% dry basis]

9. With the same principle of equation (11), the CO_2 content of the combustion air $C_{CO2,comb,air}$ can be approximated as follows:

$$C_{CO2,comb,air} \approx \frac{(V_{ambientair} \times C_{CO2,amb,air} + V_{\prime oxygen\prime gas} \times C_{CO2,\prime oxygen\prime gas})}{V_{ambientair} + V_{\prime oxygen\prime gas}}$$ Equation (13)

10. When the WtE plant installs oxygen enriched combustion, $C_{O2,comb,air}$ (calculated by equation (11)) and $C_{CO2,comb,air}$ (calculated by equation (13)) shall replace $C_{O2,air}$ and $C_{CO2,air}$ in equation (3), in equation (5) and in equation (6), respectively.

Table 1. Chemical composition of moisture-and-ash-free biogenic and fossil organic matter

Content of	Unit	Biogenic matter			Fossil organic matter		
		Symbol	mean	Standard-deviation	Symbol	mean	Standard-deviation
C	kg/kg moisture and ash free matter	C_{CB}	0.483	0.004	C_{CF}	0.777	0.016
H		C_{HB}	0.065	0.001	C_{HF}	0.112	0.006
O		C_{OB}	0.443	0.007	C_{OF}	0.061	0.013
N		C_{NB}	0.007	0.002	C_{NF}	0.014	0.005
S		C_{SB}	0.001	0.0004	C_{SF}	0.003	0.001
Cl		C_{ClB}	-	-	C_{ClF}	0.032	0.012

3. Measurement of the chemical composition of moisture-and-ash free biogenic and fossil organic matter

11. The non-obligated entity shall obtain the country-special value following the steps given underneath. Laboratory for conducting the test shall be national or internally approved.

Step 1. Sampling of waste

a) The waste shall be sampled following the Standard Guide for General Planning of Waste Sampling (ASTM D4687-14). The non-obligated entities are also allowed to choose other applicable international or national standards.

Step 2. Sorting of waste:

a) The waste shall be sorted into pure biogenic and fossil organic matter (only waste materials which can definitely be recognized as fossil or biogenic matter should be sorted out), as well as inorganic (inert) matter (e.g., glass, metals) and organic matter (not recognizable as biogenic or fossil matter).

Step 3. Analysis of waste:

a) The samples of sorted biogenic and fossil material as well as mixed samples (not recognizable as biogenic or fossil matter) shall be conditioned separately for elementary analyses and the measurement of ash content. In particular the grain size of the samples and their mass has to be reduced. The "final" grain size depends on the sample size for the elementary analysis (usually a final grain size for the analysis samples of 0.5 mm is recommended);

b) The "pure" biogenic and fossil samples as well as the mixed (not recognizable) waste samples shall be dried at 105 °C to a constant weight;

c) In case that the mass of the mixed sample is less than 20 per cent of the sum of sorted biogenic and fossil samples, only steps 3(e), 3(f), and 3(g) need to be continued. The figure underneath presents the steps when the mass of the mixed sample is less than 20 per cent.

8. Annexure 3: Conservative Baseline Emissions if multiple waste gas stream(s) with potential for interchangeable application exist in the WEG facility

1. If several waste gas streams are available in the WEG facility and can be used interchangeably for various applications or are commonly used as a part of energy sources in the facility, there is always a possibility that the potential for leakage exists due to the implementation of the ICM project. For example, in an integrated iron & steel plant the Coke Oven Gas, Blast Furnace gas and Basic Oxygen Furnace gas (LD gas) can be used independently or as a mixture of gases for various applications and therefore use of waste energy recovery from any of these gases for a specific ICM project can lead to the emissions due to firing of fossil fuel to meet the requirement of energy at some other applications in the facility or even outside of the facility. The following table, for example, can define the profile of the potential application areas of these gases.

Table 1. Potential application areas

By-product gas	Application area								
	Coke oven	Sinter plant	Blast furnace	Basic oxygen furnace	Casting and rolling	Flaring	Power generation	Sale to external consumers	Any other uses
Coke oven gas									
Blast furnace gas									
Basic oxygen furnace gas (LD gas)									

Other fossil fuel used (coal/ natural gas/ fuel oil) solely as fuel									

2. Therefore, it has to be ensured that any decrease of waste gas energy recovery of one source due to recovery of waste gas energy of another source is properly adjusted to ensure conservativeness of emission reduction.

3. The following steps can be followed in this regard.

a. Define an extended boundary of the project

4. If the waste gas energy recovered under the ICM project is usable in the other applications in the facility either independently, or by mixing with similar other waste gas energy sources in the facility, the project boundary should include the generation of all other waste gas streams and the potential applications. For example, for a blast furnace energy recovery project in an existing or a Greenfield iron & steel plant, it is well recognized that a mixture of gases can be used in the baseline to supply to the energy requirements of many applications. Based on the above table, for this ICM project, an extended boundary for the mixture of waste fuel gases can be defined as follows:

Table 2. Extended boundary for the mixture of waste fuel gases

WECM	Extended system boundary						
	Coke oven	Sinter plant	Blast furnace	Casting and rolling	Flaring	Power generation	Sale to external consumer
Common waste fuel gas (COG, BFG, LD gas combined)	Yes	Yes	Yes	Yes	Yes	Yes	No

b. Determination of conservative baseline emissions for the ICM project in an existing facility

5. An energy balance is to be established for the demand and supply of energy in all the applications covered in extended project boundary identified above, based on the historical data of one year prior to implementation of ICM project. This energy balance should be checked by the ACVA on-site, and only if it is established that there is no likelihood of decrease in energy recovery of other WECM stream(s) under the extended project boundary, the methodology is deemed applicable to the project.

6. This should be monitored by the verifying ACVA every year, and if there is a decrease in the energy recovery of WECM(s) in the extended boundary excluding the project activity WECM, a technical justification along with energy balance should be demanded explaining why the reduction in recovery is not due to the ICM project. If this explanation is not satisfactory and there are possibilities of increase in emissions due to the project activity within the extended project boundary, the methodology cannot be applied to the project activity anymore and no CCCs can be claimed for the rest of the monitoring period. Detailed monitoring procedures corresponding to this requirement shall be provided in the PDD.

9. Annexure 4: Capping Factor (f_{cap})

Capping factors

1. The methodology requires the baseline emissions to be capped irrespective of planned/unplanned or actual increase in output of plant, change in operational parameters and practices, change in fuel type and quantity resulting in an increase in generation of waste energy. The cap can be estimated using the three methods[29] described below, following this hierarchy: (i) Method-1 can be used to estimate the capping factor if required data is available; (ii) Method-2 is used if the project activities implemented in a Greenfield facility, or in existing facilities where the required data is unavailable; (iii) Method-3 is used if the non-obligated entities demonstrate technical infeasibility in direct monitoring of waste heat/pressure of waste energy carrying medium (WECM).

Method-1

2. Where the historical data on energy released by the WECM is available, the baseline emissions are capped at the maximum quantity of waste energy released into the atmosphere under normal operation conditions in the three years previous to the project activity.

3. For that purpose f_{cap} is estimated as follows: The different equations are used depending upon the type of energy recovered from WECM in project activity.

Case 1: If the WECM is in the form of waste heat

$$f_{cap}=\frac{Q_{WCM,BL}\times\left(Cp_{WCM}\times\left(t_{wcm,BL}-t_{ref}\right)+NCV_{WCM,BL}+\left(P_{WCM,BL}-P_{ref}\right)\times(9.81/10^{9})/d_{wcm,BL}\right)}{Q_{WCM,y}\times\left(Cp_{WCM}\times\left(t_{wcm,y}-t_{ref}\right)+NCV_{WCM,y}+\left(P_{WCM,y}-P_{ref}\right)\times(9.81/10^{9})/d_{wcm,BL}\right)}$$ Equation (14)

<u>Note:</u> Even if primarily energy recovery is based on waste heat, there can be additional energy recovery due to increased pressure of WECM, which can be estimated using pressure differential.

Case 2: If the WECM is in the form of waste pressure

$$f_{cap}=\frac{Q_{WCM,BL}\times\left(P_{WCM,BL}-P_{ref}\right)/d_{wcm,BL}}{Q_{WCM,y}\times\left(P_{WCM,y}-P_{ref}\right)/d_{wcm,y}}$$ Equation (15)

Case 3: if the WECM is in the form of enthalpy, which depends upon the pressure, and temperature of WECM (e.g. steam).

$$f_{cap}=\frac{Q_{WCM,BL}\times\left(H_{WCM,BL}-H_{ref}\right)}{Q_{WCM,y}\times\left(H_{WCM,y}-H_{ref}\right)}$$ Equation (16)

[29] In case the methods for determination of capping factor described in this section do not apply to the situation of project of the non-obligated entities, they may consider submitting new approaches to determine this factor.

Where:

$Q_{WCM,BL}$	=	Average quantity of WECM released (or flared or wasted) in atmosphere in three years prior to the start of the project activity (kg)
$Q_{WCM,y}$	=	Quantity of WECM used for energy generation during year *y* (kg)
Cp_{WCM}	=	Specific Heat of waste energy carrying medium (WECM) (TJ/kg/deg C)
$t_{wcm,y}$	=	Average temperature of Waste Energy Carrying Medium (WECM) in year *y* (deg C)
$t_{wcm,BL}$	=	Average temperature of Waste Energy Carrying Medium (WECM) in three years prior to the start of the project activity (deg C)
t_{ref}	=	Reference temperature to be used to determine available energy in WECM (either 0 deg C or 25 deg C)
$NCV_{WCM,y}$	=	Average net calorific value of waste gas in year *y* (if WECM is waste gas), which has unburnt components such as carbon particles, CO or CH_4 that will provide energy in waste energy recovery equipment from its combustion (TJ/kg)
$NCV_{WCM,BL}$	=	Average net calorific value of waste gas (if WECM is waste gas), three years prior to implementation of project activity which has unburnt components such as carbon particles, CO or CH_4 that will provide energy in waste energy recovery equipment from its combustion (TJ/kg)
$P_{WCM,y}$	=	Average pressure of WECM in year *y* (kg/m^2 (a))
$P_{WCM,BL}$	=	Average pressure of WECM in three years prior to the start of the project activity (kg/m^2 (a))
P_{ref}	=	Reference pressure of WECM (ambient pressure in kg/m^2 or other appropriate pressure with proper justification)
$H_{WCM,y}$	=	Average specific enthalpy of WECM in year *y* (TJ/kg)
$H_{WCM,BL}$	=	Average specific enthalpy of WECM in three years prior to the start of the project activity (TJ/kg)
H_{ref}	=	Reference specific enthalpy to be used to determine available energy in WECM (0 TJ/kg or other appropriate enthalpy with proper justification)
$d_{wcm,y}$	=	Average density of WECM at actual temperature and pressure in year *y* (kg/m^3 at actual conditions)
$d_{wcm,BL}$	=	Average density of WECM at actual temperature and pressure in three years prior to the start of the project activity (kg/m^3 at actual conditions)
$9.81/10^9$	=	Factor to convert kg-m into TJ

Method-2

4. If three-year historical data is not available, the manufacturer's data for the facility shall be used to estimate the amount of waste energy the facility generates per unit of "product". The "product" is produced by the process that generates waste energy (departmental process or process of entire WEG facility, whichever is more justifiable and accurate). If any modification is carried out by the project proponent or if the manufacturer's data is not available for an assessment, this should be carried out by independent qualified/certified external process experts such as a chartered engineer on a conservative quantity of waste energy generated by the WEG facility per unit of product manufactured by the process generating waste energy. The value arrived at based on above sources of data, shall be used to estimate the baseline cap (f_{cap}). Under this method, the following equations should be used to estimate f_{cap}.

$$f_{cap} = \frac{Q_{WCM,BL}}{Q_{WCM,y}} \quad \text{Equation (17)}$$

$$Q_{WCM,BL} = Q_{BL,product} \times q_{wcm,product} \quad \text{Equation (18)}$$

Where:

$Q_{WCM,BL}$	=	Quantity of waste energy generated prior to the start of the project activity (kg or m^3 at NTP or TJ or MWh of WECM or other relevant unit)
$Q_{WCM,y}$	=	Quantity of WECM used for energy generation during year *y* (kg or m^3 at NTP or TJ or MWh of WECM or other relevant unit)
$Q_{BL,product}$	=	Production associated with the relevant waste energy generation as it occurs in the baseline scenario. The minimum of the following two figures should be used: (1) average annual historical production data from start-up of the facility, if the facility's operational history is less than three years, or (2) the most relevant manufacture's data for normal operating conditions. In the case of Greenfield facilities or where data is not available, the manufacture's data for normal operating conditions shall be used (Units for product can be in no. of pieces, tons, m^3 or other appropriate unit)
$q_{wcm,product}$	=	Amount of waste energy per unit of product generated by the process (that generates waste energy) in the facility (Units in kg or m^3 at NTP/unit product, MWh/unit product or TJ/unit product or other appropriate unit)

Method-3

5. In some cases, it may not be possible to measure the waste energy (heat, sensible heat, heat of reaction, heat of combustion, etc.) enthalpy or pressure content of WECM (Method-1 requirement), nor the specific amount of WECM per unit of product (Method-2 requirement). In such cases, the capping shall be based on indirect information about specific parameters allowing to estimate the amount of waste energy available. These parameters should be related to the characteristics of a product or a by-product of the facility from which waste energy can be recovered (e.g. volume and heat content of hot clinker produced by a kiln in a cement plant, if this heat can be recovered using air as the WECM). These cases may be of the following two types.

   i. **Case 1**: the energy is recovered from WECM and converted into final output energy through a waste heat recovery equipment. For example, the useful energy (e.g., steam) is produced using waste energy generated by a chemical reaction. For such cases f_{cap} should be the ratio of maximum energy that could be recovered (MER) by the waste heat recovery equipment implemented under the ICM project activity and the actual energy recovered under the project activity (using direct measurement). The MER should be based on information on the characteristics of the key processes/product. For existing facilities this can be obtained from historical information and for Greenfield facilities, manufacturer's specifications on these key parameters can be used.

   ii. **Case 2**: the energy is recovered from WECM in an intermediate energy recovery equipment using an intermediate source. For example, an intermediate source to carry energy from primary WECM may include the sources such as water, oil or air to extract waste energy entrapped in chemicals (heat of reaction) or solids (sensible heat), which is further recovered in the waste heat recovery equipment to generate final output energy. For such cases f_{cap} should be the ratio of maximum energy that could be recovered (MER) by waste heat recovery equipment implemented under the ICM project activity (considering the losses due to exchange of energy) and actual intermediate energy recovered under the project activity (using direct measurement). The MER should be based on information on the characteristics of the key processes/product. For existing facilities this can be collected from historical information and for Greenfield facilities, manufacturers' specifications on these key parameters can be used.

6. The following equation should be used to determine f_{cap}:

$$f_{cap} = \frac{Q_{OE,BL}}{Q_{OE,y}} \quad \text{Equation (19)}$$

Where:

$Q_{OE,BL}$	=	Output/intermediate energy that can be produced (TJ), to be determined on the basis of maximum energy that could be recovered (i.e. gross or net) from the WECM (MER), which would have been released (or WECM would have been flared or energy content of WECM would have been wasted) in the absence of ICM project activity
$Q_{OE,y}$	=	Quantity of actual output/intermediate energy generated (i.e. gross or net) during year *y* (TJ)

Note: The calculation in equation (46) should be performed with the same definition for both parameters $Q_{OE,BL}$ and $Q_{OE,y}$, i.e. utilizing gross energy in both cases.

10. Annexure 5: Electricity and heat generation from WECM and fossil fuels (f_{wcm})

Electricity and heat generation from WECM and fossil fuels

1. The procedure specified below should be applied when the direct measurement of the electricity/heat generated using the WECM is not possible, as other fossil fuel(s) along with WECM are used for energy generation. The relative share of the total generation from WECM is calculated by ratio of energy supplied by WECM to the total amount input energy fed by WECM and other fuels used, and the average efficiency of the plants where the energy is produced.

2. The fraction of energy produced by using the WECM in the project activity is calculated as follows:

$$f_{WCM} = \frac{\sum_{h=1}^{8760} Q_{WCM,h} \times \left(Cp_{wcm} \times \left(t_{wcm,h} - t_{ref}\right) + NCV_{WCM,y}\right)}{\sum_{h=1}^{8760} \sum_{i=1}^{I} Q_{i,h} \times \left(Cp_i \times \left(t_{i,h} - t_{ref}\right) + NCV_i\right)} \quad \text{Equation (20)}$$

3. If the WECM is used for heat generation in unit process *n*, $f_{WCM,n,y}$ can be calculated as follows.

$$f_{WCM,n,y} = \frac{\sum_{h=1}^{8760} Q_{WCM,n,h} \times \left(Cp_{wcm} \times \left(t_{wcm,n,h} - t_{ref}\right) + NCV_{WCM,y}\right)}{\sum_{h=1}^{8760} \sum_{i=1}^{I} Q_{i,n,h} \times \left(Cp_i \times \left(t_{i,n,h} - t_{ref}\right) + NCV_i\right)} \quad \text{Equation (21)}$$

Where:

f_{WCM}	=	Fraction of total electricity or mechanical energy generated by the project activity using waste energy
$Q_{WCM,h}$	=	Quantity of WECM recovered (kg) in hour *h*
Cp_{wcm}	=	Specific Heat of WECM (TJ/kg -deg C)
$t_{wcm,h}$	=	The temperature of WECM in hour *h* (deg C)
t_{ref}	=	Reference temperature (0 deg C or any other suitable reference temperature with proper justification)
$NCV_{WCM,y}$	=	Net Calorific Value of WECM in year *y* (TJ/kg)
$Q_{i,h}$	=	Amount of individual fuel (WECM and other fuel(s)) *i* consumed at the energy generation unit during hour h (kg)
Cp_i	=	Specific Heat of WECM *i* (TJ/kg -deg C or other suitable unit)
$t_{i,h}$	=	The temperature of individual fuel (WECM and other fuel(s)) *i* consumed at the energy generation unit during hour h (deg C)
NCV_i	=	Net calorific value annual average for each individual consumed fuel including WECM (TJ/ kg)
$f_{WCM,n,y}$	=	Fraction of total heat generated in the unit process/element process/reactor n by the project activity using waste energy
$Q_{WCM,n,h}$	=	Quantity of waste energy consumed in unit process *n* during hour h(kg)

$t_{wcm,n,h}$	=	Temperature of WECM in unit process *n* in hour *h* (deg C)
$Q_{i,n,h}$	=	Amount of individual fuel (WECM and other fuel(s)) *i* consumed in unit process *n* during hour *h* (kg)
$t_{i,n,h}$	=	The temperature of individual fuel (WECM and other fuel(s)) *i* consumed in the unit process n during hour h (deg C)

Note: If index *i* represents fossil fuels, the energy content corresponding to the sensible heat of fossil fuel *i* should be zero, as given follows.

$$Q_{i,h} \times Cp_i \times \left(t_{i,h} - t_{ref}\right) = 0$$ Equation (22)

Steam generation from WECM and fossil fuels

4. An alternative method that could be used when it is not possible to measure the net calorific value of the waste gas/heat and steam generated with different fuels in dedicated boilers are fed to turbine(s) through common steam header takes into account that the relative share of the total generation from WECM is calculated by considering the total steam produced and the amount of steam generated from each boiler. The fraction of energy produced by the waste gas/heat WECM in project activity is calculated as follows:

$$f_{WCM} = \frac{ST_{whr,y}}{ST_{whr,y} + ST_{other,y}}$$ Equation (23)

Where:

$ST_{whr,y}$	=	Energy content of the steam generated in waste heat recovery boiler fed to turbine via common steam header (TJ)
$ST_{other,y}$	=	Energy content of steam generated in other boilers fed to turbine via common steam header (TJ)

5. This alternative method requires that:

a) All the boilers have to provide superheated steam;

b) The calculation should be based on the energy supplied to the steam turbine. The enthalpy and the steam flow rate must be monitored for each boiler to determine the steam energy content. The calculation implicitly assumes that the properties of steam (temperature and pressure) generated from different sources are the same. The enthalpy of steam and feed water will be determined at measured temperature and pressure and the enthalpy difference will be multiplied with quantity measured by steam meter;

c) Any vented steam should be deducted from the steam produced with waste gas/heat.

Revision/Changes in the Document

Version	*Date*	*Description*

1.0	DD MM YYYY	Initial Adoption