CLEAN DEVELOPMENT MECHANISM

**ACM0022**

# Large-scale Consolidated Methodology

# Alternative waste treatment processes

Version 03.0

Sectoral scope(s): 01 and 13

United Nations Framework Convention on Climate Change

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# 1. Introduction

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

**Table 1. Methodology key elements**

| | |
|---|---|
| **Typical projects** | Project activities involve the installation and operation of new plants for the treatment of fresh waste through any combination of the following processes:<br>• Composting process under aerobic conditions;<br>• Gasification process to produce syngas and its use;<br>• Anaerobic digestion with biogas recovery and flaring and/or its use);<br>• Mechanical/thermal treatment to produce refuse-derived fuel (RDF)/stabilized biomass (SB) and its use;<br>• Incineration of fresh waste to produce thermal/electric energy;<br>• Co-composting/anaerobic digestion of wastewater in combination with solid waste. |
| **Type of GHG emissions mitigation action** | • Greenhouse gas (GHG) emissions avoidance:<br>$CH_4$ emissions due to anaerobic decay of organic waste are avoided by alternative waste treatment processes.<br>• Renewable energy:<br>Fresh waste is used as renewable source of energy. |

# 2. Scope, applicability, and entry into force

## 2.1. Scope

2. This methodology covers project activities implementing and operating new plants for the treatment of fresh waste, that would otherwise be disposed in a solid waste disposal site (SWDS)

## 2.2. Applicability

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

(a) Composting process under aerobic conditions;

(b) Anaerobic digestion with biogas recovery and flaring and/or its use;

(c) Co-composting of wastewater in combination with solid waste;

(d) Anaerobic co-treatment of wastewater in combination with solid waste;

(e) Mechanical/thermal treatment process to produce refuse-derived fuel (RDF) or stabilized biomass (SB) that is produced within the project boundary and its use[1];

(f) Gasification process to produce syngas and its use;

(g) Incineration of fresh waste for the generation of thermal/electric energy.

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

(i) The project plant only treats fresh waste/wastewater for which emission reductions are claimed, except for cases involving composting, co-composting and anaerobic digestion;

(j) Neither the fresh waste nor the products from the project plant are stored on-site under anaerobic conditions;

(k) Any wastewater discharge resulting from the project activity is treated in accordance with applicable regulations;

(l) 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 clean development mechanism project design document (CDM-PDD);

(m) 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[2];

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

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

(a) The disposal of the fresh waste in a SWDS with or without a partial LFG capture system (M2 or M3)[3];

(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 (W1 or W4);

(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);

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[1] The methodology is not applicable to project activities using RDF produced outside of the project boundary.

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

[3] Project participants 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.

(d) In the case of heat generation, the heat is generated in an existing/new fossil fuel fired cogeneration plant, boiler or air heater (H2 or H4).[4]

5. Specific applicability conditions for the different processes are provided in Table 2 below.

**Table 2. Specific applicability conditions for the different waste treatment processes**

| Waste treatment option under the project activity | Applicable types of wastes that may be treated | Applicable products and their use | Applicable waste by-products | Specific applicability conditions |
|---|---|---|---|---|
| Composting or co-composing | Types of waste as specified in the scope and applicability section of "TOOL13: Project and leakage emissions from composting";<br>Wastewater;<br>Wastewater discharge | Compost: any use applicable | Non-biodegradable materials that may have market value (i.e. glass, metals and plastics);<br>Wastewater discharge | Any applicability conditions specified in "TOOL13: Project and leakage emissions from composting" |
| Anaerobic digestion | Wastewater;<br>Fresh waste<br>Wastewater discharge | Biogas may be flared, used to generate electricity or heat, and/or upgraded and distributed in a natural gas distribution grid | Non-biodegradable materials that may have market value (i.e. glass, metals and plastics);<br>Wastewater discharge<br>Digestate | Any applicability conditions specified in "TOOL14: Project and leakage emissions from anaerobic digesters" |
| Thermal treatment | Fresh waste | RDF/SB: any use is applicable | Non-biodegradable materials that may have market value (i.e. glass, metals and plastics) | - |
| Mechanical treatment | Fresh waste | RDF/SB: any use is applicable | Wastewater discharge;<br>Non-biodegradable materials that may have market value (i.e. glass, metals and plastics) | - |
| Gasification | Fresh waste | Syngas may be used to generate electricity and/or heat | Gasification by-products (e.g. inert materials);<br>Wastewater discharge;<br>Non-biodegradable materials that may have market value (i.e. glass, metals and plastics) | - |

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

| Waste treatment option under the project activity | Applicable types of wastes that may be treated | Applicable products and their use | Applicable waste by-products | Specific applicability conditions |
|---|---|---|---|---|
| Incineration | Fresh waste | Electricity and/or heat | Incineration by-product (e.g. inert materials);<br>Wastewater discharge;<br>Non-biodegradable materials that may have market value (i.e. glass, metals and plastics) | Incineration technology is rotary kiln, rotating fluidized bed, circulating fluidized bed, hearth or grate type;<br>The fraction of energy generated by auxiliary fossil fuels is not more than 50% of the total energy generated in the incinerator |

### 2.3. Entry into force

6. The date of entry into force of the methodology is the date of the publication of the EB 111 meeting report on 9 September 2021.

### 2.4. Applicability of sectoral scope

7. For validation and verification of CDM projects and programmes of activities by a designated operational entity (DoE) using this methodology, sectoral scopes 01 and 13 are mandatory.

# 3. Normative references

8. This baseline and monitoring methodology is based on the following approved baseline and monitoring methodologies and elements of the following proposed new methodologies:

   (a) “NM0090: Organic waste composting at the Matuail landfill site Dhaka, Bangladesh” whose baseline study, monitoring and verification plan and project design document were prepared by World Wide Recycling B.V. and Waste Concern;

   (b) “NM0127: PT Navigat Organic Energy Indonesia Integrated Solid Waste Management (GALFAD) project in Bali, Indonesia” whose baseline study, monitoring and verification plan and project design document were prepared by Mitsubishi Securities Co.;

   (c) “NM0032: Municipal solid waste treatment cum energy generation project, Lucknow, India” whose baseline study, monitoring and verification plan were

prepared by Infrastructure Development Finance Company Limited on behalf of Prototype Carbon Fund;

(d) “NM0178: Aerobic thermal treatment of municipal solid waste (MSW) without incineration in Parobé - RS” whose baseline study, monitoring and verification plan and project design document were prepared by ICF Consulting;

(e) “NM0174-rev: MSW Incineration Project in Guanzhuang, Tianjin City” whose baseline study, monitoring and verification plan and project design document were prepared by Global Climate Change Institute (GCCI) of Tsinghua University, Energy Systems International and Tianjin Taida Environmental Protection Co. Ltd;

(f) “AM0025: “Alternative waste treatment processes”;

(g) “AM0039: “Methane emissions reduction from organic wastewater and bioorganic solid waste using co-composting”.

9. This methodology also refers to the latest approved versions of the following tools and guidelines:

(a) “TOOL11: Assessment of the validity of the original/current baseline and update of the baseline at the renewal of the crediting period”;

(b) “TOOL02: Combined tool to identify the baseline scenario and demonstrate additionality”;

(c) “TOOL06: Project emissions from flaring”;

(d) “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”;

(e) “TOOL03: Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion”;

(f) “TOOL09: Determining the baseline efficiency of thermal or electric energy generation systems”.

(g) “TOOL04: Emissions from solid waste disposal sites”;

(h) “TOOL13: Project and leakage emissions from composting”;

(i) “TOOL14: Project and leakage emissions from anaerobic digesters”;

(j) “TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream”;

(k) “Guidelines on the consideration of suppressed demand in CDM methodologies”.

10. For more information regarding the proposed new methodologies and the tools as well as their consideration by the Executive Board (hereinafter referred to as the Board) of the clean development mechanism (CDM) please refer to <http://cdm.unfccc.int/methodologies/PAmethodologies/index.html>.

### 3.1. Selected approach from paragraph 48 of the CDM modalities and procedures

11. “Emissions from a technology that represents an economically attractive course of action, taking into account barriers to investment”;

or

12. “Existing actual or historical emissions, as applicable”.

# 4. Definitions

13. The definitions contained in the Glossary of CDM terms shall apply.

14. For the purpose of this methodology the following definitions apply:

(a) **Anaerobic digester** - Equipment that is used to generate biogas from liquid or solid waste through anaerobic digestion. The digester is covered or encapsulated to enable biogas capture for heat and/or electricity generation or feeding biogas into a natural gas network;

(b) **Anaerobic digestion** - Degradation and stabilization of organic materials by the action of anaerobic bacteria that result in production of methane and carbon dioxide. Typical organic materials that undergo anaerobic digestion are municipal solid waste (MSW), animal manure, wastewater, organic industrial effluent and biosolids from aerobic wastewater treatment plants;

(c) **Anaerobic lagoon** - a treatment system consisting of a deep earthen basin with sufficient volume to permit sedimentation of settleable solids, to digest retained sludge, and to anaerobically reduce some of the soluble organic substrate. Anaerobic lagoons are not aerated, heated, or mixed and anaerobic conditions prevail except possibly for a shallow surface layer in which excess undigested grease and scum are concentrated;

(d) **Biogas** - Gas generated from anaerobic digestion of organic matter. 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) **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;

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

(g) **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);

(h) **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;

(i) **Fresh waste** - solid waste that is intended for disposal in a SWDS but has not yet been disposed. This may comprise MSW and excludes old waste and hazardous waste;

(j) **Gasification** - the process of thermal decomposition of organic compounds at high temperatures, typically more than 800˚C. Gasification converts organic compounds, of both biogenic and fossil origin, into combustible gas, e.g. syngas;

(k) **Hazardous waste** - waste generated by industries or hospitals, which. may be hazardous or infectious;

(l) **Incineration** - the controlled combustion of organic compounds of both biogenic and fossil origin with or without heat capture and utilisation. Ideally, all the organic content is converted into $CO_2$ and $H_2O$. Practically, as combustion is incomplete and as inert matter is also in the combusted waste, ashes are also an important by-product;

(m) **Landfill gas (LFG)** - the gas generated by decomposition of waste in a SWDS. LFG is mainly composed of methane, carbon dioxide and small fractions of ammonia and hydrogen sulphide;

(n) **LFG capture system** - a system to capture LFG. The system may be passive, active or a combination of both active and passive components. Passive systems capture LFG by means of natural pressure, concentration, and density gradients. Active systems use mechanical equipment to capture LFG by providing pressure gradients. For the purpose of this methodology, captured LFG can be flared or used;

(o) **Municipal solid waste (MSW)** - a heterogeneous mix of different solid waste types, usually collected by municipalities or other local authorities. MSW includes household waste, garden/park waste and commercial/institutional waste;

(p) **Old waste** - solid waste that has been disposed of in a SWDS. Old waste has different characteristics than fresh waste, such as a lower organic matter content, limiting its application to some alternative treatment processes that require waste with a minimum level of organic material (e.g. composting and anaerobic digesters);

(q) **Organic waste** - waste that contains degradable organic matter.

(r) **Refuse-derived fuel (RDF)** - a fuel which is derived from the mechanical and/or thermal treatment of waste and which is used in an incineration or co-incineration process. RDF is produced by shredding and dehydrating solid waste with a waste converter technology;

(s) **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;

(t) **Stabilized biomass (SB)** - a fuel which is derived from the mechanical and/or thermal treatment of waste and which is used in an incineration or co-incineration process. SB is produced from agricultural waste and is treated to prevent further degradation in the environment. Examples of SB are: pellets, briquettes and torrified wood chips;

(u) **Solid waste** - discarded and insoluble material (including gases or liquids in cans or containers);

(v) **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 designated operational entity (DOE) confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist);

(w) **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;

(x) **Syngas** - a gas mixture consisting primarily of carbon monoxide and hydrogen and small amounts of carbon dioxide. It is produced from gasification and may be used as a fuel for energy generation or as an intermediate for the production of other chemicals;

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

# 5. Baseline methodology

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

15. Identify the baseline scenario and demonstrate additionality using “TOOL02: Combined tool to identify the baseline scenario and demonstrate additionality”.

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

(a) M1: The project activity without being registered as a CDM project activity (i.e. any (combination) of the waste treatment processes listed in Table 2);

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

(c) M3: Disposal of the fresh waste in a SWDS without a LFG capture system;

(d) M4: Part of the fresh fraction of the solid waste is recycled and not disposed in the SWDS;

(e) M5: Part of the fresh fraction of the solid waste is treated aerobically and not disposed in the SWDS;

(f) M6: Part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS;

(g) M7: Part of the organic fraction of the solid waste is gasified and not disposed in the SWDS;

(h) M8: Part of the organic fraction of the solid waste is treated in an anaerobic digester and not disposed in the SWDS;

(i) M9: Part of the organic fraction of the solid waste is mechanically or thermally treated to produce RDF/SB and not disposed in the SWDS.

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

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

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

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

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

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

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

(g) W7: Other treatment processes provided in table 6.3, Volume 5, chapter 6 of the IPCC 2006 guidelines for greenhouse gas inventory.

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

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

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

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

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

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

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

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

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

    (b) H2: Use of (an) existing or construction of (a) new on-site or off-site fossil fuel fired cogeneration plant(s);[5]

    (c) H3: Use of (an) existing or construction of (a) new on-site or off-site renewable based cogeneration plant(s);[6]

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

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

    (f) H6: District heat;

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

20. Project participants shall demonstrate that the identified baseline fuel used for generation of heat is available in abundance in the host country and there is no supply constraint. In case of supply constraints (e.g. partial or seasonal supply), project participants shall consider the period when there are availability constraints and choose the fuel(s) that result in the most conservative estimation of baseline emissions.

21. Detailed justifications shall be provided and documented in the CDM-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.

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

23. In applying Sub-step 1b of the tool, mandatory applicable legal and regulatory requirements may include mandatory LFG capture or destruction requirements because of safety issues or local environmental regulations.[7] Other policies could include local policies promoting productive use of LFG, such as those for the production of renewable energy, or those that promote the processing of fresh waste.

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[5] Scenarios P2 and H2 are related to the same fossil fuel cogeneration plant.

[6] Scenarios P3 and H3 are related to the same renewable energy-based cogeneration plant.

[7] The project participant shall consider relevant clarifications on the treatment of national and/or sectoral policies and regulations in determining a baseline scenario as per annex 3 to the 22nd meeting of the Board and any other forthcoming guidance from the Board on this subject.

24. If the products or by-products are used by another CDM project activity and if the project participants of both CDM 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.

25. Project activities implementing greenfield composting facilities for the treatment of MSW are deemed automatically additionalwhen any of conditions below is fulfilled:

(a) The host country is a LDC;[8] or

(b) MSW collection coverage is below 50 per cent for the applicable geographical region; or

(c) MSW collection coverage is 50–80 per cent for the applicable geographical region[9] and the waste received by the project composting facility does not have formal segregation of wet and dry waste (i.e. excluding recycling by the informal sector); or

(d) No gate/tipping fees are received by the project composting facility or any upstream waste collection or segregation facility which is contractually bound to provide waste to the project composting facility[10]; or

(e) Less than two per cent of the collected MSW of the municipality (or the region from where the MSW treated by the project activity is sourced) are treated by composting in the year before the PDD is published for global stakeholder consultation.

26. For project activities that are deemed automatically additional above, the baseline scenario is assumed to be the continued disposal of the fresh waste in the nearest SWDS (where the LFG is released or captured and destructed through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons). If condition (d) or (e) applies, it shall also be demonstrated that 80 per cent of the collected MSW of the municipality (or the region from where the MSW treated by the project activity is sourced)[11] are treated in SWDS or stockpiles or are dumped in the year before the PDD is published for global stakeholder consultation.

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[8] For LDCs, windrow or similar technology may be considered, which (i) applies locally appropriate machinery operable without a strong dependence on external actors or conditions, (ii) employs trained and skilled waste workers with adequate protection against health risks arising from the handling of the waste stream(s), and (iii) includes a process including an intensive (>55°C) treatment process and a longer curing phase of the compost product.

[9] May be certified by a municipal authority or another MSW treatment facility in the municipality.

[10] May be certified by a municipal authority or another MSW treatment facility in the municipality.

[11] The applicable geographical region may be the host country, the region or the municipality where the project activity is located.

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.

## 5.2. Project boundary

28. The spatial extent of the project boundary is the SWDS where the waste is disposed of in the baseline,[12] anaerobic lagoons or sludge pits treating organic wastewater in the baseline, 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). The project boundary does not include facilities for waste collection and transport.

29. 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.

30. Sample diagrams of the project boundary for each alternative waste treatment process are included in Appendix 1.

31. The GHG emission sources included in or excluded from the project boundary are listed in Table 3.

**Table 3. 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 |
| | 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 |

[12] 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** |
|---|---|---|---|---|
| | | $CO_2$ | 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 |
| **Project activity** | Emissions from on-site fossil fuel consumption due to the project activity other than for electricity generation | $CO_2$ | Yes | May be an important emission source. Includes heat generation for mechanical/thermal treatment process, start-up of the gasifier, auxiliary fossil fuels needed to be added into incinerator, etc. It does not include transport |
| | | $CH_4$ | 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 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 |

| Source | | Gas | Included | Justification/explanation |
|---|---|---|---|---|
| | | $N_2O$ | 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, incineration, syngas produced and RDF/SB combustion |
| | | $CO_2$ | 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 incineration, gasification, composting and RDF/SB combustion |
| | 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 Board's 20th meeting report) are not accounted as GHG emissions. Where the combustion or decomposition of biomass under a CDM 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.

## 5.3. Baseline emissions

32. Baseline emissions are determined as follows:

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

Where:

| | | |
|---|---|---|
| $BE_y$ | = | Baseline emissions in year *y* (t $CO_2$e) |
| $BE_{CH4,t,y}$ | = | Baseline emissions of methane from the SWDS in year *y* (t $CO_2$e) |
| $BE_{WW,t,y}$ | = | 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 $CO_2$e) |
| $BE_{EN,t,y}$ | = | 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* [13] |
| $t$ | = | Type of alternative waste treatment process |

### 5.3.1. Baseline emissions of methane from the SWDS ($BE_{CH4,t,y}$)

33. Baseline methane emissions from the SWDS are determined using “TOOL04: Emissions from solid waste disposal sites”. The following requirements shall be complied with when applying the tool:

(a) $W_{j,x}$ in the tool is the amount of organic fresh waste prevented from disposal in the baseline SWDS due to its treatment in any (combination) alternative waste treatment process[14];

(b) Emission amounts are calculated using Application B in the tool (only fresh waste avoided from disposal after the start of the first crediting period shall be considered;

(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

[13] Determined once for each crediting period, based on the most recent data available at the time of submission of the CDM-PDD to the DOE for validation.

[14] In case a combination of treatment processes is implemented in parallel, $W_{j,x}$ is determined for each process.

(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 $f_y = 0.2$.[15]

#### 5.3.1.1. Suppressed demand scenario

34. When applying the tool, a default MCF of 0.4[16] for baseline emissions may be used to account for the scenario of a suppressed demand as described in the "Guidelines on the consideration of suppressed demand in CDM methodologies" when all the following conditions apply:

(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.

### 5.3.2. Baseline emissions from organic wastewater ($BE_{WW,t,y}$)

35. 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:

$$BE_{WW,t,y} = min\{Q_{CH4,y}; BE_{CH4,MCF,y}\} \quad \text{Equation (2)}$$

Where:

| | | |
|---|---|---|
| $BE_{WW,t,y}$ | = | Baseline methane emissions from anaerobic treatment of the wastewater[17] in open anaerobic lagoons or of sludge in sludge pits in the absence of the project activity in year *y* (t $CO_2$e) |

[15] Project participants may propose and justify an alternative default value as a request for revision to this methodology.

[16] 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 project participants 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 M9 discussed in the procedure for the selection of the most plausible baseline scenario and demonstration of additionality.

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

| | | |
|---|---|---|
| $Q_{CH4,y}$ | = | Amount of methane produced from wastewater in year *y* after the implementation of the project activity (t $CO_2$e) |
| $BE_{CH4,MCF,y}$ | = | Baseline methane emissions determined using the Methane Conversion Factor (t $CO_2$e) |

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

36. Projects proponent shall use Step 1 "Determination of the quantity of methane produced in the digester ($Q_{CH4,y}$)" of the latest version of "TOOL14: Project and leakage emissions from anaerobic digesters" to determine the amount of methane produced from wastewater after the implementation of the project activity ($Q_{CH4,y}$).

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

37. $BE_{CH4,MCF,y}$ 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:

$$BE_{CH4,MCF,y} = GWP_{CH4} \times MCF_{BL,y} \times B_o \times COD_{BL,y} \quad \text{Equation (3)}$$

Where:

| | | |
|---|---|---|
| $BE_{CH4,MCF,y}$ | = | Baseline methane emissions determined using the Methane Conversion Factor (t $CO_2$e) |
| $GWP_{CH4}$ | = | Global Warming Potential of methane valid for the commitment period (t $CO_2$e/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) |

#### 5.3.2.2.1. Determination of $COD_{BL,y}$

38. 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.

$$COD_{BL,y} = \rho\left(1 - \frac{COD_{out,x}}{COD_{in,x}}\right) \times COD_{PJ,y} \quad \text{Equation (4)}$$

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 |
| $\rho$ | = | Discount factor to account for the uncertainty of the use of historical data to determine $COD_{BL,y}$ |

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

$$COD_{PJ,y} = \sum_{m=1}^{12} F_{PJ,AD,m} \times COD_{AD,m} \quad \text{Equation (5)}$$

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 |

#### 5.3.2.2.2. Determination of $MCF_{BL,y}$

40. 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:

$$MCF_{BL,y} = f_d \times f_{T,y} \times 0.89 \quad \text{Equation (6)}$$

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 |

#### 5.3.2.3. Determination of $f_d$

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

$$f_d = \begin{cases} 0; & if\ D < 1m \\ 0.5; & if\ 1m \le D < 2\,m \\ 0.7; & if\ D \ge 2\,m \end{cases}$$ Equation (7)

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) |

#### 5.3.2.4. Determination of $f_{T,y}$

42. 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 |

43. 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.

44. 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 |

45. 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 |

### 5.3.3. Baseline emissions from generation of energy

46. 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.

#### 5.3.3.1. Separate generation of electricity and heat

$$BE_{EN,y} = BE_{EC,y} + BE_{HG,y} \quad \text{Equation (13)}$$

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* ($t\ CO_2$) |

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

47. The baseline emissions associated with electricity generation in year *y* ($BE_{EC,y}$) shall be calculated using "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". 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* ($EG_{t,y}$).

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

48. If the facility where heat generated by the project activity is used is a cement plant, then project participants may not account for baseline emissions associated with heat generation under this methodology.

49. 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:

$$BE_{HG,y} = \frac{HG_{PJ,y} \times EF_{CO2,BL,HG}}{\eta_{HG,BL}} \qquad \text{Equation (14)}$$

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) |

50. To estimate the baseline energy efficiency of the boiler or air heater in the baseline ($\eta_{HG,BL}$) project participants shall apply "TOOL09: Determining the baseline efficiency of thermal or electric energy generation systems".

### 5.3.4. Cogeneration of electricity and heat

51. 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:

$$BE_{EN,y} = \frac{(EG_{t,y} \times 3.6) \times 10^{-3} + HG_{PJ,y}}{\eta_{cogen}} \times EF_{CO2,BL,CG} \qquad \text{Equation (15)}$$

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) |
| $\eta_{cogen}$ | = | Efficiency of the cogeneration plant that would have been used in the absence of the project activity (ratio) |

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

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

$$BE_{NG,y} = BIOGAS_{NG,y} \times NCV_{BIOGAS,NG,y} \times EF_{CO2,NG,y}$$ Equation (16)

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) |

53. $EF_{CO2,NG,y}$ is determined using the relevant provisions in "TOOL03: Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion".

## 5.4. Project emissions

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

$$PE_y = PE_{COMP,y} + PE_{AD,y} + PE_{GAS,y} + PE_{RDF\_SB,y} + PE_{INC,y}$$ Equation (17)

Where:

| | | |
|---|---|---|
| $PE_y$ | = | Project emissions in year *y* (t $CO_2$e) |
| $PE_{COMP,y}$ | = | Project emissions from composting or co-composting in year *y* (t $CO_2$e) |
| $PE_{AD,y}$ | = | Project emissions from anaerobic digestion and biogas combustion in year *y* (t $CO_2$e) |
| $PE_{GAS,y}$ | = | Project emissions from gasification in year *y* (t $CO_2$e) |
| $PE_{RDF\_SB,y}$ | = | Project emissions associated with RDF/SB in year *y* (t $CO_2$e) |
| $PE_{INC,y}$ | = | Project emissions from incineration in year *y* (t $CO_2$e) |

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

55. Project emissions associated with composting or co-composting ($PE_{COMP,y}$) are calculated according to "TOOL13: Project and leakage emissions from composting".

### 5.4.2. Project emissions from anaerobic digestion (*$PE_{AD,y}$*)

56. $PE_{AD,y}$ is calculated according to "TOOL14: Project and leakage emissions from anaerobic digesters". 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).

### 5.4.3. Project emissions from gasification (***$PE_{GAS,y}$***)

57. Project emissions from gasification include carbon dioxide emissions as well as small amounts of methane and nitrous oxide emissions associated with the combustion, if fossil carbon is used in the gasification process ($PE_{COM,GAS,y}$). Project emissions from gasification shall also account for electricity consumption, fossil fuel consumption and wastewater treatment (if associated with the gasification treatment process). Project emissions are therefore determined as follows:

$$PE_{GAS,y} = PE_{COM,GAS,y} + PE_{EC,GAS,y} + PE_{FC,GAS,y} + PE_{ww,GAS,y}$$ Equation (18)

Where:

| | | |
|---|---|---|
| $PE_{GAS,y}$ | = | Project emissions from gasification in year *y* (t $CO_2e$) |
| $PE_{COM,GAS,y}$ | = | Project emissions from combustion associated with gasification in year *y* (t $CO_2$) |
| $PE_{EC,GAS,y}$ | = | Project emissions from electricity consumption associated with gasification in year *y* (t $CO_2e$) |
| $PE_{FC,GAS,y}$ | = | Project emissions from fossil fuel consumption associated with gasification in year *y* (t $CO_2e$) |
| $PE_{ww,GAS,y}$ | = | Project emissions from the wastewater treatment associated with gasification in year *y* (t $CH_4$) |

58. $PE_{COM,GAS.y}$ is determined according to the procedure “Project emissions from combustion within the project boundary”, where $PE_{COM,GAS,y}$=$PE_{COM,c,y}$ and the combustor *c* is the gasifier or the syngas burner.

59. $PE_{EC,GAS,y}$ is determined according to the procedure “Project emissions from electricity use”, where $PE_{EC,GAS,y}$=$PE_{EC,t,y}$ and the alternative waste treatment process *t* is gasification.

60. $PE_{FC,GAS,y}$ is determined according to the procedure “Project emissions from fossil fuel use”, where $PE_{FC,GAS,y}$=$PE_{FC,t,y}$ and the alternative waste treatment process *t* is gasification.

61. $PE_{ww,GAS,y}$ is determined according to the procedure “Project emissions from wastewater treatment”, where $PE_{ww,GAS.y}$=$PE_{ww,t,y}$ and the alternative waste treatment process *t* is gasification.

### 5.4.4. Project emissions associated with mechanical or thermal production of RDF/SB (***$PE_{RDF\_SB,y}$***)

62. Project emissions associated with RDF/SB comprise both the emissions from the mechanical/thermal production process (e.g. electricity, fossil fuel consumption and

wastewater treatment, if relevant) as well as the combustion of RDF/SB (if this is part of the project activity[18]). . Project emissions are determined as follows:

$$PE_{RDF\_SB,y} = PE_{COM,RDF\_SB,y} + PE_{EC,RDF\_SB,y} + PE_{FC,RDF\_SB,y} + PE_{ww,RDF\_SB,y}$$ Equation (19)

Where:

| | | |
|---|---|---|
| $PE_{RDF\_SB,y}$ | = | Project emissions associated with RDF/SB in year *y* (t $CO_2$e) |
| $PE_{COM,RDF\_SB,y}$ | = | Project emissions from combustion of fossil waste associated with combustion of RDF/SB within the project boundary in year *y* (t $CO_2$) |
| $PE_{EC,RDF\_SB,y}$ | = | Project emissions from electricity consumption associated with RDF/SB (production and on-site combustion) in year *y* (t $CO_2$e) |
| $PE_{FC,RDF\_SB,y}$ | = | Project emissions from fossil fuel consumption associated with RDF/SB (production and on-site combustion) in year *y* (t $CO_2$e) |
| $PE_{ww,RDF\_SB,y}$ | = | Project emissions from the wastewater treatment associated with RDF/SB (production and on-site combustion) in year *y* (t $CH_4$) |

63. $PE_{EC,RDF\_SB,y}$ is determined according to the procedure "Project emissions from electricity use", where $PE_{EC,RDF\_SB,y}=PE_{EC,t,y}$ and the alternative waste treatment process *t* is production of RDF/SB. The electricity generated onsite from combustion of fossil waste and RDF/SB may be excluded.

64. $PE_{COM,RDF\_SB,y}$ is determined according to the procedure "Project emissions from combustion within the project boundary", where $PE_{RDF\_SB,COM,y}=PE_{COM,t,y}$ and the combustor *c* is the RDF/SB combustor.

65. $PE_{FC,RDF\_SB,y}$ is determined according to the procedure "Project emissions from fossil fuel use", where $PE_{FC,RDF\_SB,y}=PE_{FC,t,y}$ and the alternative waste treatment process *t* is the production of RDF/SB.

66. $PE_{ww,RDF\_SB,y}$ is determined according to the procedure "Project emissions from wastewater treatment", where $PE_{ww,RDF\_SB,y}=PE_{ww,t,y}$ and the alternative waste treatment process *t* is the production of RDF/SB.

### 5.4.5. Project emissions from incineration ($PE_{INC,y}$)

67. Project emissions from incineration include emissions from combustion within the project boundary ($PE_{COM,INC,y}$). If associated with the incineration process, then project emissions shall also account for electricity consumption, fossil fuel consumption and wastewater treatment (if associated with the incineration process). Project emissions are therefore determined as follows:

$$PE_{INC,y} = PE_{COM,INC,y} + PE_{EC,INC,y} + PE_{FC,INC,y} + PE_{ww,INC,y}$$ Equation (20)

[18] For any amount of RDF/SB disposed of in a SWDS or which is not used in year *y*, leakage effects shall be considered in accordance with section 5.5 below (Leakage emissions).

Where:

| | | |
|---|---|---|
| $PE_{INC,y}$ | = | Project emissions from incineration in year *y* (t $CO_2e$) |
| $PE_{COM,INC,y}$ | = | Project emissions from combustion within the project boundary of fossil waste associated with incineration in year *y* (t $CO_2$) |
| $PE_{EC,INC,y}$ | = | Project emissions from electricity consumption associated with incineration year *y* (t $CO_2e$) |
| $PE_{FC,INC,y}$ | = | Project emissions from fossil fuel consumption associated with incineration in year *y* (t $CO_2e$ ) |
| $PE_{ww,INC,y}$ | = | Project emissions from the wastewater treatment associated with incineration in year *y* (t $CH_4$) |

68. $PE_{EC,INC,y}$ is determined according to the procedure "Project emissions from electricity use", where $PE_{EC,INC,y}=PE_{EC,t,y}$ and the alternative waste treatment process *t* is incineration. The electricity generated by onsite incineration may be excluded.

69. $PE_{COM,INC,y}$ is determined according to the procedure "Project emissions from combustion within the project boundary", where $PE_{INC,COM,y}=PE_{COM,t,y}$ and the combustor *c* is the incinerator.

70. $PE_{FC,INC,y}$ is determined according to the procedure "Project emissions from fossil fuel use", where $PE_{FC,INC,y}=PE_{FC,t,y}$ and the alternative waste treatment process *t* is incineration.

71. $PE_{ww,INC,y}$ is determined according to the procedure "Project emissions from wastewater treatment", where $PE_{ww,INC,y}=PE_{ww,t,y}$ and the alternative waste treatment process *t* is incineration.

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

72. 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 "TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation". 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 project participants 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).

### 5.4.7. Project emissions from fossil fuel use ($PE_{FC,t,y}$)

73. The project emissions from fossil fuel combustion associated with waste treatment process *t* implemented under the project activity ($PE_{FC,t,y}$) shall be calculated using "TOOL03: Tool to calculate project or leakage $CO_2$ emissions from fossil fuel combustion". When applying the tool:

    (a) Processes *j* in the tool correspond to the sources of fossil fuel consumption due to the alternative waste treatment process, other than for electricity generation.

Consumption sources shall include, as relevant, fossil fuels used for starting the gasifier, auxiliary fossil fuels for operating the incinerator, heat generation for mechanical/thermal treatment process and on-site fossil fuel combustion during co-firing with waste. Fossil fuels used as part of the on-site processing or management of feedstocks and by-products shall also be included;

(b) If the project activity consists of more than one alternative waste treatment process, then project participants may choose to monitor fossil fuel consumption for the entire site and then allocate consumption to one of the different alternative waste treatment processes.

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

74. This procedure estimates emissions from gasifiers, incinerators, RDF/SB combustors and syngas burners ($PE_{COM,c,y}$). 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:

$$PE_{COM,C,y} = PE_{COM,CO2,c,y} + PE_{COM,CH4,N2O,c,y}$$ Equation (21)

Where:

| | | |
|---|---|---|
| $PE_{COM,C,y}$ | = | Project emissions from combustion within the project boundary associated with combustor *c* in year *y* (t $CO_2$e) |
| $PE_{COM,CO2,c,y}$ | = | 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 or syngas burner, incinerator or RDF/SB combustor |

### 5.4.9. Project emissions of $CO_2$ from combustion within the project boundary ($PE_{COM\_CO2,c,y}$)

75. Carbon dioxide project emissions associated with on-site combustion ($PE_{COM\_CO2,c,y}$) are calculated based either on the fossil carbon content of the fresh waste or RDF/SB combusted, or on the fossil carbon content of the stack gas. The biogenic carbon content is not considered.[19]

76. Project participants may select from three options to calculate $PE_{COM\_CO2,c,y}$. Option 1 requires sorting the fresh waste into components of waste type *j* and then determining the fossil-based carbon content of each waste type *j*. Option 2 determines the fossil-based carbon content of the unsorted fresh waste or RDF/SB (noting that Option 1, sorting into waste fractions, is not applicable if only RDF/SB is combusted). Option 3 measures directly the fossil-based carbon content of the stack gas.

[19] $CO_2$ emissions from the combustion or decomposition of biomass (see definition by the Board in annex 8 of the Board's 20th meeting report) are not accounted as GHG emissions. Where the combustion or decomposition of biomass under a CDM 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.

77. For gasifiers producing syngas for on-site utilisation, the fossil carbon content is determined and accounted for once, either evaluating the waste composition at the gasifier's inlet (Options 1, 2), or the stack gas at the syngas' stack (Option 3). All the syngas has to be combusted.

#### 5.4.9.1. Option 1: Waste sorted into waste type fractions

$$PE_{COM,CO2,c,y} = EFF_{COM,c,y} \times \frac{44}{12} \times \sum_{j} Q_{j,c,y} \times FCC_{j,y} \times FFC_{j,y} \quad \text{Equation (22)}$$

Where:

| | | |
|---|---|---|
| $PE_{COM,CO2,c,y}$ | = | Project emissions of $CO_2$ from combustion within the project boundary associated with combustor *c* in year *y* (t $CO_2$) |
| $Q_{j,c,y}$ | = | Quantity of fresh waste type *j* fed into combustor *c* the in year *y* (t) |
| $FCC_{j,y}$ | = | Fraction of total carbon content in waste type *j* in year *y* (t C/t) |
| $FFC_{j,y}$ | = | Fraction of fossil carbon in total carbon content of waste type *j* in year *y* (weight fraction) |
| $EFF_{COM,c,y}$ | = | Combustion efficiency of combustor *c* in year *y* (fraction) |
| $\frac{44}{12}$ | = | Conversion factor (t $CO_2$/t C) |
| $c$ | = | Combustor used in the project activity: gasifier, incinerator or RDF/SB combustor |
| $j$ | = | Waste type |

78. Project participants may select to either directly monitor the amount of waste type *j* fed into the combustor *c* in year *y* ($Q_{j,c,y}$) or calculate this parameter based on monitoring the total waste fed to the combustor and sampling the waste to determine the fraction of waste type *j* as per the following equation:

$$Q_{j,c,y} = Q_{waste,c,y} \times \frac{\sum_{n=1}^{z} p_{n,j,y}}{z} \quad \text{Equation (23)}$$

Where:

| | | |
|---|---|---|
| $Q_{j,c,y}$ | = | Quantity of waste type *j* fed into combustor *c* in year *y* (t) |
| $Q_{waste,c,y}$ | = | Quantity of fresh waste or RDF/SB fed into combustor *c* in year *y* (t) |
| $P_{n,j,y}$ | = | Fraction of waste type *j* in the sample *n* collected during the year *y* (weight fraction) |
| $z$ | = | Number of samples collected during the year *y* |
| $n$ | = | Samples collected in year *y* |
| $j$ | = | Waste type |

#### 5.4.9.2. Option 2: Based on unsorted waste

$$PE_{COM,CO2,c,y} = \frac{44}{12} \times FF_{COM,c,y} \times Q_{waste,c,y} \times FFC_{waste,c,y} \quad \text{Equation (24)}$$

Where:

| | | |
|---|---|---|
| $PE_{COM,CO2,c,y}$ | = | Project emissions of $CO_2$ from combustion within the project boundary associated with combustor *c* in year *y* (t $CO_2$) |
| $Q_{waste,c,y}$ | = | Quantity of fresh waste or RDF/SB fed into combustor *c* in year *y* (t) |
| $FFC_{waste,c,y}$ | = | Fraction of fossil-based carbon in waste or RDF/SB fed into combustor *c* in year *y* (t C/t) |
| $FF_{COM,c,y}$ | = | Combustion efficiency of combustor *c* in year *y* (fraction) |
| $\frac{44}{12}$ | = | Conversion factor (t $CO_2$/t C) |
| $c$ | = | Combustor used in the project activity: gasifier, incinerator or RDF/SB combustor |
| $j$ | = | Waste type, including RDF/SB |

#### 5.4.9.3. Option 3: Based on stack gas measurement

$$PE_{COM,CO2,c,y} = \frac{44}{12} \times SG_{c,y} \times FFC_{stack,c,y} \quad \text{Equation (25)}$$

Where:

| | | |
|---|---|---|
| $PE_{COM,CO2,c,y}$ | = | Project emissions of $CO_2$ from combustion within the project boundary associated with combustor *c* in year *y* (t $CO_2$) |
| $SG_{c,y}$ | = | Volume of stack gas from combustor *c* in year *y* ($Nm^3$) |
| $FFC_{stack,c,y}$ | = | Concentration of fossil-based carbon in the stack gas of the combustor *c* in year *y* (t C/$Nm^3$) |
| $\frac{44}{12}$ | = | Conversion factor (t $CO_2$/t C) |
| $c$ | = | Combustor used in the project activity: gasifier, syngas burner, incinerator or RDF/SB combustor |

### 5.4.10. Project emissions of $CH_4$ and $N_2O$ from combustion within the project boundary ($PE_{COM\_CH4,N2O,c,y}$)

79. Emissions of $N_2O$ and $CH_4$ from combustion of RDF/SB are neglected because they are considered very minor. For the case of gasification or incineration, project participants may choose either Option 1 or Option 2 to estimate emissions of $N_2O$ and $CH_4$ from combustion within the project boundary. Option 1 calculates the emissions based on monitoring the $N_2O$ and $CH_4$ content in the stack gas. Option 2 calculates the emissions using default emission factors for the amount of $N_2O$ and $CH_4$ emitted per tonne of fresh waste combusted.

### 5.4.10.1. Option 1: Monitoring the $N_2O$ and $CH_4$ content in the stack gas

$$PE_{COM\_CH4,N2O,c,y} = SG_{c,y} \times \left(C_{N2O,SG,c,y} \times GWP_{N2O} + C_{CH4,SG,c,y} \times GWP_{CH4}\right) \quad \text{Equation (26)}$$

Where:

| | | |
|---|---|---|
| $PE_{COM\_CH4,N2O,c,y}$ | = | Project emissions of $CH_4$ and $N_2O$ from combustion within the project boundary of fossil carbon in combustor *c* in year *y* (t $CO_2$) |
| $SG_{c,y}$ | = | Volume of stack gas from combustor *c* in year *y* ($Nm^3$) |
| $C_{N2O,SG,c,y}$ | = | Concentration of nitrous oxide in the stack gas from combustor *c* in year *y* (t $N_2O/Nm^3$) |
| $GWP_{N2O}$ | = | Global Warming Potential of nitrous oxide (t $CO_2e$/t $N_2O$) |
| $C_{CH4,SG,c,y}$ | = | Concentration of methane in the stack gas from combustor *c* in year *y* (t $CH_4/Nm^3$) |
| $GWP_{CH4}$ | = | Global Warming Potential of methane valid for the commitment period (t $CO_2e$/t $CH_4$) |
| $c$ | = | Combustor used in the project activity: gasifier, incinerator |

### 5.4.10.2. Option 2: Using default emission factors

$$PE_{COM\_CH4,N2O,c,y} = Q_{waste,c,y} \times \left(EF_{N2O,t} \times GWP_{N2O} + EF_{CH4,t} \times GWP_{CH4}\right) \quad \text{Equation (27)}$$

Where:

| | | |
|---|---|---|
| $PE_{COM\_CH4,N2O,c,y}$ | = | Project emissions of $CH_4$ and $N_2O$ from combustion within the project boundary associated with combustor *c* in year *y* (t $CO_2$) |
| $Q_{waste,c,y}$ | = | Quantity of fresh waste or RDF/SB fed into combustor *c* in year *y* (t) |
| $EF_{N2O,t}$ | = | Emission factor for $N_2O$ associated with waste treatment process *t* (t $N_2O$/t waste) |
| $EF_{CH4,t}$ | = | Emission factor for $CH_4$ associated with treatment process *t* (t $CH_4$/t waste) |
| $GWP_{N2O}$ | = | Global Warming Potential of nitrous oxide (t $CO_2e$/t $N_2O$) |
| $GWP_{CH4}$ | = | Global Warming Potential of methane valid for the commitment period (t $CO_2e$/t $CH_4$) |
| $c$ | = | Combustor used in the project activity: gasifier, incinerator |
| $t$ | = | Type of alternative waste treatment processes: gasification, incineration |

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

80. 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.

81. 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”.

82. 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 project participants 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 (28)

(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 (29)

(c) For cases with complete flaring/combustion of the methane generated by the wastewater discharge:

$$PE_{ww,t,y} = \frac{PE_{flare,ww,y}}{GWP_{CH4}}$$ Equation (30)

Where:

| | | |
|---|---|---|
| $PE_{ww,t,y}$ | = | Project emissions of methane from wastewater discharge associated with alternative waste treatment process *t* in year *y* (t $CO_2$e) |
| $Q_{ww,y}$ | = | Amount of wastewater discharge generated by the project activity and treated anaerobically or released untreated from the project activity in year *y* ($m^3$) |
| $P_{COD,y}$ | = | COD of the wastewater discharge generated by the project activity in year *y* (tCOD/$m^3$) |
| $B_O$ | = | 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) |
| $MCF_{ww}$ | = | Methane conversion factor (fraction) |
| $GWP_{CH4}$ | = | Global Warming Potential of methane valid for the commitment period (t $CO_2$e/t $CH_4$) |

| | | |
|---|---|---|
| $PE_{flare,ww,y}$ | = | Emissions from flaring associated with wastewater discharge treatment in year *y* (t $CO_2$e) |
| $F_{CH4,flare,y}$ | = | Amount of methane in the wastewater discharge treatment emissions which is sent to the flare/combustor in year *y* (t $CH_4$) |

83. "TOOL06: Project emissions from flaring" 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 project participants 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:

$$PE_{com,ww,y} = F_{CH4,flare,y} \times 0.1$$ Equation (31)

Where:

| | | |
|---|---|---|
| $PE_{com,ww,y}$ | = | Emissions from combustion of methane generated from wastewater treatment in year *y* (t $CO_2$e) |
| $F_{CH4,flare,y}$ | = | Amount of methane in the wastewater treatment gas that is sent to the flare/combustor in year *y* (t $CO_2$e) |

84. $F_{CH4,flare,y}$ is determined using "TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream", applying these requirements:

(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 (17) 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 $CH_4$).

85. 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.

## 5.5. Leakage

86. Leakage emissions are associated with composting/co-composting, anaerobic digestion and the use of RDF/SB 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 ($PE_{COMP,y}$).

87. Leakage emissions are determined as follows:

$$LE_y = LE_{COMP,y} + LE_{AD,y} + LE_{RDF\_SB,y}$$ Equation (32)

Where:

| | | |
|---|---|---|
| $LE_y$ | = | Leakage emissions in the year $y$ (t $CO_2$e) |
| $LE_{COMP,y}$ | = | Leakage emissions from composting or co-composting in year $y$ (t $CO_2$e) |
| $LE_{AD,y}$ | = | Leakage emissions from anaerobic digester in year $y$ (t $CO_2$e) |
| $LE_{RDF\_SB,y}$ | = | Leakage emissions associated with RDF/SB in year $y$ (t $CO_2$e) |

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

88. Leakage emissions associated with composting ($LE_{COMP,y}$) are calculated according to "TOOL13: Project and leakage emissions from composting".

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

89. Leakage emissions associated with anaerobic digestion of waste ($LE_{AD,y}$) are calculated according to "TOOL14: Project and leakage emissions from anaerobic digesters".

### 5.5.3. Leakage emissions associated with RDF/SB ($LE_{RDF\_SB,y}$)

90. Leakage emissions associated with RDF/SB are accounted for the organic waste by-products of the treatment process (not by-products from the RDF/SB combustor), which may be composted or disposed of in a SWDS, and the end-use of RDF/SB that is exported off-site, as follows:

$$LE_{RDF\_SB,y} = LE_{ENDUSE\_RDF\_SB,y} + LE_{SWDS,WBP\_RDF\_SB,y}$$ Equation (33)

Where:

| | | |
|---|---|---|
| $LE_{RDF\_SB,y}$ | = | Leakage emissions associated with RDF/SB in year $y$ (t $CO_2$e) |
| $LE_{SWDS,WBP\_RDF\_SB,y}$ | = | Leakage emissions associated with disposing of waste by-products associated with RDF/SB production in a SWDS in year $y$ (t $CO_2$e) |
| $LE_{ENDUSE\_RDF\_SB,y}$ | = | Leakage emissions associated with the end-use of RDF/SB exported outside the project boundary in year $y$ (t $CO_2$e) |

### 5.5.4. Leakage emissions from disposal of waste by-products from RDF/SB production in a SWDS ($LE_{SWDS,WBP\_RDF\_SB,y}$)

91. $LE_{SWDS,WBP\_RDF\_SB,y}$ is determined using "TOOL04: Emissions from solid waste disposal sites". In the tool, $x$ begins with the start of the CDM project activity and extends to the end

of year *y* (e.g. emissions are calculated using Application B in the tool and waste disposed from the start of the first crediting period shall be considered).

92. $W_{j,x}$ in the tool is the amount of organic waste contained in the waste by-products from the production of RDF/SB in year *y* (e.g. it does not include waste by-products that are composted instead of being disposed to a SWDS in the project activity or waste by-products from the combustion of RDF/SB).

### 5.5.5. Leakage emissions associated with end use of RDF/SB exported outside the project boundary ($LE_{ENDUSE,RDF\_SB,y}$)

93. The potential leakage emissions associated with the use of the RDF/SB that is exported outside the project boundary are that it may be combusted or decompose anaerobically. Emissions are therefore calculated allowing for the situation that RDF/SB exported in year *y* may have three different end uses *u,* as follows:

(a) End use 1: documented evidence is provided that the RDF/SB exported off-site is used as raw material in fertilizer, ceramic manufacture or as a fuel that is combusted in a CDM project activity. In this case, no leakage emissions are estimated;

(b) End use 2: documented evidence is provided that the RDF/SB exported off-site is combusted or used as a raw material in furniture: In this case, the RDF/SB is considered to be combusted and $LE_{ENDUSE,RDF\_SB,y}$ shall be calculated, according to procedure below;

(c) End use 3: no documented evidence is provided that the off-site end use of RDF/SB is either combustion, furniture manufacture, fertilizer or ceramic production. In this case, the RDF/SB may decay anaerobically or be combusted. Therefore, it is conservatively assumed that the RDF/SB decays anaerobically according to the procedure below.

### 5.5.6. Leakage emissions from combusted off-site end use of RDF/SB ($LE_{ENDUSE,RDF\_SB,y}$) (End use 2)

94. This procedure estimates emissions associated with combustion of RDF/SB outside the project boundary, where the combustor is outside the control of the project participants. Carbon dioxide emissions ($LE_{ENDUSE,RDF\_SB,y}$) are calculated as follows:

$$LE_{ENDUSE\_RDF\_SB,y} = Q_{RDF\_SB,COM,y} \times NCV_{RDF\_SB,y} \times EF_{CO2\_RDF\_SB,y} \quad \text{Equation (34)}$$

Where:

| | | |
|---|---|---|
| $LE_{ENDUSE\_RDF\_SB,y}$ | = | Leakage emissions of $CO_2$ from off-site combustion of RDF/SB in year *y* (t $CO_2$) |
| $Q_{RDF\_SB,COM,y}$ | = | Quantity of RDF/SB exported off-site with potential to be combusted in year *y* (t) |
| $EF_{CO2\_RDF\_SB,y}$ | = | $CO_2$ emissions factor for RDF/SB in year *y* (t $CO_2$/GJ) |
| $NCV_{RDF\_SB,y}$ | = | Net calorific value of RDF/SB in year *y* (GJ/t) |

### 5.5.7. Leakage emissions from off-site anaerobic decomposition of RDF/SB (End use 3)

95. Leakage emissions from anaerobic decay of RDF/SB are accounted by adjusting the quantity of organic waste used to produce RDF/SB ($W_{RDF\_SB,j,x}$) in the calculation of baseline emissions from solid waste disposal sites, as follows:

$$W_{RDF\_SB,j,x,adj} = \frac{Q_{export,RDF\_SB,y}}{Q_{RDF\_SB,y}} \times W_{RDF\_SB,j,x}$$ Equation (35)

Where:

| | | |
|---|---|---|
| $W_{RDF\_SB,j,x,adj}$ | = | Amount of solid waste type *j* prevented from disposal in the SWDS by using the waste to produce RDF/SB in the year *x*, adjusted by the proportion of RDF/SB that is disposed of in a SWDS (t) |
| $W_{RDF\_SB,j,x}$ | = | Amount of solid waste type *j* prevented from disposal in the SWDS by using the waste to produce RDF/SB in the year *x* (t) |
| $Q_{export,RDF\_SB,y}$ | = | Amount of RDF/SB exported offsite with potential to decay anaerobically in year *y* (t) |
| $Q_{RDF\_SB,y}$ | = | Amount of RDF/SB produced by the project activity in year *y* (t) |

## 5.6. Emission reductions

96. To calculate the emission reductions the project participant shall apply the following equation:

$$ER_y = BE_y - PE_y - LE_y$$ Equation (36)

Where:

| | | |
|---|---|---|
| $ER_y$ | = | Emissions reductions in year *y* (t $CO_2$e) |
| $BE_y$ | = | Baseline emissions in year *y* (t $CO_2$e) |
| $PE_y$ | = | Project emissions in the year *y* (t $CO_2$e) |
| $LE_y$ | = | Leakage emissions in year *y* (t $CO_2$e) |

97. If the sum of $PE_y$ and $LE_y$ is smaller than 1 per cent of $BE_y$ in the first full operation year of a crediting period, the project participants may choose to assume a fixed percentage of 1 per cent for the sum of $PE_y$ and $LE_y$ for the remaining years of the crediting period.

98. In the case that overall negative emission reductions arise in a year, CERs are not issued to project participants for the year concerned and in subsequent years, until emission reductions from subsequent years have compensated the quantity of negative emission reductions from the year concerned. (For example: if negative emission reductions of 30 t $CO_2$e occur in the year *y* and positive emission reductions of 100 t $CO_2$e occur in the year *y*+1, 0 CERs are issued for year *y* and only 70 CERs are issued for the year *y*+1.)

## 5.7. Changes required for methodology implementation in 2nd and 3rd crediting periods

99. The required changes shall be assessed using the tool for "Assessment of the validity of the current/original baseline and update of the baseline at the renewal of the crediting period".

## 5.8. Project activity under a programme of activities

100. In addition to the requirements set out in the latest approved version of the "Standard for demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programme of activities", the following shall be applied for the use of this methodology in a project activity under a programme of activities (PoAs).

101. The PoA may consist of one or several types of CPAs. CPAs are regarded to be of the same type if they are similar with regard to the demonstration of additionality, emission reduction calculations and monitoring. The CME shall describe in the CDM-PoA-DD for each type of CPAs separately:

(a) Eligibility criteria for CPA inclusion used for each type of CPAs;

(b) In case of combinations of treatment processes in one CPA, the eligibility criteria shall be defined for each treatment option, separately;

(c) Emission reduction calculations for each type of CPAs;

(d) Monitoring provisions for each type of CPAs.

102. The coordinating/managing entity (CME) shall describe transparently and justify in the CDM-PoA-DD which CPAs are regarded to be of the same type. CPAs are not regarded to be of the same type if one of the following conditions is different:

(a) The baseline scenario with regard to any of the following aspects:

  (i) The disposal of organic waste in a SWDS without an LFG capture system;

  (ii) The disposal of organic waste in a SWDS with a partial LFG capture system;

  (iii) In case of co-composting, the treatment of organic wastewater in:

    a. Existing anaerobic lagoon;

    b. New to be built anaerobic lagoon;

    c. New sludge pit;

    d. Existing sludge pit;

(b) The project activity with regard to a treatment process used as well as any of the following aspects of the treatment process:

  (i) Composting:

    a. Closed composting;

    b. Open composting (wind rows);

(ii) Co-composting:

a. Closed composting;

b. Open composting (wind rows);

(iii) Thermal treatment:

a. Generation of electricity;

b. Generation of heat;

c. Combination of heat and electricity generation;

d. Any other use;

(iv) Mechanical treatment:

a. Generation of electricity;

b. Generation of heat;

c. Combination of heat and electricity generation;

d. Any other use;

(v) Gasification:

a. Generation of electricity;

b. Generation of heat;

c. Combination of heat and electricity generation;

d. Any other use;

(vi) Incineration:

a. Generation of electricity;

b. Generation of heat;

c. Combination of heat and electricity generation;

d. Any other use;

(vii) Combination of any treatment processes or use of the product/by-product (e.g. heat or electricity from biogas) for within a treatment process listed above;

(c) The legal and regulatory framework.

103. When defining eligibility criteria for CPA inclusion for a distinct type of CPAs, the CME shall consider relevant technical and economic parameters, such as:

(a) Type of solid waste disposal site:

(i) New solid waste disposal site;

(ii) Existing solid waste disposal site;

(b) Ranges of capacity of the treatment plant or unit;

(c) Composition of the waste (e.g. mixed or single type of waste);

(d) Ranges of costs (capital investment, operating and maintenance costs, etc.);

(e) Ranges of revenues (income from electricity, heat or biogas sale, subsidies/fiscal incentives, official development assistance (ODA)).

104. When Option (ii) in the latest approved version of the "Standard for demonstration of additionality, development of eligibility criteria and application of multiple methodologies for programmes of activities" is applied, that is related to defining technical and economic criteria as ranges of values for each input parameter required for the inclusion of the CPA in the PoA-DD, the eligibility criteria related to the costs and revenues parameters shall be updated every two years in order to correctly reflect the technical and market circumstances of a CPA implementation.

## 5.9. Data and parameters not monitored

105. As applicable, all the provisions regarding data and parameters not monitored as contained in the tools referred to in this methodology shall be followed.

**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 |
| Any comment: | Calculated based on the number of instances of compliance identified at the time of the investment decision and updated once for every subsequent crediting period |

**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 |

| | |
|---|---|
| Value to be applied: | For MSW the following values for the different waste types *j* may be applied:<br>**Table 4: Default values for $FFC_{j,y}$**<br><table><tr><td>**Waste type *j***</td><td></td></tr><tr><td>Paper/cardboard</td><td>5</td></tr><tr><td>Textiles</td><td>50</td></tr><tr><td>Food waste</td><td>-</td></tr><tr><td>Wood</td><td>-</td></tr><tr><td>Garden and Park waste</td><td>0</td></tr><tr><td>Nappies</td><td>10</td></tr><tr><td>Rubber and Leather</td><td>20</td></tr><tr><td>Plastics</td><td>100</td></tr><tr><td>Metal*</td><td>NA</td></tr><tr><td>Glass*</td><td>NA</td></tr><tr><td>Other, inert waste</td><td>100</td></tr></table><br>Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common.<br>If a waste type is not comparable to a type listed in Table 4, or can not clearly be described as a combination of types in this table above, or if the project participants wish to measure $FFC_{j}$, then project participants shall measure $FFC_{j,y}$ using the following standards, or similar national or international standards:<br>ASTM D6866: "Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis";<br>ASTM D7459: "Standard Practice for Collection of Integrated Samples for the Speciation of Biomass (Biogenic) and Fossil Carbon Dioxide Emitted from Stationary Emissions Sources".<br>The frequency of measurement shall be as a minimum four times in year *y* with the mean value valid for year *y*<br>The project participates also have the option to apply the balance method (Appendix 2) to measure $FFC_{j,y}$ |
| Any comment: | Data and parameters to be monitored in respect of the balance method are shown in the Appendix 2 additionally |

**Data / Parameter table 2.**

| **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:<br>**Table 5: Default values for $FCC_{j,y}$**<br>**Waste type *j*** / (blank)<br>Paper/cardboard: 50<br>Textiles: 50<br>Food waste: 50<br>Wood: 54<br>Garden and Park waste: 55<br>Nappies: 90<br>Rubber and Leather: 67<br>Plastics: 85<br>Metal*: NA<br>Glass*: NA<br>Other, inert waste: 5<br><br>*Metal and glass contain some carbon of fossil origin. Combustion of significant amounts of glass or metal is not common<br>The project participates also have the option to apply the balance method (Appendix 2) to measure *FCCj,y* |
| Any comment: | Data and parameters to be monitored in respect of the balance method are shown in the Appendix 2 additionally |

**Data / Parameter table 3.**

| **Data / Parameter:** | $GWP_{CH4}$ |
|---|---|
| Data unit: | t $CO_2$e/t $CH_4$ |
| Description: | Global Warming Potential of methane valid for the commitment period (t $CO_2$e/t $CH_4$) |
| Source of data: | IPCC |
| Value to be applied: | Default value of 25 from IPCC Fourth Assessment Report (AR4). Shall be updated according to any future COP/MOP decisions |
| Any comment: | - |

**Data / Parameter table 4..**

| **Data / Parameter:** | $GWP_{N2O}$ |
|---|---|
| Data unit: | t $CO_2$e/t $N_2O$ |
| Description: | Global Warming Potential of $N_2O$ |
| Source of data: | IPCC |
| Value to be applied: | Default value of 298 from IPCC Fourth Assessment Report (AR4). Shall be updated according to any future COP/MOP decisions |
| Any comment: | - |

**Data / Parameter table 5.**

| **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 |
| Value to be applied: | 0.25 |
| Any comment: | Applicable to the “Procedure to calculate project emissions from wastewater treatment” |

**Data / Parameter table 6.**

| **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:<br>1. Project specific data;<br>2. Country specific data; or<br>3. IPCC default values (table 6.3, chapter 6, volume 5 of IPCC 2006 guidelines) |
| Measurement procedures (if any): | - |
| Any comment: | |

**Data / Parameter table 7.**

| **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>Measurement procedures (if any):</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 CDM-PDD. If country-specific data are not available, then apply the default values listed in Table 6. For continuous incineration of industrial waste, apply the CH4 emission factors provided in Volume 2, Chapter 2, Stationary Combustion of IPCC 2006 Guidelines.<br><br>Table 6. $CH_4$ emission factors for combustion
<table>
<tr><th>Waste type</th><th colspan="2">Type of incineration/technology</th><th>$CH_4$ emission factors<br>($t\ CH_4$ / t waste) wet basis</th></tr>
<tr><td rowspan="6">MSW</td><td rowspan="2">Continuous incineration</td><td>stoker</td><td>1.21x 0.2x10$^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>~0</td></tr>
<tr><td rowspan="2">Semi-continuous incineration</td><td>stoker</td><td>1.21x 6x10$^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>1.21x 188x10$^{-6}$</td></tr>
<tr><td rowspan="2">Batch type incineration</td><td>stoker</td><td>1.21x 60x10$^{-6}$</td></tr>
<tr><td>fluidised bed</td><td>1.21x 237x10$^{-6}$</td></tr>
<tr><td colspan="3">Sludge (semi-continuous or batch type incineration)</td><td>1.21x 9 700x10$^{-6}$</td></tr>
<tr><td colspan="3">Waste oil (semi-continuous or batch type incineration)</td><td>1.21x 560x10$^{-6}$</td></tr>
</table>
<br>A conservativeness factor of 1.21 has been applied to account for the uncertainty of the IPCC default values</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 8.**

| **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 |

| | |
|---|---|
| Measurement procedures (if any): | 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 CDM-PDD. If country-specific data are not available, then apply the default values listed in Table 7.<br>**Table 7. $N_2O$ emission factors for combustion**<br>(see table below)<br>A conservativeness factor of 1.21 has been applied to account for the uncertainty of the IPCC default values |
| Any comment: | Applicable to Option 2, of procedure to estimate $PE_{COM,c,y}$ |

**Table 7. $N_2O$ emission factors for combustion**

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

**Data / Parameter table 9.**

| 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 |
| Measurement procedures (if any): | - |
| Any comment: | - |

**Data / Parameter table 10.**

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

| | |
|---|---|
| Source of data: | Project participants can choose one of the following approaches: Highest of the measured efficiencies of similar plants;<br>Highest of the efficiency values provided by two or more manufacturers for similar plants; or<br>Maximum efficiency of 90 per cent, based on net calorific values |
| Measurement procedures (if any): | - |
| Any comment: | - |

**Data / Parameter table 11.**

| Data / Parameter: | $EF_{CO2,BL,CG}$ |
|---|---|
| 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 |
| Measurement procedures (if any): | - |
| Any comment: | - |

**Data / Parameter table 12.**

| Data / Parameter: | $COD_{out,x}$<br>$COD_{in,x}$ |
|---|---|
| Data unit: | tCOD |
| Description: | COD of the effluent in the period *x.*<br>COD directed to the anaerobic lagoons or sludge pits in the period *x* (tCOD) |
| Source of data: | For existing plants:<br>If there is no effluent: $COD_{out,x} = 0$;<br>If there is effluent:<br>One year of historical data should be used, or<br>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.<br>For Greenfield projects:<br>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 |

| | |
|---|---|
| Measurement procedures (if any): | For the measurement campaign of at least 10 days:<br>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 13.**

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

**Data / Parameter table 14.**

| **Data / Parameter:** | $\rho$ |
|---|---|
| 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:<br>1. If one year of historical data is available $\rho$=1;<br>2. If a measurement campaign of at least 10 days is available $\rho$=0.89.<br>For Greenfield projects: $\rho$=1 |
| 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 15.**

| **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 |

| | |
|---|---|
| Measurement procedures (if any): | No measurement procedures. 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 |
| Any comment: | Taking into account the uncertainty of this estimate, project participants should use a value of 0.21 kg $CH_4$/kg COD as a conservative assumption for $B_o$ |

**Data / Parameter table 16.**

| **Data / Parameter:** | ***D*** |
|---|---|
| Data unit: | M |
| Description: | Average depth of the lagoons or sludge pits |
| Source of data: | For existing plants: conduct measurements.<br>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" |
| Measurement procedures (if any): | Determine the average depths of the whole lagoon/sludge pit under normal operating conditions |
| Any comment: | - |

# 6. Monitoring methodology

106. 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.

107. Describe and specify in the CDM-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.

## 6.1. Data and parameters monitored

**Data / Parameter table 17.**

| **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: | Project participants |
| 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 procedures: | Calibration shall be according to manufacturer's specifications |

| | |
|---|---|
| Any comment: | Applicable to baseline emissions procedure (D) |

**Data / Parameter table 18.**

| **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* (Nm3) |
| Source of data: | Project participants |
| 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 procedures: | 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 19.**

| **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:<br>1. Project specific data;<br>2. Country specific data; or<br>3. IPCC default values |
| Measurement procedures (if any): | - |
| Monitoring frequency: | Annually |
| QA/QC procedures: | - |
| 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 20.**

| **Data / Parameter:** | $SG_{c,y}$ |
|---|---|
| Data unit: | $m^3/yr$ |
| Description: | Volume of stack gas from combustor *c* in year *y* |
| Source of data: | Project participants |

| | |
|---|---|
| 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 procedures: | 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 21.**

| **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: | Project participants |
| Measurement procedures (if any): | - |
| Monitoring frequency: | At least every three months |
| QA/QC procedures: | 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 22.**

| **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: | Project participants |
| Measurement procedures (if any): | - |
| Monitoring frequency: | At least every three months |
| QA/QC procedures: | 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 23.**

| 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: | Project participants |
| Measurement procedures (if any): | Measured with calibrated scales or load cells |
| Monitoring frequency: | Continuously, aggregated at least annually |
| QA/QC procedures: | - |
| Any comment: | Parameter required for procedure to calculate project emissions from combustion within the project boundary |

**Data / Parameter table 24.**

| 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 project participants |
| 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 procedures: | - |
| Any comment: | - |

**Data / Parameter table 25.**

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

**Data / Parameter table 26.**

| 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 Appendix 1 |
| Monitoring frequency: | Continuous |
| QA/QC procedures: | 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 “TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation”<br>$EC_{t,y}$ 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 27.**

| **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 procedures: | 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 28.**

| **Data / Parameter:** | $EG_{INC,y}$ |
|---|---|
| Data unit: | GJ |
| Description: | Amount of electricity generated by incineration during the year *y* |
| Source of data: | Electricity meter |

| | |
|---|---|
| Measurement procedures (if any): | Electricity generation needs to be converted to thermal energy (1 MWh = 3.6 GJ) |
| Monitoring frequency: | Continuous, aggregate annually |
| QA/QC procedures: | - |
| Any comment: | This parameter will be used to assess that the fraction of energy generated by fossil fuel is no more than 50 per cent of the total energy generated in the incinerator |

**Data / Parameter table 29.**

| **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.<br>In case of hot air: the temperature, pressure and mass flow rate will be measured |
| Monitoring frequency: | Monthly, aggregated yearly |
| QA/QC procedures: | 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 30.**

| **Data / Parameter:** | $HG_{INC,y}$ |
|---|---|
| Data unit: | GJ |
| Description: | Quantity of thermal energy generated by incineration in year *y* |
| 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.<br>In case of hot air: the temperature, pressure and mass flow rate will be measured |
| Monitoring frequency: | Annually |
| QA/QC procedures: | 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: | This parameter will be used to assess that the fraction of energy generated by fossil fuel is no more than 50 per cent of the total energy generated in the incinerator |

**Data / Parameter table 31.**

| **Data / Parameter:** | $Q_{RDF\_SB,COM,y}$ |
|---|---|
| Data unit: | T |
| Description: | Quantity of RDF/SB exported off-site with potential to be combusted in year *y* |
| Source of data: | Project site |
| Measurement procedures (if any): | Sale invoices of the RDF/SB should be kept at the project site. They shall contain customer contact details, physical location of delivery, type, amount (in tons) and purpose of RDF/SB (use as fuel or as material in furniture, etc.). A list of customers and delivered SD amount shall be kept at the project site |
| Monitoring frequency: | Weekly |
| QA/QC procedures: | - |
| Any comment: | See procedure to calculate leakage emissions associated with RDF/SB for further information |

**Data / Parameter table 32.**

| **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 procedures: | - |
| Any comment: | - |

**Data / Parameter table 33.**

| **Data / Parameter:** | $Q_{export,RDF\_SB,y}$ |
|---|---|
| Data unit: | T |
| Description: | Quantity of RDF/SB exported outside the project boundary that is considered to decay anaerobically in year *y* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Weighbridge. All RDF/SB for which documented evidence is not available that it is combusted, or used for fertilizer of furniture manufacture |
| Monitoring frequency: | Annually |
| QA/QC procedures: | Weighbridge will be subject to periodic calibration (in accordance with stipulation of the weighbridge supplier) |

| | |
|---|---|
| Any comment: | - |

**Data / Parameter table 34.**

| **Data / Parameter:** | $Q_{RDF\_SB,y}$ |
|---|---|
| Data unit: | T |
| Description: | Quantity of RDF/SB produced in year *y* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Weighbridge |
| Monitoring frequency: | Annually |
| QA/QC procedures: | Weighbridge will be subject to periodic calibration (in accordance with stipulation of the weighbridge supplier) |
| Any comment: | - |

**Data / Parameter table 35.**

| **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 procedures: | 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 36.**

| **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 procedures: | 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 37.**

| **Data / Parameter:** | ***$EG_{INC,FF,y}$*** |
|---|---|
| Data unit: | GJ |
| Description: | Energy generated by auxiliary fossil fuel added in the incinerator |
| Source of data: | Project site |
| Measurement procedures (if any): | This parameter will be estimated multiplying the amount of auxiliary fossil fuel added in the incinerator to the net calorific value of this auxiliary fossil fuel |
| Monitoring frequency: | Annually |
| QA/QC procedures: | - |
| Any comment: | This parameter will be used to assess that the fraction of energy generated by fossil fuel is no more than 50 per cent of the total energy generated in the incinerator. $EG_{INC,FF,y} < 0.50 \times (HG_{INC,y} + EG_{INC,y})$ |

**Data / Parameter table 38.**

| **Data / Parameter:** | ***$EF_{CO2,RDF\_SB,y}$*** |
|---|---|
| Data unit: | t $CO_2$/GJ |
| Description: | Weighted average $CO_2$ emission factor for RDF/SB in year *y* |
| Source of data: | $EF_{CO2,RDF\_SB,y}$ is zero for biomass residues, otherwise determine from one of the following sources:<br><br>**Data source** — **Conditions for using the data source**<br>(a) Measurements by the project participants — This is the preferred data source<br>(b) IPCC default values at the upper/lower limit [20] of the uncertainty at a 95 per cent confidence interval as provided in table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories — If (a) is not available |
| Measurement procedures (if any): | For (a): Measurements shall be undertaken in line with national or international fuel standards |

[20] To be conservative, choose the upper limit where project emissions are calculated and the lower limit where baseline emissions are calculated.

| | |
|---|---|
| Monitoring frequency: | For (a): the $CO_2$ emission factor shall be obtained for each shipment of RDF/SB exported from the project site for which there is documented evidence that it will be combusted, from which weighted average annual values shall be calculated.<br>For (b): any future revision of the IPCC Guidelines shall be taken into account |
| QA/QC procedures: | - |
| Any comment: | This parameter is required for the procedure to calculate leakage emissions for the combustion of RDF/SB outside the project boundary |

**Data / Parameter table 39.**

| **Data / Parameter:** | $\boldsymbol{NCV_{RDF\_SB,y}}$ |
|---|---|
| Data unit: | GJ/mass or volume units |
| Description: | Weighted average net calorific value of RDF/SB in year *y* |
| Source of data: | Measurements by the project participants |
| Measurement procedures (if any): | Measurement is not required for RDF/SB produced wholly from biomass residues, otherwise measurements shall be undertaken in line with national or international fuel standards |
| Monitoring frequency: | The NCV shall be obtained for each shipment of RDF/SB exported from the project site for which there is documented evidence that it will be combusted, from which weighted average annual values shall be calculated |
| QA/QC procedures: | - |
| Any comment: | This parameter is required for the procedure to calculate leakage emissions for the combustion of RDF/SB outside the project boundary |

**Data / Parameter table 40.**

| **Data / Parameter:** | $\boldsymbol{F_{PJ,AD,m}}$ |
|---|---|
| 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 procedures: | - |
| 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 41.**

| **Data / Parameter:** | $COD_{AD,m}$ |
|---|---|
| Data unit: | t COD/m³ |
| 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.<br>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 procedures: | - |
| 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 42.**

| **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 project participants decide to measure temperature in the project site:<br>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 procedures: | In case that project participants decide to measure temperature in the project site:<br>Uncertainty of the measurements provided by temperature sensor supplier should be discounted from the readings |
| Any comment: | - |

# Appendix 1. Typical boundary layouts of what is included in the project boundary

**Figure 1. Composting**

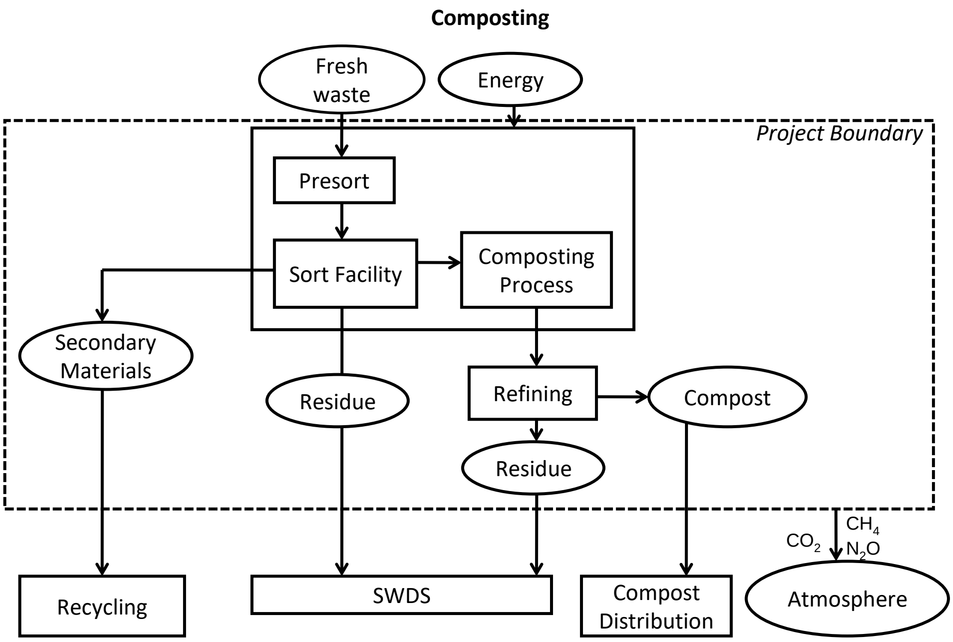



**Figure 2. Co-composting**

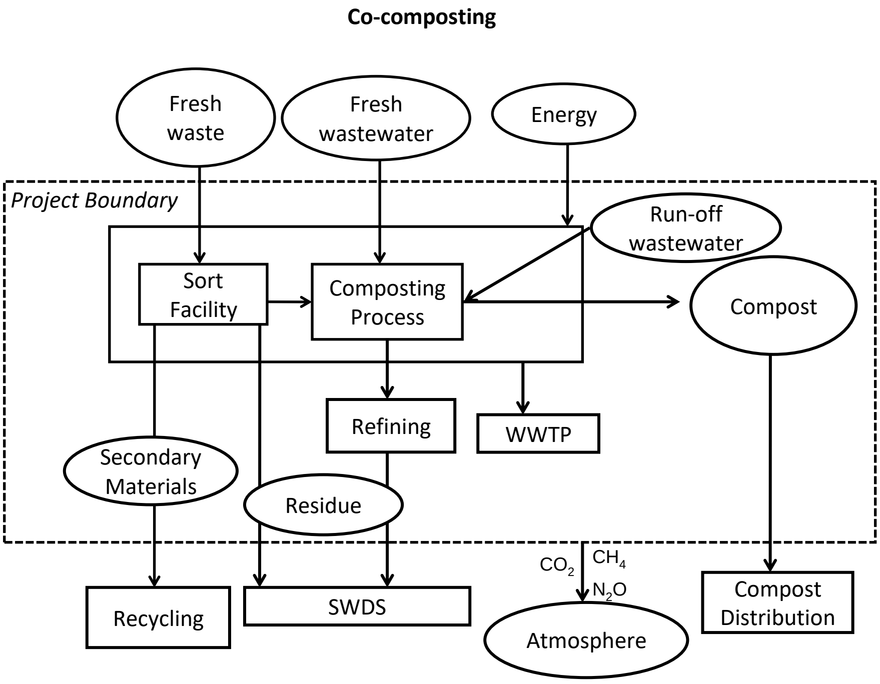


**Figure 3. Anaerobic digestion with biogas collection and flaring and/or its use**

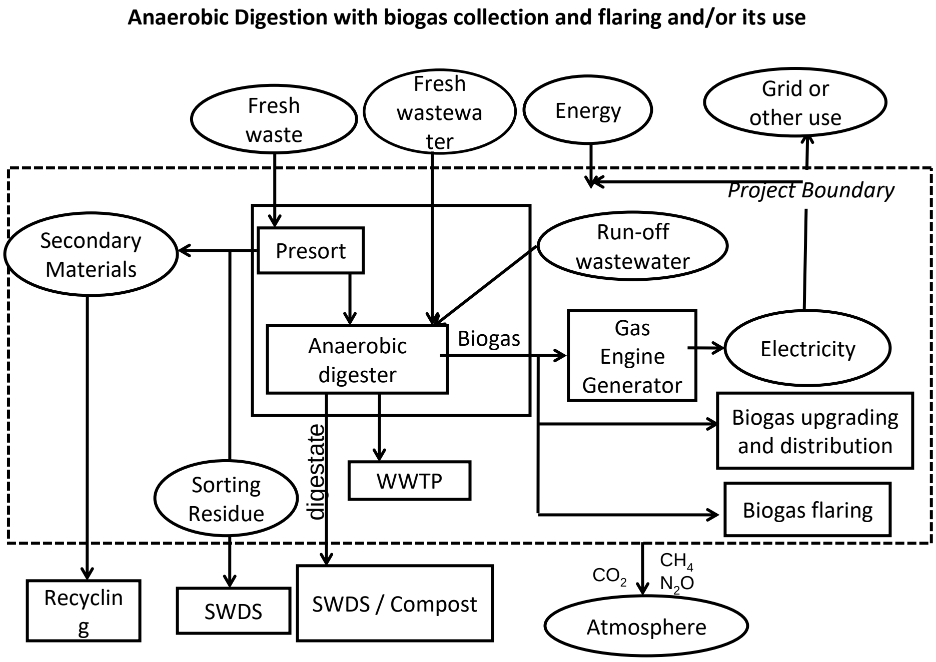



**Figure 4. Mechanical/thermal treatment process to produce refuse-derived fuel (RDF)/stabilized biomass (SB) on-site power generation**

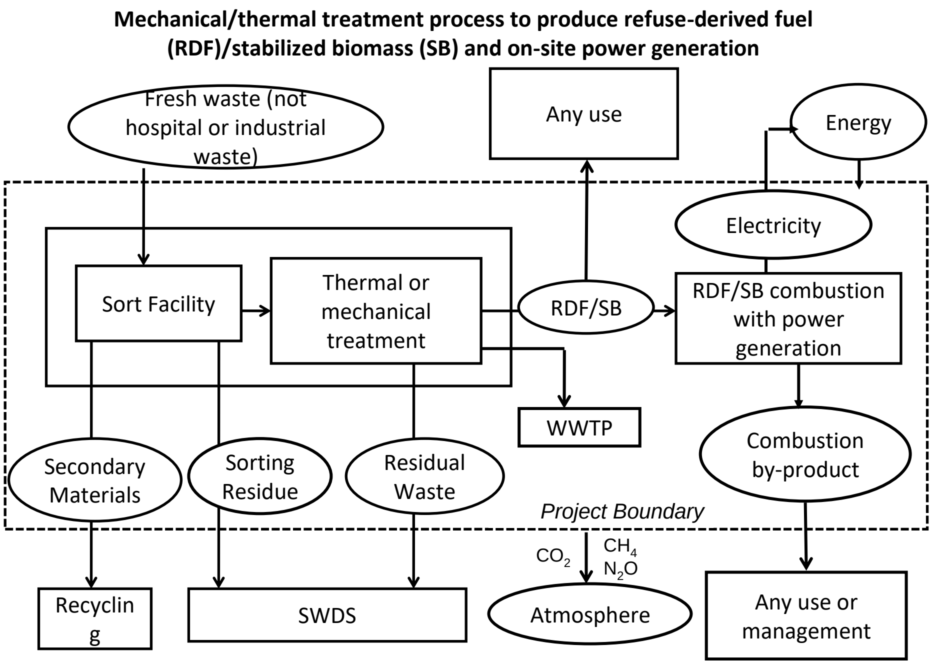


**Figure 5. Gasification**

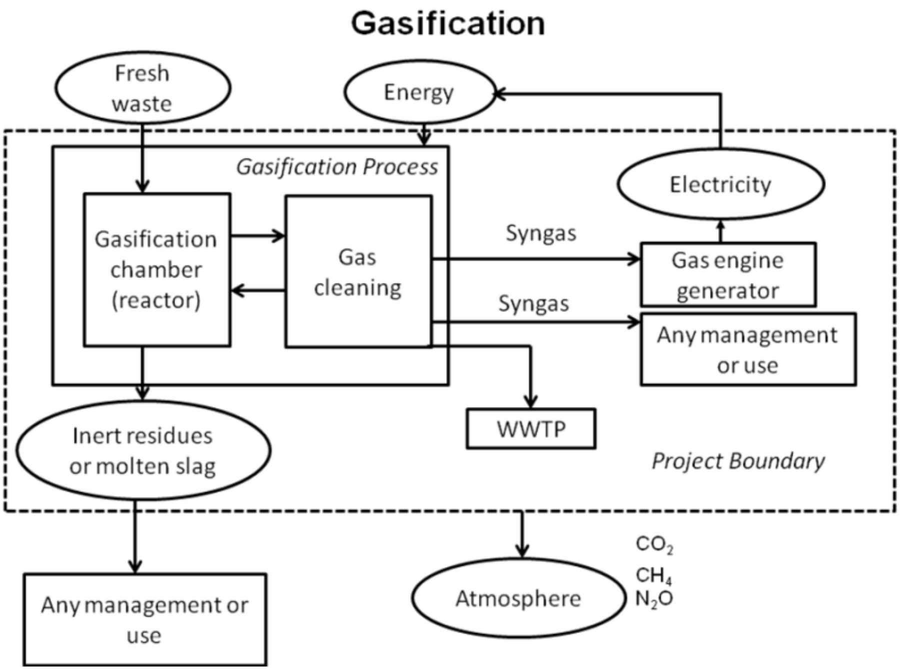
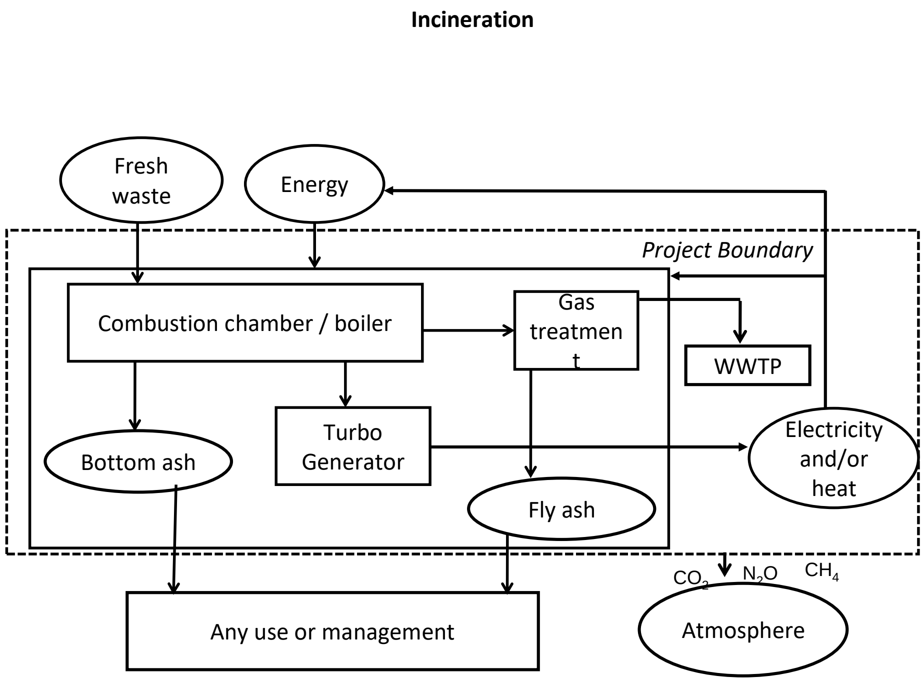



**Figure 6. Incineration**



# Appendix 2. The measurement of $FFC_{j,y}$ by balance method

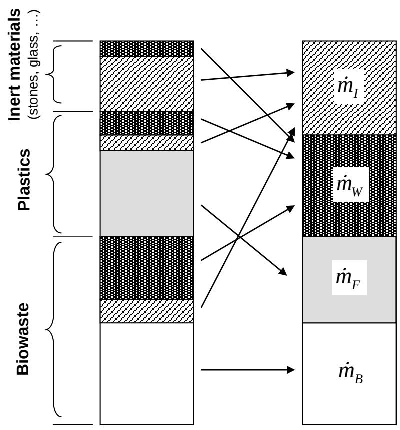
## 1. Balance method in the conventional waste combustion using ambient air

1. The balance method is based on five mass balances and one energy balance (see below)[1] 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;

[1] 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.

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

Where:

| | | |
|---|---|---|
| $M_{waste}$ | = | Mass of waste feed into the WtE plant within a defined period hour *h* [tons] |
| $\sum M_{solidresidues}$ | = | 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 $C_{Cwaste}$ 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;

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

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 (22.414$Ndm^3$/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 *HVwaste* 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 *Mwaste*, the mass flow of auxiliary fuels *FCi,h* and their respective calorific value *HVFCi,h*, and the energy efficiency of the boiler η) of the plant;

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

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] |
| $\Delta h$ | = | 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;

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

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*[2]) |
| $O_{2,consum}$ | = | 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 $d_{O2-CO2}$ 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;

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

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

Equation (6)

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

$$FFC_j = \frac{m_F \times C_{CF}}{m_B \times C_{CB} + m_F \times C_{CF}}$$

Equation (7)

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

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

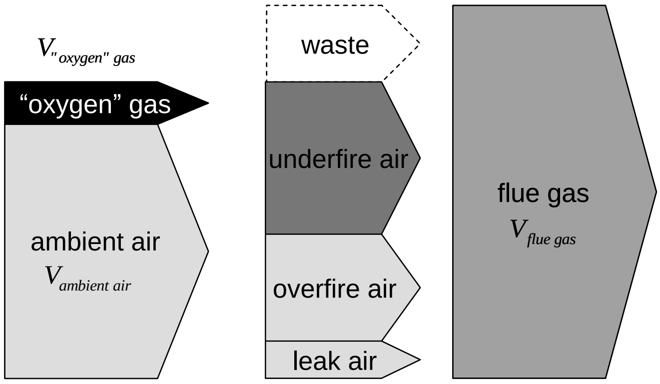
Equation (8)

[3] When a software following the balance method is applied in the calculation, the project participate(s) have to demonstrate the applicability and the reliability of the software to DOE.

## 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 ($CO_2$,comb,air and $CCO_2$,comb,air) equal to those of the ambient air ($CO_2$,air and $CCO_2$,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.[4]

[4] 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.

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

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:

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

Where:

| | | |
|---|---|---|
| $C_{CO2,'oxygen'gas}$ | = | $CO_2$ 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:

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

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 project proponent shall obtain the country-special value following the steps given underneath. Laboratory for conducting the test shall be national or internally approved.

12. 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 project participates are also allowed to choose other applicable international or national standards.

13. 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).

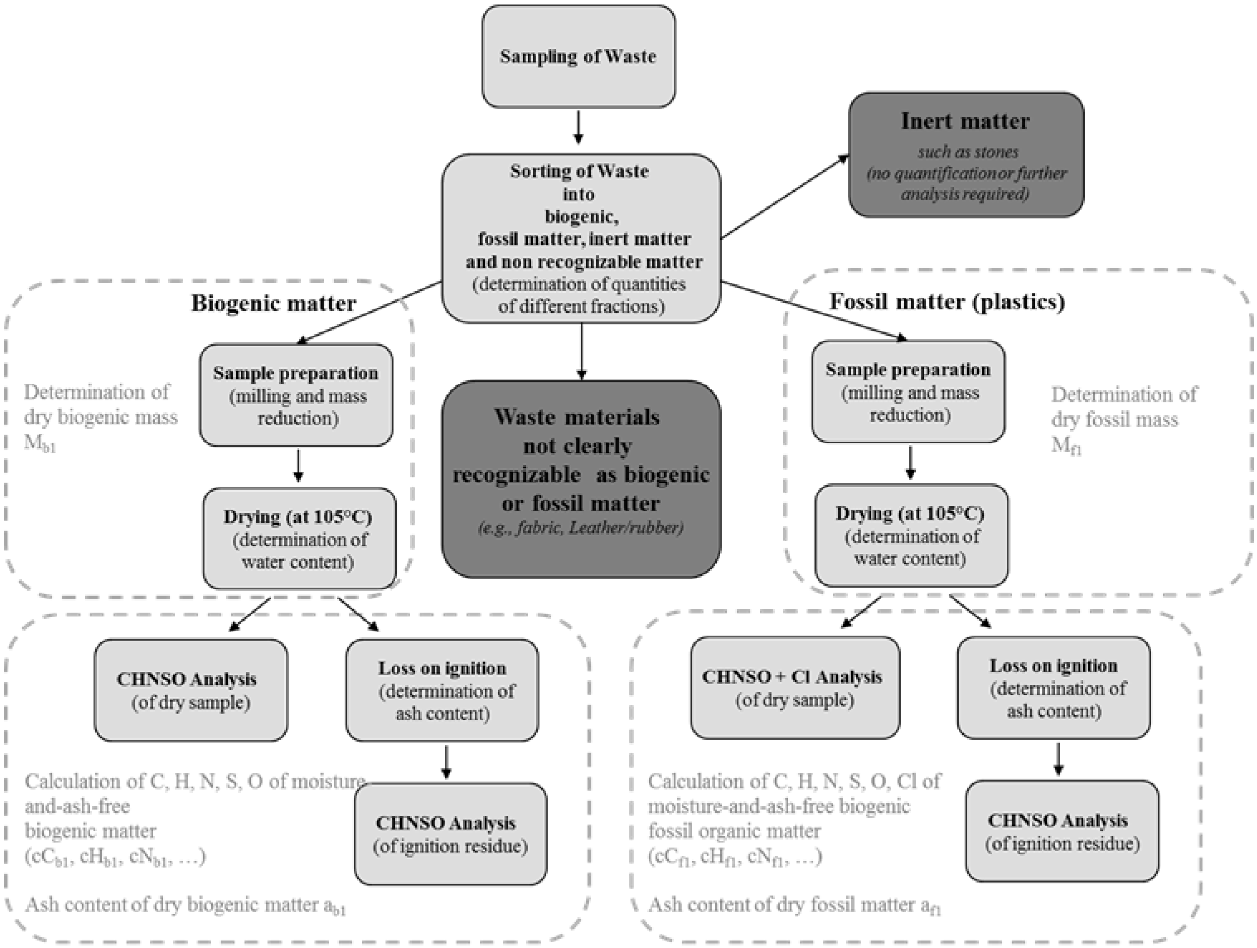
14. Step 3. Analysis of waste:

    (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;

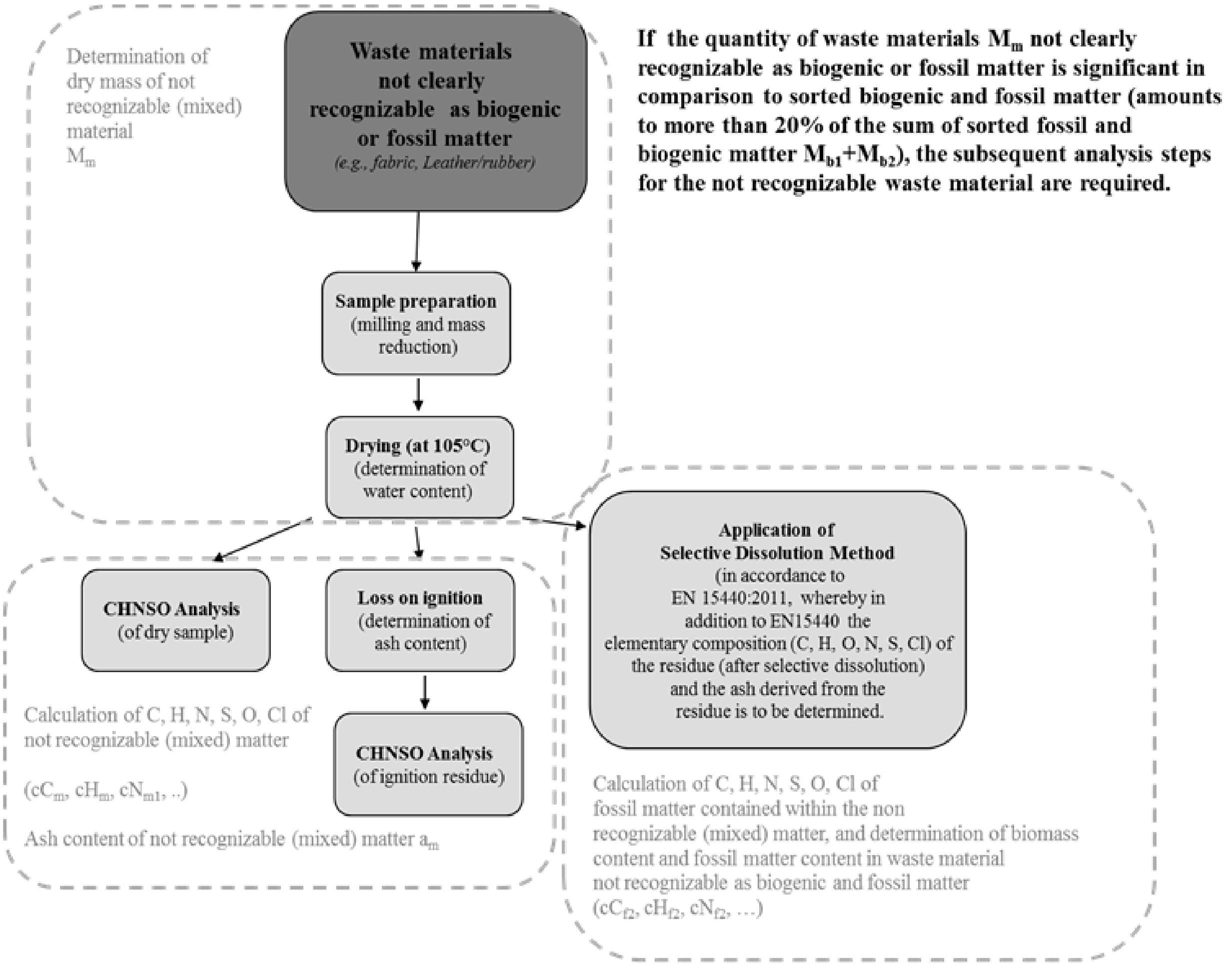
    (c) In case that the mass of the mixed sample is less than 20 per cent of the sum of sorted biogenic and fossil samples, only steps 3(e), 3(f), and 3(g) need to be continued. The figure underneath presents the steps when the mass of the mixed sample is less than 20 per cent;

**Figure 3. Steps when the mass of the mixed sample is less than 20 per cent**




(d) In case that the mass of the mixed sample is more than 20 per cent of the sum of sorted biogenic and fossil samples, steps 3(e), 3(f), 3(g), 3(h), 3(i), 3(j), 3(k), 3(l) and 3(m) need to be continued. The figure underneath presents the steps for the mixed sample (waste material not clearly recognizable) when the mass of the mixed sample is more than 20 per cent;

**Figure 4. Steps for the mixed sample**




(e) Part of the sample material is used to determine the ash content and loss on ignition (at 550 °C);

(f) The elementary composition (C, H, N, S, O and Cl) of the dry biogenic and fossil waste samples and the composition (C, H, N, S, O and Cl) of their ignition residue shall be determined, respectively;

(g) The elementary composition (C, H, N, S, O and Cl) of moisture and ash free biogenic and fossil organic matter shall be calculated using information determined in step 3(e) and 3(f). (see Table 2 – step A below). These data, which correspond to the parameter of Table 1, can only be considered as representative on condition that step 3(c) is fulfilled;

(h) Determination of the elementary composition (C, H, N, S, O and Cl) of the dry mixed (not recognizable) waste samples and the composition (C, H, N, S, O and Cl) of their ignition residue, respectively;

(i) Application of the selective dissolution method to the dry mixed (not recognizable) waste samples in order to determine the fraction of fossil and biogenic matter in the dry mixed (not recognizable) waste samples;

(j) Determination of the elementary composition (C, H, N, S, O and Cl) of the residues of selective dissolution (generated during step 3(i)) and also of the ignition loss of the selective dissolution residue;

(k) Calculation of elementary composition of moisture and ash-free biogenic and fossil organic matter present in the dry mixed (not recognizable) waste samples (see Table 2 – step B, C & D);

(l) Combination of results of step 3(k) and step 3(g) in order to determine representative values for the content of C, H, N, S, O and Cl in moisture and ash-free biomass present in waste (Data of Table 1) (see Table 2 – step E).

15. The total amount of C, H, O, S and N for moisture and ash free biogenic matter and the total amount of C, H, O, S, N and Cl for moisture and ash free fossil matter shall be within the range of 950 to 1050 g/kg moisture and ash free biogenic/fossil matter. Otherwise, measurements are to be repeated. The respective chemical content shall be corrected by multiplying the value of each element by 1/(cCb+cHb +cNb + cSb + cOb) in case of biogenic matter and 1/(cCf+cHf +cNf + cSf + cOf+cClf) in case of fossil matter.

16. If C-content of moisture and ash free fossil matter determined by the project proponent is 10 per cent lower than the figures given in Table 1,[5] data for fossil matter composition of Table 1 shall be used.

17. If C-content of moisture and ash free biogenic matter determined by PP´s own tests is 10 per cent higher than the figures given in Table 1, data for biogenic matter composition of Table 1 shall be used.

**Table 2. Calculation steps of C, H, N, S, O of moisture-and-ash-free biogenic and fossil organic matter**

**<u>Step A:</u>** Calculation of C, H, N, S, O of moisture-and-ash-free matter for the sorted biogenic and fossil matter **$cC_{b1}$, $cH_{b1}$, $cN_{b1}$, … & $cC_{f1}$, $cH_{f1}$, $cN_{f1}$, …**

| | |
|---|---|
| $cC_{b1} = TC_{b1} - TCa_{b1} \times a_{b1}$ | $TC_{b1}$ = total carbon content of dry biogenic sample (sorted biomass),<br>$TCa_{b1}$ = total carbon content of ash derived from dry biogenic sample (sorted biomass),<br>$a_{b1}$ = ash content of dry biogenic sample (sorted biomass); |
| $cH_{b1} = TH_{b1} - THa_{b1} \times a_{b1}$ | $TC_{b1}$ = total hydrogen content of dry biogenic sample (sorted biomass),<br>$TCa_{b1}$ = total hydrogen content of ash derived from dry biogenic sample (sorted biomass),<br>$a_{b1}$ = ash content of dry biogenic sample (sorted biomass); |
| $cC_{f1} = TC_{f1} - TCa_{f1} \times a_{f1}$ | $TC_{f1}$ = total carbon content of dry fossil sample (sorted fossil material),<br>$TCa_{f1}$ = total carbon content of ash derived from dry fossil sample (sorted fossil material),<br>$a_{f1}$ = ash content of dry fossil sample (sorted fossil material); |

In case that the dry mass of non-recognizable material is less than 20% of the sorted dry biomass and fossil matter, values for the parameter **$cC_{b1}$, $cH_{b1}$, $cN_{b1}$, … & $cC_{f1}$, $cH_{f1}$, $cN_{f1}$, …** can be considered as representative for C, H, N, S, O, Cl of moisture-and-ash-free matter of biogenic and fossil matter present in the waste (data of Table 1).

[5] Table 1 provides the reference values of the chemical composition of moisture-and-ash free biogenic and fossil organic matter that are representative in European countries.

In case that the dry mass of non-recognizable material is more than 20% of the sorted dry biomass and fossil matter, further calculation steps are required to derive representative values for C, H, N, S, O, Cl of moisture-and-ash-free matter of biogenic and fossil matter present in the waste (data of Table 1).

**Step B:** Calculation of C, H, N, S, O of moisture-and-ash-free matter present in mixed (non-recognizable) waste material samples **$cC_m$, $cH_m$, $cN_m$, … & $cC_m$, $cH_m$, $cN_m$, …**

$cC_m = TC_m - TCa_m \times a_m$

*$TC_m$ = total carbon content of mixed (non-recognizable) sample,*
*$TCa_m$ = total carbon content of ash derived from mixed (non-recognizable) sample,*
*$a_m$ = ash content of mixed (non-recognizable) sample;*

**Step C:** Determination of C, H, N, S, O of moisture-and-ash-free fossil matter present in mixed (non-recognizable) waste material samples **$cC_{f2}$, $cH_{f2}$, $cN_{f2}$, …**

$cC_{f2} = TC_{f2} - TCa_{f2} \times a_{f2}$

*$TC_m$ = total carbon content of residue from selective dissolution of mixed (non-recognizable) waste material samples,*
*$TCa_m$ = total carbon content of residue from selective dissolution of mixed (non-recognizable) waste material samples,*
*$a_m$ = ash content of residue from selective dissolution of mixed (non-recognizable) waste material samples*

**Step D:** Calculation of C, H, N, S, O of moisture-and-ash-free biogenic matter present in mixed (non-recognizable) waste material samples **$cC_{b2}$, $cH_{b2}$, $cN_{b2}$,** …

$cC_{b2} = (cC_m - cC_{f2} \times m_{f2}) / (1 - m_{f2})$
$cH_{b2} = (cH_m - cH_{f2} \times m_{f2}) / (1 - m_{f2})$

*$m_{f2}$ = mass fraction of fossil matter (referred to moisture-and-ash-free matter) in the mixed (non-recognizable) waste material samples (determined applying the selective dissolution method)*

**Step E:** Calculation of representative values for C, H, N, S, O of moisture-and-ash-free biogenic matter present in the waste (combining data for sorted biogenic and fossil matter **$cC_{b1}$, $cH_{b1}$, $cN_{b1}$, … & $cC_{f1}$, $cH_{f1}$, $cN_{f1}$, …** – data of step A AND data for biogenic and fossil matter contained in mixed (non-recognizable) waste material samples **$cC_{b2}$, $cH_{b2}$, $cN_{b2}$,** …**$cC_{f2}$, $cH_{f2}$, $cN_{f2}$,** … – data of step C and D)

$cC_b = cC_{b1} \times M_{b1} \times (1-a_{b1}) + cC_{b2} \times M_m \times (1-m_{f2}) \times (1-a_m) / (M_{b1} \times (1-a_{b1}) + M_m \times (1-m_{f2}) \times (1-a_m))$
$cH_b = cH_{b1} \times M_{b1} \times (1-a_{b1}) + cH_{b2} \times M_m \times (1-m_{f2}) \times (1-a_m) / (M_{b1} * (1-a_{b1}) + M_m \times (1-m_{f2}) \times (1-a_m))$
…
$cC_f = cC_{f1} \times M_{f1} * (1-a_{f1}) + cC_{f2} \times M_m \times m_{f2} \times (1-a_m) / (M_{f1} \times (1-a_{f1}) + M_m \times m_{f2} \times (1-a_m))$
$cH_f = cH_{f1} \times M_{f1} \times (1-a_{f1}) + cH_{f2} \times M_m * m_{f2} \times (1-a_m) / (M_{f1} \times (1-a_{f1}) + M_m \times m_{f2} \times (1-a_m))$
..

*$M_{b1}$ = dry mass of biogenic sample (sorted biomass),*
*$M_{f1}$ = dry mass of fossil sample (sorted fossil material)*
*$M_m$ = dry mass of not recognizable (mixed) material*
*$cC_b$ = carbon content of moisture-and-ash-free biogenic matter present in the waste*
*$cH_b$ = hydrogen content of moisture-and-ash-free biogenic matter present in the waste*
*….*
*$cC_f$ = carbon content of moisture-and-ash-free fossil matter present in the waste*
*$cH_f$ = hydrogen content of moisture-and-ash-free fossil matter present in the waste*
*….*

**$cC_b$, $cH_b$, $cN_b$, $cC_f$, $cH_f$, $cN_f$ represent the representative values for Table 1**.

## 4. Data and parameters monitored for the balance method in conventional combustion and oxygen-enriched combustion

**Data / Parameter table 1.**

| **Data / Parameter:** | $M_{waste}$ |
|---|---|
| Data unit: | tons/h |
| Description: | Mass of waste feed into the WtE plant within a defined period hour *h* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured with calibrated scales or load cells |
| Monitoring frequency: | Hourly |
| QA/QC procedures: | The instrument shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Any comment: | - |

**Data / Parameter table 2.**

| **Data / Parameter:** | $FC_{i,h}$ |
|---|---|
| Data unit: | tons/h |
| Description: | The quantity of auxiliary fuel *i* (e.g. fuel oil or natural gas, if exists) combusted during hour *h* |
| Source of data: | Onsite measurement by project participants |
| Measurement procedures (if any): | (a) Use either mass or volume meters. In cases where fuel is supplied from small daily tanks, rulers can be used to determine mass or volume of the fuel consumed, with the following conditions: The ruler gauge must be part of the daily tank and calibrated at least once a year and have a book of control for recording the measurements (on a daily basis or per shift);<br>(b) Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance;<br>(c) In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Monitoring frequency: | Continuously |
| QA/QC procedures: | - |
| Any comment: | The parameter isn't used for the calculation of the project emission. It is used to calculate the mass flow of carbon in the combustion process during hour *h* |

**Data / Parameter table 3.**

| **Data / Parameter:** | $\sum M_{solid\ residues}$ |
|---|---|
| Data unit: | tons/h |
| Description: | Solid residues (dry substance) of the WtE plant within a defined period |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured with calibrated scales or load cells |
| Monitoring frequency: | Daily |
| QA/QC procedures: | The instrument shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Any comment: | Data about the generation of solid residues (slag and ashes) at waste incineration plants may be not available at an hourly or daily basis. Weekly or even monthly data could be used to determine the average ratio between the generation of solid residues (slag & ashes) and the mass of waste incinerated. These ratios could be subsequently used to assess the hourly generation of slag ($\sum M_{slag}$) and ash ($\sum M_{ash}$) by simply multiplying the ratio with the quantity of waste incinerated during hour *h* |

**Data / Parameter table 4.**

| **Data / Parameter:** | $V_{flue\ gas}$ |
|---|---|
| Data unit: | $Nm^3/h$ on a dry basis |
| Description: | Flue gas volume of the WtE plant within a defined period hour *h* |
| Source of data: | Project participants |
| 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. Direct measurement of the air inlet flow rate shall be made using a flow meter |
| Monitoring frequency: | At minimum averaged hourly |
| QA/QC procedures: | The meters shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Any comment: | - |

**Data / Parameter table 5.**

| **Data / Parameter:** | $C_{O2,fg}$ |
|---|---|
| Data unit: | Vol-% dry basis |
| Description: | Average $O_2$ concentration in the flue gas of the WtE plant during hour *h* |

| | |
|---|---|
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by the gas analyzer |
| Monitoring frequency: | At minimum averaged hourly |
| QA/QC procedures: | The analyzers shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days.<br>It shall be measured in the dry flue gas. It is also required to calibrate the measurement device throughout the experiment with high quality calibration gas of similar composition as expected in the flue gas (e.g. calibration gas with $O_2$ concentration of 7-8 Vol % and $CO_2$ concentration of 11-12 Vol-%. A gas analyzer with a reproducibility of 0.5% or lower is required |
| Any comment: | - |

**Data / Parameter table 6.**

| **Data / Parameter:** | $C_{CO2,fg}$ |
|---|---|
| Data unit: | Vol-% dry basis |
| Description: | Average $CO_2$ concentration in the flue gas of the WtE plant during hour *h* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by the gas analyzer |
| Monitoring frequency: | At minimum averaged hourly |
| QA/QC procedures: | The analyzers shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days.<br>It shall be measured in the dry flue gas. It is also required to calibrate the measurement device throughout the experiment with high quality calibration gas of similar composition as expected in the flue gas (e.g. calibration gas with $O_2$ concentration of 7-8 Vol % and $CO_2$ concentration of 11-12 Vol-%. A gas analyzer with a reproducibility of 0.5% or lower is required |
| Any comment: | - |

**Data / Parameter table 7.**

| **Data / Parameter:** | $C_{O2,'oxygen'\ gas}$ |
|---|---|
| Data unit: | Vol-% dry basis |
| Description: | Average $O_2$ concentration of the 'oxygen' enriched gas of the WtE plant during hour *h* |

| | |
|---|---|
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by the gas analyzer |
| Monitoring frequency: | At minimum averaged hourly |
| QA/QC procedures: | The analyzers shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days.<br>It shall be measured in the dry flue gas. It is also required to calibrate the measurement device throughout the experiment with high quality calibration gas of similar composition as expected in the flue gas (e.g. calibration gas with $O_2$ concentration of 7-8 Vol % and $CO_2$ concentration of 11-12 Vol-%. A gas analyzer with a reproducibility of 0.5% or lower is required |
| Any comment: | Only required if oxygen enriched combustion air is utilised |

**Data / Parameter table 8.**

| **Data / Parameter:** | $V_{'oxygen'gas}$ |
|---|---|
| Data unit: | $Nm^3/h$ on a dry basis |
| Description: | The volume of 'oxygen' enriched gas during hour *h* |
| Source of data: | Project participants |
| Measurement procedures (if any): | Measured by the gas analyzer |
| Monitoring frequency: | At minimum averaged hourly |
| QA/QC procedures: | The analyzers shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days.<br>It shall be measured in the dry flue gas. It is also required to calibrate the measurement device throughout the experiment with high quality calibration gas of similar composition as expected in the flue gas (e.g. calibration gas with $O_2$ concentration of 7-8 Vol % and $CO_2$ concentration of 11-12 Vol-%. A gas analyzer with a reproducibility of 0.5% or lower is required |
| Any comment: | Only required if oxygen enriched combustion air is utilised |

**Data / Parameter table 9.**

| **Data / Parameter:** | ***S*** |
|---|---|
| Data unit: | kg/h |
| Description: | Steam production of the WtE plant within a defined period hour *h* |
| Source of data: | The data shall be monitored and gained by the project participants |

| | |
|---|---|
| Measurement procedures (if any): | Measured by the steam meter |
| Monitoring frequency: | Hourly |
| QA/QC procedures: | The instrument shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Any comment: | - |

**Data / Parameter table 10.**

| **Data / Parameter:** | $\Delta h$ |
|---|---|
| Data unit: | MJ/kg |
| Description: | Net enthalpy of steam cycle of the WtE plant |
| Source of data: | Project participants |
| Measurement procedures (if any): | It is calculated with three parameters: $T_{steam}$, $T_{feed\ water}$ and $P_{steam}$. They will be measured by temperature meter and pressure meter |
| Monitoring frequency: | Averaged hourly |
| QA/QC procedures: | The instruments shall be subject to a regular maintenance and testing regime to ensure accuracy. Calibration shall be according to manufacturer's specifications.<br>The data shall be collected accumulatively at least half working day. In order to obtain reliable and realistic monitoring data, it is recommended to take the data for three days |
| Any comment: | - |

**Data / Parameter table 11.**

| **Data / Parameter:** | $\eta$ |
|---|---|
| Data unit: | - |
| Description: | Energy efficiency of the steam boiler of the WtE plant(s) |
| Source of data: | Project participants |
| Measurement procedures (if any): | The source of data shall be the following, in order of preference:<br>1. Project specific data;<br>2. Country specific data; or<br>3. IPCC default values |
| Monitoring frequency: | Annually |
| QA/QC procedures: | - |
| Any comment: | - |

- - - - -

## Document information

| *Version* | *Date* | *Description* |
|---|---|---|
| 03.0 | 9 September 2021 | EB 111, Annex 7<br>Revision to address inconsistencies and ambiguities identified in the methodology. |
| 02.0 | 28 November 2014 | EB 81, Annex 13<br>Revision to:<br>• Introduce standardized approaches for the demonstration of additionality;<br>• Introduce the balance method for determining fossil fraction of wastes;<br>• Improve the provision for the use of this methodology in a project activity under a PoA. |
| 01.0.0 | 13 September 2012 | EB 69, Annex 11<br>Initial adoption. |

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