ARTICLE 6.4 MECHANISM

A6.4-MEP008-A04

Draft Methodology

Flaring or use of landfill gas

Version 01.0

Sectoral scope(s): 01 and 13

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The Supervisory Body of the Article 6.4 mechanism (SBM), at its fifteenth meeting, approved its workplan for 2025 for the Methodological Expert Panel (MEP) and requested the MEP to initiate work on the revision of CDM methodologies / methodological tools / Standard / Guidelines, including the methodology "ACM0001: Flaring or use of landfill gas" (hereinafter referred to as the approved CDM methodology).

2. Purpose

2. The purpose of this new methodology is to provide the procedures, requirements and guidelines for the development and monitoring of Article 6.4 activities[1] that involve the capture and/or use of the landfill gas (LFG) generated in solid-waste disposal sites (SWDSs) and accounting of associated Article 6.4 emission reductions (A6.4 ERs).

3. This proposed new methodology was developed based on elements from the approved CDM methodology "ACM0001: Use of landfill gas" version 19.0, and applying proper revisions to include the requirements from the Article 6.4 mechanism approved standards.

3. Key issues and proposed solutions

4. The sub-sections below provide the key elements of the proposed new methodology followed by a comparison with the approved CDM methodology.

3.1. Applicability conditions

5. The proposed new methodology will be applicable to Article 6.4 activities that collect and destroy LFG in flares or use the LFG generated in an existing or new SWDS to generate electricity, heat or to supply consumers with LFG or biomethane through trucks,[2] dedicated pipeline or natural gas distribution network.

6. The proposed new methodology also contains applicability conditions to ensure that Article 6.4 activities:

    (a) Do not divert the organic fraction of the solid waste disposed in the SWDS that would have been recycled;

    (b) Do not change the SWDS management practices to deliberately increase the generation of LFG; and

[1] This version of the methodology is only applicable for Article 6.4 projects and may be amended in the future to cover activities at other scales (e.g., programmes of activities, policies, sectoral approaches, etc) once the adopted standards for the development of mechanism methodologies (e.g. additionality standard, baseline setting standard, etc) are revised.

[2] Under this methodology "trucks" mean container trucks that transport LFG or biomethane pressurized or liquefied.

(c) Avoids any leakage from the use of the baseline heat generation equipment outside of the activity boundary by requiring activity participants to demonstrate that the baseline heat generation equipment is scrapped, or the existing heat generation equipment is used outside of the activity boundary and has a higher efficiency than any equipment it may replace.

Table 1. Comparison of applicability conditions between the approved CDM methodology and the proposed new methodology

Key applicability conditions under the approved CDM methodology	Key applicability conditions under the proposed new methodology
Applicable to activities that collect and destroy in flares or use the LFG generated in an existing or new SWDS to generate electricity, heat or to supply consumers with compressed/liquefied LFG through trucks, dedicated pipeline or natural gas distribution network	Same conditions, except for the introduction of the supply of biomethane to consumers.
Procedure to identify the baseline scenario confirms pre-determined scenarios for LFG, heat generation, electricity generation and consumption of natural gas by consumers	Baseline scenario is pre-determined as existing actual or historical emissions for LFG component in existing SWDS, electricity displaces from the grid or existing captive power plants or heat displaced from existing heat generation equipment. Baseline scenario based on BAT is used for LFG component for SWDS, electricity displacing generation from new power plants, and heat displacing heat from new heat generating equipment determined by applying. A stepwise process included in the methodology.
Activity participants shall ensure that the amount of organic waste that would be recycled in the absence of the project is not reduced and the management of the SWDS is not deliberately changed to increase the methane generation.	Same conditions. An exception was added if the change in the management of the SWDS is due to a requirement by a law or regulation.
N/A	Activity participants shall demonstrate that no leakage exists if the baseline heat generation equipment is replaced.

3.2. Activity boundary

7. The proposed new methodology sets the activity boundary as the SWDS and, as applicable, all power plants physically connected to the same grid as the Article 6.4 activity, the heat generation equipment and the consumers of the LFG or biomethane.

8. The main greenhouse gases (GHG) emission sources were identified in a table which indicates which GHGs are included and whether they are controlled / related to / affected by the Article 6.4 activity, as required by the baseline standard. The sources were identified for baseline emissions, activity emissions and leakage.

Table 2. Comparison of the activity boundary between the approved CDM methodology and the proposed new methodology

Activity boundary under the approved CDM methodology	Activity boundary under the proposed new methodology
Sites where the LFG is flared or used and, as applicable, the captive power plants or power plants connected to the same electricity grid as the project, heat generation equipment and consumers of compressed/liquefied LFG.	Same boundary.
Baseline emissions: CH_4 from the decomposition of the waste in the SWDS, CO_2 from electricity generation, CO_2 from heat generation, CO_2 from the use of natural gas by consumers Project emissions: CO_2 emissions from fossil fuel consumed (if any), CO_2 emissions from electricity consumption (from grid or captive), CH_4 emissions from flaring, CO_2 emissions from the transportation of compressed/liquefied LFG using trucks	Same sources. The table also indicates if the gases are controlled, related to or affected by the Article 6.4 activity. Activity emissions from fossil fuel consumption accounts for N_2O and CH_4 emissions The proposed new methodology accounts for the leakage from upstream CO_2, CH_4 and N_2O emissions.

3.3. Demonstration of additionality

9. The proposed new methodology requires demonstration of additionality based on the following steps:

(a) Regulatory analysis: activity participants shall review the current environmental legislation and the legislation applicable to solid waste management and confirm that the legal requirements do not enforce the implementation of the Article 6.4 activity. The regulatory analysis shall be updated annually;

(b) Lock-in analysis: Article 6.4 activities implemented at closed SWDS and Article 6.4 activities implemented at new SWDSs and otherwise eligible under this methodology are not deemed to have a lock-in risk. For Article 6.4 activities that involve only flaring of the LFG in existing SWDSs, the proposed new methodology also reduces the risk of lock-in by encouraging the use of the LFG for energy purposes through the application of specific downward adjustment provisions;

Note from the panel: MEP would like to seek feedback on approaches to assess lock-in risk for the cases not covered by paragraph 24 of the methodology.

(c) Investment analysis: activity participants must conduct the investment analysis through two options, i.e. by applying the “Methodological tool: Investment analysis” (hereinafter referred to as the investment analysis tool) that is still under development (Option 1) or by following a specific procedure included in the methodology (Option 2). Under Option 1, the methodology provides guidance at the methodology level for which financial indicator to use, provides for only using the investment comparison or benchmark analyses and provides guidance on the limits for the sensitivity analysis. Under Option 2, the methodology specifies the requirements and stepwise approaches for conducting the simple cost analysis, the benchmark analysis or the investment comparison analysis. Moreover, guidance on the limits to be used for sensitivity analysis are provided;

(d) Common practice analysis: activity participants shall conduct the common practice analysis by applying the draft “Methodological tool: Common practice analysis” (hereinafter referred toas the common practice tool). The proposed new methodology specifies the approach for common practice analysis, the indicator for common practice, the sample space, the applicable geographical area, the relevance of scale, the identification of comparable activities and similar activities, the applicable capacity/output and the common practice threshold. The proposed thresholds to be applied are 16% for Article 6.4 activities implemented in non-LDCs/SIDs (based on the threshold of moving from early adopters to early majority as identified in the Roger diffusion curve)[3] and 20% for Article 6.4 activities implemented in LDCs/SIDs (the proposed upper limit for LDCs and SIDS in the common practice tool to account for their special circumstances).

Table 3. Comparison of the demonstration of additionality between the approved CDM methodology and the proposed new Article 6.4 methodology

Demonstration of additionality under the approved CDM methodology	Demonstration of additionality under the proposed new methodology
Simplified approach to identify the baseline scenario and demonstrate additionality based on positive list of technologies.	Simplified approach not included
Application of the steps of the combined tool to identify the baseline scenario and demonstrate additionality: - identification of alternative scenarios; - barrier analysis to remaining alternative scenarios; - investment analysis for the remaining alternative scenarios; - common practice analysis (if project is not first-of-its-kind).	The methodology requires activity participants to: - demonstrate, based on specific guidance provided by the methodology, that the Article 6.4 activity is aligned with environmental and waste management legal requirements in the host country; - Analysis of lock-in risk; - Undertake an investment analysis following either guidance from the investment analysis tool (Option 1), or following a specific procedure contained in the methodology (Option 2); - Demonstrate based on the common practice tool that the Article 6.4 activity is not common practice.

3.4. Baseline scenario

10. The following are the baseline approach and the baseline scenario for the different types of Article 6.4 activities eligible under this proposed new methodology:

[3] Rogers, E. M. *Diffusion of Innovations*. 5th ed. New York: Free Press, 2003.

Table 4. Baseline approaches and baseline scenarios for each type of Article 6.4 activity eligible under this proposed new methodology

Component	Baseline approach	Justification for the baseline approach	Baseline scenario
LFG – Article 6.4 activities implemented in an existing SWDS	Existing actual or historical emissions	Data from the waste management sector is strongly heterogeneous and emissions are highly activity- or site-specific (e.g. SWDSs located in humid regions tend to have higher methane generation rates when compared with SWDSs located in dry regions)	The continuation of the pre-activity scenario, i.e. the methane generated is emitted to the atmosphere or is partially capture and/or partially destroyed, up to the capacity of the landfill. For waste generated beyond the capacity of the SWDS, the baseline
LFG – Article 6.4 activities implemented in new SWDS	Best available technologies that represent an economically feasible and environmentally sound course of action	The activity (treatment of solid waste in a SWDS) and alternative technologies for waste treatment (such as waste incineration, composting, pyrolysis, gasification, etc) provide reasonably homogeneous outputs (i.e. waste treated) for the same pool of users (i.e. population served by the SWDS)	Determined based on a procedure set by the methodology
Electricity generation and supply to the electric grid	Existing actual or historical emissions	Sector data shows strongly heterogeneous circumstances	The continuation of the pre-activity scenario, i.e. the electricity would have been generated in by existing power plants connected to the same electric grid
Electricity generation replacing electricity generated in an existing captive fossil fuel fired power plant	Existing actual or historical emissions	Emissions per ton of electricity generated are highly activity- or site-specific, meaning the type and characteristics of the electricity produced depends on the type of fuel used by the fossil fuel fired captive power plant.	The continuation of the pre-activity scenario, i.e. the electricity would have been generated in the existing captive fossil fuel fired power plant using the same baseline fossil fuel up to the end of the remaining lifetime of the captive fossil fuel fired power plant – after the end of the lifetime of the captive fossil fuel fired power plant, the baseline shall be determined based on BAT.

Component	Baseline approach	Justification for the baseline approach	Baseline scenario
Electricity generation replacing electricity generated in a new captive fossil fuel fired power plant	Best available technologies that represent an economically feasible and environmentally sound course of action	The activity and alternative technologies provide reasonably homogeneous outputs (i.e., electricity) for the pool of users (captive consumers).	Determined based on a procedure set by the methodology.
Heat generation replacing heat generated in existing equipment	Existing actual or historical emissions	Emissions per ton of heat generated are highly activity- or site-specific, meaning the type and characteristics of the heat produced depends on its usage (e.g. hot air, high-pressure steam, low-pressure steam, hot water, etc) and the fuel type used (e.g. coal, diesel, NG, etc.).	The continuation of the pre-activity scenario, i.e. the heat would be generated in the same heat generation equipment using the same fuels up to the end of the remaining lifetime of the heat generation equipment. After the end of the lifetime of the heat generation equipment, the baseline shall be determined based on BAT.
Heat generation replacing heat generated in new equipment	Best available technologies that represent an economically feasible and environmentally sound course of action	The emissions per unit of output are determined primarily by the technology(ies) and/or practice(s) used in the Article 6.4 activity (e.g. boiler, glass melting furnace, water heater, air heater, brick kiln, etc) and the same output is provided for the same pool of users by the activity and by other technologies and/or practices (i.e. a boiler is used to produce steam or hot water; a brick kiln is used to produce bricks; a glass melting furnace is used to produce melted glass, etc)	Determined based on a procedure set by the methodology.
Supply of biomethane or compressed/liquefied LFG to consumers	Existing actual or historical emissions		The continuation of the pre-activity scenario, i.e. consumers would be supplied with natural gas

11. For the types of Article 6.4 activities that determine the baseline based on best available technologies that represent an economically feasible and environmentally sound course of action approach (BAT), the proposed new methodology provides a stepwise procedure to determine the emission intensity of the BAT including (i) identification of the geographical area, (ii) identification of technologies and/or practices available in the geographical area, (iii) identification of the environmentally sound technologies available in the geographical area and (iv) Identification of economically viable technologies in the geographical area, and:

    (a) Specifies that the host Country as the baseline geographical reference area by default, and allows activity participants to identify a narrower area provided it is properly justified;

    (b) Provides a non-exhaustive list of the technologies and/or practices for solid waste treatment, electricity generation and heat generation to be considered in the determination of BAT;

    (c) Specifies that technologies and/or practices are deemed economically viable if they have been implemented by at least one facility within the geographical reference area. In case the technologies are accessible off the shelf or via tendering, a benchmark investment analysis should be conducted to assess economic viability.

12. For activities developed in new SWDSs, the proposed new methodology is only applicable if the technology that constitutes the BAT is a managed SWDS implemented with an LFG collection system and with or without an LFG destruction system.

3.5. Calculation of baseline emissions prior to downward adjustment

13. Baseline emissions are calculated separately for each component, i.e. methane emissions from the SWDS, electricity generation, heat generation and LFG or biomethane supply to consumers.

14. For the methane destruction component, baseline emissions are determined based on:

    (a) The amount of methane sent to flares, to the power plant, to the heat generation equipment and supplied to consumers;

    (b) The amount of methane that would have been destroyed in the baseline;

    (c) The fraction of methane in the LFG that would be oxidized due to cover material in the baseline;

    (d) The efficiency of the flare and the efficiency of the heat generation equipment;

    (e) The operating hours of any the flare, power plant and heat generation equipment.

15. For the electricity generation component, baseline emissions are determined based on:

    (a) The quantity of electricity generated and supplied to the electric grid or to the captive consumers;

    (b) Conservative emission factors of the electricity grid or of the captive power plant (determined based on the existing captive fossil fuel fired power plant or based on

BAT). These emission factors are proposed as interim solutions since the work on the revision of the CDM methodologies “ACM0002: Grid-connected electricity generation from renewable sources”, “AMS-I.D.: Grid-connected renewable electricity generation” and “Tool: Emission factor for an electricity system” could not be finalized. This proposed new methodology will be revised accordingly to include the calculation of baseline emissions and activity emissions from electricity generated and electricity consumed once the work on the revision of ACM0002, AMS-I.D. and the “Tool: Emission factor for an electricity system” is concluded and respective standard(s) are adopted by the Supervisory Body.

16. For the heat generation component, baseline emissions are determined based on:

(a) For the generation of heat that replaces heat generated in an existing equipment:

(i) The quantity of methane sent to the existing heat generation equipment;

(ii) The efficiency of the existing heat generation equipment. A default conservative efficiency was proposed as interim solutions since the work on the revision of the “Tool: Determine the baseline efficiency of thermal or electric energy generation systems” could not be finalized. The methodology will be revised accordingly to reflect the requirements and options to determine the efficiency of heat generation equipment once the revision of the tool is concluded and the tool is adopted by the Supervisory Body;

(iii) The CO_2 emission factor of the fuel used in the baseline;

(b) For the generation of heat that replaces heat generated in a new equipment:

(i) The quantity of heat generated by the new heat generation equipment;

(ii) The emissions intensity of the BAT.

17. For the supply of LFG or biomethane to consumers, baseline emissions are determined based on:

(a) The quantity of methane supplied to the consumers;

(b) The CO_2 emission factor of the natural gas.

18. The proposed new methodology provides the equations and options for the calculation.

3.6. Application of the downward adjustment

3.6.1. Calendar year of the start of the first crediting period

19. For baseline components determined based on existing actual or historical emissions, the downward adjustment is determined based on the requirements from the baseline standard and applied in the calendar year of the start date of the first crediting period, i.e. determine the highest between (i) the adjusted baseline emissions based on uncertainty in the in the calendar year of the start date of the first crediting, or (ii) 10% of the emission reductions in the calendar year of the start of the first crediting period.

20. For baseline components based on BAT, no adjustment in the calendar year of the start of the start date of the first crediting period is applied.

3.6.2. Subsequent years

21. For the subsequent years, the downward adjustments applied for the different types of Article 6.4 activities eligible under this proposed new methodology are:

    (a) Methane Destruction Component:

        (i) Destruction of LFG in flares: maximum between the 1% increase in the downward adjustment to the baseline emissions in the calendar year of the start date of the first crediting period and baseline emissions from flaring of LFG discounted by the “adjustment factor”. This factor encourages ambition by requiring activity participants to multiply the quantity of methane flared by an “adjustment factor” that decreases linearly over the first crediting period (or over the first 5 years for Article 6.4 activities with fixed crediting periods) until it reaches a value of 0 at the first year of the second crediting period (or at the 6th year for Article 6.4 activities with fixed crediting periods). For the 2nd and 3rd crediting periods (or from the 6th year onwards for Article 6.4 activities with fixed crediting periods), an adjustment factor of 0% shall be applied. This approach is proposed to also encourage the development of activities that make energy use of the collected LFG;

        (ii) Other uses of LFG, electricity generation, heat generation and supply of LFG or biomethane to consumers: annual increase that represents 1% of the baseline emissions in the calendar year of the start date of the first crediting period.

    (b) Displacement of Energy Components (electricity, heat and supply of LFG or biomethane to consumers): annual increase that represents 1% of the baseline emissions in the calendar year of the start date of the first crediting period.

3.7. Identification of conservative BAU baseline and calculation of BAU emissions

22. The proposed new methodology provides the equations and options for the calculation of the BAU emissions.

23. The conservative BAU emissions are determined based on the requirements from the baseline standard (i.e. determine the uncertainty from measurements at the lower bound during the first crediting period, calculate the conservative BAU emissions based on uncertainty, determine the minimum conservative value for BAU emissions, use the lower between the two values).

3.8. Comparison of the downward adjusted baseline and the conservative business-as-usual baseline

24. The crediting baseline shall be the lower of the downward adjusted baseline emissions or the conservative BAU emissions.

3.9. Activity emissions

25. Activity emissions are calculated based on the amount of electricity and/or fossil fuel consumed to operate the project, the amount of fuel consumed to transport the LFG or biomethane to consumers via trucks and the physical leakage to transport the LFG or biomethane to consumers via dedicated pipeline.

26. The proposed new Article 6.4 methodology provides the equations and options for the calculation and requires activities emissions to be adjusted due to uncertainties.

3.10. Leakage

27. Leakage under the proposed new Article 6.4 methodology may happen (i) if the heat generation equipment used in the baseline replaces a new heat generation equipment that is used outside of the activity boundary and (ii) due to upstream emissions from the manufacturing of the equipment used in the activity scenario (e.g. HDPE pipeline, flares, engines, trucks and storage vessels).

28. Leakage from the use of the baseline equipment outside of the activity boundary is avoided as per one of the applicability conditions of the methodology, whereas leakage from the upstream emissions is addressed by discounting 0.5% of the baseline emissions, conservatively represented by the upstream emissions to manufacture the HDPE pipeline used for the collection of the LFG in the SWDS (the rationale for reaching this discount is provided in Appendix 2).

3.11. Data and parameters

29. The data and parameters not monitored, the data and parameters monitored are provided in sections 13 and 14 of the methodology.

30. For Article 6.4 activities that chose to determine the parameter OX_y based on the monitoring of the parameter J_{out} either ex-post or once prior to the start of the crediting period, Appendix 1 contains the procedure for the monitoring using the flux-box method.

3.12. Avoidance of double-counting

31. As required by the “Standard: Setting baseline in mechanism methodologies” (hereinafter referred to as the baseline standard), the proposed new methodology contains requirements to avoid double-counting by:

    (a) Requiring consumers of outputs (electricity, heat, LFG or biomethane) to sign contracts that explicitly states that A6.4 ERs will only be claimed by the activity participants;

    (b) Requiring activity participants to declare, in each monitoring report, that the outcomes from the Article 6.4 activity (e.g. flaring, electricity generation) were not claimed by any other environmental market or accounting framework;

    (c) Requiring activity participants to demonstrate and justify, in each monitoring report, that the Article 6.4 activity does not overlap with mandatory domestic mitigation schemes.

32. Such requirement to avoid double-counting did not exist in the approved CDM methodology.

3.13. Alignment with NDCs, LT-LEDS, long-term temperature goal of the Paris Agreement and long-term goals of the Paris Agreement

33. Activity participants shall provide to the DOE a confirmation from the DNA of the host Party that the DNA has undertaken an assessment of the activity's consistency with Decision 3/CMA.3 paragraph 40 (c) and paragraph 27 (a), as part of the host Party's approval.

4. Impacts

34. The approval of this proposed new methodology will allow the development of new Article 6.4 activities that aim to capture and destroy methane or use it for energy purposes.

5. Subsequent work and timelines

35. The MEP agreed to seek public inputs from stakeholders on this draft version of the proposed new methodology. The MEP will incorporate the stakeholders' inputs received and recommend a revised draft proposed new methodology for recommendation of approval by the Supervisory Body.

6. Recommendations to the Board

36. Not applicable (Document is published for a call for public inputs).

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1. Introduction

1.1. Scope

1. This methodology applies to Article 6.4 activities[1] that capture landfill gas (LFG) from a solid waste disposal site (SWDS) and (a) flare it, and/or (b) use it to produce energy (i.e. power or heat), and/or (c) use it to supply consumers through a natural gas distribution network, dedicated pipeline or trucks.[2] GHGs are reduced as a result of methane destruction and, where applicable, displacement of a more GHG intensive energy source.

1.2. Entry into force and validity

2. This document enters into force on DD/MM/YYYY and is valid for 5 years, i.e. until DD//MM/YYYY, unless an earlier date applies if the methodology is revised or withdrawn in accordance with the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).

1.3. Applicability of sectoral scopes

3. Designated operational entities validating and verifying Article 6.4 activities that use this methodology shall apply sectoral scopes 1 and 13.

2. Definitions

4. The following definitions shall apply:

   (a) **Aged SWDS cell:** A SWDS cell containing waste which has been in the SWDS for more than 20 years;

   (b) **Biogas processing facility:** A facility which processes and upgrades the LFG collected from a SWDS, through a process that removes the CO_2 and other contaminants present in the LFG, and compresses/liquefies it with the purpose of supplying it to end-users;

   (c) **Biomethane:** A near-pure source of methane produced by processing and upgrading the LFG in a biogas processing facility;

   (d) **Continuous brick kiln:** A brick kiln where bricks are loaded continuously into the kiln, rather than in batches. Continuous brick kilns are distinguished as moving ware kilns and moving fire annular kilns. Moving ware kilns include tunnel and vertical shaft kilns. Moving fire annular kilns use Hoffmann, Bull's trench and Zig-zag technologies;

[1] This version of the methodology is only applicable for Article 6.4 projects and may be amended in the future to cover activities at other scales (e.g., programmes of activities, policies, sectoral approaches, etc) once the adopted standards for the development of mechanism methodologies (e.g. additionality standard, baseline setting standard, etc) are revised.

[2] Under this methodology "trucks" mean container trucks that transport LFG or biomethane pressurized or liquefied.

(e) **Existing LFG capture system**: A LFG capture system, as defined above that has been in operation at any time in the last year prior to the start of operation of the Article 6.4 activity;

(f) **Features**: Areas in the solid waste disposal site from which emissions are higher (hotspots) and need to be delineated from the zone within which they exist;

(g) **Intermittent brick kiln:** A brick kiln where bricks are loaded into the kiln and fired in batches. Types include Clamp, Scotch and Scove technologies;

(h) **Immature SWDS cell**: A SWDS cell containing waste which has been in the SWDS for less than 5 years;

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

(j) **Legal requirements:** Laws, statutes, regulations, court orders, decrees, consent agreements[3], executive orders, permitting conditions or any other legally binding mandates;

(k) **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. Captured LFG can be vented, flared or used;

(l) **Mature SWDS cell:** A SWDS cell containing waste which has been in the SWDS between 5 and 20 years;

(m) **Operational time:** The total time that the equipment has been operating since its first commissioning. The operational time is expressed in years or hours of operation;

(n) **Reference conditions**: Conditions are defined as 0^{o}C (273.15 K, 32^{o}F) and 1 atm (101.325 kN/m^2, 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr);

(o) **Remaining lifetime:** The time for which the existing equipment can continue to operate before it has to be replaced/discarded for technical reasons, such as the age of the equipment, safety reasons, or deteriorated performance. The remaining lifetime is expressed in years or hours of operation;

(p) **Solid waste**: Material that is unwanted and insoluble (including gases or liquids in cans or containers). Hazardous waste is not included in the definition of solid waste;

(q) **Solid waste disposal site (SWDS)**: Designated areas intended as the final storage place for solid waste;

(r) **Technical lifetime:** The total time for which the equipment is technically designed to operate from its first commissioning. The technical lifetime is expressed in years or hours of operation.

[3] For example, agreements between parties, such as between a private sector entity and a government, to take an action in exchange for avoiding court action.

5. Further definitions from the Article 6.4 Glossary of Terms, still under development, shall apply when adopted by the Supervisory Body.

3. Normative references

6. This mechanism methodology is based on elements from version 19.0 of the Clean Development Mechanism (CDM) Methodology “ACM0001: Flaring or use of landfill gas” and the following approved Standards:

(a) “Standard: Demonstration of additionality in mechanism methodologies”, version 01 (A6.4-STAN-METH-003, hereinafter referred to as the additionality standard);

(b) “Standard: Setting the baseline in mechanism methodologies”, version 01 (A6.4-STAN-METH-004, hereinafter referred to as the baseline standard);

(c) “Standard: Addressing leakage in mechanism methodologies”, version 01 (A6.4-STAN-METH-005, hereinafter referred to as the leakage standard);

7. This methodology also refers to the following draft methodological tools:[4]

(a) “Methodological tool: Activity emissions from flaring”;

(b) “Methodological tool: Determination of the mass flow of a greenhouse gas in a gaseous stream”;

(c) “Methodological tool: Emissions from solid waste disposal sites”;

(d) “Methodological tool: Common practice analysis”;

(e) “Methodological tool: Investment analysis”.

4. Applicability

8. The methodology is applicable to Article 6.4 activities that involve:

(a) The installation of a new LFG capture system in an existing or new (Greenfield) SWDS where no LFG capture system was installed prior to the implementation of the Article 6.4 activity (except for legal or contractual requirements) or would be installed in the absence of the Article 6.4 activity; or

(b) Investing into an existing (active or passive) LFG capture system to increase the recovery rate where the captured LFG prior to the implementation of the Article 6.4 activity was flared and not used, and:

(i) The amount of LFG captured by the existing system is collected and measured separately from the system implemented as part of the Article 6.4 activity; or

(ii) The efficiency of the existing system is not impacted by the system implemented as part of the Article 6.4 activity, and historical data on the

[4] These draft methodological tools are still under development and are yet to be adopted by the Supervisory Body. The draft new methodology will be revised accordingly if changes to the versions of these draft methodological tools are made by the time of their adoption.

amount of LFG captured and flared is available (if such historical data is not available, no A6.4 ERs can be claimed);

9. For both cases (a) and (b) above, the collected LFG under the Article 6.4 activity is flared and/or used in any (combination) of the following:

   (a) Generating electricity;

   (b) Generating heat in a boiler, air heater or kiln (brick firing only) or glass melting furnace;

   (c) Supplying the biomethane produced from the LFG to consumers through a natural gas distribution network;

   (d) Supplying the LFG or the biomethane produced from the LFG to consumers via trucks;

   (e) Supplying the LFG or the biomethane produced from the LFG to consumers through a dedicated pipeline.

10. The methodology is only applicable if the project does not reduce the amount of organic waste that would be recycled in the absence of the Article 6.4 activity.

11. The methodology is only applicable for the following baseline scenarios:

   (a) For the LFG component:

      (i) For Article 6.4 activities developed in an existing SWDS, the most plausible baseline scenario is that the LFG generated in the SWDS would be either released to the atmosphere or captured and destroyed through flaring to comply with legal or contractual requirements, to address safety and odour concerns, or for other reasons;

      (ii) For Article 6.4 activities implemented in a greenfield SWDS, the most plausible baseline scenario, as identified based on the BAT approach, is that the LFG generated in the SWDS would be either released to the atmosphere or captured and destroyed through flaring to comply with legal or contractual requirements, to address safety and odour concerns, or for other reasons;[5]

   (b) For the electricity generation component:

      (i) If the electricity generated by the Article 6.4 activity is supplied to the grid, the most plausible baseline scenario is the same amount of electricity is generated from other power plants connected to the same electric grid;

      (ii) If the electricity generated by the Article 6.4 activity replaces the electricity generated in an existing captive fossil fuel fired power plant, the most plausible baseline scenario is the continued operation of the existing captive power plant located within the activity boundary using the same fossil fuel;

[5] If the identified baseline based on the best available technology results in another baseline scenario, activity participants may request a revision to the methodology through the latest version of the "Procedure: Development, revision and clarification of methodologies and methodological tools" (A6.4-PROC-METH-001).

(iii) If the electricity generated by the Article 6.4 activity replaces the electricity generated in a new captive fossil fuel fired power plant, the baseline scenario is determined based on the best available technology approach.

(c) For the heat generation component:

(i) If the heat generated by the Article 6.4 activity is replacing heat generated in an existing equipment (boiler, air heater, glass melting furnace or brick kiln), the most plausible baseline scenario is the continued generation of heat in the existing equipment located within the activity boundary using the same fuel;

(ii) If the heat generated by the Article 6.4 activity is replacing heat generated in a new equipment (boiler, air heater, glass melting furnace or kiln), the baseline scenario is determined based on the best available technology approach;

(d) For the supply of LFG or biomethane to consumers through trucks or dedicated pipeline (or biomethane through natural gas dedicated network), the most plausible baseline scenario is the consumption of natural gas from an existing natural gas network.

12. If the Article 6.4 activity involves heat generation and results in existing heat generation equipment being replaced as per paragraph 11(c)(i) above, then activity participants shall demonstrate that:

(a) The existing heat generation equipment that is replaced is scrapped, and provide evidence of the scrapping to the DOE performing the validation or at first verification; or

(b) The existing heat generation equipment is used outside of the activity boundary, and has a higher efficiency than any equipment it may replace. Evidence of the efficiency of the replaced heat generation equipment outside of the activity boundary shall be provided to the DOE performing the validation; or

(c) Neither of the previous two conditions is fulfilled, and leakage emissions shall be calculated based on the difference in efficiency between the existing heat generation equipment and the typical heat generation equipment that is used outside the activity boundary.

13. This methodology is not applicable:

(a) When applied in combination with other approved mechanism methodologies. For instance, it cannot be used to claim emission reductions for the displacement of fossil fuels in a kiln or glass melting furnace, where the purpose of the activity is to implement energy efficiency measures at a kiln or glass melting furnace;

(b) If the management of the SWDS in the Article 6.4 activity scenario is changed in a manner that increases methane generation (for example by recirculating the leachate) compared to the situation prior to the implementation of the project activity, unless the change is implemented due to legal requirements. At the validation and at each verification, the DOE shall assess whether any changes in the design or management of the SWDS have been implemented and review any applicable legal requirements (e.g. changes to the maximum allowable emission limit for VOCs).

14. The above provisions shall be demonstrated as follows:

    (a) The provisions in paragraphs 8, 9, 11 and 13(a) above shall be demonstrated in the Project Design Document (PDD) and be assessed at the initial validation;

    (b) The provisions in paragraphs 10, 12 and 13(b) above shall be demonstrated in each monitoring report and be assessed at each verification.

15. The applicability conditions included in the tools referred to above also apply.

5. Activity boundary

16. The Article 6.4 activity boundary shall include the site where the LFG is captured and, as applicable:

    (a) Sites where the LFG is flared or used (e.g. flare, power plant, boiler, air heater, glass melting furnace, kiln, natural gas distribution network, dedicated pipeline or biogas processing facility);

    (b) Captive power plant(s) (including emergency diesel generators) or power generation sources connected to the grid, which are supplying electricity to the Article 6.4 activity;

    (c) Captive power plant(s) (including emergency diesel generators) or power generation sources connected to the grid, which are supplying electricity in the baseline scenario that is displaced by electricity generated by captured LFG in the Article 6.4 activity scenario;

    (d) Heat generation equipment or sources which are supplying heat in the baseline scenario that is displaced by heat generated by captured LFG in the Article 6.4 activity scenario; and

    (e) The transportation equipment of the LFG or biomethane from the biogas processing facility to consumers.

17. The activity boundary of the Article 6.4 activity is defined by the emission sources illustrated in the figure and listed in the table below. Note that the table also specifies the circumstances under which some emission sources are included or excluded.

Figure 1. Activity boundary

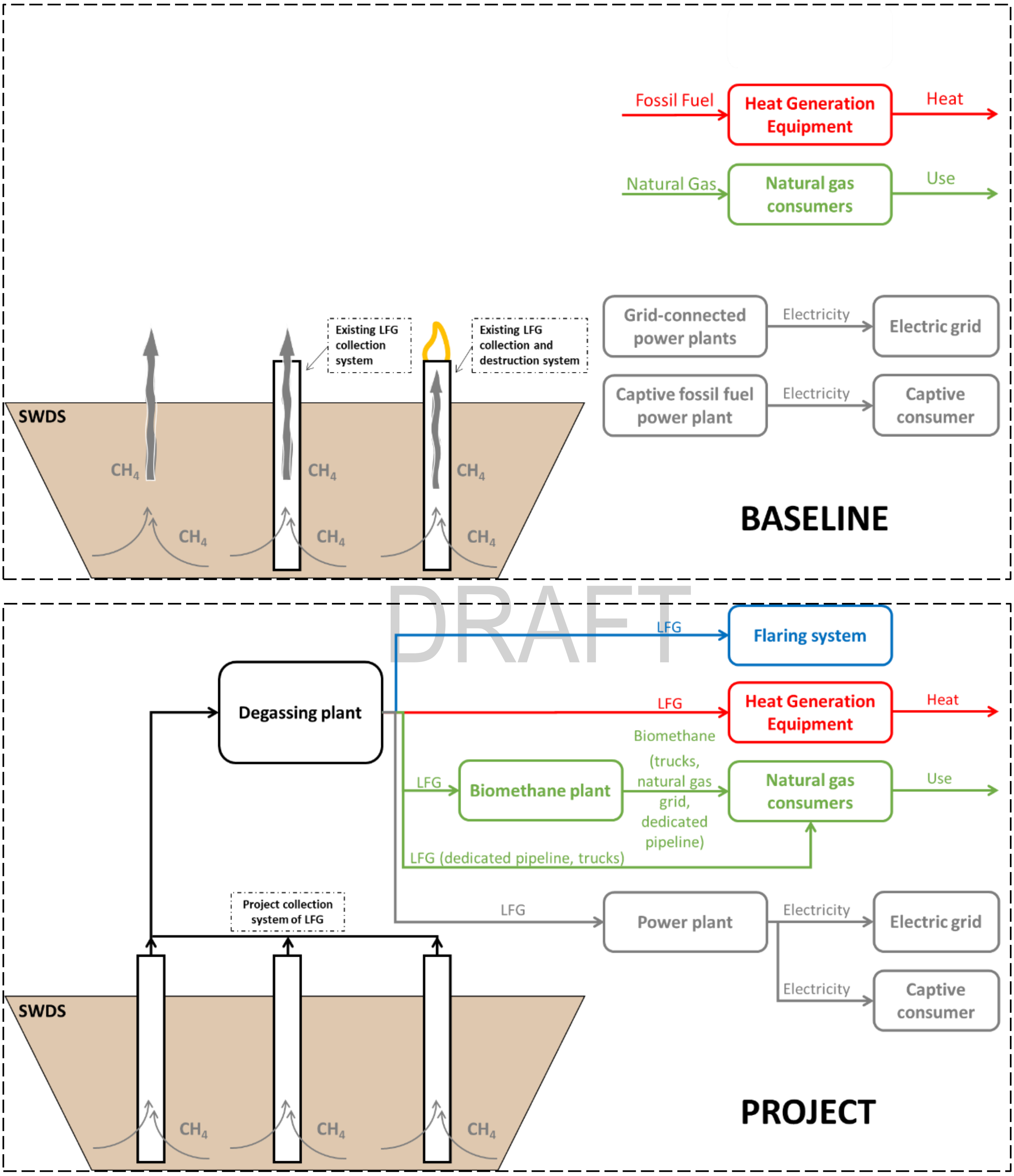


Table 5. Emissions sources included in or excluded from the activity boundary

	Source	GHG	Included?	Controlled / Related to / Affected by?	Justification / Explanation
BASELINE SCENARIO	Emissions from decomposition of waste in the SWDS (venting or flaring)	CO_2	No		Not accounted for since the CO_2 is also released in the Article 6.4 activity scenario
		CH_4	Yes	Controlled	Major emission source
		N_2O	No		Emissions are small compared to CH_4 emissions from SWDS and exclusion is conservative
	Emissions from electricity generation by power plants connected to the electric grid or captive power plant(s) displaced by the Article 6.4 activity	CO_2	Yes	Affected by	Major emission source if the project involves the generation of electricity using LFG
		CH_4	No		Excluded for simplification and conservativeness
		N_2O	No		Excluded for simplification and conservativeness
	Emissions from heat generation displaced by Article 6.4 Activity	CO_2	Yes	Related to	Major emission source if the project involves the generation of heat using LFG
		CH_4	No		Excluded for simplification and conservativeness
		N_2O	No		Excluded for simplification and conservativeness
	Emissions from the use of natural gas by consumers	CO_2	Yes	Related to	Major emission source if the project involves the supply of biomethane or LFG to consumers
		CH_4	No		Excluded for simplification and conservativeness
		N_2O	No		Excluded for simplification and conservativeness
ARTICLE 6.4 ACTIVITY SCENARIO	Emissions from on-site fossil fuel consumption for purposes other than electricity generation	CO_2	Yes	Controlled	Significant emission source if fossil fuels are consumed to operate the project
		CH_4	Yes	Controlled	Accounted for in the emission factor for equivalent CO_2 emissions.
		N_2O	Yes	Controlled	Accounted for in the emission factor for equivalent CO_2 emissions.
	Emissions from on-site electricity consumption	CO_2	Yes	Controlled	Significant emission source if electricity is consumed to operate the project
		CH_4	No		Excluded for simplification
		N_2O	No		Excluded for simplification

	Source	GHG	Included?	Controlled / Related to / Affected by?	Justification / Explanation
	Emissions from flaring of LFG	CO_2	No		Not accounted (biogenic)
		CH_4	Yes	Controlled	Significant emission source
		N_2O	No		Excluded for simplification
	Emissions from distribution of biomethane using trucks or through the natural gas distribution network	CO_2	Yes	Controlled Related to	- "Controlled" emission source from the consumption of fuel by trucks; - "Related to" emission source from the use of biomethane by consumers
		CH_4	Yes	Controlled Related to	- "Controlled" emission source from the consumption of fuel by trucks; - "Related to" emission source from the use of biomethane by consumers
		N_2O	No		Excluded for simplification
	Emissions from distribution of biomethane or LFG to consumers using dedicated pipelines	CO_2	Yes	Controlled	Significant emission source
		CH_4	Yes	Controlled	Significant emission source
		N_2O	No		Excluded for simplification
LEAKAGE	Upstream emissions	CO_2	Yes	Affected by	Included in LCA analysis
		CH_4	Yes	Affected by	Included in an LCA analysis
		N_2O	Yes	Affected by	Included in an LCA analysis

18. Activity participants shall specify, in the PDD, the location of the Article 6.4 activity in the form of Keyhole Markup Language (KML) files or similar formats as one or more polygon(s), by specifying the coordinates of the geographic boundary using a known coordinate system or any other method.

6. Demonstration of additionality

19. To demonstrate additionality, activity participants shall apply:

(a) A regulatory analysis (section 6.1 below);

(b) A lock-in analysis (section 6.2 below);

(c) An investment analysis (section 6.3.1 below); and

(d) A common practice analysis (section 6.3.2 below).

20. The proposed Article 6.4 activity shall only be considered additional if all four analyses are concluded positively.

6.1. Regulatory analysis

21. Activity participants shall demonstrate and justify, based on a review of legal requirements on environmental and waste management applicable to the host country and the proposed Article 6.4 activity, that the emission reductions resulting from the Article 6.4 activity would not occur as a result of any of these legal requirements (unless the law or regulation refers to or formally integrates the mechanism as an instrument for implementation) by confirming that these legal requirements do not:

    (a) Explicitly require SWDSs to install an LFG capturing and flaring system, or an LFG capturing and utilization system;

    (b) Include requirements for the treatment of waste in SWDSs which can only be achieved by either collecting and flaring LFG or collecting and utilizing the LFG for energy purposes;

    (c) Prohibit the use of specific waste treatment technologies e.g. incineration, and mandates the collection, flaring and/or utilization of the LFG for energy as part of the waste treatment technology or practice;

    (d) Establish a support scheme that:

        (i) Is designed to achieve a quantitative target for methane destruction in SWDSs;

        (ii) Is applicable to the collection of LFG and its destruction in flares and/or use; and;

        (iii) Would likely result in the same amount of emission reductions if the Article 6.4 activity was not implemented.

22. If one of the above applies to the Article 6.4 activity, A6.4ERs cannot be claimed for emission reductions that results from meeting the legal requirement(s). However, A6.4ERs with respect to emission reductions achieved by exceeding the regulatory requirements may be claimed.

23. Activity participants shall update the regulatory analysis annually to reflect any changes in legal requirements and update the parameter $F_{CH4,BL,y}$ as per section 7.2.2.1.3 below accordingly.

6.2. Avoidance of locking-in the level of emissions

Note from the panel: MEP would like to seek feedback on approaches to assess lock-in risk for the cases not covered by paragraph 24 below.

24. Article 6.4 activities implemented at closed SWDS and Article 6.4 activities implemented at new SWDSs and otherwise eligible under this methodology are not deemed to have a lock-in risk.

25. This assessment is based on the following considerations: in the case of closed landfill, no more waste is added to the landfill. In that case, the implementation of the activity does not prolong the lifetime for which emissions occur but only reduces them. In the case of Article 6.4 activities implemented at new SWDS, this methodology requires determining the best available technology as the baseline. Here the lowest emission technology is selected among those that economically viable. This prevents the Article 6.4 activity from

implementing a technology that is not among the lowest emissions technologies that are available.

26. The methodology includes in the section on downward adjustment provisions that strongly encourage the adoption of landfill gas utilization instead of landfill gas flaring over time. This encourages ambition and contributes to reducing the lock-in risk associated with landfill gas flaring Article 6.4 activities in existing and new SWDS under this methodology. Moreover, in the context of this specific methodology, mandating the investment comparison analysis for LFG flaring Article 6.4 activities in case alternative scenarios generate revenues (i.e. energy recovery scenarios) ensures that flaring Article 6.4 activities will not prevent the implementation of the lower GHG intensive technologies in case such Article 6.4 activities are financially attractive, which contributes to reducing the lock-in risk.

6.3. Investment analysis and Common practice analysis

6.3.1. Investment analysis

{OPTION 1: Use of the investment analysis tool (under development)}

27. Under this methodology, investment analysis shall be conducted by activity participants following the provisions of the “Methodological tool: Investment analysis” (hereinafter referred toas the investment analysis tool).

28. In applying the tool, activity participants shall:

(a) Identify realistic and credible alternative scenarios to the proposed Article 6.4 activity, which shall include but not be limited to the following:

(i) LFG1: The Article 6.4 activity implemented without being registered under the Article 6.4 mechanism (i.e. capture and flaring or use of LFG);

(ii) LFG2: Atmospheric release of the LFG or capture of LFG in a managed SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;

(iii) LFG3: Atmospheric release of the LFG or capture of LFG in an unmanaged SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;

(iv) LFG4: LFG generation is partially avoided because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;

(v) LFG5: LFG generation is partially avoided because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;

(vi) LFG6: LFG generation is partially avoided because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

(b) Use the investment comparison analysis or, if the only alternative to the proposed Article 6.4 activity is the continuation of the current situation prior to the implementation of the Article 6.4 activity, use the benchmark analysis;

(c) Use the net present value (NPV) as financial indicator where the investment comparison analysis is applied and choose an appropriate indicator where the benchmark analysis is applied, such as internal rate of return (IRR) or NPV;

(d) Assume that the Article 6.4 activity could be implemented by either the activity participants or other entities, unless activity participants can demonstrate that in the specific context of the proposed Article 6.4 activity that it can only be implemented by the activity participants and not by any other entities;

29. In conducting the sensitivity analysis, apply a variation of at least ± 10% to the input values which constitute more than 20% of the total costs or total revenues

{End of OPTION 1}

{OPTION 2: Use of a methodology-specific procedure}

30. Activity participants shall apply the investment analysis following the steps set out hereunder.

31. The sensitivity analysis shall use a variation of at least ± 10% to the input values which constitute more than 20% of the total costs or total revenues.

32. Activity participants shall demonstrate additionality for the Article 6.4 activity in its entirety. The following are alternative combination of different project activity types where investment analysis shall be conducted:

(a) Activity 1: LFG capture and flaring;

(b) Activity 2: LFG capture and use for electricity generation;

(c) Activity 3: LFG capture and use for heat generation;

(d) Activity 4: LFG capture, supply of LFG or biomethane to consumers;

(e) Activity 5: Any combination of Activities 2 to 4 above.

33. The investment analysis shall follow the general requirements from paragraphs 37-40, 42 and 43 of the additionality standard.

{End of OPTION 2}

6.3.1.1. Simple cost analysis

34. This option is only applicable if the activity falls under Activity 1.

35. The simple cost analysis shall be conducted in the following steps:

(a) Identify and describe the alternative scenarios to be considered in conducting the analysis in addition to the LFG capture and flaring activity;

(b) Determine the assessment period;

(c) Demonstrate that the LFG capture and flaring activity does not generate any cost savings or revenues other than from A6.4ERs during the assessment period, and justify the analysis with appropriate evidence;

(d) Demonstrate that the alternative scenarios do not generate any cost savings or revenues during the assessment period, and justify the analysis with appropriate evidence;

(e) [Describe how the incentives from the mechanism can enable the implementation of the Article 6.4 activity;[6]]

(f) [Document any public funding provided to the LFG capture and flaring activity. If the public funding, expressed in grant equivalents, is larger than the expected revenues from A6.4ERs, demonstrate that public funding would not have filled the funding gap in the absence of revenues from A6.4Ers. This may, for example, apply to public funding schemes that are designed to pay for the funding gap of mitigation activities.]

36. The simple cost analysis is concluded positively if [it is demonstrated that the Article 6.4 activity is not financially viable without the incentives from the mechanism [and that the incentives from the mechanism enable the implementation of the activity], the steps under paragraph 35(a)-[(d)] [(f)] above are satisfied.

37. If the conditions under paragraphs 35(a)-[(d)] [(f)] above are not satisfied, proceed to investment comparison analysis.

6.3.1.2. Benchmark analysis

38. This option applies to activities that fall under Activities 2 to 5.

39. To apply this option, activity participants shall demonstrate, in the PDD, that the A6.4 activity generates revenues other than from A6.4 ERs and can be implemented by the activity participants or by other entities.

40. Activity participants shall describe and justify in the PDD which is the suitable financial indicator for the financial viability, i.e. IRR (internal rate of return) or NPV (net present value), and how it was determined as follows:

(a) If the Article 6.4 activity is implemented by the activity participants only, the financial indicator shall be based on the benchmark used by the activity participant implementing the Article 6.4 activity;

(b) If the Article 6.4 activity is implemented by the activity participants or by other entities, the financial indicator shall be based on the more conservative value between (i) the benchmark used by the entity implementing the Article 6.4 activity and (ii) the weighted average cost of capital (or the cost of equity, as applicable) that is commonly applicable to the country, sector and type of activity.

41. If it is concluded, based on credible data and input parameters to the investment analysis, that the Article 6.4 activity is not financially attractive, then proceed to the common practice analysis; otherwise, the Article 6.4 activity is not additional.

6.3.1.3. Investment comparison analysis

42. This option applies to activities that fall under Activities 2 to 5.

[6] This could be demonstrated by providing indicative information that revenues from carbon credits have, in principle, the ability to close the funding gap for an activity.

43. To apply this option, activity participants shall demonstrate, in the PDD, that the Article 6.4 activity generates revenues other than from A6.4 ERs and the activity scenario and other alternative activity scenarios can be implemented by the activity participants.

44. The activity participants shall identify all credible and plausible alternative scenarios to the article 6.4 activity. The considered alternatives shall treat the same amount of waste or produce the same amount of energy similar to the Article 6.4 activity, which shall include but not be limited to the following:

(a) LFG1: The project activity implemented without being registered as a CDM project activity (i.e. capture and flaring or use of LFG);

(b) LFG2: Atmospheric release of the LFG or capture of LFG in a managed SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;

(c) LFG3: Atmospheric release of the LFG or capture of LFG in an unmanaged SWDS and destruction through flaring to comply with regulations or contractual requirements, to address safety and odour concerns, or for other reasons;

(d) LFG4: LFG generation is partially avoided because part of the organic fraction of the solid waste is recycled and not disposed in the SWDS;

(e) LFG5: LFG generation is partially avoided because part of the organic fraction of the solid waste is treated aerobically and not disposed in the SWDS;

(f) LFG6: LFG generation is partially avoided because part of the organic fraction of the solid waste is incinerated and not disposed in the SWDS.

45. Use the NPV as financial indicator where the investment comparison analysis is applied.

46. The Article 6.4 activity shall only be considered additional if the analysis demonstrates that the project has a lower financial indicator compared to other alternatives, based on credible data parameters to the investment analysis.

6.3.2. Common practice analysis

47. Activity participants shall assess common practice by applying the draft “Methodological tool: Common practice analysis” (hereinafter referred toas the common practice tool). The following specific guidance shall be followed when applying the different steps in the tool:

(a) **Specification of the Approach for common practice analysis:** Approach A, which is based on identification of existing ‘comparable activities’ and differentiation between ‘similar’ and ‘different’ activities, shall be used for the common practice analysis.

(b) **Specification of the indicator of common practice:** a count-based indicator of common practice shall be used in the analysis, based on for example the number of SWDSs or number of incineration plants, etc.

(c) **Sample basis to be used in the analysis:** a stock-based approach shall be used in the common practice analysis, considering all operational SWDS by the time of conducting the common practice analysis.

(d) **Identification of the applicable geographical area:** the applicable geographical area is the host country. If the applicable geographical area is different than the geographical reference area used to determine the baseline geographical reference area, this should be justified.

(e) **Relevance of scale or capacity in the common practice analysis:** the capacity or scale of the different activity types shall be considered relevant for the common practice analysis under this methodology. The scale of output for the SWDS and the output capacity of the technologies involved in the different types of activities are:

(i) Activity 1: the capacity does not apply;

(ii) Activities 2, 3 and 4: $\pm$ [50%][25%] of the daily waste received by the SWDS.

(f) **Identifying comparable activities:** activities shall be considered comparable to the Article 6.4 activity if they treat comparable type (e.g. municipal waste) of waste as the proposed Article 6.4 activity using different technologies, such as landfilling, composting, incineration, recycling, etc.

(g) **Distinguishing between similar and different activities:** the differentiation between similar and different activities is based on the type of measure (LFG destruction and/or energy recovery) applied in the geographical area. Therefore, similar activities under this methodology shall be identified as follows:

(i) For Activity 1: managed SWDSs with a passive or active LFG collection system and methane destruction and/or energy recovery (flaring, electricity generation, heat generation, supply of LFG or biomethane to consumers);

(ii) For Activities 2, 3 and 4: managed SWDSs with a passive or active LFG collection system energy recovery (electricity generation, heat generation, supply of LFG or biomethane to consumers).

(h) **Determining the common practice threshold (F_{max}):** the common practice factor threshold[s] to be applied under this methodology [is][are] 16%[7] [for Article 6.4 activities located in non-LDCs/SIDS, and 20% for Article 6.4 activities located in LDCs/SIDS].

48. The Article 6.4 activity is only additional if it is demonstrated that:

(a) Emission reductions or net removals resulting from an Article 6.4 activity would not occur as a result of the legal requirements as per the outcome of section 6.1 above; and

(b) The Article 6.4 activity is not financially viable, as per the outcome of section 6.3.1 above; and

(c) The Article 6.4 activity is not common practice, as per the outcome of section 6.3.2 above.

[7] Value proposed based on the threshold of moving from early adopters to early majority as identified in the Roger diffusion curve (Rogers, E. M. *Diffusion of Innovations*. 5th ed. New York: Free Press, 2003).

7. Baseline scenario

7.1. Selection of the baseline approaches from paragraph 36 of the rules, modalities and procedures

49. The selected approach to determine the baseline for the different possible components of Article 6.4 activities eligible under the methodology are:

(a) For the LFG component:

(i) For Article 6.4 activities developed in existing SWDSs, the baseline is determined through existing actual or historical emissions (paragraph 36(iii) of the RMPs) since data from existing SWDS is strongly heterogeneous and emissions are highly activity- or site-specific (e.g. SWDSs located in humid regions tend to have higher methane generation rates when compared with SWDSs located in dry regions);

(ii) For Article 6.4 activities developed in new SWDSs, the baseline is determined based on the best available technology that represent an economically feasible and environmentally sound course of action(paragraph 36(i) of the RMPs) since the activity (treatment of solid waste in a new SWDS) using alternative technologies for waste treatment (such as waste incineration, composting, pyrolysis, gasification, etc) provides reasonably homogeneous outputs (i.e. waste treated) for the same pool of users (i.e. population served by the SWDS);

(b) For the electricity generation component:

(i) If the electricity generated by the Article 6.4 activity is supplied to the grid, the baseline is determined through existing actual or historical emissions (paragraph 36(iii) of the RMPs);

(ii) If the electricity generated by the Article 6.4 activity replaces the electricity generated in an existing captive fossil-fuel fired power plants, the baseline is determined through existing actual or historical emissions (paragraph 36(iii) of the RMPs). The approach shall apply until the end of the remaining lifetime[8] of the baseline equipment;

(iii) After the end of the remaining lifetime of the baseline equipment, or if the electricity generated by the Article 6.4 activities replaces the electricity generated in new captive fossil-fuel fired power plants, the baseline is determined through the best available technology that represents an economically feasible and environmentally sound course of action (paragraph 36(i) of the RMPs);

(c) For the heat generation component:

(i) If the heat generated from the LFG or the biomethane is replacing heat generated in an existing equipment, the baseline is determined through existing actual or historical emissions (paragraph 36(iii) of the RMPs) since emissions per ton of heat generated are highly activity- or site-specific, since

[8] The remaining lifetime is determined as a difference between the technical lifetime provided by the manufacturer and the operational time since the commissioning of the equipment.

the type and characteristics of the heat produced depends on its usage (e.g. hot air, high-pressure steam, low-pressure steam, hot water, etc) and the fuel type used (e.g. coal, diesel, NG, etc.). The approach shall apply until the end of the remaining lifetime[9] of the baseline equipment;

(ii) After the end of the remaining lifetime of the baseline equipment, or if the heat generated from the LFG or the biomethane is replacing heat produced in new equipment, the baseline is determined based on the best available technology that represent an economically feasible and environmentally sound course of action(paragraph 36(i) of the RMPs) since the emissions per unit of output (i.e. tCO_2e/unit of output such as tonnes of steam, tonnes of hot water, tonnes of brick, tonnes of melted glass, etc) are determined primarily by the technology(ies) and/or practice(s) used in the Article 6.4 activity (e.g. boiler, glass melting furnace, water heater, air heater, brick kiln, etc). In addition, the same output is provided for the same pool of users by the activity and by other technologies and/or practices (i.e. a boiler is used to produce steam or hot water; a brick kiln is used to produce bricks; a glass melting furnace is used to produce melted glass, etc).

(d) For the supply of LFG or biomethane to consumers component, the baseline is determined through existing actual or historical emissions (paragraph 36(iii) of the RMPs).

7.2. Application of the selected approach, prior to implementation of a downward adjustment

7.2.1. Procedure for the identification of the baseline scenario

50. The baseline scenario for the different components of Article 6.4 activities eligible under the methodology are described in the table below:

Table 6. Baseline scenario for different components of Article 6.4 activities eligible under the methodology

Component	Baseline approach	Baseline scenario
LFG – Article 6.4 activities implemented in an existing SWDS	Existing actual or historical emissions	The continuation of the pre-activity scenario, i.e. the methane generated is emitted to the atmosphere or is partially captured and/or partially destroyed.
LFG – Article 6.4 activities implemented in new SWDS	Best available technologies that represent an economically feasible and environmentally sound course of action	Determined based on section 7.2.1.1 below.

[9] The remaining lifetime is determined as a difference between the technical lifetime provided by the manufacturer and the operational time since the commissioning of the equipment.

Component	Baseline approach	Baseline scenario
Electricity generation and supply to the electric grid	Existing actual or historical emissions (grid emission factor)	The continuation of the pre-activity scenario, i.e. the electricity would have been generated by existing power plants connected to the same electricity grid.
Electricity generation replacing electricity generated in an existing fossil fuel fired captive power plant	Existing actual or historical emissions	The continuation of the pre-activity scenario, i.e. the electricity would have been generated in the existing captive power plant using the same fossil fuel up to the end of the remaining lifetime of the captive fossil fuel power plant. After the end of the lifetime of the captive fossil fuel power plant, the baseline shall be determined based on BAT.
Electricity generation replacing electricity generated in new captive fossil fuel fired power plant	Best available technologies that represent an economically feasible and environmentally sound course of action	Determined based on section 7.2.1.2 below.
Heat generation replacing heat generated in an existing equipment	Existing actual or historical emissions	The continuation of the pre-activity scenario, i.e. the heat would be generated in the same heat generation equipment using the same fuels up to the end of the remaining lifetime of the heat generation equipment. After the end of the lifetime of the heat generation equipment, the baseline shall be determined based on BAT.
Heat generation replacing heat generated in new equipment	Best available technologies that represent an economically feasible and environmentally sound course of action	Determined based on section 7.2.1.3 below.
Supply of LFG or biomethane to consumers	Existing actual or historical emissions	The continuation of the pre-activity scenario, i.e. consumers would be supplied with natural gas from the network.

7.2.1.1. Identification of the baseline scenario for Article 6.4 activities implemented in a new SWDS

51. Activity participants shall determine the best available technology and economically feasible and environmentally sound course of action for Article 6.4 activities implemented in a new SWDS based on the stepwise process described below:

7.2.1.1.1. Step 1: Identification of the baseline geographical reference area

52. The baseline geographical reference area is the host country by default.

53. Activity participants may choose to limit the baseline geographical reference area to a narrower specific geographical area (such as municipality, province, states, etc.) within the host country if they can demonstrate and justify that there are essential distinctions between the identified specific geographical area and rest of the host country. For example, such distinctions may include certain benefits that make the Article 6.4 activity financially/economically more attractive (e.g., subsidies or other financial flows), different climatic conditions, or unfeasible distances to transport the solid waste.

7.2.1.1.2. Step 2. Identification of technologies and/or practices available in the baseline geographical reference area

54. Activity participants shall identify the technologies and/or practices (including their combinations) for solid waste treatment that are available (i.e. meaning accessible off the shelf, or via a tendering or direct contracting process, or by direct implementation by an end user within the boundary of potential Article 6.4 activities) in the baseline geographical reference area and which can deliver the same solid waste treatment capacity. The technologies and/or practices include, but are not limited to, disposal in managed SWDS with or without LFG collection and destruction, incineration of solid waste with and without heat recovery for electricity generation, composting of solid waste, production of residue derived fuel (RDF), treatment of solid waste in anaerobic reactors with and without recovery of the biogas for energy generation, gasification of solid waste, pyrolysis of solid waste with or without energy recovery and treatment of the solid waste using plasma.

7.2.1.1.3. Step 3. Identification of the environmentally sound technologies

55. Out of the technologies and/or practices identified in Step 2 above, activity participants shall exclude from the analysis those that are not in line with legal requirements in the applicable baseline geographical reference area. For example, this may apply to waste treatment facilities that are not in compliance with limits or thresholds for atmospheric emissions (NOx, VOCs, particulates and black carbon, etc), proper management of leachate and wastewater, proper management of odour, proper management of noise, etc.

7.2.1.1.4. Step 4. Identification of the economically viable technologies

56. Out of the technologies and/or practices that are environmentally sound, as identified in Step 3 above, activity participants shall further identify those that are deemed economically viable, i.e. that provide sufficient returns to cover investment, operations & maintenance costs.

57. Technologies and/or practices are deemed economically viable if:

(a) They have been implemented by at least one facility within the applicable baseline geographical reference area without the revenues from carbon credits or other incentives; or

(b) They are accessible off the shelf or via tendering within the applicable baseline geographical reference area and are economically viable when compared against a benchmark. The benchmark and the investment analysis shall be carried out following the same requirements used for the additionality demonstration as per section 6.3.1 above. Activity participants shall collect the information directly from the technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the costs from similar facilities located outside of the baseline geographical reference area or from peer reviewed studies and papers, providing proper justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to the waste treatment technology in the baseline geographical reference area.

7.2.1.1.5. Step 5. Define the emissions intensity of each of the remaining technologies

58. Out of the economically viable technologies and/or practices identified in Step 4, activity participants shall determine the emissions intensity per tonne of waste treated.

59. Activity participants shall collect the information directly from the operator of the facility or technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the emissions intensity from similar facilities located outside of the baseline geographical reference area or from peer reviewed studies and papers, providing proper justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to the waste treatment technology in the baseline geographical reference area.

60. In case managed SWDS are identified in the above step, then their emission intensity shall be determined as the product of the estimated methane collected using the draft “Methodological tool: Emissions from solid waste disposal sites” (hereinafter referred toas the solid waste tool) throughout the total duration of the crediting period (10 or 15 years), the GWP of methane and the average collection efficiency of an LFG destruction system and the default efficiency of the assumed flare as per the solid waste tool or 100% for energy utilization, divided by the amount of waste that would be delivered to the SWDS through the total duration of the crediting period (10 or 15 years).

7.2.1.1.6. Step 6. Selection of the BAT

61. The technology that constitutes the BAT is the one with the lowest emission intensity among those that are economically feasible and environmentally sound.

7.2.1.2. Identification of the baseline scenario for electricity generation replacing electricity generated in new captive power plants

62. Activity participants shall determine the best available technology and economically feasible and environmentally sound course of action for Article 6.4 activities that involve

the electricity generation replacing the electricity generated in new captive power plants based on the stepwise process described below:

7.2.1.2.1. Step 1: Identification of the geographical area

63. The geographical area by default is the host Country.

64. Activity participants may choose to limit the baseline geographical reference area to a narrower specific geographical area (such as municipality, province, states, etc.) within the host country if they can demonstrate and justify that there are essential distinctions between the identified specific geographical area and rest of the host country. For example, such distinctions may include certain benefits that make the Article 6.4 activity financially/economically more attractive (e.g., subsidies or other financial flows).

7.2.1.2.2. Step 2. Identification of technologies and/or practices available in the geographical area

65. Activity participants shall identify the technologies and/or practices (including their combinations) for electricity generation that are available (i.e. meaning accessible off the shelf, or via a tendering or direct contracting process, or by direct implementation by an end user within the boundary of potential Article 6.4 activities) in the baseline geographical reference area, and that generates electricity to the same pool or users from the Article 6.4 activity, have the same capacity and indicate the type of fuel used.

7.2.1.2.3. Step 3. Identification of the environmentally sound technologies available in the geographical area

66. Out of the technologies and/or practices identified in Step 2 above, activity participants shall exclude from the analysis those that are not in line with legal requirements in the applicable geographical reference area. For example, this may apply to power plants that are not in compliance with limits or thresholds for atmospheric emissions (NOx, VOCs, particulates and black carbon, etc).

7.2.1.2.4. Step 4. Identification of economically viable technologies in the geographical area

67. Out of the technologies and/or practices that are environmentally sound, as identified in Step 3 above, activity participants shall further identify those that are deemed economically viable, i.e. that provide sufficient returns to cover investment, operations & maintenance costs.

68. Technologies and/or practices are deemed economically viable if:

   (a) They have been implemented by at least one facility within the applicable baseline geographical reference area without the revenues from carbon credits or other incentives; or

   (b) They are accessible off the shelf or via tendering within the applicable baseline geographical reference area and are economically viable when compared against a benchmark. The benchmark and the investment analysis shall be carried out following the same requirements used for the additionality demonstration as per section 6.3.1 above. Activity participants shall collect the information directly from the technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the costs from similar facilities located outside of the baseline geographical reference area or from peer reviewed studies and papers, providing proper justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to the electricity generation technology in the baseline geographical reference area.

7.2.1.2.5. Step 5. Define the emissions intensity of each of the remaining technologies

69. Out of the economically viable technologies and/or practices identified in Step 4, activity participants shall determine the emissions intensity per unit of electricity generated (i.e. tCO_2e/kWh, tCO_2e/MWh, etc.), taking into account the different types of fuels used to generate electricity.

70. Activity participants shall collect the information directly from the operator of the facility or technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the emissions intensity from similar facilities located outside of the baseline geographical reference area or from peer reviewed studies and papers, providing justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to the electricity generating equipment in the baseline geographical reference area.

7.2.1.2.6. Step 6. Selection of the BAT

71. The technology that constitutes the BAT is the one with the lowest emission intensity among those that are economically feasible and environmentally sound.

7.2.1.3. Identification of the baseline scenario for heat generation replacing heat generated in new equipment

72. Activity participants shall determine the best available technology and economically feasible and environmentally sound course of action for Article 6.4 activities that involve the heat generation replacing heat generated in new equipment based on the stepwise process described below:

7.2.1.3.1. Step 1: Identification of the geographical area

73. The geographical area by default is the host Country.

74. Activity participants may choose to limit the baseline geographical reference area to a narrower specific geographical area (such as municipality, province, states, etc.) within the host country if they can demonstrate and justify that there are essential distinctions between the identified specific geographical area and rest of the host country. For example, such distinctions may include certain benefits that make the Article 6.4 activity financially/economically more attractive (e.g., subsidies or other financial flows).

7.2.1.3.2. Step 2. Identification of technologies and/or practices available in the geographical area

75. Activity participants shall identify the technologies and/or practices (including their combinations) for heat generation that are available (i.e. meaning accessible off the shelf, or via a tendering or direct contracting process, or by direct implementation by an end user within the boundary of potential Article 6.4 activities) in the baseline geographical reference area, that generates the same type of output produced by the Article 6.4 activity (e.g. hot water, hot air, saturated steam, overheated steam, brick, melted glass, etc) to the same pool or users from the Article 6.4 activity (e.g. a specific industrial process,

residential or institutional/commercial consumers), have the same capacity and indicate the type of fuel used.

7.2.1.3.3. Step 3. Identification of the environmentally sound technologies available in the geographical area

76. Out of the technologies and/or practices identified in Step 2 above, activity participants shall exclude from the analysis those that are not in line with legal requirements in the applicable baseline geographical reference area. For example, this may apply to heat generation facilities that are not in compliance with limits or thresholds for atmospheric emissions (NOx, VOCs, particulates and black carbon, etc).

7.2.1.3.4. Step 4. Identification of economically viable technologies in the geographical area

77. Out of the technologies and/or practices that are environmentally sound, as identified in Step 3 above, activity participants shall further identify those that are deemed economically viable, i.e. that provides sufficient returns to cover investment, operations & maintenance costs.

78. Technologies and/or practices are deemed economically viable if:

(a) They have been implemented by at least one facility within the applicable baseline geographical reference area without the revenues from carbon credits or other incentives; or

(b) They are accessible off the shelf or via tendering within the applicable baseline geographical reference area and are economically viable when compared against a benchmark. The benchmark and the investment analysis shall be carried out following the same requirements used for the additionality demonstration as per section 6.3.1 above. Activity participants shall collect the information directly from the technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the costs from similar facilities located outside of the baseline geographical reference area or from peer reviewed studies and papers, providing proper justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to heat generation technology in the baseline geographical reference area.

7.2.1.3.5. Step 5. Define the emissions intensity of each of the remaining technologies

79. Out of the economically viable technologies and/or practices identified in Step 4, activity participants shall determine the emissions intensity per unit of the output produced identified in Step 2 above (e.g. tonnes of CO_2 per tonnes of hot water, per tonnes of steam, per tonnes of brick, per tonnes of glass, etc), taking into account the different types of fuels used to generate the heat.

80. Activity participants shall collect the information directly from the operator of the facility or technology suppliers. If it is not possible to collect this information, activity participants may alternatively determine the emissions intensity from similar facilities located outside of the geographical reference area or from peer reviewed studies and papers, providing justifications that the figures from the other facilities or from the studies and papers can reasonably be applied to the heat generation technology in the baseline geographical reference area.

7.2.1.3.6. Step 6. Selection of the BAT

81. The technology that constitutes the BAT is the one with the lowest emission intensity among those that are economically feasible and environmentally sound.

7.2.2. Calculation of baseline emissions prior to downward adjustment

82. Baseline emissions are determined according to the equation below and comprise the following sources, as applicable:

(a) Methane emissions from the SWDS;

(b) Electricity generation;

(c) Heat generation; and

(d) Natural gas used from a natural gas network.

$$BE_y = BE_{CH4,y} + BE_{EG,y} + BE_{HG,y} + BE_{NG,y} \quad \text{Equation (1)}$$

Where:

BE_y	=	Baseline emissions in year *y* (tCO_2e/year)
$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (tCO_2e/year)
$BE_{EG,y}$	=	Baseline emissions associated with electricity generation in year *y* (tCO_2e/year)
$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (tCO_2e/year)
$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (tCO_2e/year)

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

83. Baseline emissions of methane from Article 6.4 activities developed in an existing or new SWDS are determined based on the amount of actual methane that is captured under the activity, discounted by the amount that would have been captured and destroyed in the baseline (such as due to legal requirements). In addition, the effect of methane oxidation due to the cover material in the baseline shall be taken into account:

$$BE_{CH4} = \left[F_{CH4,AC,y} \times \left(1 - OX_y\right) - F_{CH4,BL,y}\right] \times GWP_{CH4} \quad \text{Equation (2)}$$

Where:

$BE_{CH4,y}$	=	Baseline emissions of methane from the SWDS in year *y* (t CO_2e/year)
OX_y	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline scenario in year *y* (dimensionless)
$F_{CH4,AC,y}$	=	Amount of methane in the LFG which is collected and sent to flares and/or use under the Article 6.4 activity scenario in year *y* (t CH_4/year)
$F_{CH4,BL,y}$	=	Amount of methane in the LFG that would be destroyed in the baseline in year *y* (t CH_4/year)
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

7.2.2.1.1. Ex post determination of $F_{CH4,AC,y}$

84. During the crediting period, $F_{CH4,AC,y}$ is determined as the sum of the quantities of methane flared, used for electricity or heat generation, and supplied to consumers via a natural gas distribution network and/or dedicated pipeline and/or to the trucks, as follows:

$$F_{CH4,AC,y} = F_{CH4,flared,y} + F_{CH4,EL,y} + \left(F_{CH4,HG,y} \times fd_{CH4,HG,j,default}\right) + F_{CH4,NG,y} \quad \text{Equation (3)}$$

Where:

$F_{CH4,AC,y}$	=	Amount of methane in the LFG which is collected and sent to flares and/or use under the Article 6.4 activity scenario in year *y* (t CH_4/year)
$F_{CH4,flared,y}$	=	Amount of methane in the LFG which is flared in year *y* (t CH_4/year)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG or in the biomethane which is used for electricity generation in year *y* (t CH_4/year)
$F_{CH4,HG,y}$	=	Amount of methane in the LFG or in the biomethane which is used for heat generation in year *y* (t CH_4/year)
$fd_{CH4,HG,j,default}$	=	Default value for the fraction of methane destroyed when used for heat generation equipment type *j*
$F_{CH4,NG,y}$	=	Amount of methane in the LFG or in the biomethane which is supplied to consumers via a natural gas distribution network and/or dedicated pipeline and/or trucks in year *y* (t CH_4/year)

85. $F_{CH4,flared,y}$ is determined as the difference between the amount of methane supplied to the flare(s) and any methane emissions from the flare(s), as follows:

$$F_{CH4,flared,y} = F_{CH4,sent-flares,y} - \frac{AE_{flare,y}}{GWP_{CH4}} \quad \text{Equation (4)}$$

Where:

$F_{CH4,sent-flares,y}$	=	Amount of methane in the LFG which is sent to the flares in year y (tCH4/year)
$AE_{flare,y}$	=	Activity emissions from flaring of the residual gas in year *y* (tCO_2e/year), determined as per the draft “Methodological tool: Activity emissions from flaring” (hereinafter referred to as the flaring tool)

86. $F_{CH4,sent-flares,y}$, $F_{CH4,EL,y}$, $F_{CH4,HG,y}$ and $F_{CH4,NG,y}$ are determined using the draft “Methodological tool: Determination of the mass flow of a greenhouse gas in a gaseous stream” (hereinafter referred toas the mass flow tool) and monitoring the working hours, so that no emission reduction are claimed for methane destruction during non-working hours. This is taken into account by monitoring the hours that the equipment utilizing the LFG is operating in year *y* ($Op_{j,h,y}$).

87. The following requirements apply:

(a) As per the mass flow tool, if the LFG is used for multiple purposes (e.g. flaring or energy generation), and all methane destruction devices are verified to be operational (e.g. by means of flame detectors records, energy generated), a single flow meter may be used to record the flow into multiple destruction devices. The destruction efficiency of the least efficient among the destruction devices shall be used as the destruction efficiency for all destruction devices monitored by this flow meter. If there are any periods for which one or more destruction devices are not operational, paragraph 5(a) and (b) of the Appendix of the mass flow tool shall be followed;

(b) CH_4 is the greenhouse gas for which the mass flow should be determined;

(c) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations (3) or (17) in the tool);

(d) The mass flow should be calculated on an hourly basis for each hour h in year y;

(e) The mass flow calculated for hour h is 0 if the equipment is not working in hour h ($Op_{j,h}$ = not working), the hourly values are then summed to a yearly unit basis.

7.2.2.1.2. Determination of OX_y

88. For Article 6.4 activities developed in existing SWDSs, the methodology provides three options to determine this parameter:

(a) **Option 1:** Annual monitoring of the parameter J_{out} (flux of methane leaving the surface, in g_{CH4}/m^2d) using the flux box method[10] and using the corresponding value for OX_y from Table 4;

(b) **Option 2:** Monitoring of the parameter J_{out} using the flux box method once prior to the start of each crediting period and using the corresponding value for OX_y from Table 4 for the whole crediting period, unless any changes to the cover are made during the crediting period. In that case, the flux must be re-measured after the change in the affected zone(s) and the higher value of OX_y for the cover layer before the change and after the change shall be used;

(c) **Option 3:** Use of the default values provided in Data / Parameters table 1 under section 11 below.

89. Table 8 sets out which of the three options may be applied by activity participants under which circumstances, depending on the type of SWDS, age of the SWDS cell and type of cover material. In the table, “X” indicates that the relevant option may be used; an empty cell indicates that the option shall not be used.

Table 7. Options applicable to determine OX_y for different types of SWDSs, the different age of the SWDS cell and the different types of cover materials

Type of SWDS	Age of the SWDS cell	Type of cover material	Option 1	Option 2	Option 3
Existing SWDS	Immature and mature	No cover (LDCs/SIDS)			X
		No cover (non-LDCs/SIDS)			X
		Synthetic			X

[10] Refer to Appendix 1 for the monitoring requirements using the flux box method.

Type of SWDS	Age of the SWDS cell	Type of cover material	Option 1	Option 2	Option 3
		Soil	X	X	X
	Aged	Soil	X		X
Hypothetical SWDS	N/A	Synthetic			X
		Soil			X

90. Where Option 1 or 2 is used, the activity participants shall divide the SWDS into different zones and measure the average flux of methane leaving the surface (J_{out}) for each zone, as per the procedure contained in Appendix 1. For each zone *i*, a value of the oxidation factor (OX_i) based on the measured flux shall be selected as per the table below:

Table 8. Values of OX_i, to be applied based on the measurements of J_{out}

J_{out} ($g_{CH4}/m^2.d$)	OX_i[11,(a)]
Lower than 10	0.384 +/- 8% uncertainty
Between 10 and 70	0.274 +/- 12% uncertainty
Above 70	0.124 +/- 45% uncertainty

[(a)] Uncertainties are based on the standard error, multiplied by 1.96 and divided by the mean, calculated from the statistics provided in table 3 of SWICS (2012), rounded up to the third decimal place, as per the guidance from Volume 1, Chapter 3 of the 2019 Refinement to the 2006 IPCC guidelines for national greenhouse gases inventories

91. Since the average flux of methane from the surface of the SWDS could differ significantly between different zones, OX_y is determined as the weighted average value based on the size of each zone[12], as follows:

$$OX_y = \sum_{i=1}^{n} OX_i \times \frac{Area_i}{Area_{Total}} \qquad \text{Equation (5)}$$

Where:

OX_y	=	Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline scenario (dimensionless)
OX_i	=	Average oxidation factor for the zone *i*

[11] Solid Waste Industry for Climate Solutions (SWICS); *Methane Oxidation Addendum;* 19 November 2012; Available at https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwic-PDexKiOAxX91AIHHVS9AAAQFnoECBgQAQ&url=https%3A%2F%2Fdownloads.regulations.gov%2FEPA-HQ-OAR-2012-0934-0088%2Fcontent.pdf&usg=AOvVaw2Gu9QjQcpN2qXPzko8Df7M&opi=89978449; accessed on 07 June 2025.

[12] Appendix 1 contains guidance to divide the landfill into different zones and to determine the number of locations and quantity of samples.

$Area_i$	=	Surface area of the zone *i* (m^2)
$Area_{Total}$	=	Surface area of the entire SWDS (m^2)
i	=	Zones of the SWDS

92. For Article 6.4 activities developed in new SWDSs, OX_y shall be based on the default values provided in Data / Parameters table 1 under section 13 below.

7.2.2.1.3. Determination of $F_{CH4,BL,y}$

93. This section provides a procedure to determine the amount of LFG that would have been captured and destroyed (by flaring) in the baseline due to legal or contractual requirements, to address safety and odour concerns, or for other reasons (collectively referred to as “requirements” in this section). The four cases in the table below are distinguished. Activity participants shall identify the appropriate case, and follow the corresponding instructions.

94. For Article 6.4 activities developed in new SWDSs, $F_{CH4,BL,y}$ shall be determined using Case 1 if there are no requirements to capture and destroy LFG or using Case 2 if there are requirements to capture and destroy LFG.

Table 9. Cases for determining LFG captured and destroyed in the baseline

Situation at the start of the project activity	Requirements to capture and destroy LFG	Existing LFG capture system
Case 1	No	No
Case 2	Yes	No
Case 3	No	Yes
Case 4	Yes	Yes

7.2.2.1.4. Determining $F_{CH4,BL,y}$ for Case 1

95. In the absence of a requirement to capture and destroy LFG and in the absence of an existing LFG capture and destruction system, $F_{CH4,BL,y} = 0$.

7.2.2.1.5. Determining $F_{CH4,BL,y}$ for Case 2

96. In this situation, $F_{CH4,BL,y} = F_{CH4,BL-case\ 2,y}$, and $F_{CH4,BL-case\ 2,y}$ is determined based on the different scenarios below:

 (a) Scenario A: If the requirement specifies the absolute amount of LFG ($F_{LFG,BL,R,y}$) that must be flared, then:

$$F_{CH4,BL-case\ 2,y} = F_{LFG,BL,R,y} \quad \text{Equation (6)}$$

(b) Scenario B: If the requirement specifies a fraction of the captured LFG ($F_{LFG,PJ,capt,y}$) that must be flared, the amount shall be calculated as follows:

$$F_{CH4,BL-case\ 2,y} = \rho_{reg,y} \times F_{LFG,AC,capt,y}$$ Equation (7)

(c) Scenario C: If the requirement does not specify the amount or the fraction of the captured LFG that must be flared but requires the installation of an LFG capture system, without requiring the LFG to be flared then:

$$F_{CH4,BL-case\ 2,y} = 0$$ Equation (8)

(d) Scenario D: if the requirement does not specify the amount or the percentage of the captured LFG that must be flared but requires the installation of a passive LFG capture system for safety reasons and flaring the LFG, then a typical destruction rate of 40% is assumed[13]:

$$F_{CH4,BL-case\ 2,y} = 0.4 \times F_{LFG,AC,capt,y}$$ Equation (9)

(e) Scenario E: If the requirement enforces the captured LFG to be flared without specifying the amount or fraction, no A6.4 ERs can be claimed.

Where:

$F_{CH4,BL-case\ 2,y}$	=	Amount of methane that would be destroyed in the baseline scenario in year *y* as per Case 2 (tCH_4/year)
$F_{LFG,BL,R,y}$	=	Amount of LFG which is flared in the baseline due to a requirement in year *y* (m^3/year), which is converted to the amount of methane (tCH_4/year) as per paragraph 97 below.
$\rho_{reg,y}$	=	Fraction of LFG that is required to be destroyed due to a requirement in year *y*
$F_{CH4,AC,capt,y}$	=	Amount of LFG which is captured in the activity scenario in year *y* (m^3/year), which is converted to the amount of methane (tCH_4/year) as per paragraph 97 below.

97. The following options apply to the approaches from paragraphs 96(a), 96(b) and 96(c) above to determine $F_{LFG,BL,R,y}$ and $F_{LFG,AC,capt,y}$:

(a) **Option 1:** Calculate the parameter using the mass flow tool, applying the following requirements:

(i) The mass flow tool shall be applied to the LFG pipeline immediately downstream of the LFG capture system and before any split in the gaseous flow to different uses or flares;

(ii) CH_4 is the greenhouse gases for which the mass flow should be determined;

[13] This default value of 40 per cent is based on assuming a situation in which: the efficiency of the LFG capture system in the activity scenario is 50 per cent; the efficiency of the LFG capture system in the baseline is 20 per cent; and the amount captured in the baseline is flared using an open flare with a destruction efficiency of 100 per cent, as a conservative approach. Activity participants may propose and justify an alternative default value as a request for revision to this methodology.

(iii) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations (3) or (17) in the tool); and

(iv) The mass flow should be calculated on an hourly basis for each hour *h* in year *y*.

(b) **Option 2:** Calculate the parameter as the sum of the amount of methane that is sent to the flare, used for electricity or heat generation or provided to consumers through dedicated pipeline, natural gas distribution network or trucks in year *y*, as determined in section 7.2.2.1.1 above.

7.2.2.1.6. Determining $F_{CH4,BL,y}$ for Case 3

98. In this situation, $F_{CH4,BL,y} = F_{CH4,BL-case\ 3,y}$, and $F_{CH4,BL-case\ 3,y}$ is determined based on the different scenarios below:

(a) Scenario A: If the amount of methane captured with the existing system can be monitored separately from the amount captured under the project, and the efficiency of the existing system is not impacted by the project system during the crediting period(s), then $F_{CH4,BL\text{-}case\ 3,y}$ is determined as follows:

$$F_{CH4,BL-case\ 3,y} = F_{CH4,BL-flare,y}$$ Equation (10)

(b) Scenario B: If the amount of methane captured with the existing system cannot be monitored separately from the amount captured under the project, but there is historic data on the amount of methane that was captured during the three years prior to the implementation of the project activity, then $F_{CH4,BL\text{-}case\ 3,y}$ is determined as the average fraction of LFG that was recovered in the three years prior to the implementation of the project activity will be the same fraction recovered under the project activity. In case data for less than 3 years, but at least for one year, is available, use the average fraction in the available years:

$$F_{CH4,BL-case\ 3,y} = \frac{\sum_{i=1}^{3} \frac{F_{CH4,BL,x-i}}{F_{CH4,x-i}}}{i} \times F_{CH4,AC,capt,y}$$ Equation (11)

Where:

$F_{CH4,BL-case\ 3,y}$	=	Amount of methane in the LFG that would be destroyed in the baseline scenario in year y as per Case 3 (tCH_4/year)
$F_{CH4,BL-flare,y}$	=	Amount of methane in the LFG which is sent to flare(s) under the baseline year *y* and which can be monitored separately (tCH_4/year)
$F_{CH4,BL,x-i}$	=	Amount of methane in the LFG which is captured and destroyed in the year *i* prior to the implementation of the Article 6.4 activity (tCH_4/year), calculated as per paragraph 99(b) below
$F_{CH4,x-i}$	=	Amount of methane in the LFG generated in the SWDS in the year *i* prior to the implementation of the Article 6.4 activity (tCH_4/year), calculated as per paragraph 99(b) below
$F_{CH4,AC,capt,y}$	=	Amount of methane in the LFG which is captured in the activity scenario in year *y* (tCH_4/year)
i	=	Year prior to the implementation of the Article 6.4 activity (i = 1, 2, 3)

99. The following applies to the scenarios from paragraph 98 above:

(a) $F_{CH4,BL\text{-}flare,y}$ shall be determined using mass flow tool and applying the requirements described in section 5.4.1.1, where the gaseous stream the tool shall be applied to is the pipeline collecting LFG from the existing LFG capture system.

(b) $F_{CH4,\ x\text{-}i}$ shall be estimated using the solid waste tool. The guidance and requirements described in section 5.4.1.2 for applying the tool shall be followed. The year *y* in the tool is equivalent to the year prior to the implementation of the project.

7.2.2.1.7. Determining $F_{CH4,BL,y}$ for Case 4

100. In this situation, $F_{CH4,BL,y}$ shall be determined as the higher between $F_{CH4,BL,y}$ determined for Case 2 and Case 3 above:

$$F_{CH4,BL-case\ 4,y} = max\{F_{CH4,BL-case\ 2,y}; F_{CH4,BL-case\ 3,y}\}$$ Equation (12)

Where:

$F_{CH4,BL-case\ 4,y}$	=	Amount of methane in the LFG that would be destroyed in the baseline scenario in year y as per Case 4 (tCH_4/year)
$F_{CH4,BL-case\ 2,y}$	=	Amount of methane in the LFG that would be destroyed in the baseline scenario in year y as per Case 2 (tCH_4/year), as per paragraphs 96–97 above
$F_{CH4,BL-case\ 3,y}$	=	Amount of methane in the LFG that would be destroyed in the baseline scenario in year y as per Case 3 (tCH_4/year), as per paragraphs 98–99 above

7.2.2.1.8. Ex ante estimation of $F_{CH4,PJ,y}$

101. An ex-ante estimate of $F_{CH4,PJ,y}$ is required to estimate baseline emission of methane from the SWDS (according to equation (2)) in order to estimate the emission reductions of the proposed Article 6.4 activity in the PDD. It is determined as follows:

$$F_{CH4,AC,y} = \eta_{AC} \times BE_{CH4,SWDS,y} / GWP_{CH4}$$ Equation (13)

Where:

$F_{CH4,AC,y}$	=	Amount of methane in the LFG which is flared and/or used in the activity in year *y* (t CH_4/year)
$BE_{CH4,SWDS,y}$	=	Amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y* (t CO_2e/year)
η_{AC}	=	Efficiency of the LFG capture system that will be installed in the activity
GWP_{CH4}	=	Global warming potential of CH_4 (t CO_2e/t CH_4)

102. $BE_{CH4,SWDS,y}$ is determined using the solid waste tool. The following guidance should be taken into account when applying the tool:

(a) f_y in the tool shall be assigned a value of 0 because the amount of LFG that would have been captured and destroyed is already accounted for in equation (2) of this methodology;

(b) In the tool, *x* begins with the year that the SWDS started receiving waste (e.g. the first year of SWDS operation);

(c) OX_y is determined as the weighted average OX_i calculated for the SWDS if information of OX_i from different zones are available; otherwise, use the default values from the table Data / Parameter 1 under section 11 below; and

(d) Sampling to determine the fractions of different waste types is not necessary because the waste composition can be obtained from previous studies.

7.2.2.2. Baseline emissions associated with electricity generation ($BE_{EG,y}$)

7.2.2.2.1. Electricity generated and supplied to the electric grid

103. Baseline emissions from electricity generated and supplied to the electric grid are calculated as follows:

$$BE_{EG,grid,y} = EG_y \times EF_{grid,y}$$ Equation (14)

Where:

$BE_{EG,grid,y}$	=	Baseline emissions from electricity generated and supplied to the electric grid in year *y* (tCO_2/year)
EG_y	=	Quantity of electricity generated by the power plant in the activity scenario in year *y* (MWh/year)
$EF_{grid,y}$	=	Emission factor of the electric grid in year *y* (tCO_2/MWh)

104. Apply one of the following default values for $EF_{grid,y}$:

(a) 0.2 tCO_2/MWh for electricity supplied to the electric grid where the proportion of renewable energy (including solar and wind) and nuclear energy in the annual electricity generation in the electric grid is 33% or less for the latest year which data is available;

(b) 0.1 tCO_2/MWh for electricity supplied to the electric grid where the proportion of renewable energy (including solar and wind) and nuclear energy in the annual electricity generation in the electric grid exceeds 33% but is less than 67% for the latest year which data is available;

(c) 0.03 CO2/MWh for electricity supplied to the electric grid where the proportion of renewable energy (including solar and wind) and nuclear energy in the annual electricity generation in the electric grid exceeds 67% for the latest year which data is available, or where its proportion is uncertain.

7.2.2.2.2. Electricity generation replacing electricity generated in an existing captive fossil fuel fired power plant

105. Baseline emissions from electricity generation replacing electricity generated in an existing captive fossil fuel fired power plant are calculated as follows:

$$BE_{EG,captive-existing,y} = EG_y \times EF_{captive,y}$$ Equation (15)

Where:

$BE_{EG,captive-existing,y}$	=	Baseline emissions from electricity generated replacing electricity generated in an existing captive fossil fuel fired power plant in year *y* (t CO_2/year)
EG_y	=	Electricity generated by the power plant in the activity scenario in year *y* (MWh/year)
$EF_{captive,y}$	=	Emission factor of the replaced captive fossil fuel fired power plant in year y (MWh/year)

106. Apply a default value equal to 0.3 tCO_2/MWh for $EF_{captive,y}$.

7.2.2.2.3. Electricity generation replacing electricity generated in a new captive fossil fuel fired power plant

107. Baseline emissions from electricity generation replacing electricity generated in a new captive fossil fuel fired power plant are calculated as follows:

$$BE_{EG,captive-new,y} = EG_y \times EF_{CO2,EG,BAT} \quad \text{Equation (16)}$$

Where:

$BE_{EG,captive-new,y}$	=	Baseline emissions from electricity generated replacing electricity generated in a new captive fossil fuel fired power plant in year *y* (tCO_2/year)
EG_y	=	Electricity generated by the power plant in the activity scenario in year *y* (MWh/year)
$EF_{CO2,EG,BAT}$	=	CO_2 emissions intensity of the best-available technology (tCO_2e/MWh) identified in section 7.2.1.2 above

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

7.2.2.3.1. Heat generation replacing heat generated in an existing equipment

108. The baseline emissions associated with heat generation replacing heat generated in an equipment in year *y* ($BE_{HG,y}$) are determined based on the amount of methane in the LFG or the biomethane which is sent to the heat generation equipment in the Article 6.4 activity (boiler, air heater, glass melting furnace(s) and/or kiln), as follows:

$$BE_{HG,y} = NCV_{CH4} \times \sum_{j=1}^{n} \left(R_{efficiency,j,y} \times F_{CH4,HG,dest,j,y} \times EF_{CO2,BL,HG,j} \right) \quad \text{Equation (17)}$$

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year *y* (tCO_2/year)
NCV_{CH4}	=	Net calorific value of methane at reference conditions (TJ/tCH_4)
$R_{efficiency,j,y}$	=	Ratio of the project and baseline efficiency of heat equipment type *j* in year *y*
$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG or the biomethane which is destroyed for heat generation by equipment type *j* in year *y* (tCH_4/year)

$EF_{CO2,BL,HG,j}$	=	CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *j* in the baseline (tCO_2/TJ)
j	=	Heat generation equipment (boiler, air heater, glass melting furnace(s) or kiln)
n	=	Number of different heat generation equipment used in the project activity

109. The ratio of the project and baseline efficiency of an air heater, boiler, glass melting furnace or kiln ($R_{efficiency,j,y}$) is determined as follows:

$$R_{efficiency,j,y} = min\left\{1; \frac{\eta_{HG,AC,j,y}}{\eta_{HG,BL,j}}\right\}$$ Equation (18)

Where:

$R_{efficiency,j,y}$	=	Ratio of the project and baseline efficiency of equipment type *j* in year *y*
$\eta_{HG,BL,j}$	=	Efficiency of the heat generation equipment type *j* used in the baseline
$\eta_{HG,ACJ,j,y}$	=	Efficiency of the heat generation equipment type *j* used in the Article 6.4 activity in year *y*
j	=	Heat generation equipment type (boiler, air heater, glass melting furnace(s) or kiln)

110. Activity participants shall apply a baseline energy efficiency as the highest between the information provided by the manufacturer of the air heater, boiler, glass melting furnace(s) or kiln ($\eta_{HG,BL,j}$) or 90%.[14]

111. The amount of methane that is destroyed in the LFG that is sent to heat generation equipment *j* ($F_{CH4,HG,dest,j,y}$) is determined with equation (19) if *j* is a boiler or air heater, or glass melting furnace, or with equation (20) if *j* is a brick kiln. For the particular case of intermittent brick kilns, project participants may choose to apply either equation (19) or (20).

$$F_{CH4,HG,dest,j,y} = fd_{CH4,HG,j,default} \times F_{CH4,HG,j,y}$$ Equation (19)

Where:

$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by equipment type *j* in year *y* (tCH_4/year)
$fd_{CH4,HG,j,default}$	=	Default value for the fraction of methane destroyed when used for heat generation equipment type *j*
$F_{CH4,HG,j,y}$	=	Amount of methane in the LFG which is used for heat generation equipment type *j* in year *y* (tCH_4/year)

[14] Value from new boilers running on natural gas, sourced from Vatopoulos, K., Andrews, D., Carlsson, J., Papaioannou, I. & Zubi, G., 2012. *Study on the state of play of energy efficiency of heat and electricity production technologies*. Luxembourg: Publications Office of the European Union. EUR 25406 EN. Available at: https://doi.org/10.2790/57624.

112. $F_{CH4,HG,j,y}$ is determined according to section 5.4.1.1, where j is each item of heat generation equipment.

$$F_{CH4,HG,dest,j,y} = \sum_{h=1}^{8,760} \left(fd_{CH4,kiln,h} \times F_{CH4,HG,kiln,h}\right)$$ Equation (20)

113. With: $fd_{CH4,kiln,h}$ = 0.9 as per the table from default values if $Q_{O2,kiln,h}$ > 0, and otherwise $fd_{CH4,kiln,h}$ = 0.

Where:

$F_{CH4,HG,dest,j,y}$	=	Amount of methane in the LFG which is destroyed for heat generation by brick kiln in year y (tCH_4/year)
$fd_{CH4,kiln,h}$	=	Fraction of methane destroyed when used for heat generation in a brick kiln in hour h
$F_{CH4,HG,kiln,h}$	=	Amount of methane in the LFG which is used for heat generation by brick kiln in hour h (tCH_4/hour)
$Q_{O2,kiln,h}$	=	Average volumetric fraction of oxygen in the exhaust gas flow of the kiln in hour h (volume of O_2/volume of the gas stream)
h	=	Hours in year y

114. $F_{CH4,HG,kiln,h}$ is determined using the mass flow tool, following the requirements given in section 5.4.1.1 for j = kiln, except that the mass flow should be summed to an hourly (not yearly) unit basis (tCH_4/hour).

7.2.2.3.2. Heat generation replacing heat generated in new equipment

115. The baseline emissions associated with heat generation replacing heat generated in new equipment in year y ($BE_{HG,y}$) are determined by multiplying the output of the heat generation equipment by the emissions intensity of the technology identified at the best available technology, as follows:

$$BE_{HG,y} = Q_{output,y} \times EF_{CO2,HG,BAT}$$ Equation (21)

Where:

$BE_{HG,y}$	=	Baseline emissions associated with heat generation in year y (tCO_2/year)
$Q_{output,y}$	=	Quantity of the output produced by the heat generation equipment in year y (units of output/year)
$EF_{CO2,HG,BAT}$	=	CO_2 emissions intensity of the best-available technology (tCO2e/unit of output) identified in section 7.2.1.3 above

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

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

$$BE_{NG,y} = 0.0504 \times F_{CH4,NG,y} \times EF_{CO2,NG,y}$$ Equation (22)

Where:

$BE_{NG,y}$	=	Baseline emissions associated with natural gas use in year *y* (tCO_2e/year)
0.0504	=	Conversion factor (TJ/tCH4)
$EF_{CO2,NG,y}$	=	Average CO_2 emission factor of natural gas in the natural gas network or dedicated pipeline, or used by consumers in year *y* (tCO2e/TJ)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG which is sent to the natural gas distribution network or dedicated pipeline or to the trucks in year *y* (t CH_4/year)

7.3. Application of the downward adjustment

7.3.1. Downward adjustment in the calendar year of the start date of the first crediting period

117. For Article 6.4 activities developed in new SWDSs, or for Article 6.4 activities that involve the electricity generation replacing electricity generated in new captive fossil fuel fired power plants or the heat generation replacing heat generated in new equipment, there is no need to determine the downward adjustment in the calendar year of the start date of the first crediting period, and activity participants shall move to section 7.3.2 below.

118. For Article 6.4 activities developed in existing SWDSs or Article 6.4 activities that involves the electricity generation and supply to the grid, or the electricity generation replacing an existing captive power plant, or that involves the heat generation replacing existing heat generation equipment or that involves the supply of LFG or biomethane to consumers, the downward adjustment to the baseline must be determined for each of these components and applied in the calendar year of the start date of the first crediting period as per the following steps:

7.3.1.1. Step 1. Determine the uncertainty at the lower bound of the uncertainty interval for each baseline emission component *i* ($UNC_{BE\ act/hist,i,CP1}$)

119. Activity participants shall determine the overall uncertainty of baseline emissions for each baseline emission component *i* (i.e. methane, electricity, heat and LFG/biomethane supply) at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante estimated baseline emissions during the first crediting period ($UNC_{BE\ act/hist,i,CP1}$), considering the uncertainty in all parameters used to calculate baseline emissions following the guidance from Volume 1, Chapter 3 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories through the error propagation method or through the Monte Carlo simulation.

120. Activity participants shall document the uncertainties used for each parameter, specify assumptions made and include any associated references for estimating the uncertainties of parameters in the PDD. The derivation of the overall uncertainty through the error propagation or Monte Carlo simulation shall be provided together with the Article6.4 PDD (e.g. through a spreadsheet).

7.3.1.2. Step 2. Determine the downward adjusted baseline emissions and/or removals based on uncertainty for each baseline emission component *i* ($BE_{adj,UNC,i,y}$)

121. For the calendar year of the start date of the first crediting period, determine the downward adjusted baseline emissions for each baseline emission component *i* based on uncertainty ($BE_{adj,UNC,i,y}$) as follows:

$$BE_{adj,UNC,i,y} = BE_{act/hist,i,y} \times \left(1 - UNC_{BE\ act/hist,i,CP1}\right) \quad \text{Equation (23)}$$

Where:

$BE_{adj,UNC,i,y}$	=	Downward adjusted baseline emissions based on uncertainty for each baseline emission component *i* in year *y* (tCO2e/year)
$BE_{act/hist,i,y}$	=	Unadjusted existing actual or historical net baseline emissions and/or removals for each baseline emission component *i* in year *y* (tCO_2e/year)
$UNC_{BE\frac{act}{hist},i,CP1}$	=	Uncertainty of baseline emissions at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante quantified unadjusted net baseline emissions for each baseline emission component *i* during the first crediting period (fraction)
y	=	Calendar year of the start date of the first crediting period
i	=	Baseline emissions component (i.e. methane, electricity, heat and LFG/biomethane supply)

7.3.1.3. Step 3. Determine the minimum downward adjusted baseline emissions ($BE_{adj,min,i,y}$)

122. The minimum downward adjusted baseline shall be determined during the first year of the crediting period for each baseline emission component *i* as follows:

$$BE_{adj,min,i,y} = BE_{act/hist,i,y} - \left(BE_{act/hist,i,y} - AE_{i,y}\right) \times 0.1 \quad \text{Equation (24)}$$

Where:

$BE_{adj,min,i,y}$	=	Minimum downward adjusted baseline emissions for each baseline emission component *i* in year *y* (tCO_2e/year)
$BE_{act/hist,i,y}$	=	Unadjusted existing actual or historical net baseline emissions for each baseline emission component *i* in year *y* (tCO_2e/year)
$AE_{i,y}$	=	Activity emissions for each baseline emission component *i* in year *y* (tCO_2e/year)
y	=	Calendar year of the start date of the first crediting period
i	=	Baseline emissions component (i.e. methane, electricity, heat and LFG/biomethane supply)

7.3.1.4. Step 4. Compare $BE_{adj,UNC,i,y}$ and $BE_{adj,min,i,y}$

123. The downward adjusted baseline shall be the minimum between $BE_{adj,UNC,i,y}$ and $BE_{adj,min,i,y}$, as follows:

$$BE_{adj,i,y} = min(BE_{adj,min,i,y}\ ;\ BE_{adj,UNC,i,y}) \quad \text{Equation (25)}$$

Where:

$BE_{adj,y}$	=	Downward adjusted baseline emissions for each baseline emission component *i* in year *y* (tCO_2e/year)
y	=	Calendar year of the start date of the first crediting period
i	=	Baseline emissions component (i.e. methane, electricity, heat and LFG/biomethane supply)

7.3.2. Downward adjustment in subsequent years

7.3.2.1. Downward adjustment in subsequent years for the methane component

124. For Article 6.4 activities implemented in existing SWDSs, where the baseline has been determined based on existing or actual/historical emissions adjusted downwards, the starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above.

125. For Article 6.4 activities implemented in new SWDS, where the baseline has been determined based on the best available technology, the starting point for increasing the downward adjustment over time shall be the emissions corresponding to the best available technology in the calendar year of the start date of the first crediting period, as determined in section 7.2.1.1.6 above.

126. For activities implemented in existing and new SWDSs, the annual increase in the downward adjustment shall be applied starting on 1 January of a calendar year. The first increase shall be applied on 1 January of the calendar year following the calendar year of the start date of the first crediting period. A pro-rata approach may be used to apply this minimum value to periods other than a full calendar year.

127. The following downward adjustments shall be applied depending on whether the LFG is destroyed in flares and/or used under the Article 6.4 activity as per the equations below:

(a) If the LFG is destroyed in flares, apply the maximum between (i) the 1% increase in the downward adjustment to the baseline emissions in the calendar year of the start date of the first crediting period and (ii) the baseline emissions from flaring of LFG by applying an Adjustment Factor ($AF_{Flare,y}$) for open and enclosed flares provided in the table below:

$$F_{CH4,flared,adj,y} = F_{CH4,flared,y} - \left[DA_{CH4,flared} + max\begin{pmatrix} F_{CH4,flared,y_1} \times 0.01 \times (y - y_1) \\ or \\ F_{CH4,flared,y} \times (1 - AF_{Flare,y}) \end{pmatrix}\right] \quad \text{Equation (26)}$$

Where:

$F_{CH4,flared,adj,y}$	=	Downward adjusted emissions from the methane which is flared in year *y* (tCH_4/year)
$F_{CH4,flaredy}$	=	Amount of methane in the LFG which is flared in year *y* (t CH_4/year), determined based on paragraph 85 above
$DA_{CH4,flared}$	=	Initial downward adjustment to the methane emissions from methane which is flared (tCH_4/year)
$F_{CH4,flared,y_1}$	=	Emissions from the methane which is flared in the calendar year of the start date of the first crediting period (tCH_4/year)
y	=	Year of the crediting period
y_1	=	Calendar year of the start date of the first crediting period
$AF_{flare,y}$	=	Adjustment factor for the methane which is flared in year *y* (%).

128. The Adjustment Factor to the default or monitored flare destruction efficiencies for open and enclosed flares is proposed as an approach to both adjust downward the baseline and to prevent locking-in the levels of emissions and carbon-intensive technologies by discouraging activities that only flare the collected LFG without energy recovery and utilization. The application of this adjustment factor is done as follows:

(a) For open flares:

(i) Monitoring of flare efficiency is not allowed; andt

(ii) Activity participants shall multiply the amount of LFG flared by the Adjustment Factor provided in Table 10 below for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period). For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an Adjustment Factor of 0% shall be applied;

(b) For enclosed flares:

(i) Monitoring of flare efficiency is allowed; and

(ii) Activity participants shall apply one of the approaches below:

a. If activity participants chose to determine the flare efficiency based on the default values as per Option A of the flaring tool, the amount of LFG flared shall be multiplied by an Adjustment Factor provided in Table 10 below for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period). For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an Adjustment Factor of 0% shall be applied.

b. If activity participants choose to determine the flare efficiency based on measurements as per Option B of the flaring tool, the values monitored during the crediting period shall be multiplied by an Adjustment Factor provided in Table 10 below for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period). For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an Adjustment Factor of 0% shall be applied.

Table 10. Adjustment Factor ($AF_{flare,y}$) for LFG destruction in flares

Calendar year of the first or fixed crediting period	$AF_{flare,y}$
1	100%
2	80%
3	60%
4	40%
5	20%
2nd crediting period onwards or 6th year of the fixed crediting period onwards	0%

{Option 1}

129. Option 1: For activities developed in SWDS that have a capacity to generate less than [1 MW] [3 MW] [5 MW] of electricity, the Overall Adjustment Factor does not have to be applied and, instead, an annual 1% reduction from the baseline emissions in the calendar year of the start date of the first crediting period shall be applied.

{End of Option 1}

{Option 2}

130. Option 2: If activity participants are able to prove that below a specific threshold for the annual amount of waste deposited in the SWDS, the energy generation or supply of LFG or biomethane to consumers is not economically attractive including the revenues from A6.4 ERs, then the Overall Adjustment Factor does not have to be applied and, instead, an annual 1% reduction from the baseline emissions in the calendar year of start date of the first crediting period shall be applied.

{End of Option 2}

{Option 3}

No text

{End of Option 3}

131. For Article 6.4 activities implemented in new SWDSs, $DA_{CH4,flared}$ is equal to 0. For activities implemented in existing SWDSs, $DA_{CH4,flared}$ is determined as follows:

$$DA_{CH4,flared} = max\begin{pmatrix} \left(F_{CH4,flared,y_1} - AE_{y_1}\right) \times 0.1 \\ or \\ F_{CH4,flared,y_1} \times UNC_{F_{CH4,flared,CP1}} \end{pmatrix}$$ Equation (27)

Where:

AE_{y_1}	=	Activity emissions in the calendar year of the start date of the first crediting period (tCO_2)
$UNC_{F_{CH4,flared,CP1}}$	=	Uncertainty of emissions from methane flared at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante quantified unadjusted emissions from methane flared during the first crediting period (fraction)

(a) If the LFG is not destroyed in flares but used for electricity or heat generation or supplied to consumers, apply an annual increase in the downward adjustment that represents 1% of the baseline emissions in the calendar year of the start date of the first crediting period – a pro-rata approach may be used to apply this minimum value to periods other than a full calendar year, as per the equations below.

$$F_{CH4,EL,adj,y} = F_{CH4,EL,y} - \left[DA_{CH4,EL} + F_{CH4,EL,y_1} \times 0.01 \times (y - y_1)\right]$$ Equation (28)

$$F_{CH4,HG,adj,y} = F_{CH4,HG,y} - \left[DA_{CH4,HG} + F_{CH4,HG,y_1} \times 0.01 \times (y - y_1)\right]$$

$$F_{CH4,NG,adj,y} = F_{CH4,NG,y} - \left[DA_{CH4,NG} + F_{CH4,NG,y_1} \times 0.01 \times (y - y_1)\right]$$

Where:

$F_{CH4,EL,adj,y}$	=	Downward adjusted emissions from the methane which is used for electricity generation in year *y* (tCH_4/year)
$F_{CH4,HG,adj,y}$	=	Downward adjusted emissions from the methane which is used for heat generation in year *y* (tCH_4/year)
$F_{CH4,NG,adj,y}$	=	Downward adjusted emissions from the methane which is supplied to consumers in year *y* (tCH_4/year)
$F_{CH4,EL,y}$	=	Amount of methane in the LFG which is used for electricity generation in year *y* (t CH_4/year), determined based on paragraph 86 above
$F_{CH4,HG,y}$	=	Amount of methane in the LFG which is used for heat generation in year *y* (t CH_4/year), determined based on paragraph 86 above
$F_{CH4,NG,y}$	=	Amount of methane in the LFG or in the biomethane which is supplied to consumers in year *y* (t CH_4/year), determined based on paragraph 86 above
$DA_{CH4,EL}$	=	Initial downward adjustment to the methane in the LFG which is used for electricity generation (t CH_4/year)
$DA_{CH4,HG}$	=	Initial downward adjustment to the methane in the LFG which is used for electricity generation in year *y* (t CH_4/year)

$DA_{CH4,NG}$	=	Initial downward adjustment to the methane in the LFG or in the biomethane which is supplied to consumers in year *y* (t CH_4/year)
F_{CH4,EL,y_1}	=	Emissions from the methane which is used for electricity generation in the calendar year of the start date of the first crediting period (tCH_4/year)
F_{CH4,HG,y_1}	=	Emissions from the methane which is used for heat generation in the calendar year of the start date of the first crediting period (tCH_4/year)
F_{CH4,NG,y_1}	=	Emissions from the methane which is supplied to consumers in the calendar year of the start date of the first crediting period (tCH_4/year)
y	=	Year of the crediting period
y_1	=	Calendar year of the start date of the first crediting period

132. For Article 6.4 activities implemented in new SWDSs, $DA_{CH4,EL}$, $DA_{CH4,HG}$ and $DA_{CH4,NG}$ are equal to 0. For activities implemented in existing SWDSs, these parameters are determined based on the same equation from paragraph 128 above replacing the index “flared” by “EL”, “HG” or “NG”.

7.3.2.2. Downward adjustment in subsequent years for the electricity generation component

133. For Article 6.4 activities that involve the electricity generation and supply to an electric grid or electricity generation replacing the electricity generated in existing captive power plant, where the baseline has been determined based on existing or actual/historical emissions adjusted downwards, the starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above.

134. For Article 6.4 activities that involve the electricity generation replacing electricity generated in new captive power plant, where the baseline has been determined based on the best available technology, the annual increase in the downward adjustment shall be applied starting on 1 January of a calendar year. The first increase shall be applied in the calendar year following the calendar year of the start date of the first crediting period. A pro-rata approach may be used to apply this minimum value to periods other than a full calendar year.

135. The starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above, and the downward adjustment shall be the decrease in the emissions from the generation of electricity by 1% of the baseline emissions in the calendar year of the start date of the first crediting period, and the downward adjusted baseline in year *y* of the crediting period is calculated based on the equation below.

$$BE_{EG,adj,y} = BE_{EG,y} - \left[DA_{BE_{EG}} + \left(BE_{EG,y_1} \times 0.01 \times (y - y_1)\right)\right] \quad \text{Equation (29)}$$

Where:

$BE_{EG,adj,y}$	=	Downward adjusted baseline emissions from the electricity generation component in year *y* (tCO_2e/year)
$BE_{EG,y}$	=	Baseline emissions from the electricity generation component in year *y* (tCO_2e/year), determined based on section 7.2.2.2 above

$DA_{BE_{EG}}$	=	Initial downward adjustment to electricity generation component (tCO_2/year)
BE_{EG,y_1}	=	Baseline emissions from the electricity generation component in the calendar year of the start date of the first crediting period (tCO_2/year)
y	=	Year of the crediting period
y_1	=	Calendar year of the start date of the first crediting period

136. For Article 6.4 activities that involve the generation of electricity replacing electricity from new captive fossil fuel fired power plant, DA_{BEEG} is equal to 0. For Article 6.4 activities that involve the generation of electricity and supply to the electric grid or that involve the generation of electricity replacing electricity from an existing captive fossil fuel fired power plant, DA_{BEEG} is determined as follows:

$$DA_{BE_{EG}} = max\begin{pmatrix} (BE_{EG,y_1} - AE_{y_1}) \times 0.1 \\ or \\ BE_{EG,y_1} \times UNC_{BE_{EG,CP1}} \end{pmatrix}$$ Equation (30)

Where:

AE_{y_1}	=	Activity emissions in the calendar year of the start date of the first crediting period (tCO_2)
$UNC_{BE_{EG,CP1}}$	=	Uncertainty of emissions from baseline emissions for the electricity generation component at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante quantified unadjusted emissions from methane flared during the first crediting period (fraction)

7.3.2.3. Downward adjustment in subsequent years for the heat generation component

137. For Article 6.4 activities that involve the generation of heat in existing heat generation equipment, where the baseline has been determined based on existing or actual/historical emissions adjusted downwards, the starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above

138. For Article 6.4 activities that involve the generation of heat replacing new heat generation equipment, where the baseline has been determined based on the best available technology, the annual increase in the downward adjustment shall be applied starting on 1 January of a calendar year. The first increase shall be applied in the calendar year following the calendar year of the start date of the first crediting period. A pro-rata approach may be used to apply this minimum value to periods other than a full calendar year.

139. The starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above, and the downward adjustment for shall be the decrease in the emissions from the heat generation equipment by 1% of the baseline emissions in the calendar year of the start date of the first crediting period, and the downward adjusted baseline in year *y* of the crediting period is calculated based on the equation below.

$$BE_{HG,adj,y} = BE_{HG,y} - \left[DA_{BE_{HG}} + BE_{HG,y_1} \times 0.01 \times (y - y_1)\right]$$ Equation (31)

Where:

$BE_{HG,adj,y}$	=	Downward adjusted baseline emissions from the heat generation component in year *y* (tCO_2e/year)
$BE_{HG,y}$	=	Baseline emissions from the heat generation component in year *y* (tCO_2e/year), determined based on section 7.2.2.3 above
$DA_{BE_{HG}}$	=	Initial downward adjustment to heat generation component (tCO_2/year)
BE_{HG,y_1}	=	Baseline emissions from the heat generation component in the calendar year of the start date of the first crediting period (tCO_2/year)
y	=	Year of the crediting period
y_1	=	Calendar year of the start date of the first crediting period

140. For Article 6.4 activities that involve the heat generation replacing heat generated in a new equipment, $DA_{BE_{HG}}$ is equal to 0. For Article 6.4 activities that involve the heat generation replacing heat generated in an existing equipment, $DA_{BE_{HG}}$ is determined as follows:

$$DA_{BE_{HG}} = max\begin{pmatrix}\left(BE_{HG,y_1} - AE_{y_1}\right) \times 0.1 \\ or \\ BE_{HG,y_1} \times UNC_{BE_{HG,CP1}}\end{pmatrix}$$ Equation (32)

Where:

AE_{y_1}	=	Activity emissions in the calendar year of the start date of the first crediting period (tCO_2)
$UNC_{BE_{HG,CP1}}$	=	Uncertainty of emissions from baseline emissions for the heat generation component at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante quantified unadjusted emissions from methane flared during the first crediting period (fraction)

7.3.2.4. Downward adjustment in subsequent years for the supply of LFG or biomethane to consumers component

141. The starting point for increasing the downward adjustment over time shall be the downward adjusted baseline values in the calendar year of the start date of the first crediting period, as determined in section 7.3.1 above, and the downward adjustment shall be the decrease in the emissions from the supply of LFG or biomethane by 1% of the baseline emissions in the calendar year of the start date of the first crediting period, and the downward adjusted baseline in year *y* of the crediting period is calculated based on the equation below.

$$BE_{NG,adj,y} = BE_{NG,y} - \left[DA_{NG} + BE_{NG,y_1} \times 0.01 \times (y - y_1)\right]$$ Equation (33)

Where:

$BE_{NG,adj,y}$	=	Downward adjusted baseline emissions from the supply of LFG or biomethane to consumers component in year *y* (tCO_2e/year)

$BE_{NG,y}$	=	Baseline emissions from the supply of LFG or biomethane to consumers component in year *y* (tCO_2e/year), determined based on section 7.2.2.4 above
$DA_{BE_{NG}}$	=	Initial downward adjustment to the supply of LFG or biomethane to consumers component (tCO_2/year)
BE_{NG,y_1}	=	Baseline emissions from the supply of LFG or biomethane to consumers in the calendar year of the start date of the first crediting period (tCO_2/year)
y	=	Year of the crediting period
y_1	=	Calendar year of the start date of the first crediting period

142. $DA_{BE_{NG}}$ is determined as follows:

$$DA_{BE_{NG}} = max\begin{pmatrix}\left(BE_{NG,y_1} - AE_{y_1}\right) \times 0.1 \\ or \\ BE_{NG,y_1} \times UNC_{BE_{NG,CP1}}\end{pmatrix}$$ Equation (34)

Where:

AE_{y_1}	=	Activity emissions in the calendar year of the start date of the first crediting period (tCO_2)
$UNC_{BE_{NG,CP1}}$	=	Uncertainty of emissions from baseline emissions for the supply of LFG or biomethane to consumers component at the lower bound of the 95% confidence interval relative to the central estimate of the ex-ante quantified unadjusted emissions from methane flared during the first crediting period (fraction)

7.4. Identification of the conservative BAU scenario

143. The conservative business-as-usual (BAU) scenario for each component of Article 6.4 activities eligible under this methodology are:

Table 11. BAU for the different components of Article 6.4 activities eligible under the methodology under the different baseline approaches

Component	Baseline approach (see Table 6 above)	BAU
LFG – Article 6.4 activities implemented in an existing SWDS	Existing actual or historical emissions	Continuation of the historical situation, i.e. the collection and destruction of the LFG in the existing SWDS to address legal requirements, contractual requirements or safety and odour concerns.

Component	Baseline approach (see Table 6 above)	BAU
LFG – Article 6.4 activities implemented in new SWDS	Best available technologies that represent an economically feasible and environmentally sound course of action	SWDS using the similar design and management practices in the geographical area, i.e. the collection and destruction of the LFG to address legal requirements, contractual requirements or safety and odour concerns, with the same cover type identified under the BAT.
Electricity generation and supply to the grid	Existing actual or historical emissions (grid emission factor)	Continuation of the historical situation, i.e. the generation of electricity from power plants connected to the grid;
Electricity generation replacing existing captive power plants	Existing actual or historical emissions	Continuation of the historical situation, i.e. the generation of electricity in the captive power plant using the baseline fuel
Electricity generation replacing new captive power plants	Best available technologies that represent an economically feasible and environmentally sound course of action	The average emissions intensity of any new capacity from other new power plants in similar projects that started operations in the past three years, provided that: a. The new captive power plants operate within the geographical reference area; b. The users of the electricity generated from the new captive power plants are the same; c. The new captive power plant has equivalent capacity of the new captive power plant installed as part of the project
Heat generation replacing existing heat generation equipment	Existing actual or historical emissions	Continuation of the historical situation, i.e. the generation of heat using the baseline equipment and fuel

Component	Baseline approach (see Table 6 above)	BAU
Heat generation replacing new heat generation equipment	Best available technologies that represent an economically feasible and environmentally sound course of action	The average emissions intensity of any new capacity from other new heat generation equipment in similar projects that started operations in the past three years, provided that: a. The other new heat generation equipment operates within the geographical reference area; b. The type of output (e.g. hot water, hot air, saturated steam, overheated steam, brick, melted glass, etc) and the users (e.g. residential, commercial and institutional consumers, industrial processes, etc) of the other new heat generation equipment are the same; c. The other new heat generation equipment has equivalent capacity of the new heat generation equipment installed as part of the project.
Supply of LFG or biomethane to consumers	Existing actual or historical emissions	Continuation of the historical situation, i.e. consumers supplied by natural gas.

144. In determining the BAU scenario and quantifying the BAU emissions, activity participants shall identify and incorporate in the BAU:

(a) Any policies that are active or scheduled to take effect within the crediting period, unless they refer to or formally integrate the mechanism as an instrument for implementation. All legal requirements shall be deemed to be enforced while recognizing that regulatory environments vary; and

(b) Any specific national or sub-national targets for the sector or the type of activity, as long as these are supported by policy frameworks for implementation, but not general goals that are not specific to the sector or type of activity (e.g. national emissions target).

7.4.1. Calculation of the conservative BAU emissions

145. BAU emissions for each component *i* (methane, electricity, heat and supply of LFG/biomethane) are determined as follows:

(a) For Article 6.4 activities where the BAU for the component *i* is the continuation of the historical situation: through the same equations applied to determine baseline emissions included in section 7.2.2 above;

(b) For Article 6.4 activities where the BAU for the component *i* is SWDS using the similar design and management practices in the geographical area: through the same equations applied to determine baseline emissions under section 7.2.2.1

above but applying the oxidation factor corresponding to the cover type identified under the BAT analysis in section 7.2.1.1 above. The oxidation factor shall be determined based on the default values provided in the Data / Parameter table 1;

(c) For Article 6.4 activities where the BAU for the component *i* is determined based on the average emissions intensity of any new capacity in the past 3 years, use the equations below:

$$BAU_{HG,y} = Q_{output,y} \times EF_{CO2,HG,BAU}$$ Equation (35)

$$BAU_{EG,y} = EG_y \times EF_{CO2,EG,BAU}$$ Equation (36)

Where:

$BAU_{HG,y}$	=	BAU emissions associated with heat generation in year *y* (tCO_2/year)
$Q_{output,y}$	=	Quantity of the output produced by the heat generation equipment in year *y* (units of output/year)
$EF_{CO2,HG,BAU}$	=	Average CO_2 emissions intensity of any new capacity from other new heat generation plants in similar projects that started operations in the past three years (tCO_2e/unit of output)
$BAU_{EG,y}$	=	BAU emissions associated with heat generation in year *y* (tCO_2/year)
EG_y	=	Electricity generated by the power plant in the activity scenario in year *y* (MWh/year)
$EF_{CO2,EG,BAU}$	=	Average CO_2 emissions intensity of any new capacity from other new power plants in similar projects that started operations in the past three years (tCO_2e/MWh)

146. The conservative BAU emissions shall be determined based on the stepwise process below:

7.4.1.1. Step 1. Determine the uncertainty at the lower bound of the uncertainty interval ($UCN_{BAU,CP1,i,y}$)

147. The 95% confidence interval for uncertainty shall be determined considering uncertainty in all parameters used to calculate BAU emissions during the first crediting period following the guidance from Volume 1, Chapter 3 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories through the error propagation method or through the Monte Carlo simulation.

148. Uncertainties should be traceable for each and every parameter, with clear values and assumptions for uncertainty and any associated references for estimating uncertainties of parameters.

7.4.1.2. Step 2. Determine the conservative BAU baseline emissions and/or removals based on uncertainty ($BE_{cons,UNC,i,y}$)

149. Determine the conservative BAU emissions based on the uncertainty ($BAU_{cons,UNC,i,y}$) as follows:

$$BAU_{cons,UNC,i,y} = BAU_{i,y} \times \left(1 - UNC_{BAU,CP1,i,y}\right)$$ Equation (37)

Where:

$BAU_{cons,UNC,i,y}$	=	Conservative BAU baseline emissions based on the uncertainty for the component *i* in year *y* (tCO_2e/year)
$BAU_{i,y}$	=	Most likely net BAU baseline emissions for the component *i* in year *y* (tCO_2e/year), determined based on guidance from paragraph 145 above
$UNC_{BAU,CP1,i,y}$	=	Uncertainty at the lower bound of the uncertainty interval relative to the central estimate of the ex-ante quantified most likely net BAU baseline emissions for the component *i* during the first crediting period year *y* (fraction)
y	=	Relevant year or period
i	=	BAU component (i = methane, electricity, heat and supply of LFG/biomethane)

7.4.1.3. Step 3. Determine the minimum conservative value of the BAU baseline ($BAU_{cons,min,i,y}$)

$$BAU_{cons,min,i,y} = BAU_{i,y} - \left(BAU_{i,y} - AE_y\right) \times 0.1$$ Equation (38)

Where:

$BAU_{cons,min,i,y}$	=	Minimum conservative BAU baseline emissions for the component *i* in year *y* (tCO_2e/year)
AE_y	=	Activity emissions in year *y* (tCO_2e/year)
y	=	Relevant year or period
i	=	BAU component (i = methane, electricity, heat and supply of LFG/biomethane)

7.4.1.4. Step 4. Compare $BAU_{cons,UNC,i,y}$ and $BAU_{cons,min,i,y}$

150. The conservative BAU baseline emissions shall be the lowest between $BAU_{cons,UNC,y}$ and $BAU_{cons,min,y}$, as follows:

$$BAU_{cons,i,k,y} = min\left(BAU_{cons,min,i,y}\ ;\ BAU_{cons,UNC,i,y}\right)$$ Equation (39)

Where:

$BAU_{cons,i,k,y}$	=	Conservative BAU baseline emissions for the component *i* in year *y* (tCO_2e/year)
y	=	Relevant year or period

i	=	BAU component (i = methane, electricity, heat and supply of LFG/biomethane)

151. The BAU scenario shall be determined ex ante and described in the PDD at the start of the first crediting period for the same duration as the crediting period of the proposed Article 6.4 activity, and shall be redetermined at each crediting period renewal.

152. The quantification of the BAU emissions shall be determined:

(a) Ex ante and in the PDD at the start of the first crediting period for the same duration as the crediting period of the proposed Article 6.4 activity and specified for each calendar year within the crediting period; and

(b) Ex post for each calendar year within the crediting period.

7.5. Comparison of crediting baselines

153. Activity participants shall compare, in the PDD, the downward adjusted baseline ($BE_{adj,y}$) determined in section 7.3.1.4 above with the conservative BAU baseline ($BAU_{cons,y}$) determined in section 7.4.1.4 above.

154. If, as a result of the comparison, the ex-ante $BAU_{cons,y}$ is lower than the ex-ante $BE_{adj,y}$ for any calendar year or cumulatively over the crediting period, activity participants shall revise the quantitative methods and factors to determine the downward adjustment in section 7.3 above to ensure that the downward adjusted baseline is lower than the conservative BAU baseline for each calendar year and cumulatively for the crediting period or use a discounted value of conservative BAU ($BAU_{cons,y}$).

155. Activity participants shall also compare in monitoring reports, for each individual calendar year during the crediting period, the ex-post calculated downward adjusted baseline for the year and the ex-post calculated conservative BAU baseline for the same year to confirm that the downward adjusted baseline is lower than the conservative BAU baseline. If it is not, then the conservative BAU baseline shall be used for that specific calendar year.

8. Activity scenario

8.1. Calculation of activity emissions

156. Activity emissions are calculated as follows:

$$AE_y = AE_{EC,y} + AE_{FC,y} + AE_{DT,y} + AE_{SP,y}$$ Equation (40)

Where:

AE_y	=	Activity emissions in year y (t CO_2/year)
$AE_{EC,y}$	=	Activity emissions from consumption of electricity due to the project activity in year y (tCO_2/year)
$AE_{FC,y}$	=	Activity emissions from consumption of fossil fuels due to the project activity for purpose other than electricity generation in year y (tCO_2/year)
$AE_{DT,y}$	=	Activity emissions from the distribution of LFG or biomethane using trucks, in year y (tCO_2/year)

$AE_{SP,y}$	=	Activity emissions from the supply of biomethane or LFG to consumers through a dedicated pipeline, in year *y* (tCO_2/year)

8.1.1. Activity emissions from the consumption of electricity

157. Activity emissions from electricity consumption are calculated as follows:

$$AE_{EC,y} = \left(EC_{grid,y} \times EF_{EC,grid,y} \times F_{TDL,grid}\right) + \left(EC_{captive,y} \times EF_{EC,captive,y} \times F_{TDL,captive}\right) \quad \text{Equation (41)}$$

Where:

$AE_{EC,y}$	=	Activity emissions from electricity consumption in year *y* (t CO_2/yr)
$EC_{grid,y}$	=	Quantity of electricity consumed from the electric grid in year *y* (MWh/yr)
$EF_{EC,grid,y}$	=	Emission factor from the electric grid in year *y* (t CO_2/MWh)
$F_{TDL,grid}$	=	Factor to account for transmission and distribution losses from the electric grid (unitless)
$EC_{captive,y}$	=	Quantity of electricity consumed from the captive fossil fuel fired power plant in year *y* (MWh/yr)
$EF_{EC,captive,y}$	=	Emission factor from the fossil fuel fired captive power plant in year *y* (t CO_2/MWh)
$F_{TDL,captive}$	=	Factor to account for transmission and distribution losses from the captive power plant (unitless)

158. Apply one of the following default values for $EF_{EC,grid,y}$:

(a) A default emission factor of 1.3 t CO_2/MWh where the proportion of renewable and nuclear energy (excluding solar and wind) in the annual electricity generation is 33% or less for the latest year which data is available, or where its proportion is uncertain;

(b) A default emission factor of 0.87 CO_2/MWh where the proportion of renewable and nuclear energy (excluding solar and wind) in the annual electricity generation exceeds 33% but is less than 67% for the latest year which data is available.

(c) A default emission factor of 0.44 CO_2/MWh for electricity sourced from the grid where the proportion of renewable and nuclear energy (excluding solar and wind) in the annual electricity generation exceeds 67% for the latest year which data is available.

159. Apply a value of 1.3 tCO_2/MWh for $EF_{EC,captive,y}$.

160. For the parameter $F_{TDL,grid}$, apply a value of 1.25. For the parameter $F_{TDL,captive}$, apply a value of 1.

8.1.2. Activity emissions from the consumption of fossil fuel

161. The activity emissions from fossil fuel combustion for purposes other than electricity generation ($AE_{FC,y}$) shall be calculated as follows:

$$AE_{FC,y} = \sum_{i} \left(FC_{i,y} \times COEF_{i,y} \right)$$ Equation (42)

Where:

$FC_{i,y}$	=	Is the quantity of fuel type *i* combusted in process *j* during the year *y* (mass or volume unit/year)
$COEF_{i,y}$	=	Is the CO_2 emission coefficient of fuel type *i* in year *y* (tCO_2/mass or volume unit)
i	=	Are the fuel types combusted during the year *y*

162. The CO_2 emission coefficient ($COEF_{i,y}$) can be calculated using one of the following three options, depending on the availability of data on the fossil fuel type *i*, as follows:

(a) Option A.1: Calculated based on the chemical composition of the fossil fuel type *i*, if $FC_{i,y}$ is measured in a mass unit:

$$COEF_{i,y} = w_{c,i,y} \times 44/12$$ Equation (43)

(b) Option A.2: Calculated based on the chemical composition of the fossil fuel type *i*, if $FC_{i,y}$ is measured in a volume unit:

$$COEF_{i,y} = w_{c,i,y} \times \rho_{,i,y} \times 44/12$$ Equation (44)

Where:

$w_{c,i,y}$	=	Mass fraction of carbon in fuel type *i* in year *y* (t_C/mass unit of the fuel)
$\rho_{,i,y}$	=	Density of fuel type *i* in year *y* (mass unit/volume unit of the fuel)

(c) Option B: Calculated based on net calorific value and CO_2 emission factor of the fuel type *i*, as follows:

$$COEF_{i,y} = NCV_{i,y} \times EF_{CO2e,i,y}$$ Equation (45)

Where:

$NCV_{i,y}$	=	Net calorific value of the fuel type *i* in year *y* (GJ/mass or volume unit)
$EF_{CO2e,i,y}$	=	CO_2 emission factor of fuel type *i* in year *y* (tCO_2/GJ)

163. Options A.1 and A.2 should be the preferred approaches, if the necessary data are available.

8.1.3. Activity emissions from the distribution of LFG or biomethane to consumers using trucks

164. The activity emissions from the distribution of LFG or biomethane using trucks ($AE_{DT,y}$) is determined by the sum of emissions arising from the transportation of LFG or biomethane using trucks and possible leaks during the transportation, as follows:

$$AE_{DT,y} = AE_{TR,y} + AE_{leaks,y} \quad \text{Equation (46)}$$

Where:

$AE_{TR,y}$	=	Activity emissions from the transportation of LFG or biomethane using trucks in year *y* (tCO_2/year)
$AE_{leaks,y}$	=	Emissions from CH_4 leaks during the transportation of LFG or biomethane in year *y* (tCO_2/year)

8.1.3.1. Emissions from the transportation of LFG biomethane using trucks

165. This source of activity emissions may be monitored using the following two options below:

8.1.3.1.1. Option A: Monitoring fuel consumption

166. Under this option, apply the equations and requirements provided in section 8.1.2 above to determine $AE_{TR,y}$.

8.1.3.1.2. Option B: Using conservative default values

167. This option relies on conservative default emission factors to estimate project or leakage emissions from road transportation of freight. These default values are established for two vehicle classes: light vehicles and heavy vehicles.

168. Under this option, the following data shall be monitored separately for each freight transportation activity *f* to estimate the emissions:

(a) The quantity of freight transported in year *y* ($FR_{f,y}$);

(b) The origin and destination of the freight transported and the road (or rail line) distance between the origin and the destination (D_f); and

(c) The vehicle class used, if the freight is transported by road.

169. The equation to calculate $AE_{TR,y}$shall be calculated as follows:

$$AE_{TR,y} = \sum_{f} D_f \times FR_{f,y} \times EF_{CO2,f} \times 10^{-6} \quad \text{Equation (47)}$$

Where:

D_f	=	Return trip distance between the origin and destination of freight transportation activity *f* (km)
$FR_{f,y}$	=	Total mass of freight transported in freight transportation activity *f* in year *y* (t)
$EF_{CO2,f}$	=	Default CO_2 emission factor for freight transportation activity f (gCO_2/tkm)

170. Activity participants shall document in the PDD which freight transportation activities *f* will occur under the activity scenario, including for each transportation activity information on:

(a) The origin and destination of the freight (to the extent that this is known at validation);

(b) The type(s) of freight that are planned to be transported;

(c) The planned number of trips made and/or the planned quantity of freight that should be transported; and

(d) The option selected (A or B) to determine emissions.

171. For a particular freight transportation activity *f*, the option selected for determining emissions from freight transportation shall not be changed during the crediting period.

8.1.3.2. Emissions from the leaks of LFG or biomethane using trucks

172. This source of activity emissions is determined as follows:

$$AE_{leaks,y} = GWP_{CH4} \times \left(F_{CH4,NG-TR,y} - F_{CH4,NG-cons,y}\right) \quad \text{Equation (48)}$$

Where:

GWP_{CH4}	=	Global Warming Potential of CH4
$F_{CH4,NG-TR,y}$	=	Amount of methane in the LFG or biomethane which is sent to trucks in year *y* (tCH_4/year)
$F_{CH4,NG-cons,y}$	=	Amount of methane in LFG or biomethane which is delivered to consumers using trucks in year *y* (tCH_4/year)

173. The parameters $F_{CH4,NG-TR,y}$ and $F_{CH4,NG-TR,y}$ are determined based on the mass flow tool.

8.1.4. Activity emissions from physical leakage due to the supply of LFG or biomethane to consumers through a dedicated pipeline

174. This activity emission source is determined as follows:

$$AE_{SP,y} = 0.0504 \times DEFT_{SP,y} \times F_{CH4,NG,y} \quad \text{Equation (49)}$$

Where:

$AE_{SP,y}$	=	Activity emissions from the supply of LFG or biomethane through a dedicated pipeline to consumers due to physical leakage from the dedicated pipeline, in year *y* (tCO_2)

0.0504	=	Conversion factor (TJ/tCH4)
$DEFT_{SP}$	=	Default emission factor for the supply of LFG or biomethane to consumers through a dedicated pipeline due to physical leakage (tCO_2e/TJ)
$F_{CH4,NG,y}$	=	Amount of methane in the LFG or biomethane which is sent to the consumer through a dedicated pipeline in year *y* (tCH_4/year), determined based on the equation from paragraph 173 above.

8.2. Activity emissions uncertainties

175. Activity participants shall determine the mean activity emissions and the 95% confidence interval for uncertainty following the guidance from Volume 1, Chapter 3 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories through the error propagation method or through the Monte Carlo simulation.

176. [Activity emissions shall be calculated based on mean plus the upper bound of the 95% confidence interval.]

177. [If the uncertainty range is below +/- 10%, the mean value for activity emissions can be used.]

9. Leakage

178. Adjusted yearly baseline emissions shall be discounted by 0.5% to account for leakage emissions[15], as follows:

$$LE_y = 0.005 \times BE_{adj,y}$$ Equation (50)

Where:

LE_y	=	Leakage emissions in year *y* (tCO_2e/year)
0.005	=	Leakage discount factor (%), determined as per Appendix 2
$BE_{adj,y}$	=	Downward adjusted baseline emissions in year *y* (tCO_2e/year)]

10. Emission reductions

179. Emission reductions are determined ex-ante as follows:

$$ER_y = BE_{adj,y} - AE_{cons,y} - LE_y$$ Equation (51)

Where:

ER_y	=	Emission reductions in year *y* (tCO_2e/year)
$BE_{adj,y}$	=	Downward adjusted baseline emissions in year *y* (tCO_2e/year)
$AE_{cons,y}$	=	Conservative activity emissions in year *y* (tCO_2e/year). Determined by applying the uncertainties to the parameters from equation (40) above.
LE_y	=	Leakage emissions in year *y* (tCO_2e/year)

[15] The rationale for the proposed default factor, including the detailed calculation, is provided in Appendix 2.

11. Avoidance of double counting

180. Activity participants shall demonstrate that the Article 6.4 activity will not result in double counting by:

(a) For Article 6.4 activities that involve the utilisation of the LFG by consumers other than the activity participants: signing contracts with the consumers of the heat, electricity, LFG or biomethane generated under the Article 6.4 activity which explicitly address that A6.4ERs can only be claimed by the activity participants and that the users of the heat, electricity, LFG or biomethane shall not claim A6.4ERs or carbon credits from any carbon crediting programme;

(b) For any Article 6.4 activity eligible under this methodology: declaring, in each monitoring report, that the outcomes from the Article 6.4 activity (e.g. flaring, electricity generation) were not claimed by any other environmental market or accounting framework (e.g. guarantees of origin for renewable energy generation), except for outcomes not related to reducing greenhouse gases emissions (e.g., air contaminant reductions or positive social impacts);

(c) For any Article 6.4 activity eligible under this methodology: demonstrating that the Article 6.4 activity does not overlap with mandatory domestic mitigation schemes (e.g. emissions trading systems) by:

(i) Declaring and providing evidence in each monitoring report that the Article 6.4 activity and the activities displaced in the baseline scenario (e.g. heat generation using fossil fuels) do not fall within the scope of any mandatory domestic mitigation scheme; or

(ii) Where the Article 6.4 activity or the activities displaced in the baseline scenario fall within the scope of a mandatory domestic mitigation scheme:

a. Providing evidence in each monitoring report that the mitigation outcomes of the Article 6.4 activity are not counted in the mandatory mitigation scheme to reduce the obligations by the entities covered by the scheme. For example, in the case of an emissions trading system covering electricity generation, a confirmation from the operator of the emissions trading system may be sought that a number of allowances equal to the A6.4 ERs being requested for issuance for the electricity generation component were cancelled before the issuance of the A6.4 ERs; or

b. The project participants not requesting issuance of A6.4ERs for the emission reductions resulting from a component of the Article 6.4 that falls within the scope of the mandatory domestic scheme. For example, in the case of an emissions trading system covering electricity generation, the baseline emissions from electricity generation may not be included in the calculation of the total emission reductions.

12. Demonstration of alignment with the policies, options and implementation plans with regard to the NDC and LT-LEDS of the host Party and the long-term temperature goal of the Paris Agreement and long-term goals of the Paris Agreement

181. Activity participants shall attach to the PDD presented to the DOE performing the validation a confirmation from the DNA of the host Party that the DNA has undertaken an assessment of the activity's consistency with Decision 3/CMA.3 paragraph 40 (c) and paragraph 27 (a), as part of the host Party's approval, to demonstrate that the activity does not constrain, but aligns with the policies, options and implementation plans of the host Party with regard to the nationally determined contribution (NDC) of the host Party, its long-term low greenhouse gas emission development strategies (LT-LEDS) if it has submitted one, and the long-term temperature goal of the Paris Agreement and long-term goals of the Paris Agreement.

13. Data and parameters not monitored

182. For parameters where the uncertainty was not provided, activity participants shall assume uncertainty based on expert judgement and justify the estimates.

Data / Parameter table 1.

<table>
<tr><td>Data/parameter</td><td>OX_y</td></tr>
<tr><td>Description</td><td>Default values as per section 8.2.2.1.2: Fraction of methane in the LFG that would be oxidized in the top layer of the SWDS in the baseline.</td></tr>
<tr><td>Data unit</td><td>(2), (5)</td></tr>
<tr><td>Equations referred</td><td>Section 8.2.2.1, paragraph 12</td></tr>
<tr><td>Purpose of data</td><td>☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Type of SWDS</th><th>Age of the SWDS cell</th><th>Type of cover material</th><th>OX_y (mean)</th><th>Uncertainty</th></tr>
<tr><td rowspan="5">Existing SWDS</td><td rowspan="4">Immature and mature</td><td>No cover (LDCs/SIDS)</td><td>0</td><td>N/A</td></tr>
<tr><td>No cover (non-LDCs/SIDS)</td><td>0.1</td><td></td></tr>
<tr><td>Synthetic</td><td>0.1</td><td></td></tr>
<tr><td>Soil</td><td>0.384</td><td>± 8%</td></tr>
<tr><td>Aged</td><td>Soil</td><td>0.384</td><td>± 8%</td></tr>
</table>
</td></tr>
</table>

Hypothetical SWDS	N/A	Synthetic	0.1	
		Soil	0.384	± 8%

Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	- The IPCC 2019 refinement proposes a value of 0 for SWDSs without cover. The default value of 0 is proposed for no cover case in existing SWDSs in LDCs/SIDS taking into account the circumstances of LDCs/SIDS and since negligible amounts of CH_4 may be oxidized in case of no cover; - The default value of 0.1 is proposed for existing SWDSs with immature and/or mature waste cells and located in non-LDCs/SIDS with no cover as a conservative assumption since a negligible amount of CH_4 may be oxidized in case of no cover. However, for conservativeness, a value of 0.1 is proposed; - The default value of 0.1 is proposed for SWDSs with synthetic cover as a conservative assumption; - The default value of 0.384 is proposed for existing SWDSs with immature and/or mature and/or aged cells and located in non-LDCs/SIDS with soil cover calculated from the statistics provided in Table 3 of SWICS (2012) for flux below 10 $g_{CH4}/m^2.d$ (low-flox),[11] rounded up to the third decimal place. The uncertainty determined is equal to ± 8%
Treatment of uncertainties	See table under "Value(s) applied"
Additional comments	-

Data / Parameter table 2.

Data/parameter	GWP_{CH4}
Description	Global warming potential of CH_4
Data unit	tCO_2e/tCH_4
Equations referred	(2), (4), (13)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	28
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Default value and uncertainty from IPCC Fifth Assessment Report (AR5). Shall be updated according to any future CMA decisions.
Treatment of uncertainties	N/A
Additional comments	-

Data / Parameter table 1.

<table>
<tr><td>Data/parameter</td><td>$AF_{flare,y}$</td></tr>
<tr><td>Description</td><td>Adjustment factor for the methane destroyed in flares in year y</td></tr>
<tr><td>Data unit</td><td>%</td></tr>
<tr><td>Equations referred</td><td>(26)</td></tr>
<tr><td>Purpose of data</td><td>☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions</td></tr>
<tr><td>Value(s) applied</td><td>
<table>
<tr><th>Calendar year of the first crediting period</th><th>Adjustment factor</th></tr>
<tr><td>1</td><td>100%</td></tr>
<tr><td>2</td><td>80%</td></tr>
<tr><td>3</td><td>60%</td></tr>
<tr><td>4</td><td>40%</td></tr>
<tr><td>5</td><td>20%</td></tr>
<tr><td>2nd crediting period onwards or 6th year of the fixed crediting period onwards</td><td>0%</td></tr>
</table>
</td></tr>
<tr><td>Source of data</td><td>☐ Measured ☒ Other sources</td></tr>
<tr><td>Choice of data or measurement methods and procedures</td><td>For open flares: multiply the amount of LFG flared by an Adjustment Factor provided in the Table for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period). For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an overall adjustment factor of 0% shall be applied;

For enclosed flares, apply one of the options below:
(i) If activity participants chose to determine the flare efficiency based on the default values as per Option A of the flaring tool, the amount of LFG flared shall be multiplied by an Adjustment Factor provided in the Table for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period). For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an overall adjustment factor of 0% shall be applied;
(ii) If activity participants choose to determine the flare efficiency based on measurements as per Option B of the flaring gool, the values monitored during the crediting period shall be multiplied by an Adjustment Factor provided in the Table for each year of the first crediting period (or throughout the first 5 years for Article 6.4 activities with fixed crediting period).For the second and third crediting periods (or from the 6th year onwards for Article 6.4 activities with a fixed crediting period), an overall adjustment factor of 0% shall be applied.</td></tr>
</table>

Treatment of uncertainties	N/A
Additional comments	-

Data / Parameter table 2.

Data/parameter	$F_{CH4,x-i}$
Description	Amount of methane in the LFG which is captured and destroyed in the year *i* prior to the implementation of the Article 6.4 activity
Data unit	tCH_4/year
Equations referred	(11)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	N/A (not a fixed value)
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Determined by applying the solid waste tool based on guidance provided for Application A.
Treatment of uncertainties	Uncertainties calculated based on the solid waste tool
Additional comments	Uncertainty already considered when applying the solid waste tool

Data / Parameter table 3.

Data/parameter	η_{AC}
Description	Efficiency of the LFG capture system that will be installed in the activity
Data unit	%
Equations referred	(13)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	Technical specifications of the LFG capture system to be installed (if available) or a default value of 50 per cent (+/- 50% uncertainty)
Source of data	☒ Measured ☒ Other sources
Choice of data or measurement methods and procedures	If “measured”, demonstrate how the value was determined.
Treatment of uncertainties	N/A
Additional comments	-

Data / Parameter table 4.

Data/parameter	$BE_{CH4,SWDS,y}$
Description	Ex-ante estimated amount of methane in the LFG that is generated from the SWDS in the baseline scenario in year *y*

Data unit	tCO_2e/year
Equations referred	(13)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	N/A (not a fixed value)
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Determined by applying the solid waste tool
Treatment of uncertainties	Uncertainty already considered when applying the solid waste tool
Additional comments	-

Data / Parameter table 5.

Data/parameter	$\boldsymbol{EF_{CO2,BL,HG,j}}$; $\boldsymbol{EF_{CO2,NG,y}}$
Description	$\boldsymbol{EF_{CO2,BL,HG,j}}$: CO_2 emission factor of the fossil fuel type used for heat generation by equipment type *j* in the baseline $\boldsymbol{EF_{CO2,NG,y}}$: Average CO_2 emission factor of natural gas in the natural gas network or dedicated pipeline or in the trucks in year *y*
Data unit	tCO_2/TJ
Equations referred	$\boldsymbol{EF_{CO2,BL,HG,j}}$: Section 8.2.2.3, paragraph 31 $\boldsymbol{EF_{CO2,NG,y}}$: Section 8.2.2.4, paragraph 39
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	Variable (depends on the type of fuel)
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Sourced from Table 1.4 of Chapter 1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories.
Treatment of uncertainties	Apply uncertainties based on the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Additional comments	-

Data / Parameter table 6.

Data/parameter	$\boldsymbol{EF_{CO2,EG,BAT}}$
Description	CO_2 emissions intensity of the best-available technology
Data unit	tCO_2e/MWh
Equations referred	(16)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	Determined based on procedure to identify the baseline scenario for electricity generation replacing electricity generated in new captive power plants contained in section 7.2.1.2 above

Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	As per the procedure contained in section 7.2.1.2 above
Treatment of uncertainties	Apply uncertainties based on the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Additional comments	-

Data / Parameter table 7.

Data/parameter	$\eta_{HG,BL,j}$
Description	Efficiency of the heat generation equipment type *j* used in the baseline
Data unit	%
Equations referred	(18)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	90%
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Value from new boilers running on natural gas, sourced from Vatopoulos, K., Andrews, D., Carlsson, J., Papaioannou, I. & Zubi, G., 2012. *Study on the state of play of energy efficiency of heat and electricity production technologies*. Luxembourg: Publications Office of the European Union. EUR 25406 EN. Available at: https://doi.org/10.2790/57624.
Treatment of uncertainties	N/A
Additional comments	-

Data / Parameter table 8.

<table>
<tr><td>Data/parameter</td><td>$fd_{CH4,HG,j,default}$</td></tr>
<tr><td>Description</td><td>Default value for the fraction of methane destroyed when used for heat generation equipment type j</td></tr>
<tr><td>Data unit</td><td>%</td></tr>
<tr><td>Equations referred</td><td>(2), (19)</td></tr>
<tr><td>Purpose of data</td><td>☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions</td></tr>
<tr><td>Value(s) applied</td><td>Use the values below for the different types of heat generation equipment:
<table>
<tr><th>Fraction of CH_4 destroyed</th><th>Equipment type j</th></tr>
<tr><td>1</td><td>Boilers</td></tr>
<tr><td>1</td><td>Air heaters</td></tr>
<tr><td>1</td><td>Glass melting furnaces</td></tr>
<tr><td>0.9</td><td>Intermittent brick kiln</td></tr>
</table></td></tr>
</table>

Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	The values for boilers and air heaters are based on default values provided in the 2006 IPCC Guidelines (Tier 3 approach for Chapter 2: Stationary Combustion of Volume 2: Energy Use). The value for intermittent brick kilns is based on the assumption that combustion temperatures in the kiln will exceed 600 °C and that the time of exposure is sufficiently long to support 90 per cent combustion
Treatment of uncertainties	N/A
Additional comments	-

Data / Parameter table 9.

Data/parameter	$EF_{CO2,HG,BAT}$
Description	CO_2 emissions intensity of the best-available technology (tCO2e/unit of output) identified in section 7.2.1.3 above
Data unit	tCO_2e/unit of output
Equations referred	(21)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Value(s) applied	Determined based on procedure to identify the baseline scenario for heat generation replacing heat generated by existing equipment contained in section 7.2.1.2 above
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	As per the procedure contained in section 7.2.1.3 above
Treatment of uncertainties	Apply uncertainties based on the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.
Additional comments	-

Data / Parameter table 10.

Data/parameter	$EF_{CO2,f}$
Description	Default CO_2 emission factor for freight transportation activity *f*
Data unit	gCO_2/tkm
Equations referred	(47)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	- Light vehicles: 245 gCO_2/tkm; - Heavy vehicles: 129 gCO_2/tkm;
Source of data	☐ Measured ☒ Other sources

Choice of data or measurement methods and procedures	The default CO_2 emission factors take into account emissions generated by loaded outbound trips and empty return trips and were from two sources: - For light vehicles: empirical data from European vehicles; - For heavy vehicles: derived based on custom design transient speed-time-gradient drive cycle (adapted from the international FIGE cycle), vehicle dimensional data, mathematical analysis of loading scenarios, and dynamic modelling based on engine power profiles, which, in turn, are a function of gross vehicle mass (GVM), load factor, speed/acceleration profiles and road gradient. The following assumptions on key parameters have been made: an average driving speed of 30 km/h, an average gradient of 1%, and a load factor attained when biomass5 is transported were assumed
Additional comments	-

Data / Parameter table 11.

Data/parameter	$DEFT_{SP}$
Description	Default emission factor for the supply of LFG to consumers due to physical leakage through the dedicated pipeline
Data unit	tCO_2e/TJ
Equations referred	(49)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	2.2
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Value determined based on Natural gas distribution from Table 1 of the Appendix 3
Additional comments	Value sourced from the GREET Model for NG distribution, Pressure let down from the transmission system and transport in medium and low-pressure pipelines to the end users.

14. Data and parameters monitored

Data / Parameter table 12.

Data/parameter	***Management of the SWDS***
Description	Management of the SWDS
Data unit	-
Equations referred	N/A. This parameter is monitored to ensure compliance with the applicability condition that the management of the SWDS in the project activity is not deliberately changed during the crediting in order to increase methane generation (for example by recirculating the leachate) compared to the situation prior to the implementation of the project activity.
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Measurement methods and procedures	Use different sources of data: (a) Original design of the SWDS;

	(b) Technical specifications for the management of the SWDS; (c) Local or national regulations	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Annually	
QA/QC procedures	-	
Treatment of uncertainties	N/A	
Additional comment	For Article 6.4 activities that determine the $OX_{top\text{-}layer,y}$ based on Option 1, the type of cover used under the activity scenario must be the same as the one used historically. Evidence that the type of cover before and after the implementation of the Article 6.4 activity is the same must be provided to the DOE undertaking the verification.	

Data / Parameter table 13.

Data/parameter	***Amount of organic fraction***
Description	Amount of organic fraction recycled impacted by the Article 6.4 activity
Data unit	tonnes or %
Equations referred	N/A. This parameter is monitored to ensure compliance with the applicability condition that the project does not reduce the amount of organic waste that would be recycled in the absence of the Article 6.4 activity.
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Measurement methods and procedures	(a) Determine the yearly amount of organic waste disposed in the SWDS by multiplying the amount of waste disposed in the SWDS (W_x or W_i) by the organic fraction of the waste ($p_{n,j,x}$ or $p_{n,j,i}$), following the monitoring requirements of these parameters from solid waste tool, with samples of waste collected at least every year; (b) Describe the prevailing waste management practices pertinent to organic waste recycling in the area that is served by the SWDS identified during the validation of the PDD to comply with the requirements of paragraph 10 above; (c) Identify the facility(ies) that recycle organic waste in the area identified in (a) above; (d) Activity participant may conduct interviews with authorities, refer to national/local statistics or studies related to solid waste management in the area, and obtain opinion from relevant local experts. If data is available for the historical amount of organic waste recycled and the annual amount of organic waste for the recycling facility during the implementation of the

	Article 6.4 activity, a comparison can be done to conclude that there is no change in the amount of recycled organic fraction of the waste by existing facilities; (e) In case there is extra capacity in the identified recycling facilities, activity participants may provide evidence that there is surplus organic waste available in the area. Activity participants may use other evidence to conclude that there is no diversion of the organic fraction of the solid waste that would have been processed by the recycling facility.	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	At least annually	
QA/QC procedures	-	
Treatment of uncertainties	N/A	
Additional comment	-	

Data / Parameter table 14.

Data/parameter	$F_{CH4,flare,y}$; $F_{CH4,EL,y}$; $F_{CH4,HG,y}$; $F_{CH4,HG,kiln,h}$; $F_{CH4,NG,y}$; $F_{CH4,NG\text{-}cons,y}$; $F_{CH4,NG\text{-}TR,y}$
Description	$F_{CH4,flare,y}$: Amount of methane in the LFG which is send to flare(s) year y $F_{CH4,EL,y}$: Amount of methane in the LFG which is used for electricity generation in year y; $F_{CH4,HG,y}$: Amount of methane in the LFG which is used for heat generation in year *y* $F_{CH4,HG,kiln,h}$: Amount of methane in the LFG which is used for heat generation by brick kiln in hour *h* $F_{CH4,NG,y}$: Amount of methane in the LFG or in the biomethane which is sent to the natural gas distribution network and/or dedicated pipeline and/or to the trucks in year *y* $F_{CH4,NG\text{-}TR,y}$: Amount of methane in the LFG or biomethane which is sent to trucks in year *y* $F_{CH4,NG\text{-}cons,y}$: Amount of methane in LFG or biomethane which is delivered to consumers using trucks in year *y*
Data unit	tCH_4/year
Equations referred	(3), (19), (20), (22), (26), (27), (28), (48)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions

Measurement methods and procedures	As per the requirements of the mass flow tool	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	As per the requirements of the mass flow tool
	Accuracy class	As per the requirements of the mass flow tool
	Calibration requirements	As per the requirements of the mass flow tool
	Location	As per the requirements of the mass flow tool
Measurement intervals	As per the requirements of the mass flow tool	
QA/QC procedures	As per the requirements of the mass flow tool	
Treatment of uncertainty	Uncertainties are determined based on the measuring instruments and propagated through error propagation method or Monte Carlo Simulation as per the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gases Inventories	
Additional comment	-	

Data / Parameter table 15.

Data/parameter	$J_{out,i}$	
Description	Flux of methane leaving the surface of zone *i* of the SWDS	
Data unit	gCH_4/m^2d	
Equations referred	N/A. The measured values will be associated with a value for the parameter OX_i.	
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Apply guidance from Appendix 1	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Flux box (designed as per Appendix 1)
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	- Annual measurements if OX_y is determined based on Option 1. - Measured once prior to the start date of the crediting period if OX_y is determined based on Option 2.	

QA/QC procedures	As per Appendix 1
Treatment of uncertainty	Uncertainty values for OX_y from Data / Parameters table 1 are used based on the measured values of J_{out}
Additional comment	-

Data / Parameter table 16.

Data/parameter	$F_{CH4,BL,R,y}$
Description	Absolute amount of methane that must be destroyed in year y as per the specifications from the requirement
Data unit	tCH_4/year
Equations referred	(6)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions
Measurement methods and procedures	N/A. Information is sourced directly from the law, regulation or contractual requirement.
Entity/person responsible for the measurement	Activity participants
Measuring instrument(s) — *Type of instrument*	N/A
Measuring instrument(s) — *Accuracy class*	N/A
Measuring instrument(s) — *Calibration requirements*	N/A
Measuring instrument(s) — *Location*	N/A
Measurement intervals	Annual check of the law, regulation or contractual requirements.
QA/QC procedures	-
Treatment of uncertainty	N/A
Additional comment	-

Data / Parameter table 17.

Data/parameter	$\rho_{reg,y}$
Description	Fraction of LFG that is required to be destroyed due to a requirement in year *y*
Data unit	%
Equations referred	(7)
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions

Measurement methods and procedures	N/A. Information is sourced directly from the law, regulation or contractual requirement.	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Annual check of the law, regulation or contractual requirements.	
QA/QC procedures	-	
Treatment of uncertainties	N/A	
Additional comment	-	

Data / Parameter table 18.

Data/parameter	$\eta_{HG,PJ,j,y}$	
Description	Efficiency of the heat generation equipment type *j* used in the project activity in year *y*	
Data unit	%	
Equations referred	(18)	
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Use one of the following options to determine the efficiency: - Option 1: Measured efficiency during monitoring; - Option 2: Manufacturer's information on the efficiency; or - Option 3: Use a default value of 60%	
Entity/person responsible for the measurement	- Option 1: Activity participants; - Option 2: Manufacturer of the heat generation equipment	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Annual if measurements are conducted as per Option 1.	

QA/QC procedures	If measurements are conducted as per Option 1, use recognized standards for the measurement of the heat generator efficiency, such as the “British Standard Methods for Assessing the thermal performance of boilers for steam, hot water and high temperature heat transfer fluids” (BS845). Where possible, use preferably the direct method (dividing the net heat generation by the energy content of the fuels fired during a representative time period), as it is better able to reflect average efficiencies during a representative time period compared to the indirect method (determination of fuel supply or heat generation and estimation of the losses). Document measurement procedures and results and manufacturer’s information transparently in the PDD
Treatment of uncertainties	For Option 1, the uncertainty is to be determined based on the guidance from the standard BS845. For Option 2, the uncertainty is to be provided by the manufacturer.
Additional comment	-

Data / Parameter table 19.

Data/parameter	$\boldsymbol{Op_{j,h}}$	
Description	Operation of the equipment *j* that consumes the LFG in hour *h*	
Data unit	Hours	
Equations referred	N/A. This parameter is measured to determine whether the equipment *j* is in operation during the hour *h*.	
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	For each equipment unit j using the LFG monitor that the plant is operating in hour h by the monitoring any one or more of the following three parameters: - <u>Temperature:</u> Determine the location for temperature measurements and minimum operational temperature based on manufacturer’s specifications of the burning equipment. Document and justify the location and minimum threshold in the PDD; - <u>Flame:</u> Flame detection system is used to ensure that the equipment is in operation. This option is applicable only for flares; - <u>Products generated:</u> Monitor the generation of steam for the case of boilers and air-heaters and glass for the case of glass melting furnaces. This option is not applicable to brick kilns	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Every minute (temperature and flame detector), or every hour (products)	

QA/QC procedures	-
Treatment of uncertainties	N/A
Additional comment	A value of 0 shall be assigned for the specific hour *h* when: (a) One of more temperature measurements are missing or below the minimum threshold in hour h (instantaneous measurements are made at least every minute); (b) Flame is not detected continuously in hour h (instantaneous measurements are made at least every minute); (c) No products are generated in the hour h.

Data / Parameter table 20.

Data/parameter	EG_y	
Description	Electricity generated by the power plant in the activity scenario in year y	
Data unit	MWh/year	
Equations referred	(16)	
Purpose of data	☒ Baseline emissions ☐ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Directly measured using electricity meters	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Bi-directional energy meter
	Accuracy class	Regulated electricity-meters: in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements Non-regulated electricity-meters: in accordance with the stipulation of the meter supplier or national requirements (if the standards are not available and meter supplier does not specify, calibrate the meters every 3 years and use the meters with at least 0.5 accuracy class)
	Calibration requirements	Regulated electricity-meters: in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators Non-regulated electricity-meters: in accordance with national standards or requirements set by the meter supplier
	Location	For electricity supplied to the electric grid: installed at the grid interface. For electricity supplied to captive consumers: installed at the entrance of the electricity consuming facility.

Measurement intervals	Continuous measurement and at least monthly recording	
QA/QC procedures	Electricity meters will be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements. The electricity generation (gross or net) shall be cross-checked with records of electricity sale (e.g. sales receipt).	
Treatment of uncertainties	Uncertainties are determined based on the measuring instruments	
Additional comment	-	

Data / Parameter table 21.

Data/parameter	$EC_{grid,y}$; $EC_{captive,y}$	
Description	$EC_{grid,y}$: Quantity of electricity consumed from the electric grid in year y $EC_{captive,y}$: Quantity of electricity consumed from the captive fossil fuel fired power plant in year y	
Data unit	MWh/year	
Equations referred	(41)	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Directly measured using electricity meters	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Electricity-meters
	Accuracy class	Regulated electricity-meters: in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements Non-regulated electricity-meters: in accordance with the stipulation of the meter supplier or national requirements (if the standards are not available and meter supplier does not specify, calibrate the meters every 3 years and use the meters with at least 0.5 accuracy class)
	Calibration requirements	Regulated electricity-meters: in accordance with national standards or requirements set by the meter supplier or requirements set by the grid operators Non-regulated electricity-meters: in accordance with national standards or requirements set by the meter supplier
	Location	Installed at the electricity consumption sources
Measurement intervals	Continuous measurement and at least monthly recording	

QA/QC procedures	Electricity meters will be subject to regular maintenance and testing in accordance with the stipulation of the meter supplier and/or as per the requirements set by the grid operators or national requirements.
Treatment of uncertainties	Uncertainties are determined based on the measuring instruments
Additional comment	-

Data / Parameter table 22.

<table>
<tr><td>Data/parameter</td><td colspan="2">$FC_{i,y}$</td></tr>
<tr><td>Description</td><td colspan="2">Is the quantity of fuel type i combusted in process j during the year y</td></tr>
<tr><td>Data unit</td><td colspan="2">Mass or volume unit/year</td></tr>
<tr><td>Equations referred</td><td colspan="2">(42)</td></tr>
<tr><td>Purpose of data</td><td colspan="2">☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions</td></tr>
<tr><td>Measurement methods and procedures</td><td colspan="2">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);
Accessories such as transducers, sonar and piezoelectronic devices are accepted if they are properly calibrated with the ruler gauge and receiving a reasonable maintenance.
In case of daily tanks with pre-heaters for heavy oil, the calibration will be made with the system at typical operational conditions</td></tr>
<tr><td>Entity/person responsible for the measurement</td><td colspan="2">Activity participants</td></tr>
<tr><td rowspan="4">Measuring instrument(s)</td><td>Type of instrument</td><td>Mass or volume meters, ruler gauge (that is part of daily tanks), transducers, sonar and piezoelectronic devoces</td></tr>
<tr><td>Accuracy class</td><td>N/A</td></tr>
<tr><td>Calibration requirements</td><td>Ruler gauge must be calibrated at least once a year.
Transducers, sonar and piezoelectronic devices must be calibrated with the ruler gauge and receiving a reasonable maintenance</td></tr>
<tr><td>Location</td><td>N/A</td></tr>
<tr><td>Measurement intervals</td><td colspan="2">Continuously</td></tr>
<tr><td>QA/QC procedures</td><td colspan="2">The consistency of metered fuel consumption quantities should be cross-checked by an annual energy balance that is based on purchased quantities and stock changes.
Where the purchased fuel invoices can be identified specifically for the Article 6.4 activity, the metered fuel consumption quantities should also be cross-checked with available purchase invoices from the financial record</td></tr>
<tr><td>Treatment of uncertainties</td><td colspan="2">Uncertainties are determined based on the measuring instruments</td></tr>
</table>

Additional comment	Article 6.4 activities faced with data gaps due to meter failure or other reasons unforeseen, may estimate the quantity of fuel, using one of the following options, provided the gap period does not exceed 30 consecutive days within six consecutive months: - The purchased fuel/energy invoices/bills, where the purchased fuel can be identified specifically for the Article 6.4 activity; - The energy produced by the equipment, adjusted by efficiency. A conservative value for efficiency of the equipment is of 40% for combustion engines and generator and 80% for thermal heaters shall be used, while energy produced is measured directly or calculated based on operation hours; - The highest value of the parameter for the same calendar period of the previous years; - The fuel consumption of a representative sample of the first batch1 of project devices. It may be assumed that the fuel consumption measured in a representative sample of the first batch of project devices apply to all subsequent batches

Data / Parameter table 23.

Data/parameter	D_f	
Description	Return trip distance between the origin and destination of freight transportation activity *f*	
Data unit	km	
Equations referred	(47)	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Determined for each freight transportation activity *f* for a reference trip	
Entity/person responsible for the measurement	Activity participants or vehicle operator (if the trucks are not owned by the activity participants)	
Measuring instrument(s)	*Type of instrument*	Vehicle odometer, other appropriate sources (e.g. on-line sources)
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Determined once for each freight transportation activity f. To be updated whenever the distance changes	
QA/QC procedures		
Treatment of uncertainties	Uncertainties are determined based on the measuring instruments	
Additional comment		

Data / Parameter table 24.

Data/parameter	$FR_{f,m}$	
Description	Total mass of freight transported in freight transportation activity *f* in monitoring period *m*	
Data unit	Tonnes	
Equations referred	(47)	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement methods and procedures	Determined for each freight transported f	
Entity/person responsible for the measurement	Activity participants or vehicle operator (if the trucks are not owned by the activity participants)	
Measuring instrument(s)	*Type of instrument*	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
Measurement intervals	Continuously	
QA/QC procedures		
Treatment of uncertainties	Uncertainties are determined based on the measuring instruments	
Additional comment		

Data / Parameter table 25.

Data/parameter	$w_{c,i,y}$
Description	Weighted average mass fraction of carbon in fuel type *i* in year *y*
Data unit	t C /mass unit of the fuel
Equations referred	(43), (44)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	Variable (depends on the type of fuel)
Source of data	☒ Measured ☒ Other sources
Choice of data or measurement methods and procedures	- Values provided by the supplier of the fuel (preferred source); - Measurements by activity participants undertaken in line with national or international fuel standards
Treatment of uncertainties	Uncertainties are determined based on the measuring instruments

Additional comments	Verify if the values measured or sourced from the fuel supplier or from measurements are within the uncertainty range of the product of the IPCC default values as provided in Table 1.2 and Table 1.3, Vol. 2 of the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements. The laboratories in (b) should have ISO17025 accreditation or justify that they can comply with similar quality standards

Data / Parameter table 26.

Data/parameter	$\rho_{,i,y}$
Description	Weighted average density of fuel type *i* in year *y*
Data unit	Mass unit/volume unit of the fuel
Equations referred	(43), (44)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	Variable (depends on the type of fuel)
Source of data	☒ Measured ☒ Other sources
Choice of data or measurement methods and procedures	- Values provided by the supplier of the fuel (preferred source); - Measurements by activity participants undertaken in line with national or international fuel standards (if the values provided by the supplier of the fuel are not available); - Regional or national default values (if the values provided by the supplier of the fuel are not available and only for liquid fuels)
Additional comments	For option 1: The density of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated.

Data / Parameter table 27.

Data/parameter	$NCV_{i,y}$
Description	Weighted average net calorific value of the fuel type *i* in year *y*
Data unit	TJ per Mass unit or volume unit of the fuel
Equations referred	(45)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	Variable (depends on the type of fuel)
Source of data	☒ Measured ☒ Other sources
Choice of data or measurement methods and procedures	- Option 1: Values provided by the supplier of the fuel (preferred source). The density of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated; - Option 2: Measurements by activity participants undertaken in line with national or international fuel standards (if the values provided by the supplier of the fuel are not available). The NCV of the fuel should be obtained for each fuel delivery, from which weighted average annual values should be calculated;

	- Option 3: Regional or national default values (if the values provided by the supplier of the fuel are not available and only for liquid fuels). Values shall be reviewed annually; - Option 4: Upper bound of the 95% confidence interval from IPCC default values provided in Table 1.2 of Chapter 1 of Vol. 2 (Energy) of the 2019 Refinement to the 2006 IPCC Guidelines on National GHG Inventories (if the values provided by the supplier of the fuel are not available). Update based on future revisions of the IPCC Guidelines.
Treatment of uncertainties	Verify if the values under Options 1, 2 and 3 are within the uncertainty range of the IPCC default values as provided in Table 1.2, Vol. 2 of the 2019 Refinement to the 2006 IPCC Guidelines. If the values fall below this range collect additional information from the testing laboratory to justify the outcome or conduct additional measurements – the laboratories in Options 1, 2 and 3 should have ISO17025 accreditation or justify that they can comply with similar quality standards
Additional comments	

Data / Parameter table 28.

Data/parameter	$EF_{CO2e,i,y}$
Description	Weighted average CO_2e emission factor of fuel type *i* in year *y*
Data unit	tCO_2e/GJ
Equations referred	(45)
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions
Value(s) applied	Variable (depends on the type of fuel)
Source of data	☒ Measured ☒ Other sources
Choice of data or measurement methods and procedures	- Option 1: Values provided by the supplier of the fuel (preferred source) in line with national or international fuel standards; - Option 2: Measurements by activity participants undertaken in line with national or international fuel standards (if the values provided by the supplier of the fuel are not available); - Option 3: Regional or national default values (if the values provided by the supplier of the fuel are not available and only for liquid fuels). Values shall be reviewed annually; - Option 4: Upper bound of the 95% confidence interval from IPCC default values provided in the 2019 Refinement to the 2006 IPCC Guidelines on National GHG Inventories (if the values provided by the supplier of the fuel are not available). Update based on future revisions of the IPCC Guidelines.
Additional comments	For Option 1, if the fuel supplier of the fuel does provide the NCV value and the CO_2 emission factor on the invoice and these two values are based on measurements for this specific fuel, this CO2 factor should be used. If another source for the CO2 emission factor is used or no CO_2 emission factor is provided, Options 2, 3 and 4 should be used. The emission factors of CH_4 and N_2O shall be converted to tCO_2e/GJ and added to the emission factor of CO_2 to estimate a total equivalent emission factor in tCO_2e/GJ for the three greenhouse gases.

14.1. Frequency of submission of monitoring reports

183. N/A, since this requirement is only applicable for activities involving removals and for emission reduction activities with risks of reversals.

Appendix 1. Measurements of methane flux leaving the surface of the landfill using flux box technique

1. General concept of the flux box method

1. The method elaboratd in this appendix is proposed based on the UK Environment Agency Guideline "*Guidance on monitoring landfill gas surface emissions*, (LFTGN07 v2)". Although LFTGN07 v2 is intended for accurately estimating the baseline emissions from the entire SWDS's surface, selecting the most appropriate OX value requires a conservative estimation of the average flux from each zone of a SWDS using a passive flux box that consists of an enclosure of known volume, with two ports fitted to the top, where the inlet port is used for pressure equilibration and the outlet port for removing samples. The subsections below discusses the step-by-step guidance on designing a flux box survey in LFTGN07 v2 and the adjustment that may be needed for the purpose of OX selection.[1]

2. Preparatory work

2. LFTGN07 v2 recommends that a desk study be conducted based on the history of waste received, installation of the top cover and operation of the gas collection system in order to help identifying potential anomalies in the SWDS surface, to form some expectations about the flux and to help to identifying the most suitable timing for conducting the measurements.

3. The study referred above should be followed by a "walk-over" in which the SWDS is screened for hotspots using a handheld instrument to ensure that each zone is relatively homogeneous and to delineate any areas of high emissions ("features").

3. Survey design

4. The aim of the survey design should be to provide a representative estimate of the flux in each zone that would allow a conservative choice of OX, taking into consideration the spatial and temporal variability of flux.

5. Based on the findings during the desk study and walk-over exercises referred above, the SWDS should be divided into zones of homogenous flux. Once the zones are defined, for each zone, the number and locations of measurement points (sample number) must be determined. To decide an appropriate timing for conducting the measurements, the LFG collection maintenance schedule (if it exists prior to the project) and meteorological information should be consulted in order to determine the month of the year which represents the average conditions of the year. Details of each step are described below.

3.1. Zoning

6. The SWDS should be divided into zones, depending on the expected emissions, so as to capture any variability among zones and to ensure homogeneity within each zone.

[1] Detailed instructions on how to construct the flux box and conduct the measurements are contained in Appendix A of LFTGN07v2.

7. Based on the desk study and walk-over exercises, LFTGN07 v2 recommends the SWDS to be divided into closed and operational zones and features, both of which should be annotated on the site plan. More zones may be considered if different cover materials or thickness are used across the SWDS.

8. Features are areas from which emissions are higher (hotspots) and need to be delineated from the zone within which they exist for exclusion from the measurements. Features could arise from imperfection (e.g., cracks), installation (e.g. wells) or topography (e.g., slopes). For the purpose of flux box measurements, areas with daily cover, as opposed to intermediate cover, may be considered as feature, since emissions through such covers are typically high.

9. At minimum, SWDS should be divided into zones by cells since the flux is known to vary depending on the age of the waste. The cell may be further divided into smaller zones to ensure that each zone is homogenous in terms of surface methane emissions, for example, depending on the cover properties (materials, soil thickness, vegetation). This may include careful inspection of the surface during walkover, as well as history of the waste received.

10. Features must be correctly identified and excluded from zones as they are likely to have significantly higher flux than the rest. In addition, features typically have small areas and are situated in such a way that makes measurements difficult. Considering the cost implications and technical challenges, and more importantly, for the conservativeness of the resulting OX, features shall be excluded from the measurements.

3.2. Sample size and location

11. Number of measurements per zone *(n)* recommended by LFTGN07 v2, is based solely on the area of the zone, $Area_i$ (m^2) and it is calculated as follows:

$$n = 6 + 0.15 \times \sqrt{Area_i}$$ Equation (1)

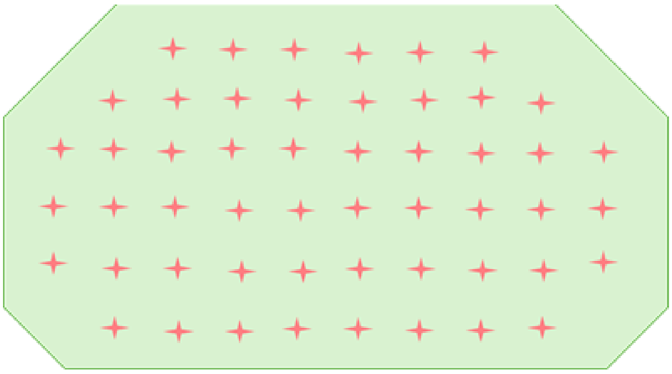
12. The table below lists examples of the number of locations necessary and approximate spacing between the measurement locations.

Table 12. Number of sample points and average spacing between them recommended by the UK Environment Agency (source: Table 5.2 of LFTGN 07 v2)

Zone size (m^2)	Number of locations	Average spacing (approx.)
5,000	16	18 metres
10,000	21	22 metres
100,000	53	43 metres
1,000,000	156	80 metres

13. Assuming that each zone is homogenous with respect to the surface emissions, sampling points can be distributed evenly throughout the zone, but avoiding the edges of the zone, as illustrated in the figure below.

Figure 2. Illustration of distribution of sampling location in a zone



3.3. Timing of measurement

14. In order to ensure that the flux measured is representative, temporal variability must be taken into consideration, both seasonal (during a month that represents an average climate of the area, in terms of temperature and humidity) and diurnal (during late morning, avoiding between 12:00 pm and 6:00 pm during which emissions vary typically the highest).

15. In addition, measurements during any anomaly in the meteorological or ground conditions, or the operation of the gas collection system must be avoided. Based on the guidance in LFTGN07 v2 and Environmental Protection Agency of Ireland (2011), the following may be considered:

    (a) Measurements be taken during normal operation of the gas collection system; maintenance, or any malfunctioning should be avoided.

    (b) Meteorological conditions:

        (i) Avoid periods of extremely high or low ambient pressure, or of rapid change, as low pressure is typically associated with higher flux and strong wind can interfere with the measurements.

        (ii) Avoid periods during or immediately after heavy rain (see also ground conditions).

        (iii) Avoid irregular ground conditions that impede or alter the courses of flux be avoided, including water-logged ground, and frost or ice-covered ground.

    (c) Measurement should be avoided if high ambient concentration of flammable substances is detected, as it can affect the sensitivity of the gas analyser.

16. The date and time of the measurements, as well as the ambient temperature, atmospheric pressure, relative humidity, and any other notable information related to the ambient (e.g., wind speed) and ground condition (e.g., puddles, frost), should be recorded for verification.

3.4. Number of measurements per location

17. The following options could be considered to ensure that the flux of each measurement location is representative:

    (a) At least 3 measurements per location, at least 30 minutes in between, within a period of one week; or

    (b) At least 3 measurements per location, except for immature SWDSs cells, for which at least 6 measurements should be taken per location, at least 30 minutes in between, within a period of one week; or

    (c) The number of measurements per each sampling location should be such that the estimated mean flux fits within either 10% or 20% of the true mean with 95% confidence.

3.5. Frequency of measurements

18. The methodology allows activity participants to choose between the monitoring once before the start of the crediting period and every year, based on the applicable Option.

4. Estimating the average flux of each zone

19. Assuming that each zone is homogenous with respect to flux, and the sampling points are distributed evenly, the average flux of each zone may be calculated as a simple arithmetic mean of all measurement points within the zone.

20. The duration of each measurement depends on the size of the box and the flux and should not extend beyond a point at which the concentration change starts slowing down.[1] LFTGN07 v2 appendix C may be followed for the calculation methods and appendix D for ways to minimise uncertainties.

21. Flux for each measurement is calculated as follows:

$$J_{out} = \frac{V \times {}^{dc}/_{dt}}{A} \times \frac{86{,}400}{1{,}000}$$ Equation (2)

Where:

	=	Flux of methane leaving the surface ($g_{CH4}/m^2.d$)
V	=	Internal volume of the box (m^3)
	=	Rate of change in the concentration of methane in the box ($mg_{CH4}/m^3.s$)
A	=	Surface area of the SWDS covered by the box (m^2)
$86{,}400$	=	Number of seconds in a year (s/d)
$1{,}000$	=	Number of milligrams in a gram (mg/g)

[1] The concentration measurements in the first few minutes may be unstable and after a certain period of time, as the concentration in the box becomes high, the rate starts to slow down, typically before 30 minutes, depending on the volume of the box.

22. LFTGN07 v2 recommends the rate of change of the gas concentration *(dc/dt)* to be determined as follows:

(a) Plot the concentration (mg/m^3) measurements against time (in seconds).

(b) Remove individual data points from the ends[1]: first from the last datum collected and then the initial one, alternatingly until a correlation coefficient (R^2) is at least 0.8.

(c) Provided that the three criteria below are satisfied, *dc/dt* is the slope of the line correlation.

(i) $R^2 > 0.8$;

(ii) The plot has more than five data points remaining; and

(iii) The change in the concentration is greater than zero.

(d) If no change in concentration is detected, use the lower detection limit of the equipment.

Appendix 2. Identification and avoidance or minimization of leakage

1. Identification of leakage emission sources

1. As required by the leakage standard, the following potential sources of leakage are considered:

    (a) Baseline equipment transfer;

    (b) Competition for resource use;

    (c) Diversion of existing production processes or outputs;

    (d) Increases in release of GHGs from the environment as a result of Article 6.4 activity;

    (e) Additional leakage sources not covered by the leakage standard:

        (i) Upstream emissions from the manufacturing of flares used by the Article 6.4 activity;

        (ii) Upstream emissions from the manufacturing of HDPE pipeline used for LFG collection and supply of LFG or biomethane to consumers;

        (iii) Upstream emissions from the manufacturing of the containers used for the transportation of the LFG or the biomethane, manufacturing of trucks, and manufacturing of equipment used for LFG compression or upgrade to biomethane;

        (iv) Upstream emissions from the generation of energy using fossil fuels, including emissions from the production, processing and transportation of fossil fuels to the energy plant, manufacturing of the energy generation equipment and construction of the energy generation plant.

2. Avoidance or minimization of leakage

2. Out of the potential sources identified above, the following are not impacted by typical Article 6.4 activities eligible under this methodology and, therefore, do not need to be further considered:

    (a) Diversion of existing production processes or outputs: the types output provided by typical Article 6.4 activities eligible under this methodology are the same as in the baseline, (i.e. treated waste, biomethane/LFG to replace natural gas, heat or electricity);

    (b) Increases in release of GHGs from the environment as a result of the project: the project will be implemented in SWDS, therefore there will be no release of GHG from the environment.

3. Leakage from the transfer of baseline equipment may happen if the heat generation equipment used in the baseline replaces a new heat generation equipment that is used

outside of the activity boundary. In order to avoid this leakage, an applicability condition was added requiring activity participants to either demonstrate that the heat generation equipment used in the baseline scenario are scrapped or that the existing heat generation equipment used outside of the activity boundary has a lower efficiency than the heat generation equipment used in the baseline scenario.

4. Leakage from the competitive use of the solid waste may happen if solid waste used for other activities, e.g. recycling, is diverted to the SWDS. To avoid this leakage, an applicability condition was introduced in this methodology that requires activity participants to demonstrate that the Article 6.4 activity does not reduce the amount of organic waste that would be recycled in the absence of the project activity.

3. Discount of leakage

5. As justified above, the leakage emissions sources that need to be accounted are those associated with the:

   (a) Upstream emissions from the manufacturing of flares used by the project;

   (b) Upstream emissions from the manufacturing of HDPE pipeline used for LFG collection and supply of LFG or biomethane to consumers via dedicated pipeline;

   (c) Upstream emissions from the manufacturing of the containers used for the transportation of the LFG or the biomethane, of manufacturing of trucks, and manufacturing of equipment used for LFG compression and biomethane upgrade and compression;

   (d) Upstream emissions from the generation of energy using fossil fuels, including emissions from the production, processing and transportation of fossil fuel to the energy plant, manufacturing of the energy generation equipment and construction of the energy plant.

6. The table below illustrates the upstream emission sources identified for the baseline and for the activity scenarios associated with the type of Article 6.4 activity being implemented based on the different components:

Table 13. Upstream baseline and activity emission sources identified for each component of Article 6.4 activities eligible under this methodology

Type of project	Baseline situation	Source of upstream baseline emissions	Activity situation	Source of upstream activity emissions
Flaring only	• Operation of the landfill without implementing the LFG collection and destruction systems that are part of the project;	• N/A	• Installation of an efficient LFG collection system; • Installation of one or more flares to destroy the methane	• Manufacturing of HDPE pipeline to collect the LFG • Manufacturing of flares

Type of project	Baseline situation	Source of upstream baseline emissions	Activity situation	Source of upstream activity emissions
Supply of biomethane or LFG to consumers	• Operation of the landfill without implementing the LFG collection system that is part of the project; • Consumers would have been supplied with natural gas from the distribution network.	• N/A • Production, processing and transportation of the natural gas to the consumers;	• Installation of an efficient LFG collection system; • Installation of biomethane production plant; • Transportation of the biomethane to consumers via pipeline, natural gas grid or trucks	• Manufacturing of HDPE pipeline to collect the LFG; • Construction of the biomethane production plant; • Manufacturing of biomethane transportation pipelines, trucks and vessels.
Electricity generation	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: electricity would have been generated by a natural gas power plant	• N/A • Production, processing and transportation of the natural gas to the power plant	• Installation of an efficient LFG collection system; • Construction of a LFG power plant	• Manufacturing of HDPE pipeline to collect the LFG; • Manufacturing of LFG engines and construction of the power plant.
Heat generation and replacement of existing equipment	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: heat would have been generated in the same natural gas boiler	• N/A • Production, processing and transportation of the natural gas to the boiler	• Installation of an efficient LFG collection systems	• Manufacturing of HDPE pipeline to collect the LFG;

Type of project	Baseline situation	Source of upstream baseline emissions	Activity situation	Source of upstream activity emissions
Heat generation and replacement of new equipment	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: heat would have been generated in a natural gas boiler	• N/A • Production, processing and transportation of the natural gas to the boiler;	• Installation of an efficient LFG collection system; • Installation of a new boiler	• Manufacturing of HDPE pipeline to collect the LFG; • Manufacturing of the boiler

7. The upstream the leakage emissions shall be determined as the difference between the upstream activity emissions and the upstream baseline emissions.

8. The sections below elaborate on how each of the upstream sources were determined.

4. Upstream activity emissions from the manufacturing or flares

9. In the absence of a published life-cycle analysis for the production of flares, the upstream emissions from the manufacturing of the flares were estimated as the product between the weight of a flare (assuming that flares are 100% composed of steel) by the CO_2 emission factor for the production of steel (1.27 tCO_2e/t_{steel}, as per Appendix 3 of the approved CDM methodology AMS-III.BA.[1]), and the result is multiplied by 1.3 to account for 30% more emissions due to the transportation and assembly of the flare in the activity site. Therefore, upstream emissions to produce a 5,000 $m^3{}_{LFG}/h$ flare that weighs 9.6 tons (information provided by a manufacturer) is equal to 15.8 tCO_2e.

10. A SWDS with a capacity to collect 5,000 m3/h of LFG can generate around 360,000 tCO_2e/year (determine by applying the mass flow tool, assuming the gas has a methane concentration equals to 50%, an operational temperature of 323 K and a manometric pressure of 50 Pa). Applying the discount factors for downward adjustment as per the adjustment factor, it results in or 1,000,000 tCO_2e over a 5-years crediting period. Therefore, the upstream emissions from the production of the flare can be neglected since it represents 0.001% of the baseline emissions achieved during a 5-years crediting period.

5. Upstream activity emissions from the manufacturing or HDPE pipeline for the collection of LFG and for the distribution of biomethane or LFG to consumers via dedicated pipeline

11. Upstream emissions from the manufacturing of HDPE pipeline were estimated based on public available information on the specific weight of a SDR11 HDPE pipeline per meter

[1] Approved small-scale CDM methodology 'AMS-III.BA: Recovery and recycling of materials from E-waste', available at https://cdm.unfccc.int/UserManagement/FileStorage/30BQNA7GEM4ZCPWI895FHDXRLJTSK6.

(equals to 25.6 kg/m^2), and the emission factor of HDPE (equals to 2.6 kg_{CO2e}/kg_{HDPE} [3]), assuming that the pipe is 100% composed by HDPE, and adding 30% to account for emissions associated with the transportation and installation of the pipes in the site. The result is equal to 0.087 t_{CO2e}/m_{HDPE}.

12. The assumption that this is the type of HDPE pipes (SDR11) employed by SWDSs for wells, headers, gas lines and distribution lines to consumers is conservative since it is used for fluids with an internal pressure up to 10 bar and gas flow above 15,000 m^3/h, whereas the typical operating pressure of LFG collection system is 6-8 bar and the estimated waste disposed to achieve such flow of gas should be around 8,000 tonnes/day – or a SWDS that receives the waste from around 8,000,000 inhabitants.

13. Large-scale LFG-to-energy activities (LFG generation rate above 10,000 m3/h that can be used to generate electricity in a power plant with more than 10 MW installed capacity) tend to install the longest pipeline network possible in the SWDSs in order to maximize the amount of LFG collected, however the total pipeline length installed (gas wells, headers, and gas lines) does not usually reach 50 km. Therefore, the upstream emissions from the manufacturing of 50 km of HDPE results in 4,350 tCO_2e. If another 20 km are added to connect the SWDS with the natural gas distribution network or with the dedicated consumer, upstream emissions would be rounded up to 6,100 tCO_2e.

14. For sake of comparison, this leakage would represent 0.3% of the baseline emissions over a 5-years crediting period for Article 6.4 activities with a collection design of 5,000 m^3/h (360,000 tCO_2e/year, or 1,850,000 over a 5-years period for a project that involves 100% of the FLG being supplied to consumers via dedicated pipeline without destruction in flares, see rationale in paragraph 10 above).

6. Upstream activity emissions from the manufacturing of the containers used for the transportation of the LFG or the biomethane, of trucks, and equipment used for LFG compression/liquefaction or upgrade to biomethane

15. This upstream emission source will be assessed separately for the manufacturing of the containers, for the manufacturing of trucks and for the manufacturing and construction of the biomethane production plant.

6.1. Upstream activity emissions from the manufacturing of the containers used for the transportation of the LFG or biomethane

16. In the absence of a published life-cycle analysis for the production of containers used for the transportation of the LFG or biomethane, the CO2 emissions were estimated assuming that:

(a) The cylinder used for the storage of the LFG or biomethane is a Type 3 vessel, with maximum operating pressure of 250 bar and hydraulic volume of 120 L. The vessel is manufactured using a mix of carbon fibre and epoxy composite for the structural shell and glass fibre and epoxy composite as protective barrier and has

[2] https://www.youmats.com/en/plumbing/pipe-and-fittings/hdpe-pipes-and-fittings/hdpe-pipes/hdpe-pipe-pn-10-bar-pe-80-od-315-mm-black-color-alwasail-194/.

[3] Life cycle greenhouse gas emissions and energy use of polylactic acid, bio-derived polyethylene, and fossil-derived polyethylene (page 14).

a mass equal to 57 kg.[4] For conservative reasons, the calculation will assume that the cylinder is 100% composed by carbon fibre due to its higher LCA emissions compared to glass fibre (53.4 $kgCO_2e/kg_{carbon\ fibre}$[5] and 2.02 $kgCO_2e/kg_{glass\ fibre}$[6]);

(b) The mass of biomethane that can be stored at 250 bar and 15ºC in a 120 L vessel is around 20 kg. Transportation trucks can be designed with different storage capacities, ranging from 1,000 to 2,500 hydraulic L – or with a storage capacity from 170 to 420 kg of biomethane at 250 bar. For simplification, trucks with 2,500 hydraulic L capacity (or 420 kg of biomethane) vessels will be considered in the calculations;

(c) The LFG collected from a SWDS with a collection capacity of 5,000 m3/h at standard conditions can produce 1.6 tons/hour of biomethane, meaning that for every hour a total of 4 trucks can be filled with biomethane at the same time.

17. The estimation of upstream leakage will depend on the number of trucks available to make the transportation, which depends on the duration of a round-trip to transport the biomethane to consumers: if the round-trip is 1 hour, the project must operate with 8 trucks (4 to transport the biomethane whereas the other 4 are being filled with biomethane); if the round-trip is 2 hours, the project must operate with 16 trucks – and so on and so forth.

18. The upstream emissions to manufacture the 2,500 hydraulic L vessel used in this example is equal to 64 tons of CO_2 (21 vessels x 57 kg/vessel x 53.4 $kgCO_2e/kg_{vessel}$, assuming the vessels are 100% made of carbon fibre). Therefore, for a round-trip of 1 hour, upstream emissions will be equal to 8 trucks x 64 tCO2e/truck, which is equal to 512 tCO2e.

19. Converting the upstream emissions to tCO2e per MJ to transport 14,000 tons of biomethane (616 TJ) in one year, the result is 512 tCO2e / 616 TJ = 0.83 tCO2e/TJ (or 0.83 gCO2e/MJ)

6.2. Upstream activity emissions from the manufacturing of the trucks used for the transportation of the LFG or the biomethane

20. Data is available to determine the cradle-to-gate emissions from the manufacturing and use of heavy-duty trucks, in gCO_2e/km. According to the white paper published by the ICCT[7], the LCA emissions from a 40-tonnes articulated truck (tractor trailer) driving 1,300,000 km over a 20 years lifetime and consuming a mix of diesel and biofuel. The upstream emissions from the manufacturing of the truck can be conservatively assumed from Figure 4 of this white paper as 100 gCO2e/km, which results in emissions equals to 100 gCO2e/km x 1,300,000 km = 130 tCO2e to manufacture one 40-tonnes truck. The

[4] https://steelheadcomposites.com/sites/default/files/2024-01/CNG-Brochure.pdf.

[5] Available at https://www.sciencedirect.com/science/article/pii/S1526612523000944?ref=pdf_download&fr=RR-7&rr=976f1ff31c261db8, accessed on 11 August 2025.

[6] Available at https://glassfibreeurope.eu/life-cycle-assessment-of-continuous-filament-glass-fibre-products-2/, accessed on 11 August 2025.

[7] **International Council on Clean Transportation (ICCT)**. *The life-cycle greenhouse gas emissions of European heavy-duty vehicles and fuels*. 2023. White paper. Available at <https://theicct.org/wp-content/uploads/2023/02/Lifecycle-assessment-trucks-and-buses-emissions-Europe.pdf>, accessed on 10 August 2025.

upstream emissions for manufacturing the 8 trucks used for the transportation of the biomethane above will be equal to 1,040 tCO2e.

21. Therefore, the upstream emissions for the supply of biomethane from the collection of 5,000 m3/h of LFG, assuming that the round-trip between the SWDS and the consumer is 1 hour, is equal to 1,500 tCO2e.

22. Over a year, the SWDS with a capacity to collect 5,000 m3/h of biogas can produce 70,200 MJ/h, assuming the biomethane has the same composition as the natural gas and the NCV of the natural gas is equal to 48 TJ/GJ (as per Table 1.2 from Chapter 1, Volume 2 of the 2006 IPCC guidelines for national greenhouse gases inventories). On an yearly basis, the SWDS would produce around 14,000 tonnes of biomethane – or 673 TJ. Therefore, the upstream emissions for the manufacturing of the vessels to store the biomethane and the trucks to transport the biomethane to the consumers is equal to 1,500 tCO2e / 673,000,000 = 2.2 tCO2e/TJ, or 2.2 gCO2e/MJ.

6.3. Upstream activity emissions from the manufacturing of the equipment used for LFG compression/liquefaction or upgrade to biomethane

23. In the absence of a published life-cycle analysis for the manufacturing of a biomethane production plant from LFG, a proxy was considered based on upstream emissions to process natural gas. The National Energy Technology Laboratory, published, in 2024, the report "Life cycle analysis of natural gas extraction and power generation: U.S. 2020 emissions profile"[8] containing an analysis of the U.S. natural gas (NG) supply chain and a study on the impact associated with an average unit of NG traversing from the upstream production basins to the downstream delivery regions. According to analysis, the upstream emissions of a processing natural gas plant is equal to 2.08 gCO2/MJ. Adding this value to the 2.2 gCO2e/MJ determined in section 3.2 above gives a total of 4.28 gCO2/MJ.

7. Upstream activity emissions from the generation of electricity

24. In the absence of LCAs that provide the emissions from the construction of an LFG power plant and from the manufacturing of engines, an approximate emission factor per kWh was estimated by:

(a) Calculating the electricity generation by a 4 MW gas engine as the product between 8,760 hours/year x 4 MW x 85% capacity factor (same basis as the NGCC power plant from item 5 above) x 30 years (same basis as the NGCC power plant from item 5 above), which is equal to 893,520 MWh;

(b) Determining the emissions to produce a 4 MW LFG engine by multiplying the weight of a typical 4 MW LFG engine (54 tonnes[9]) by the specific CO2 emission factor for the production of steel 1.27 tCO_2e/t_{steel} (assuming that the engine is 100% steel), and further multiplying the result by 1.3 to account for emissions from the construction of the power plant, which results in 89 tCO2 per 4 MW engine;

[8] Available at https://www.netl.doe.gov/projects/files/LifeCycleAnalysisofNaturalGasExtractionandPowerGenerationUS2020EmissionsProfile_121724.pdf, accessed on 20 August 2025.

[9] https://www.cat.com/en_US/products/new/power-systems/electric-power/gas-generator-sets/15969826.html.

(c) The upstream activity emissions is the ratio between the electricity CO2 emissions and the electricity generated, which is equal to 89 tCO2/893,520 MWh = 0.1 gCO2/kWh.

8. Upstream activity emissions form the manufacturing of a boiler

25. Upstream emissions for the manufacturing of a boiler for the construction of the energy plant were sourced from available literature of LAC for the natural gas supply chain and for a 25 $MW_{thermal}$ boiler.

26. In the absence of open LCA for the production of boilers, the upstream emissions to manufacture one boiler were estimated by multiplying the weight of the boiler by 1.27 tCO_2e/t_{steel} (assuming the boiler is 100% made of steel), plus 30% added to account for assembly and transportation emissions. To narrow down the search, a boiler with a capacity of 31.5 tonnes/h of steam at 11 bar and efficiency of 90% was considered based on the thermal energy that 5,000 m3/h of LFG can generate (approximately 25 $MW_{thermal}$) – the weight of such type of boiler is equal to 52.7 tons,[10] and its upstream emissions are equal to 52.7 tons x 1.27 tCO_2e/t_{steel} x 130% = 87 tCO_2e. If the boiler operates throughout a whole year (8,760 hours, to align with the basis of the natural gas upstream emissions determined in item 4), the total MJ produce will be equal to 6.75×10^8 MJ, which results in 0.12 gCO2/MJ.

9. Upstream baseline emissions from the production, processing and transportation of the natural gas to consumers

27. The National Energy Technology Laboratory, published, in 2024, the report "Life cycle analysis of natural gas extraction and power generation: U.S. 2020 emissions profile"[11] containing an analysis of the U.S. natural gas (NG) supply chain and a study on the impact associated with an average unit of NG traversing from the upstream production basins to the downstream delivery regions, including the calculation of two U.S. average emissions from NG produced and delivered in the year 2020: 8.8 gCO_2e/MJ for the emissions associated from the production of the NG to the distribution to final consumers via natural gas grid (the "production through distribution" life-cycle analysis, including the production, gathering and boosting, processing, transmission and distribution of natural gas to end users), and 7.8 gCO_2e/MJ for the emissions associated from the production of the NG to the transmission gas pipeline (the "production through transmission network" life-cycle analysis, including the production, gathering and boosting, processing and transmission of natural gas to the natural gas network).

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[10] Available at https://cdn0.scrvt.com/2828ebc457efab95be01dd36047e3b52/8fde0b1cea96b7c1/22e104ceb3e7/Vitomax-HS-Technical-Data.PDF?utm_source=chatgpt.com, accessed on 20 August 2025. Refer to the dry weight of boiler size G for 10 bar (page 9 of the catalogue).

[11] Available at https://www.netl.doe.gov/projects/files/LifeCycleAnalysisofNaturalGasExtractionandPowerGenerationUS2020EmissionsProfile_121724.pdf, accessed on 20 August 2025.

10. Upstream baseline emissions form the generation of electricity using fossil fuels

28. Upstream baseline emissions from the generation of electricity using fossil fuels, including emissions from the production, processing and transportation of fossil fuel to the energy plant, manufacturing of the energy generation equipment and construction of the energy plant were sourced from available literature of lifecycle analysis (LAC)[12], based on a natural gas combined cycle (NGCC) power plant located in Europe, with an installed capacity of 497 MW with an operational lifetime of 30 years.

29. The LCA provides emissions equal to 434 gCO_2e/kWh for the full life-cycle of the power plant, from the natural gas production to the decommissioning of the power plant. According to Figure 9 of the report, emissions from the production and transportation of natural gas and for the construction of the power plant is between 15% and 20% of the life-cycle emissions. To be conservative, the analysis assume that the upstream baseline emissions are equal to 20% of the life-cycle analysis, or 87 gCO2/kWh.

11. Addressing upstream leakage under the methodology

30. As explained in sections 1 above, the upstream activity emissions from the production of flares can be neglected since it represents 0.002% of the baseline emissions for an Article 6.4 activity with a capacity to collect 5,000 m^3/h of LFG.

31. As explained in section 2 above, the upstream activity emissions from the manufacturing of a long and conservative length of HDPE pipeline represent less than 0.5% of total baseline reductions achieved during the first crediting period for an Article 6.4 activity with a capacity to collect 5,000 m^3/h of LFG.

32. For activities that involve the supply of biomethane or LFG via trucks, dedicated pipelines or via natural gas distribution grid, the activity upstream emissions for the production and transportation of the biomethane or LFG to consumers can be neglected since the baseline upstream emissions to produce the same amount of natural gas (in an energy basis) is 4 times higher.

33. For activities that involve the generation of electricity, the activity upstream emissions for the production of 1 kWh (including the manufacturing of the LFG engines and the construction of the power plant) represents 0.11% of the baseline upstream emissions for the production, processing and transportation of natural gas and construction of the power plant. However, this comparison is not realistic since the upstream baseline emissions were determined for a power plant with a capacity more than 100 times higher than the activity plant, therefore it's necessary to allocate the emissions proportionally to the same power plant capacity. By multiplying the CO_2 emissions of the NGCC power plant by 4 MW / 497 MW, the result is 0.8%; multiplying this value by 87 gCO_2/kWh results in 0.696 gCO_2/kWh – which is still higher than the emissions to manufacture a 4MW engine, therefore this upstream source can be neglected.

34. For activities that involve the generation of heat in the baseline heat generation equipment, the upstream baseline emissions are determined for the production, processing and

[12] United Nations Economic Commission for Europe; *Life Cycle Assessment of Electricity Generation Options; Geneva, 2021*; Available at https://unece.org/sed/documents/2021/10/reports/life-cycle-assessment-electricity-generation-options.

transportation of natural gas, whereas no upstream activity emissions take place in the activity scenario, therefore it is conservative to neglect this upstream source.

35. For activities that involve the generation of heat in a new baseline heat generation, the upstream baseline emissions are determined for the production, processing and transportation of natural gas (7.912 gCO_2e/MJ), whereas the upstream activity emissions are associated with the manufacturing of the new heat generation equipment (0.12 gCO_2/MJ) and represent 1.5% of the upstream baseline emissions, therefore they can be neglected.

36. The table below summarizes the upstream baseline and activity emissions.

Table 14. Upstream baseline and activity emissions for each component of Article 6.4 activities eligible under this methodology

Type of project	Baseline situation	Source of upstream baseline emissions	Upstream baseline emissions	Activity situation	Source of upstream activity emissions	Upstream activity emissions	Proposal to address leakage
Flaring only	• Operation of the landfill without implementing the LFG collection and destruction systems that are part of the project;	• N/A	• N/A	• Installation of an efficient LFG collection system; • Installation of one or more flares to destroy the methane	• Manufacturing of HDPE pipeline to collect the LFG • Manufacturing of flares	• 0.5% of baseline emissions • Neglected (0.002% of baseline emissions)	• Discount 0.5% from the baseline emissions
Supply of biomethane or LFG to consumers	• Operation of the landfill without implementing the LFG collection system that is part of the project; • Consumers would have been supplied with natural gas from the distribution network.	• N/A • Production, processing and transportation of the natural gas to the consumers;	• N/A • 8.8 gCO_2/TJ;	• Installation of an efficient LFG collection system; • Installation of biomethane production plant; • Transportation of the biomethane to consumers via pipeline, natural gas grid or trucks	• Manufacturing of HDPE pipeline to collect the LFG; • Construction of the biomethane production plant; • Manufacturing of biomethane transportation pipelines, trucks and vessels.	• 0.5% of baseline emissions • 2.08 gCO2/MJ • 2.2 gCO2/MJ (the sum can be neglected since it’s 2 times lower than baseline upstream emissions)	• Discount 0.5% from the baseline emissions

Type of project	Baseline situation	Source of upstream baseline emissions	Upstream baseline emissions	Activity situation	Source of upstream activity emissions	Upstream activity emissions	Proposal to address leakage
Electricity generation	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: electricity would have been generated by a natural gas power plant	• N/A • Production, processing and transportation of the natural gas to the power plant and generation of electricity	• N/A • 87 gCO_2/kWh;	• Installation of an efficient LFG collection system; • Construction of a LFG power plant	• Manufacturing of HDPE pipeline to collect the LFG; • Manufacturing of LFG engines and construction of the power plant.	• 0.5% of baseline emissions • 0.1 gCO_2/kWh (can be neglected since it represents 0.11% of baseline upstream emissions)	• Discount 0.5% from the baseline emissions
Heat generation in an existing equipment	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: heat would have been generated	• N/A • Production, processing and transportation of the natural gas to the boiler	• N/A • 87 gCO_2/kWh;	• Installation of an efficient LFG collection system;	• Manufacturing of HDPE pipeline to collect the LFG;	• 0.5% of baseline emissions	• Discount 0.5% from the baseline emissions

Type of project	Baseline situation	Source of upstream baseline emissions	Upstream baseline emissions	Activity situation	Source of upstream activity emissions	Upstream activity emissions	Proposal to address leakage
	in the same natural gas boiler						
Heat generation in a new equipment	• Operation of the landfill without implementing the LFG collection system that is part of the project; • For simplification: heat would have been generated in a natural gas boiler	• N/A • Production, processing and transportation of the natural gas to the boiler;	• N/A • 7.912 gCO_2/MJ;	• Installation of an efficient LFG collection system; • Installation of a new boiler	• Manufacturing of HDPE pipeline to collect the LFG; • Manufacturing of the boiler	• 0.5% of baseline emissions • 0.12 gCO2/MJ (can be neglected since it is lower than the baseline upstream emissions)	• Discount 0.5% from the baseline emissions

37. In summary, the common upstream leakage source among the different types of Article 6.4 activities is the manufacturing of the HDPE pipeline, therefore it is proposed to discount 0.5% of the baseline emissions to address any potential leakage.

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Document information

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