ARTICLE 6.4 MECHANISM

A6.4-MEP008-A06

Draft Methodological tool

Activity emissions from flaring

Version 01.0

United Nations
Framework Convention on
Climate Change

COVER NOTE

1. Procedural background

1. The Supervisory Body of the Article 6.4 mechanism, 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 “Tool: Project emissions from flaring” (hereinafter referred to as the approved CDM Tool).

2. Purpose

2. The purpose of this new methodological tool is to provide the procedures, requirements and guidelines to calculate activity emissions from flaring of a residual gas, where the component with the highest concentration is methane. The source of the residual gas is biogenic (e.g., landfill gas or biogas from wastewater treatment).

3. Key issues and proposed solutions

3. This proposed new methodological tool was developed based on the approved CDM Tool[1], but with revisions to align with the Article 6.4 mechanism framework and standards.

4. This proposed new methodological tool is applicable only to biogenic residual gases (e.g., landfill gas, wastewater biogas) where methane is the main component. It excludes cases where auxiliary fuels are required to sustain combustion.

5. This proposed new methodological tool provides approaches to determine the methane destruction efficiency for both open and enclosed flares as follows:

    (a) Open flares: Assigned a default efficiency of 50%;

    (b) Enclosed flares: Participants may apply either a default efficiency (90%) or use continuously measured efficiency. Low-height enclosed flares must apply a conservative deduction of 10 percentage points to efficiency.

6. This proposed new methodological tool incorporates IPCC guidance on uncertainty analysis. Conservative adjustments (e.g., efficiency deductions, uncertainty factors) are applied to avoid underestimation of activity emission.

4. Impacts

7. The approval of this proposed new methodological tool will allow the development of new Article 6.4 activities that aim to capture and destroy the methane contained in the landfill gas or wastewater biogas.

[1] See https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-06-v4.0.pdf/history_view

5. Subsequent work and timelines

8. The MEP agreed to seek inputs from stakeholders on the draft version of the proposed new methodological tool. The MEP will analyse the inputs and consider them in preparation of a revised methodological tool at its next meeting for consideration of the Supervisory Body.

6. Recommendations to the Supervisory Body

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

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1. Introduction

1.1. Scope

1. This tool provides procedures to calculate activity emissions from flaring of a residual gas for which the component with the highest concentration is methane. The source of the residual gas is biogenic (e.g., landfill gas or biogas from wastewater treatment).

2. The tool is applicable to enclosed or open flares and activity participants should document in the PDD the type of flare used in the Article 6.4 activities.[1]

3. The tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$AE_{flare,y}$	tCO_2e	Activity emissions from flaring of the residual gas in year *y*

1.2. Entry into force and validity

4. This document enters into force on DD/MM/YYYY and is valid for five years, until DD/MM/YYYY, unless an earlier date applies if the methodological tool is revised or withdrawn in accordance with the procedure “Development, revision and clarification of methodologies and methodological tools” (A6.4-PROC-METH-001).

2. Definitions

5. The following definitions shall apply:

(a) **Auxiliary fuel**: An additional fuel added to the residual gas to increase the calorific value to the point where the mixture will sustain continuous combustion. Auxiliary fuel where needed is usually propane supplied from cylinders of gas or processed natural gas from a gas pipeline;

(b) **Enclosed flare**: The devices where the residual gas is destroyed in a combustion chamber. and where the length of chamber is more than two times the diameter or side of the enclosure. The device includes a burning system and air intake system based on natural or forced draft and it must be operated within the ranges specified by the manufacturer for an efficient combustion reaction;

(c) **Exhaust gas (EG):** The combustion gases emitted from the flaring of residual gas;

(d) **Methane destruction efficiency**: The methane destruction efficiency of the flare, defined as one minus the ratio between the mass flow of methane in the exhaust gas and the mass flow of methane in residual gas to be flared (both referred to in dry basis and reference conditions);

(e) **Flare operating specifications**: The manufacturer’s specification for operating the flare, which includes: the minimum and maximum flow rate and heating value and; other minimum and maximum operating conditions, and the details for the controlling devices;

[1] This version of the methodological tool 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.

(f) **Low height flare**: An enclosed flare for which the combustion chamber has a height between two and ten times the diameter of the combustion enclosure;

(g) **Open flare**: A device where the residual gas is burned in an open-air tip with or without any auxiliary assistance or a flare with a vertical cylindrical or rectilinear combustion chamber, for which the combustion chamber is less than two times the diameter of the enclosure;

(h) **Reference conditions:** Conditions are defined as 0ºC (273.15 K, 32ºF) and 1 atm (101.325 kN/m^2, 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr);

(i) **Residual gas:** A flammable gas containing methane that is to be flared as part of the Article 6.4 project of CP;

(j) **Residual gas component:** Chemical molecules composing the residual gas (CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2).

3. Applicability

6. This tool is applicable to the flaring of flammable greenhouse gases in the Article 6.4 activity scenario where:

   (a) Methane is the component with the highest concentration in the flammable residual gas;

   (b) The source of the residual gas is biogenic (e.g., biogas, landfill gas or wastewater treatment gas); and

   (c) Electric igniters in the flare are only used for start-up or flame recovery in case of flame quenching.

7. The tool is not applicable to the use of auxiliary fuels and therefore the residual gas must have sufficient flammable gas present to sustain combustion.

8. In the case of an enclosed flare, the tool is only applicable if the flare is operated in line with the operating instructions specified by the manufacturer.

9. The provisions in paragraphs 6 and 7 above shall be demonstrated in the Project Design Document (PDD) and be assessed at the initial validation. Moreover, the same provisions shall be demonstrated in each monitoring report and be assessed at each verification.

10. The provisions in paragraph 8 above shall be demonstrated in each monitoring report and be assessed at each verification.

4. Normative references

11. This methodological tool refers to the latest approved version of “Methodological tool: Determination of the mass flow of a greenhouse gas in a gaseous stream” (hereinafter referred to as the mass flow tool).[2]

12. References for this methodological tool are:

[2] The draft version of the mass flow tool has been published for a call for public inputs alongside this methodological tool. The MEP will analyse the inputs and consider them in preparation of a revised methodological tool at its 9th meeting for consideration of the Supervisory Body.

(a) G. J. Van Wylen, R. E. Sonntag, and C. Borgnakke, *Fundamentals of Classical Thermodynamics*, 4th ed. New York: John Wiley & Sons, 1994;

(b) UK Environment Agency, *Guidance for Monitoring Enclosed Landfill Gas Flares (LFTGN05 v2)*. Bristol: UK Environment Agency, 2010;[3]

(c) *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 1: General guidance and reporting.* Chapter 3: Uncertainties.

5. Methodological procedure

13. The calculation procedure in this tool determines the activity emissions from flaring the residual gas ($AE_{flare,y}$) based on the methane destruction efficiency ($\eta_{flare,m}$) and the mass flow of methane to the flare ($F_{CH4,RG,m}$). The methane destruction efficiency is determined for each minute *m* of year *y* based either on monitored data or default values.

14. Activity participants shall apply the the following steps to determine the activity emissions from flaring:

(a) STEP 1: Determination of the methane mass flow of the residual gas;

(b) STEP 2: Determination of the methane destruction efficiency;

(c) STEP 3: Calculation of activity emissions from flaring.

15. An excel sheet that can be used to calculate the activity emissions following this procedure (STEP 1, STEP 2 and STEP 3) is provided at the following weblink on the UNFCCC website: https://cdm.unfccc.int/methodologies/PAmethodologies/EB102_repan06_Tool06.xlsx.

5.1. Step 1: Determination of the methane mass flow in the residual gas

16. Activity participants shall determine the methane mass flow in the residual gas ($F_{CH4,m}$) using the mass flow tool as follows:

(a) The flow of the gaseous stream sent to the flares shall be measured continuously;

(b) CH_4 is the greenhouse gas *i* 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 and 17 in the mass flow tool); and

(d) The time interval *t* for which mass flow should be averaged is every minute *m*.

17. $F_{CH4,m}$, which is measured as the mass flow during minute *m*, shall then be used to determine the mass of methane in kilograms fed to the flare in the minute m ($F_{CH4,RG,m}$). $F_{CH4,m}$ shall be determined on a dry basis. In case the determination happens in different conditions (any of the conditions covered by the mass flow tool), the values must be corrected to dry basis as per the guidance in the same tool.

5.2. Step 2: Determination of methane destruction efficiency

18. The methane destruction efficiency depends on the type of flare, its combustion efficiency and the time that the flare is operating. To determine the methane destruction efficiency of enclosed flares, activity participants shall choose to determine the efficiency based on

[3] See https://www.gov.uk/government/publications/monitoring-enclosed-landfill-gas-flares-lftgn-05.

monitored data or the option to apply a default value. For open flares a default value must be applied. The time the flare is operating is determined by using a flame detector and, in the case of enclosed flares, in addition the monitoring requirements provided by the manufacturer's operating specifications for operating conditions shall be met.

5.2.1. Open flare

19. In the case of open flares, the methane destruction efficiency in the minute *m* ($\eta_{flare,m}$) is 50% when the flame is detected in the minute *m* ($Flame_m$), otherwise $\eta_{flare,m}$ is 0%. Further, additional discount factors to the methane destruction efficiency must be applied in case they are prescribed in the applicable methodology.

5.2.2. Enclosed flare

20. In the case of enclosed flares, activity participants may choose between the following two options to determine the methane destruction efficiency for minute *m* ($\eta_{flare,m}$) and shall document in the PDD which option is selected:

    (a) Option A: Apply a default value for methane destruction efficiency;

    (b) Option B: Measure the methane destruction efficiency.

21. In case of missing data for parameters relevant to the measurement of the methane destruction efficiency as per Option B above, the activity participants may also choose to follow the provisions of Option A above as a backup approach. The activity participants shall document this choice in the PDD.

22. Additional discount factors to the methane destruction efficiency must be applied in case they are prescribed in the applied methodology.

5.2.2.1. Option A: Default value

23. The methane destruction efficiency for the minute *m* ($\eta_{flare,m}$) is 90% when the following two conditions are met to demonstrate that the flare is operating:

    (a) The temperature of the flare ($T_{EG,m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer's operating specification for the flare ($SPEC_{flare}$) in the minute *m*; and

    (b) The flame is detected in minute *m* ($Flame_m$).

24. Otherwise $\eta_{flare,m}$ is 0%.

25. For enclosed flares that are defined as low height flares, the methane destruction efficiency shall be adjusted, as a conservative approach, by subtracting 10 percentile points.[4]

[4] For example, the default value applied shall be 80%, rather than 90%.

5.2.2.2. Option B: Measured methane destruction efficiency

26. The methane destruction efficiency in the minute *m* is a measured value ($\eta_{flare,m} = \eta_{flare,calc,m}$) when the following conditions are met to demonstrate that the flare is operating according to the manufacturer’s operating specifications:

   (a) The temperature of the flare ($T_{EG,m}$) and the flow rate of the residual gas to the flare ($F_{RG,m}$) is within the manufacturer’s operating specification for the flare ($SPEC_{flare}$) in the minute *m*; and

   (b) The flame is detected in minute *m* ($Flame_m$).

27. Otherwise $\eta_{flare,m}$ is 0%.

28. For the measurement of the methane destruction efficiency, the activity participants may choose one of the options below:

   (a) Option B.1: The measurement is conducted by an accredited entity at least on a biannual basis;[5]

   (b) Option B.2: The methane destruction efficiency is measured in each minute.

Box 1. Non-binding best practice example 1: Flame detection (option B)

> Activity participants may choose the flame detector that is appropriate and cost-effective for the Article 6.4 activity, ensuring that the emission reductions are not over-estimated.
>
> **Example 1 -** An Article 6.4 activity involves the installation and operation of a landfill gas recovery and flaring system.
>
> In order to monitor the operation of the flare, activity participants have installed a fixed UV/IR detector, which is sensitive to both ultraviolet and infrared wavelengths, and detects flame by comparing signals of both ranges. This detector operates continuously.
>
> **Example 2 -** An Article 6.4 activity involves the installation and operation of a biogas recovery and flaring system in an existing industrial facility.
>
> In order to monitor the operation of the flare, activity participants have installed a set of thermocouples, which continuously measure temperature, and therefore allow the detection of the presence and absence of flame.

5.2.2.2.1. Option B.1: Biannual measurement of the methane destruction efficiency

29. The calculated methane destruction efficiency $\eta_{flare,calc,m}$ is determined as the average of at least two measurements of the methane destruction efficiency made in year *y* ($\eta_{flare,calc,y}$), adjusted by an uncertainty factor of 5 percentile points as follows:

$$\eta_{flare,calc,y} = 1 - \frac{1}{n}\sum_{t=1}^{n}\left(\frac{F_{CH4,EG,t}}{F_{CH4,RG,t}}\right) - 0.05$$

Equation (1)

Where:

$\eta_{flare,calc,y}$	=	Methane destruction efficiency in the year *y*

5 If the monitoring period is shorter than one year, the measurement should be at least twice in a monitoring period and in a maximum timeframe of six months between each measurement.

$F_{CH4,EG,t}$	=	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the period *t* (kg)
$F_{CH4,RG,t}$	=	Mass flow of methane in the residual gas on a dry basis or wet at reference conditions in the period *t* (kg)
t	=	The two periods in year *y* during which the methane destruction efficiency is measured, each a minimum of one hour and separated by at least six months

30. $F_{CH4,EG,t}$ is measured according to an appropriate national or international standard. $F_{CH4,RG,t}$ is calculated according to Step 1, and consists of the sum of methane flow in the minutes *m* that make up the period *t*.

Box 2. Non-binding best practice example 2: Biannual measurement of methane destruction efficiency (option B.1)

Activity participants may choose the approach for the measurement of the methane destruction efficiency that is appropriate and cost-effective for the Article 6.4 activity, ensuring that the emission reductions are not over-estimated.

Example - An Article 6.4 activity involves the installation and operation of a small-scale biogas recovery and flaring system.

The activity participants opted to conduct the measurement of the methane destruction efficiency by an accredited entity on biannual basis. This accredited entity conducts two measurements per year of the mass flow of methane in the residual gas (kg) and the mass flow of methane in the exhaust gas of the flare (kg). The two measurements for each parameter are taken during at least one hour.

The methane destruction efficiency for year *y* is calculated based on the average of the two measurements on a dry basis at reference conditions, subtracting an uncertainty factor of 5 percentile points.

5.2.2.2.2. Option B.2: Measurement of methane destruction efficiency in each minute

31. The methane destruction efficiency ($\eta_{flare,calc,m}$) is determined based on monitoring the methane content in the exhaust gas, the residual gas, and the air used in the combustion process during the minute *m* in year *y,* as follows:

$$\eta_{flare,calc,m} = 1 - \frac{F_{CH4,EG,m}}{F_{CH4,RG,m}} \quad \text{Equation (2)}$$

Where:

$\eta_{flare,calc,m}$	=	Methane destruction efficiency in the minute *m*
$F_{CH4,EG,m}$	=	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (kg)
$F_{CH4,RG,m}$	=	Mass flow of methane in the residual gas on a dry or wet basis at reference conditions in the minute *m* (kg)

32. $F_{CH4,RG,m}$ is calculated according to Step 1.

33. Determine $F_{CH4,EG,m}$ according to Steps 2.1 - 2.4 below.

5.2.3. Step 2.1: Determine the methane mass flow in the exhaust gas on a dry basis

34. The mass flow of methane in the exhaust gas is determined based on the volumetric flow of the exhaust gas and the measured concentration of methane in the exhaust gas, as follows:

$$F_{CH4,EG,m} = V_{EG,m} \times fc_{CH4,EG,m} \times 10^{-6}$$ Equation (3)

Where:

$F_{CH4,EG,m}$	=	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (kg)
$V_{EG,m}$	=	Volumetric flow of the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (m^3)
$fc_{CH4,EG,m}$	=	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m* (mg/m^3)

5.2.4. Step 2.2: Determine the volumetric flow of the exhaust gas ($V_{EG,m}$)

35. Determine the average volume flow of the exhaust gas in the minute *m* based on a stoichiometric calculation of the combustion process. This depends on the chemical composition of the residual gas, the amount of air supplied to combust it and the composition of the exhaust gas. It is calculated as follows:

$$V_{EG,m} = Q_{EG,m} \times M_{RG,m}$$ Equation (4)

Where:

$V_{EG,m}$	=	Volumetric flow of the exhaust gas on a dry basis at reference conditions in the minute *m* (m^3)
$Q_{EG,m}$	=	Volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas on a dry basis at reference conditions in the minute *m* (m^3 exhaust gas/kg residual gas)
$M_{RG,m}$	=	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* (kg)

5.2.5. Step 2.3: Determine the mass flow of the residual gas ($M_{RG,m}$)

36. Activity participants shall determine this parameter using the mass flow tool applying the following requirements:

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

(b) The simplification for ideal gas is offered for calculating the molecular mass of the gaseous stream (equations (3) or (17) in the tool), otherwise *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2;

(c) The mass flow should be calculated on a minute basis for each minute *m* in year *y*.

5.2.6. Step 2.4: Determine the volume of the exhaust gas on a dry basis at reference conditions per kilogram of residual gas ($Q_{EG,m}$)

37. $Q_{EG,m}$ shall be determined as follows:

$$Q_{EG,m} = Q_{CO2,EG,m} + Q_{O2,EG,m} + Q_{N2,EG,m}$$ Equation (5)

Where:

$Q_{EG,m}$	=	Volume of the exhaust gas on a dry basis per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$Q_{CO2,EG,m}$	=	CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$Q_{N2,EG,m}$	=	N_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$Q_{O2,EG,m}$	=	O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)

with

$$Q_{O2,EG,m} = n_{O2,EG,m} \times VM_{ref}$$ Equation (6)

Where:

$Q_{O2,EG,m}$	=	O_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$n_{O2,EG,m}$	=	O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in the minute *m* (kmol/kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$Q_{N2,EG,m} = VM_{ref} \times \left\{ \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O2,air}}{v_{O2,air}} \right) \times \left[F_{O2,RG,m} + n_{O2,EG,m} \right] \right\}$$ Equation (7)

Where:

$Q_{N2,EG,m}$	=	N_2 (volume) in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute *m*
AM_N	=	Atomic mass of nitrogen (kg/kmol)
$v_{O2,air}$	=	Volumetric fraction of O_2 in air
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the minute *m* (kmol/kg residual gas)

$n_{O2,EG,m}$	=	O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in the minute *m* (kmol/kg residual gas)

$$Q_{CO2,EG,m} = \frac{MF_{C,RG,m}}{AM_C} \times VM_{ref}$$ Equation (8)

Where:

$Q_{CO2,EG,m}$	=	CO_2 volume in the exhaust gas per kg of residual gas on a dry basis at reference conditions in the minute *m* (m^3/kg residual gas)
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute *m*
AM_C	=	Atomic mass of carbon (kg/kmol)
VM_{ref}	=	Volume of one mole of any ideal gas at reference temperature and pressure (m^3/kmol)

$$n_{O2,EG,m} = \frac{v_{O2,EG,m}}{\left(1 - \left(v_{O2,EG,m}/v_{O2,air}\right)\right)} \times \left[\frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{N,RG,m}}{2 \times AM_N} + \left(\frac{1 - v_{O2,air}}{v_{O2,air}}\right) \times F_{O2,RG,m}\right]$$ Equation (9)

Where:

$n_{O2,EG,m}$	=	O_2 (moles) in the exhaust gas per kg of residual gas flared on a dry basis at reference conditions in the minute *m* (kmol/kg residual gas)
$v_{O2,EG,m}$	=	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute *m*
$v_{O2,air}$	=	Volumetric fraction of O_2 in the air
$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute *m*
AM_C	=	Atomic mass of carbon (kg/kmol)
$MF_{N,RG,m}$	=	Mass fraction of nitrogen in the residual gas in the minute *m*
AM_N	=	Atomic mass of nitrogen (kg/kmol)
$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the minute *m* (kmol/kg residual gas)

$$F_{O2,RG,m} = \frac{MF_{C,RG,m}}{AM_C} + \frac{MF_{H,RG,m}}{4AM_H} - \frac{MF_{O,RG,m}}{2AM_O}$$ Equation (10)

Where:

$F_{O2,RG,m}$	=	Stochiometric quantity of moles of O_2 required for a complete oxidation of one kg residual gas in the minute *m* (kmol/kg residual gas)

$MF_{C,RG,m}$	=	Mass fraction of carbon in the residual gas in the minute *m*
AM_C	=	Atomic mass of carbon (kg/kmol)
$MF_{O,RG,m}$	=	Mass fraction of oxygen in the residual gas in the minute *m*
AM_O	=	Atomic mass of oxygen (kg/kmol)
$MF_{H,RG,m}$	=	Mass fraction of hydrogen in the residual gas in the minute *m*
AM_H	=	Atomic mass of hydrogen (kg/kmol)

38. Determine the mass fractions of carbon, hydrogen, oxygen and nitrogen in the residual gas, using the volumetric fraction of component *i* in the residual gas and applying the equation below. In applying this equation, the activity participants may choose to either (a) use the measured volumetric fraction of each component *i* of the residual gas, or (b) as a simplification, measure the volumetric fraction of methane and consider the difference to 100% as being nitrogen (N_2). The same equation applies, irrespective of which option is selected.

$$MF_{j,RG,m} = \frac{\sum_i v_{i,RG,m} \times AM_j \times NA_{j,i}}{MM_{RG,m}}$$ Equation (11)

Where:

$MF_{j,RG,m}$	=	Mass fraction of element j in the residual gas in the minute *m*
$v_{j,RG,m}$	=	Volumetric fraction of component *i* in the residual gas on a dry basis in the minute *m*
AM_j	=	Atomic mass of element j (kg/kmol)
$NA_{j,i}$	=	Number of atoms of element j in component *i*
$MM_{RG,m}$	=	Molecular mass of the residual gas in the minute *m* (kg/kmol)
j	=	Elements C, O, H and N
i	=	Component of residual gas. If Option (a) is selected to measure the volumetric fraction, then *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2 or if Option (b) is selected then *i* = CH_4 and N_2

39. For enclosed flares that are defined as low height flares, the methane destruction efficiency in the minute *m* ($\eta_{flare,m}$) shall be adjusted, as a conservative approach, by subtracting 10 percentile points from the efficiency. For example, if the measured value was 99%, then the value to be used shall correspond to 89%.

5.3. Step 3: Calculation of activity emissions from flaring

40. Activity emissions from flaring are calculated as the sum of emissions for each minute *m* in year *y,* based on the methane mass flow in the residual gas ($F_{CH4,RG,m}$) and the methane destruction efficiency ($\eta_{flare,m}$), as follows:

$$AE_{flare,y} = GWP_{CH4} \times \sum_{m=1}^{525,600} F_{CH4,RG,m} \times \left(1 - \eta_{flare,m}\right) \times 10^{-3}$$ Equation (12)

Where:

$AE_{flare,y}$	=	Activity emissions from flaring of the residual gas in year *y* (tCO_2e)
GWP_{CH4}	=	Global warming potential of methane valid for the commitment period (tCO_2e/tCH_4)
$F_{CH4,RG,m}$	=	Mass flow of methane in the residual gas in the minute *m* (kg)
$\eta_{flare,m}$	=	Methane destruction efficiency in the minute *m*

5.4. Uncertainty determination

41. The uncertainty shall be determined considering the uncertainty in data and measurements of all parameters required following the guidance from Volume 1, Chapter 3 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The uncertainty shall be expressed as the standard error of the mean and shall be incorporated in the uncertainty calculations in the methodology.

5.5. Data and parameters not monitored

42. Parameters and data that are not monitored include the constants used in equations, as listed in Table 1 below. The atomic mass and its uncertainty for C, H, N and O were sourced from the periodic table published by International Union of Pure and Applied Chemistry (IUPAC).[6] The molar mass of the substances (CH_4, CO, CO_2, O_2, H_2, N_2 and NH_3) were determined based on the number of atoms and their atomic mass and the uncertainties were calculated based on the error propagation method.

Table 1. Constants used in equations

Parameter	SI Unit	Description	Value	Uncertainty (%)
MM_{CH4}	kg/kmol	Molecular mass of methane	16.0430	± 0.0137
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.0100	± 0.0079
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.0090	± 0.0064
MM_{O2}	kg/kmol	Molecular mass of oxygen	31.9980	± 0.0063
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.0160	± 0.0198
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.0140	± 0.0071
MM_{NH3}	kg/kmol	Molecular mass of ammonia	17.0310	± 0.0070
AM_C	kg/kmol (g/mol)	Atomic mass of carbon	12.011	± 0.0167
AM_H	kg/kmol (g/mol)	Atomic mass of hydrogen	1.0080	± 0.0198
AM_O	kg/kmol (g/mol)	Atomic mass of oxygen	15.999	± 0.0063
AM_N	kg/kmol (g/mol)	Atomic mass of nitrogen	14.007	± 0.0071
P_{ref}	Pa	Atmospheric pressure at reference conditions	101,325	-

[6] Available at https://iupac.org/what-we-do/periodic-table-of-elements/, accessed on 22 August 2025.

Parameter	SI Unit	Description	Value	Uncertainty (%)
R_u	Pa.m^3/kmol.K	Universal ideal gas constant	0.008314472	-
T_{ref}	K	Temperature at reference conditions	273.15	-
$v_{O2,air}$	Dimensionless	O_2 volumetric fraction of air	0.21	-
GWP_{CH4}	tCO_2/tCH_4	Global warming potential of methane valid for the commitment period	28	-
MV_n	m^3/Kmol	Volume of one mole of any ideal gas at reference conditions	22.414	-
$\rho_{CH4,\ n}$	kg/m^3	Density of methane gas at reference conditions	0.716	$\pm$ 0.0137
$NA_{i,j}$	Dimensionless	Number of atoms of element j in component *i*, depending on molecular structure	-	-
VM_{ref}	m^3 / kmol	Volume of one mole of any ideal gas at reference temperature and pressure	22.4	-

Data / Parameter table 1.

Data/parameter	***GWP_{CH4}***
Description	Global warming potential of methane valid for the commitment period
Data unit	tCO_2e/tCH_4
Equations referred	(12)
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 from IPCC AR5. Shall be updated according to any future CMA decisions
Additional comments	-

Data / Parameter table 2.

Data/parameter	***$SPEC_{flare}$***
Description	Manufacturer's flare operating specifications for temperature, flow rate and maintenance schedule
Data unit	**Temperature:** °C **Flow rate or heat flux:** kg/h or m^3/h **Maintenance schedule:** number of days
Equations referred	-
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions

Value(s) applied	Document in the PDD the flare operating specifications set by the manufacturer for the correct operation of the flare for the following parameters: (a) Minimum and maximum inlet flow rate, if necessary converted to flow rate at reference conditions or heat flux; (b) Minimum and maximum operating temperature; and (c) Maximum duration in days between maintenance events
Source of data	☐ Measured ☒ Other sources
Choice of data or measurement methods and procedures	Operating specifications sourced from the flare manufacturer
Additional comments	Only applicable in case of enclosed flares. The maintenance schedule is not required if Option A is selected to determine methane destruction efficiency of an enclosed flare

6. Monitoring methodology procedure

6.1. Data and parameters to be monitored

43. All monitored data must be linked in time, i.e. calculations shall be performed considering only a set of data acquired in the same time interval in case of continuous monitoring. Activity participants shall use one minute or a smaller discrete time interval for reporting purposes. The data and parameters to be monitored include:

Data / Parameter table 3.

Data/parameter	$F_{CH4,EG,t}$	
Description	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period *t*	
Data unit	kg	
Equations referred	(1), (2), (3)	
Purpose of data	☐ Baseline emissions ☒ Project emissions ☐ Leakage emissions	
Measurement and updating frequency	Biannual	
Measurement methods and procedures	Measure the mass flow of methane in the exhaust gas according to an appropriate national or international standard e.g. UK's Technical Guidance LFTGN05. The time period t over which the mass flow is measured must be at least one hour. The average flow rate to the flare during the time period t must be greater than the average flow rate observed for the previous six months	
Entity/person responsible for the measurement	Third party accredited entity	
Measuring instrument(s)	*Type of instrument*	>> As per UK's Technical Guidance LFTGN05.

	Accuracy class	>> As per UK's Technical Guidance LFTGN05.
	Calibration requirements	>>As per UK's Technical Guidance LFTGN05.
	Location	>>
QA/QC procedures	According to the standard/guidance applied	
Additional comment	Monitoring of this parameter is required in the case of enclosed flares and if the activity participants select Option B.1 to determine the methane destruction efficiency.	

Data / Parameter table 4.

Data/parameter	$T_{EG,m}$	
Description	Temperature in the exhaust gas of the enclosed flare in the minute *m*	
Data unit	ºC	
Equations referred	-	
Purpose of data	☐ Baseline emissions ☒ Project emissions ☐ Leakage emissions	
Measurement and updating frequency	Once per minute	
Measurement methods and procedures	Measure the temperature of the exhaust gas in the flare by an appropriate temperature measurement equipment. Measurements outside the operational temperature specified by the manufacturer may indicate that the flare is not functioning correctly and may require maintenance. Flare manufacturers must provide suitable monitoring ports for the monitoring of the temperature of the flare. These would normally be expected to be in the middle third of the flare. Where more than one temperature port is fitted to the flare, the flare manufacturer must provide written instructions detailing the conditions under which each location shall be used and the port most suitable for monitoring the operation of the flare according to manufacturer's operating specifications for temperature.	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Temperature measurement equipment
	Accuracy class	N/A
	Calibration requirements	As per QA/QC below
	Location	Monitoring ports build in the flare (expected to be in the middle third of the flare)
QA/QC procedures	Temperature measurement equipment should be replaced or calibrated in accordance with their maintenance schedule.	
Additional comment	Unexpected changes such as a sudden increase/drop in temperature can occur for different reasons. These events should be noted in the site records along with any corrective action that was implemented to correct the issue.	

	Monitoring of this parameter is applicable in case of enclosed flares. Measurements are required to determine if manufacturer's flare operating specifications for operating temperature are met

Data / Parameter table 5.

Data/parameter	$v_{i,RG,m}$	
Description	Volumetric fraction of component *i* in the residual gas on a dry basis in the minute *m* where *i* = CH_4, CO, CO_2, O_2, H_2, H_2S, NH_3, N_2	
Data unit	-	
Equations referred	(11)	
Purpose of data	☐ Baseline emissions ☒ Project emissions ☐ Leakage emissions	
Measurement and updating frequency	As per the mass flow tool	
Measurement methods and procedures	As per the mass flow tool	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	As per the mass flow tool
	Accuracy class	As per the mass flow tool
	Calibration requirements	As per the mass flow tool
	Location	
QA/QC procedures	As per the mass flow tool	
Additional comment	As a simplified approach as per the mass flow tool, activity participants may only measure the content CH_4 of the residual gas and consider the remaining part as N_2. Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the methane destruction efficiency. The methane content measurement shall be carried out close to a location in the system where a biogas flow measurement takes place.	

Data / Parameter table 6.

Data/parameter	$M_{RG,m}$
Description	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m*
Data unit	Kg
Equations referred	(4), (11)
Purpose of data	☐ Baseline emissions ☒ Project emissions ☐ Leakage emissions
Measurement and updating frequency	As per the mass flow tool

Measurement methods and procedures	As per the mass flow tool	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	As per the mass flow tool
	Accuracy class	As per the mass flow tool
	Calibration requirements	As per the mass flow tool
	Location	As per the mass flow tool
QA/QC procedures	As per the mass flow tool	
Additional comment	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the methane destruction efficiency and if activity participant selects to monitor $M_{RG,m}$ directly, instead of calculating. Monitoring of this parameter may also be necessary for confirming that the manufacturer's specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a kg/h basis	

Data / Parameter table 7.

Data/parameter	$v_{O2,EG,m}$	
Description	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute *m*	
Data unit	-	
Equations referred	(9)	
Purpose of data	☐ Baseline emissions ☒ Project emissions ☐ Leakage emissions	
Measurement and updating frequency	Continuously. Values to be averaged on a minute basis	
Measurement methods and procedures	Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height).	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Gas analyzer

	Accuracy class	N/A
	Calibration requirements	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
	Location	Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
QA/QC procedures	See calibration requirements	
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the methane destruction efficiency	

Data / Parameter table 8.

Data/parameter	$fc_{CH4,EG,m}$	
Description	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m*	
Data unit	mg/m^3	
Equations referred	(3)	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement and updating frequency	Continuously. Values to be averaged on a minute basis	
Measurement methods and procedures	Extractive sampling analysers with water and particulates removal devices or in situ analysers for wet basis determination. Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Continuous gas analyzer
	Accuracy class	N/A
	Calibration requirements	Analysers must be periodically calibrated according to the manufacturer's recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
	Location	The point of measurement (sampling point) shall be in the upper section of the flare (80% of total flare height).
QA/QC procedures	See calibration requirements	
Additional comment	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the methane destruction efficiency. Measurement instruments may read ppmv or % values. To convert from ppmv to mg/m^3 simply multiply by 0.716. 1% equals 10 000 ppmv	

Data / Parameter table 9.

Data/parameter	***$Flame_m$***	
Description	Flame detection of flare in the minute *m*	
Data unit	Flame on or Flame off	
Equations referred	-	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement and updating frequency	Once per minute.	
Measurement methods and procedures	Measure using a fixed installation optical flame detector.	
Entity/person responsible for the measurement	Activity participants	
Measuring instrument(s)	*Type of instrument*	Ultra Violet detector or Infra-Red or both
	Accuracy class	N/A
	Calibration requirements	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations
	Location	
QA/QC procedures	See calibration requirements	
Additional comment	Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off	

Data / Parameter table 10.

Data/parameter	***$Maintenance_m$***	
Description	Maintenance events completed in year y	
Data unit	Calendar dates	
Equations referred	-	
Purpose of data	☐ Baseline emissions ☒ Activity emissions ☐ Leakage emissions	
Measurement and updating frequency	Annual	
Measurement methods and procedures	Record the date that maintenance events were completed in year *y*. Records of maintenance logs must include all aspects of the maintenance including the details of the person(s) undertaking the work, parts replaced, or needing to be replaced, source of replacement parts, serial numbers and calibration certificates.	
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
QA/QC procedures	Records must be kept in a maintenance log for two years beyond the life of the flare	
Additional comment	Monitoring of this parameter is required for the case of enclosed flares and the activity participant selects Option B to determine methane destruction efficiency. These dates are required so that they can be compared to the maintenance schedule to check that maintenance events were completed within the minimum time between maintenance events specified by the manufacturer ($SPEC_{flare}$)	

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Document information

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