CLEAN DEVELOPMENT MECHANISM

TOOL06

Methodological tool

Project emissions from flaring

Version 04.0

United Nations
Framework Convention on
Climate Change

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1. Introduction

1. This tool provides procedures to calculate project 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) or coal mine methane.[1]

2. Scope, applicability, and entry into force

2.1. Scope and Applicability

2. This tool provides procedures to calculate project emissions from flaring of a residual gas. The tool is applicable to enclosed or open flares and project participants should document in the CDM-PDD the type of flare used in the project activity.

3. This tool is applicable to the flaring of flammable greenhouse gases where:

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

   (b) The source of the residual gas is coal mine methane or a gas from a biogenic source (e.g. biogas, landfill gas or wastewater treatment gas).

4. 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. In the case of an enclosed flare, there shall be operating specifications provided by the manufacturer of the flare and these shall be followed by the project participant.

2.2. Entry into force

5. The date of entry into force is the date of the publication of the EB 113 meeting report on 11 March 2022.

3. Parameters

6. This tool provides procedures to determine the following parameter:

Parameter	SI Unit	Description
$PE_{flare,y}$	t CO_2e	Project emissions from flaring of the residual gas in year *y*

[1] Emissions of CO_2 from the combustion of coal mine methane shall be accounted by the respective applicable methodology.

4. Normative references

7. This tool refers to the latest approved version of “TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream” (hereinafter referred to as TOOL08).

8. References for this methodological tool are:

   (a) Fundamentals of Classical Thermodynamics; Gordon J. Van Wylen, Richard E. Sonntag and Claus Borgnakke; 4º Edition, 1994, John Wiley & Sons, Inc.;

   (b) Environment Agency Guidance for monitoring enclosed landfill gas flares. LFTGN05 v2 2010.

5. Definitions

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

10. For the purpose of this tool, the following definitions apply:

    (a) **Auxiliary fuel** - 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 normally propane supplied from cylinders of gas or processed natural gas from a gas main;

    (b) **Enclosed flare** - devices where the residual gas is burned in a cylindrical or rectilinear enclosure and where the flame enclosure is more than two times the diameter of the enclosure. The device includes a burning system and air intake system based on natural or forced draft for the combustion reaction ;

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

    (d) **Flare efficiency** - 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) **Flareoperating specifications** - the manufacturer’s specification for operating the flare, which includes: the minimum and maximum flow rate and; other minimum and maximum operating conditions ; and the details for the controlling devices;

    (f) **Low height flare** - an enclosed flare for which the flame enclosure has a height between two and ten times the diameter of the combustion enclosure;

    (g) **Open flare** - 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 enclosure, for which the flame enclosure is less than two times the diameter of the enclosure;

    (h) **Reference conditions** - reference 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 (RG)** – the flammable gas containing methane that is to be flared as part of the project activity;

(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).

6. Methodological procedure

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

12. The project emissions calculation procedure is given in the following steps:

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

    (b) STEP 2: Determination of the flare efficiency;

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

13. An excel sheet that can be used to calculate the project emissions following this procedure (STEP 1, STEP 2 and STEP 3) is provided at the following weblink on the UNFCCC CDM website:<https://cdm.unfccc.int/Reference/tools/index.html>.

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

14. TOOL08 shall be used to determine the following parameter:

Parameter	SI Unit	Description
$F_{CH4,m}$	kg	Mass flow of methane in the residual gaseous stream in the minute *m*

15. The following requirements apply:

    (a) Tool08 shall be applied to the residual gas;

    (b) The flow of the gaseous stream shall be measured continuously;

    (c) CH_4 is the greenhouse gas *i* for which the mass flow should be determined;

    (d) The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 and 17 in the Tool08); and

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

16. $F_{CH4,m}$, 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.

6.2. Step 2: Determination of flare efficiency

17. The flare efficiency depends on the combustion efficiency ofthe flare and the time that the flare is operating. To determine the efficiency of enclosed flares project participants shall choose to determine the efficiency based on 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.

6.2.1. Open flare

18. In the case of open flares, the flare 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%.

6.2.2. Enclosed flare

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

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

(b) Option B: Measure the flare efficiency.

20. In case of missing data for parameters relevant to the measurement of the flare efficiency as per Option B above, the project participants may also choose to follow the provisions of Option A above as a backup approach. The project participant shall document this choice in the CDM-PDD.

6.2.2.1. Option A: Default value

21. The flare 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 the minute *m* ($Flame_m$).

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

23. For enclosed flares that are defined as low height flares, the flare efficiency shall be adjusted, as a conservative approach, by subtracting 10 percentile points[2].

6.2.2.2. Option B: Measured flare efficiency

24. The flare 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 the minute *m* ($Flame_m$).

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

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

26. For the measurement of the flare efficiency, the project 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[3];

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

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

Project participants may choose the flame detector that is appropriate and cost-effective for the project activity, ensuring that the emission reductions are not over-estimated. **Example 1 -** A project activity involves the installation and operation of a landfill gas recovery and flaring system. In order to monitor the operation of the flare, project 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 -** A project 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, project participants have installed a set of thermocouples, which continuously measure temperature, and therefore allow the detection of the presence and absence of flame.

6.2.2.2.1. Option B.1: Biannual measurement of the flare efficiency

27. The calculated flare efficiency $\eta_{flare,calc,m}$ is determined as the average of at least two measurements of the flare 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:

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

28. $F_{CH4,EG,t}$ 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 time period *t*.

[3] 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.

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

Project participants may choose the approach for the measurement of the flare efficiency that is appropriate and cost-effective for the project activity, ensuring that the emission reductions are not over-estimated. **Example -** A project activity involves the installation and operation of a small-scale biogas recovery and flaring system. The project participants opted to conduct the measurement of the flare 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 flare 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.

6.2.2.2.2. Option B.2: Measurement of flare efficiency in each minute

29. The flare 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:

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

Where:

$\eta_{flare,calc,m}$	=	Flare 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 basis at reference conditions in the minute *m* (kg)

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

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

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

32. 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:

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

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)

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

33. 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:

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

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)

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

34. Project participants may select to monitor the mass flow of the residual gas in the minute *m* directly (see monitored parameter $M_{RG,m}$) or, according to the procedure given in this step, calculate $M_{RG,m}$ based on the volumetric flow and the density of the residual gas. The density of the residual gas is determined based on the volumetric fraction of all components in the gas.

$$M_{RG,m} = \rho_{RG,ref,m} \times V_{RG,m} \qquad \text{Equation (5)}$$

Where:

$M_{RG,m}$	=	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m* (kg)
$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in the minute *m* (kg/m^3)
$V_{RG,m}$	=	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m* (m^3)

and

$$\rho_{RG,ref,m} = \frac{P_{ref}}{\frac{R_u}{MM_{RG,m}} \times T_{ref}} \qquad \text{Equation (6)}$$

Where:

$\rho_{RG,ref,m}$	=	Density of the residual gas at reference conditions in the minute *m* (kg/m^3)
P_{ref}	=	Atmospheric pressure at reference conditions (Pa)
R_u	=	Universal ideal gas constant (Pa.m^3/kmol.K)
$MM_{RG,m}$	=	Molecular mass of the residual gas in the minute *m* (kg/kmol)
T_{ref}	=	Temperature at reference conditions (K)

35. Use the equation below to calculate $MM_{RG,m}$. When applying this equation, project 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.

$$MM_{RG,m} = \sum_i \left(v_{i,RG,m} \times MM_i\right) \qquad \text{Equation (7)}$$

Where:

$MM_{RG,m}$	=	Molecular mass of the residual gas in the minute *m* (kg/kmol)
MM_i	=	Molecular mass of residual gas component *i* (kg/kmol)
$v_{i,RG,m}$	=	Volumetric fraction of component *i* in the residual gas on a dry basis at reference conditions in the hour h
i	=	Components of the 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

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

36. $Q_{ECO2,EG,m}$ shall be determined as follows:

$$Q_{EG,m} = Q_{CO2,EG,m} + Q_{O2,EG,m} + Q_{N2,EG,m} \qquad \text{Equation (8)}$$

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 (9)

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 (10)

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 (11)

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 (12)

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 (13)

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)

37. 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 project 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 (14)

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

38. For enclosed flares that are defined as low height flares, the flare 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%.

6.3. Step 3: Calculation of project emissions from flaring

39. Project 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 flare efficiency ($\eta_{flare,m}$), as follows:

$$PE_{flare,y} = GWP_{CH4} \times \sum_{m=1}^{525600} F_{CH4,RG,m} \times \left(1 - \eta_{flare,m}\right) \times 10^{-3}$$ Equation (15)

Where:

$PE_{flare,y}$	=	Project 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)
$\eta_{flare,m}$	=	Flare efficiency in the minute *m*

6.4. Data and parameters not monitored

40. Parameters and data that are not monitored include the constants used in equations, as listed in Table 1 below.

Table 1. Constants used in equations

Parameter	SI Unit	Description	Value
MM_{CH4}	kg/kmol	Molecular mass of methane	16.04
MM_{CO}	kg/kmol	Molecular mass of carbon monoxide	28.01
MM_{CO2}	kg/kmol	Molecular mass of carbon dioxide	44.01
MM_{O2}	kg/kmol	Molecular mass of oxygen	32.00
MM_{H2}	kg/kmol	Molecular mass of hydrogen	2.02
MM_{N2}	kg/kmol	Molecular mass of nitrogen	28.02
AM_{C}	kg/kmol (g/mol)	Atomic mass of carbon	12.00
AM_{H}	kg/kmol (g/mol)	Atomic mass of hydrogen	1.01
AM_{O}	kg/kmol (g/mol)	Atomic mass of oxygen	16.00
AM_{N}	kg/kmol (g/mol)	Atomic mass of nitrogen	14.01
P_{ref}	Pa	Atmospheric pressure at reference conditions	101 325
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	21 (for the first commitment period)
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
$NA_{i,j}$	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}***
Data unit:	tCO_2e/tCH_4
Description:	Global warming potential of methane valid for the commitment period
Source of data:	IPCC
Value to be applied:	Default value of 25 from IPCC. Shall be updated according to any future COP/MOP decisions
Any comment:	-

Data / Parameter table 2.

Data / Parameter:	***$SPEC_{flare}$***
Data unit:	Temperature - °C Flow rate or heat flux - kg/h or m³/h Maintenance schedule - number of days
Description:	Manufacturer's flare operating specifications for temperature, flow rate and maintenance schedule
Source of data:	Flare manufacturer
Value to be applied:	Document in the CDM-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
Any comment:	Only applicable in case of enclosed flares. The maintenance schedule is not required if Option A is selected to determine flare efficiency of an enclosed flare

7. Monitoring methodology procedure

7.1. Data and parameters to be monitored

41. 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. Project 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:	***$F_{CH4,EG,t}$***
Data unit:	kg
Description:	Mass flow of methane in the exhaust gas of the flare on a dry basis at reference conditions in the time period *t*
Source of data:	Measurements undertaken by a third party accredited entity
Measurement procedures (if any):	Measure the mass flow of methane in the exhaust gas according to an appropriate national or international standard e.g. UKs 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
Monitoring frequency:	Biannual
QA/QC procedures:	According to the standard applied
Any comment:	Monitoring of this parameter is required in the case of enclosed flares and if the project participants select Option B.1 to determine flare efficiency

Data / Parameter table 4.

Data / Parameter:	$T_{EG,m}$
Data unit:	°C
Description:	Temperature in the exhaust gas of the enclosed flare in the minute *m*
Source of data:	Project participants
Measurement procedures (if any):	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
Monitoring frequency:	Once per minute
QA/QC procedures:	Temperature measurement equipment should be replaced or calibrated in accordance with their maintenance schedule
Any 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:	$v_{i,RG,m}$
Data unit:	-
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_4, N_2
Source of data:	Measurements by project participants using a continuous gas analyser (values are recorded with the same frequency as the flow).
Measurement procedures (if any):	Measurement may be made on either dry or wet basis. If the value is made on a wet basis, then it shall be converted to dry basis for reporting
Monitoring frequency:	Continuously. Values are to be averaged on a minute basis
QA/QC procedures:	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 certified gas.

Any comment:	As a simplified approach, project participants may only measure the content CH_4, CO and CO_2 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 flare 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:	$V_{RG,m}$
Data unit:	m^3
Description:	Volumetric flow of the residual gas on a dry basis at reference conditions in the minute *m*
Source of data:	Measurements by project participants using a flow meter
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures:	Flow meters are to be periodically calibrated according to the manufacturer's recommendation
Any comment:	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project participant selects to calculate $V_{RG,m}$ instead of monitoring directly. Monitoring of this parameter may also be necessary for confirming that the manufacturer's operating specifications for flow rate/heat flux are met. In this case the flow rate should be measured in a m^3/h basis

Data / Parameter table 7.

Data / Parameter:	$M_{RG,m}$
Data unit:	kg
Description:	Mass flow of the residual gas on a dry basis at reference conditions in the minute *m*
Source of data:	-
Measurement procedures (if any):	Instruments with recordable electronic signal (analogical or digital)
Monitoring frequency:	Continuous, values to be averaged on a minute basis
QA/QC procedures:	Periodic calibration against a primary device provided by an independent accredited laboratory is mandatory. Calibration and frequency of calibration is according to manufacturer's specifications
Any comment:	Monitoring of this parameter is applicable in case of enclosed flares and continuous monitoring of the flare efficiency and if project 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 8.

Data / Parameter:	$v_{O2,EG,m}$
Data unit:	-
Description:	Volumetric fraction of O_2 in the exhaust gas on a dry basis at reference conditions in the minute *m*
Source of data:	Measurements by project participants using a continuous gas analyser
Measurement procedures (if any):	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). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures:	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
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare efficiency

Data / Parameter table 9.

Data / Parameter:	$fc_{CH4,EG,m}$
Data unit:	mg/m^3
Description:	Concentration of methane in the exhaust gas of the flare on a dry basis at reference conditions in the minute *m*
Source of data:	Measurements by project participants using a continuous gas analyser
Measurement procedures (if any):	Extractive sampling analysers with water and particulates removal devices or in situ analyser for wet basis determination. The point of measurement (sampling point) shall be in the upper section of the flare in order that the sampling is of the gas after consumption has taken place (80% of total flare height). Sampling shall be conducted with appropriate sampling probes adequate to high temperatures level (e.g. inconel probes)
Monitoring frequency:	Continuously. Values to be averaged on a minute basis
QA/QC procedures:	Analysers must be periodically calibrated according to manufacturer’s recommendation. A zero check and a typical value check should be performed by comparison with a standard gas
Any comment:	Monitoring of this parameter is only applicable in case of enclosed flares and continuous monitoring of the flare 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 10.

Data / Parameter:	$Flame_m$
Data unit:	Flame on or Flame off

Description:	Flame detection of flare in the minute *m*
Source of data:	Project participants
Measurement procedures (if any):	Measure using a fixed installation optical flame detector: Ultra Violet detector or Infra-Red or both
Monitoring frequency:	Once per minute. Detection of flame recorded as a minute that the flame was on, otherwise recorded as a minute that the flame was off
QA/QC procedures:	Equipment shall be maintained and calibrated in accordance with manufacturer's recommendations
Any comment:	Applicable to all flares

Data / Parameter table 11.

Data / Parameter:	$\boldsymbol{Maintenance_y}$
Data unit:	Calendar dates
Description:	Maintenance events completed in year *y*
Source of data:	Project participants
Measurement procedures (if any):	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
Monitoring frequency:	Annual
QA/QC procedures:	Records must be kept in a maintenance log for two years beyond the life of the flare
Any comment:	Monitoring of this parameter is required for the case of enclosed flares and the project participant selects Option B to determine flare 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 ($SPEC_{,flare}$)

Appendix. Calculation spreadsheet

1. Stakeholders may, on a voluntary basis, use the spreadsheet for calculating project emissions from flaring available on the CDM website <https://cdm.unfccc.int/Reference/tools/index.html>.

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Document information

Version	*Date*	*Description*
04.0	11 March 2022	EB 113, Annex 10 The revision improves the clarity and internal consistency of the tool.
03.0	28 March 2019	EB 102, Annex 6 The revision: • Includes non-binding best practice examples • Enhances the clarity of the description of options B.1 and B.2; • Aligns the tool with the latest version of "TOOL08: Tool to determine the mass flow of a greenhouse gas in a gaseous stream"; • Included the development of a spreadsheet, as an annex to this tool, to aid calculations.
02.0.0	20 July 2012	EB 68, Annex 15 The revision: • Provides an additional option for determining the methane destruction efficiency of an enclosed flare, using biannual measurements of the efficiency of the flare; • Expands the applicability of the tool to flaring gases that also contain ammonium and hydrogen sulfide; • Defines low height flares and specifies how the methane destruction efficiency shall be determined for this type of flares; • Changes the title from methodological “Tool to determine project emissions from flaring gases containing methane” to “Project emissions from flaring”; • Improves the structure and other editorial aspects.
01.0.0	15 December 2006	EB 28, Annex 13 Initial adoption.

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