Alberta Greenhouse Gas Quantification Methodologies

Chapter 2
Flaring

Technology Innovation and Emissions Reduction Regulation

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Alberta

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2. Flaring

2.1. Introduction

Flaring emissions are direct emissions from the controlled combustion of a gas or liquid stream produced at the facility, used for routine or emergency disposal of a hazardous waste stream, where the main purpose is not energy production. There are a variety of flare and incineration technologies including flare pits, ground flares, flare stacks, enclosed flares and incinerators and combustors. Methodologies for flaring/incineration of liquid fuel streams are not presented in this chapter.

Typical gases that are flared or incinerated include, but are not limited to waste petroleum gas, refinery or still gas, purge gas, pilot or assistance gas, and biogas. Flaring or incineration commonly occurs at the following types of operations:

- well testing;
- natural gas gathering system;
- processing plant operations;
- crude oil production;
- pipeline operations;
- petroleum refining;
- chemical fertilizer production and steel production; and
- waste gases generated by sewage digesters.

Emissions from flaring may fit into more than one source category. Figure 2-1 provides clarification on the emission source categories under the Technology Innovation and Emissions Reduction Regulation (TIER) and Specified Gas Reporting Regulation (SGRR).

Note that carbon dioxide (CO_2) that is entrained in the fuel (or previously referred to as formation CO_2) is reported as an emission in the respective categories that the fuel is consumed in. For example, if there is entrained CO_2 within a fuel that is combusted or flared, it would be included in the CO_2 that is emitted in the stationary fuel combustion or flaring categories, respectively. Similarly, if there is entrained CO_2 in a fuel that is vented or released as a fugitive, it would be reported as CO_2 emissions in the venting or fugitive emissions category, respectively.

Quantification methodologies are presented in this chapter for some emissions presented in Figure 2-1 even though some of these are not classified as flaring emissions. The reporter is responsible for ensuring that the emissions are reported under the correct source category.

Figure 2-1: Clarification on Flaring and Other Emissions Categories

Flaring Emissions

- CO_2, CH_4, and N_2O from flaring of waste petroleum gas, refinery or still gas, purge gas, pilot and assistance gas

Waste and Wastewater Emissions

- CH_4 and N_2O from biogas (including landfill gas) flaring
- CO_2, CH_4, and N_2O from incineration of solid waste (i.e. hospital waste, municipal waste, solid/liquid petroleum waste, wood waste etc.).

CO_2 from Biomass Combustion

- CO_2 from biogas (including landfill gas) flaring

Stationary Fuel Combustion Emissions

- Combustion of fuels with the primary purpose of useful energy production.
- Incineration of fuels with energy capture.

2.2. Flare Combustion Efficiency

The flare combustion efficiency is defined as the mole or volume fraction of carbon in the flare gas that is converted to CO_2 during the flaring process, which can be expressed as $kmol_{CO2formed}/kmol_C$ or percentage of carbon combusted or oxidized.

For the quantification of flaring emissions, the following flare combustion efficiencies were adopted from flare efficiency and thermal oxidizer studies conducted and published by the USEPA:

- 98.0% flare combustion efficiency for unassisted flares. These flares are typically found in remote oil and gas production operations;
- 99.5% flare combustion efficiency for properly-operated, highly-turbulent, air- or steam-assisted flares. These flares are typically found in gas plants, upgraders, petroleum refineries, and chemical plants; and
- 100.0% flare combustion efficiency for incinerators, oxidizers, or other “external combustion” units that operate like boilers. As a conservative approach, methane emissions based on emission factors are still applied.

A facility must select a quantification methodology in this chapter that corresponds with the level classification assigned to the facility in the Standard for Completing Greenhouse Compliance and Forecasting Reports for reporting under TIER or the Specified Gas Reporting Standard for reporting under SGRR.

Sampling and measurement frequencies may be prescribed in the quantification methodologies presented in this chapter. Where appropriate, a facility must also apply the fuel gas sampling and measurement requirements in Chapter 17 that correspond with the facility's level classification.

2.3. Carbon Dioxide and Methane

2.3.1. Introduction

Carbon dioxide emissions from flares are generated from the oxidization of carbon in the flare gas. Methane in the flare gas that is un-oxidized is released as methane emissions.

For each flare type, the mass of CO_2 and CH_4 emissions for the reporting period may be calculated using one of three quantification methodologies as illustrated in Table 2-1.

Table 2-1 provides the level classifications for three possible flaring scenarios. The flaring scenarios are adapted from Alberta Energy Regulator's (AER's) Directive 60. The descriptions of these scenarios apply to all sectors where flaring occurs.

- Routine flaring is considered to be continuous or intermittent flaring that occurs on a regular basis during normal facility operations.
- Non-routine flaring is considered to be intermittent and/or infrequent flaring and incineration. This includes any planned flaring events that occur during planned maintenance activities or shutdowns of process operations. Non-routine flaring also includes emergency or unplanned flaring events due to emergency or upset process conditions.

- Flaring emissions representing less than 1% of a facility's total emissions do not count towards the facility's negligible emission sources under TIER. For these emissions, the facility may apply any method prescribed in this chapter or an alternative method that is conservative, as indicated in Table 2-1.

Table 2-1: Level classification for quantification methodologies for CO_2 and CH_4 emissions from flaring

Flaring Scenarios	Level Classification 1	Level Classification 2	Level Classification 3
Routine flaring[1]	Method 2-1	Method 2-2 or Method 2-3	
Non-routine flaring[1]	Method 2-1 or Method 2-2		
Flaring emissions represent less than 1% of facility's total emissions[2]	Any method prescribed in this chapter or alternative method that is conservative		

1. Definitions of routine and non-routine flaring is adapted from AER Directive 60.
2. The facility should document methodologies used in the facility's Quantification Methodologies Document (QMD).

2.3.2. Method 2-1: Default Emission Factor Method

(1) Introduction

The Default Emission Factor Method is based on default CO_2 and CH_4 emission factors which were developed for different types of fuel gas types (lean to rich condensate), non-variable fuels (ethane, propane and butane), and other process gas or waste gases. The default emission factors are provided for the three flare combustion efficiencies provided in Section 2.2.

This method provides default emission factors for facilities that do not have gas analysis, but have knowledge of the flare gas properties such as the higher heating value (HHV), or whether it is rich or lean gas being sent to flare stack. Facilities are required to select emission factors from Tables 2-2 or 2-3 that would be the most representative of the flare gas. If the HHV of the flare gas falls between two HHVs in the tables, the facility is required to choose the emission factor with the higher HHV.

Methane emission factors are provided in Table 2-3 representing the un-combusted CH_4 in the flare gas based on the flare combustion efficiency. For incineration, methane emissions are conservatively added even though the flare combustion efficiency was assumed to be 100%.

Methane emission factors for different fuel gases are based on the industrial sector emission factor from Environment and Climate Change Canada (ECCC's) Greenhouse Gas Reporting Program (GHGRP). This emission factor was adjusted by the HHV of the various default gas types.

(2) Equations

For each flare source, use Equation 2-1a or Equation 2-1b to calculate the CO_2 and CH_4 mass emissions.

$$GHG = \sum_{F}^{N} V_{FL,F} \times EF_{vol,F} \times 10^{-6}$$ Equation 2-1a

$$GHG = \sum_{F}^{N} ENE_{FL,,F} \times EF_{ENE,F} \times 10^{-6}$$ Equation 2-1b

Where:

GHG	=	CO_2 or CH_4 mass emissions from flaring (tonnes) for the reporting period.
F	=	Flare gas stream.
N	=	Total number of flare gas streams.
$V_{FL,F}$	=	Volume of the flare gas stream, F, at a flare source (standard cubic meters, sm^3) at standard conditions for the reporting period.
$ENE_{FL,F}$	=	Energy of the of the flare gas stream, F, at a flare source (MJ) for the reporting period.
$EF_{vol,F}$	=	Default CO_2 or CH_4 emission factor, selected from Table 2-2 or Table 2-3 (g/m^3).

$EF_{ENE,F}$ = Default CO_2 or CH_4 emission factor, selected from Table 2-2 or Table 2-3 (g/MJ).

10^{-6} = Mass conversion factor (tonne/g).

Table 2-2: Default CO_2 Flaring Emission Factors for Different Flare Gas Types

Flare Gas Type	High Heating Value (MJ/m³)	Carbon Dioxide Emission Factors – Open Flares – Unassisted 98.0% Efficiency (g/m³)	Unassisted 98.0% Efficiency (g/MJ)	Assisted 99.5% Efficiency (g/m³)	Assisted 99.5% Efficiency (g/MJ)	Incinerators 100% Efficiency (g/m³)	Incinerators 100% Efficiency (g/MJ)
Fuel Gas Types							
Sales gas	38.02	1,853	48.75	1,882	49.49	1,891	49.74
Lean gas	40.39	2,006	49.68	2,037	50.44	2,047	50.69
Medium-rich gas	42.48	2,141	50.41	2,174	51.18	2,185	51.44
Rich gas	44.77	2,280	50.93	2,315	51.70	2,327	51.96
Process Fuel Gas Types							
HHV >50 MJ/m³	50.42	2,645	52.46	2,685	53.26	2,699	53.53
Still gas (Upgrading)	34.02	2,097	61.65	2,129	62.59	2,140	62.90
Still gas (Refinery & others)	34.02	2,081	61.16	2,112	62.09	2,123	62.40
Non-Variable Gas Types							
100% Methane (C1)	37.708	1,824	48.37	1,852	38.29	1,861	48.62
100% Ethane (C2)	66.065	3,648	55.22	3,704	56.07	3,723	56.35
100% Propane (C3)	93.936	5,472	58.25	5,556	59.15	5,584	59.44
100% Butane (C4)	121.600	7,296	60.00	7,408	60.92	7,445	61.23
Landfill Gas							

Flare Gas Type	High Heating Value (MJ/m³)	Carbon Dioxide Emission Factors: Open Flares, Unassisted, 98.0% Efficiency (g/m³)	(g/MJ)	Open Flares, Assisted, 99.5% Efficiency (g/m³)	(g/MJ)	Incinerators, 100% Efficiency (g/m³)	(g/MJ)
Flaring of landfill gas	18.85	912	48.38	926	49.12	931	49.37
Emissions from CO_2 in landfill gas	18.85	931	49.37	931	49.37	931	49.37

1. Flare combustion efficiencies have been applied in the emission factor.
2. Molecular weights and HHVs are from Gas Processors Association 2145-09.
3. Default gas compositions used in the development of the emission factors are:
   - Sales gas - 98% CH_4, 1% C_2H_6, 0.3% C_3H_8, 0.1% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Lean gas - 92% CH_4, 5% C_2H_6, 1.9% C_3H_8, 0.5% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Medium gas - 86% CH_4, 10% C_2H_6, 2.5% C_3H_8, 0.9% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Rich gas - 80% CH_4, 15% C_2H_6, 5% C_3H_8
   - Landfill gas - 50% CH_4, 50% CO_2
   - Gas with HHV > 50 MJ/m³ - 70% CH_4, 20% C_2H_6, 10% C_3H_8
4. Still gas emission factors are based on Canada's Greenhouse Gas Quantification Requirements, ECCC GHGRP, December 2019.
5. CO_2 emissions for fuel gases and still gases from entrained CO_2 in the flare gas are included in the CO_2 emission factors.

Table 2-3: Default CH_4 Flaring Emission Factors for Different Flare Gas Types

Flare Gas Type	High Heating Value (MJ/m³)	Methane Emission Factors: Open Flares Unassisted (98.0% Efficiency) (g/m³)	(g/MJ)	Open Flares Assisted (99.5% Efficiency) (g/m³)	(g/MJ)	Incinerators (100% Efficiency) (g/m³)	(g/MJ)
Natural Gas Type							
Sales gas	38.02	13.27	0.35	3.32	0.09	0.037	0.0010
Lean gas	40.39	12.46	0.31	3.11	0.08	0.040	0.0010
Medium-rich gas	42.48	11.65	0.27	2.91	0.07	0.042	0.0010
Rich gas	44.77	10.83	0.24	2.71	0.06	0.044	0.0010
Rich gas with HHV >50 MJ/m³	50.42	8.80	0.17	2.20	0.04	0.044	0.00087

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Flare Gas Type	High Heating Value (MJ/m³)	Methane Emission Factors					
		Open Flares Unassisted (98.0% Efficiency)		Open Flares Assisted (99.5% Efficiency)		Incinerators (100% Efficiency)	
		(g/m³)	(g/MJ)	(g/m³)	(g/MJ)	(g/m³)	(g/MJ)
Still gas (Upgrading)	34.02	31	0.91	7.75	0.23	0.033	0.037
Still gas (Refinery & others)	34.02	31	0.91	7.75	0.23	0.033	0.037
Non-Variable Gas Types							
100% Methane	37.708	13.54	0.36	3.39	9.43	0.037	0.0039
100% Ethane (C2)	66.065	0.00	0.00	0.00	0.00	0.00	0.00
100% Propane (C3)	93.936	0.00	0.00	0.00	0.00	0.00	0.00
100% Butane (C4)	121.600	0.00	0.00	0.00	0.00	0.00	0.00
Landfill Gas							
Landfill gas (50% methane)[7]	18.85	6.77	0.36	1.69	0.09	0.018	0.0010

1. Flare combustion efficiencies have been applied in the emission factor.
2. Methane emission factors for flaring of fuel gases and non-variable gases using incinerator technology are based on Canada's Greenhouse Gas Quantification Requirements, ECCC GHGRP, December 2019 and are adjusted by HHV of the different fuel types.
3. Molecular weights and HHVs are from Gas Processors Association 2145-09.
4. Default gas compositions used in the development of the emission factors are:
   - Sales gas - 98% CH_4, 1% C_2H_6, 0.3% C_3H_8, 0.1% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Lean gas - 92% CH_4, 5% C_2H_6, 1.9% C_3H_8, 0.5% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Medium gas - 86% CH_4, 10% C_2H_6, 2.5% C_3H_8, 0.9% C_4H_{10}, 0.3% CO_2, 0.3% N_2
   - Rich gas - 80% CH_4, 15% C_2H_6, 5% C_3H_8
   - Landfill gas - 50% CH_4, 50% CO_2
   - Gas with HHV > 50 MJ/m³ - 70% CH_4, 20% C_2H_6, 10% C_3H_8
5. Still gas emission factors are based on Canada's Greenhouse Gas Quantification Requirements, ECCC GHGRP, December 2019.
6. CO_2 emissions for fuel gases and still gases from entrained CO_2 in the flare gas are included in the CO_2 emission factors.
7. Landfill gas is assumed to be composed of 50% of methane and 50% of carbon dioxide by volume.

(3) Data requirements

- For facilities that are subject to the expansion requirements prescribed by ECCC's GHGRP, the facility should use Method 2-2 or Method 2-3 with measurement frequencies prescribed by ECCC's GHGRP.

For all other facilities:

- The volume or energy of the flare gas may be estimated using engineering estimates, fuel mass balance, manufacturer specifications, and operating time.
- If the facility have measured volumes of the flare gas, the facility is required to use the measured volumes instead of an estimated volume.
- If the flare gas volume is not measured, but the flare gas is from a venting source that is captured and sent to flaring, the facility may use a quantification methodology that is described in Chapter 4 Venting to calculate the volume of the flare gas. The facility would select a quantification methodology that is at the required level classification for the facility.
    - When a volumetric venting rate (VR) is a parameter in the venting emissions calculation equations, calculate the flare gas volume by applying VR × total venting time (t) × control factor (CF).
    - When a volumetric VR is not a parameter in the venting emission calculation equations, use the same approach of venting rate or venting volume estimation as in the equations, calculate the flare gas volume by applying VR × t × CF or Q_{vent} × CF.
    - When a mass VR is a parameter in the venting emissions calculation equations, convert the mass VR first using an appropriate density of the vented gas, then calculate the flare gas volume by applying VR × t × CF.
- Based on the facility's knowledge of the flare gas composition and flare technology, select the flare gas type that would best align with the flare gas consumed and the appropriate emission factor from Tables 2-2 or 2-3. For flare gases that are aligned with the fuel gas types, if the HHV of the flare gas falls between two HHVs in the tables, the facility is required to select the emission factor with a higher HHV.
- This method assumes that there is negligible CO_2 entrained in the fuel. If the facility is flaring fuel gas that contains greater than 5% by volume of CO_2 entrained in fuel, the facility is required to quantify the volume of flare gas and apply the volume based emission factor in this method (Equation 2-1a).

2.3.3. Method 2-2 – Multiple Flare Gas Stream Method

(1) Introduction

This method uses estimated and measured gas volumes and compositions of flare gases to calculate CO_2 and CH_4 emissions. This is applicable for multiple flare gas streams that are combined and flared as a single flare gas source.

This method may be used for emergency and/or non-routine flaring where measurements of flare gas volumes and/or gas compositions is not operationally possible. This may include waste gases generated from abnormal operating conditions, start-up or shutdown operations, or process malfunctions. Unmeasured volumes or compositions of flare gas may be calculated based on engineering estimates, fuel mass balance method, manufacturer's specified flow rates, and operating times.

Facilities may have measured volumes and compositions of gases that are routinely flared such as assistant gas, pilot gas, or purge gas streams. These flare gas streams may be equipped with online analyzers.

(2) Equations

For each flare source, use Equation 2-2 and 2-2a to calculate the total CO_2 mass emissions from the flaring of multiple flare gas streams that are combined.

$$CO_{2,flaring} = \sum_{F=1}^{N} \frac{V_{FL,F}}{MVC} \times CC_F \times 44.01 \times CE_{FL} \times 0.001$$ Equation 2-2

$$CC_F = \sum_{i}^{I} MF_{i,F} \times NC_{i,F}$$ Equation 2-2a

Where:

$CO_{2,\ flaring}$	=	CO_2 mass emissions from flaring of hydrocarbon components in the combined flare gas stream for the reporting period (tonnes).
$CO_{2,\ entrained}$	=	CO_2 mass emissions from entrained CO_2 in the combined flare gas stream for the reporting period (tonnes).
N	=	Total number of flare gas streams.
F	=	Flare gas stream.
$V_{FL,F}$	=	Measured or estimated volume of the flare gas stream, *F*, (sm^3) at standard conditions for the reporting period.
MVC	=	Standard molar volume conversion at standard molar volume as defined in Appendix B, Table B-2 (23.645 m^3/kmol).
CC_F	=	Average carbon content for flare gas stream, F, ($kmol_{carbon}/kmol_{flare\ gas,\ F}$) for the reporting period. This includes carbon from entrained CO_2 in the flare gas.
44.01	=	Molecular weight of CO_2 (kg/kmol).
0.001	=	Mass conversion factor (tonne/kg).
I	=	Total number of components in the flare gas stream, F.
i	=	Type of component.
CE_{FL}	=	Flare combustion efficiency (%).
$MF_{i,F}$	=	Normalized mole fraction of component, i, based on the estimated or measured weighted average flare gas composition in the flare gas stream, F, ($kmol_{CH4}/kmol_{flare\ gas}$) for the reporting period.
$NC_{\ i,F}$	=	Number of carbons in component, i, in the flare gas stream, F.

For methane emissions, use Equation 2-4 to calculate uncombusted methane from the flare gas:

$$CH_4 = \sum_{F=1}^{n}[V_{FL,F} \times MF_{CH4,F}] \times (1 - CE_{FL}) \times \frac{16.04}{MVC} \times 0.001 \qquad \text{Equation 2-4}$$

Where:

CH_4	=	CH_4 mass emissions from a flare source for the reporting period (tonnes);
$V_{FL,F}$	=	Measured or estimated volume of flare gas stream, F, (sm^3) at standard conditions for the reporting period.
$MF_{CH4,F}$	=	Normalized mole fraction of methane in estimated or measured average flare gas composition for flare gas stream, F ($kmol_{CH4}/kmol_{GAS}$) for the reporting period.
n	=	Number of flare gas streams.
F	=	Flare gas stream.
CE_{FL}	=	Flare combustion efficiency (%).
16.04	=	Molecular weight of CO_2 (kg/kmol).
MVC	=	Standard molar volume conversion at standard molar volume as defined in Appendix B, Table B-2 (23.645 m^3/kmol).
0.001	=	Mass conversion factor (tonne/kg).

(3) Data requirements

- For facilities subject to the expansion requirements prescribed by ECCC's GHGRP, the facility should follow measurement frequencies prescribed by ECCC's GHGRP.
- For a flare gas stream that is measured, if there is an online continuous flow measurement device or a continuous gas composition analyzer, the measured flow volumes and gas composition must be used to calculate emissions for the flare gas stream.

- For routine flaring, the following requirements apply:
  - The facility must have measured volumes and gas compositional analysis for a minimum of 60% by volume of the total flare gas stream. Note that for non-variable fuels such as propane and butane, the default gas compositions may be used. The volume and gas composition of the remaining unmeasured flare gas streams may be estimated using engineering estimates, a mass balance, or manufacturer specifications.
  - The volume and gas composition measurements must be taken daily if there is online instrumentation (i.e. flow meter and gas analyzer) or weekly if no online instrumentation is available.
  - A weighted gas composition must be used in calculating emissions and is based on the maximum sampling frequency that the facility is conducting. If the sampling frequency is higher than the prescribed frequency, the facility must apply the higher frequency in the weighted average.
  - For pilot or assistance gas used for flaring where the fuel type is known (i.e. propane, butane, sales gas, etc.), the facility may apply the gas composition of the fuel type listed in Table 2-2.
  - The volume or gas composition of the flare pilot or assistance gas may be calculated using a mass balance approach as described in Method 1-4 in Section 1.2.5 in Chapter 1.
  - If flare gas volumes and/or gas composition measurements are missing in a reporting period, the missing data procedures outlined in Section 17.5.2 of Chapter 17 should be followed.
- For emergency flaring, the volume of the flare gas may be estimated using engineering estimates, fuel mass balance, manufacturer specifications, and operating time.
- For a flare gas stream where the volume is not measured, but the flare gas is from a controlled venting emission source, the venting volume may be quantified using quantification methodologies provided in Chapter 4 Venting. Refer to the data requirements in Section 2.3.2 (Method 2-1).
- The facility may select a default flare combustion efficiency that best represents the flare technology that is applied at the facility. The selection must be supported by manufacturer specification or test data. The default flare combustion efficiencies are described in Section 2.2.

- If the sum of the mole fractions of components do not add up to 1.000 because smaller components are excluded from the analysis or are not measurable, facilities must normalize the mole fractions of the measured components in order for the sum of the mole fractions to equal 1.000.
- Flare gas volume and composition must be measured using:
  - A analytical methods required by AER Directives and other applicable regulatory requirement; or
  - The most appropriate method published by a consensus-based standards organization.

2.3.4. Method 2-3 - Combined Flare Gas Stream Method

(1) Introduction

This method requires measured volumes and gas compositions of the flare gas at the point before flaring or incineration. There may be a single flare gas stream or multiple flare gas streams that are combined before being flared at a single point. The measurements are taken at a point where the flare gas streams have been combined before flaring. This method may be applied for routine flaring operations.

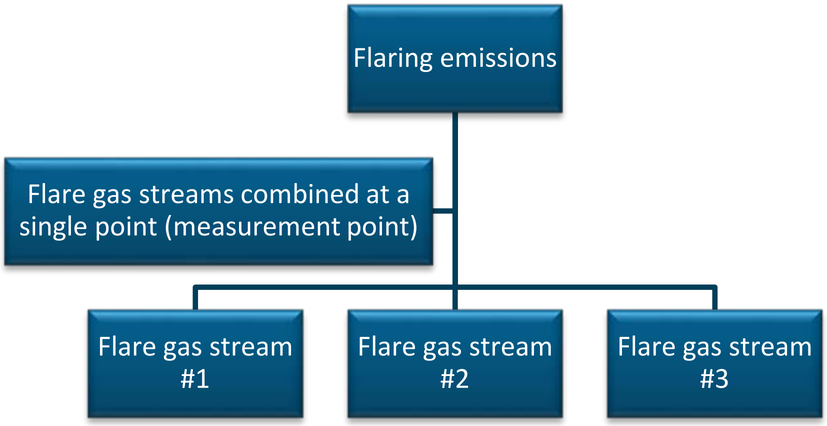

Figure 2-2: Combined fuel gas streams

(2) Equations

For each flare, calculate the CO_2 and CH_4 mass emissions for the reporting period by applying the measured flare gas volume and carbon content using Equation 2-5 and Equation 2-6, respectively.

$$CO_2 = \frac{V_{total}}{MVC} \times CC_F \times 44.01 \times CE_{FL} \times 0.001$$ Equation 2-5

$$CH_4 = V_{total} \times MF_{CH4} \times (1 - CE_{FL}) \times \frac{16.04}{MVC} \times 0.001$$ Equation 2-6

Where:

CO_2	=	CO_2 mass emissions from a flare for the reporting period (tonnes).
CH_4	=	CH_4 mass emissions from a flare for the reporting period (tonnes).
V_{total}	=	Total volume of flare gas at a flare (sm^3) at standard conditions for the reporting period.
CC_F	=	Weighted average carbon content of the combined flare gas (mol of carbons/mol of flare gas) by using Equation 2-2a. This includes carbon from entrained CO_2 in the flare gas.
MVC	=	Standard molar volume conversion at standard conditions as defined in Appendix B, Table B-2 (23.645 m^3/kmol).
0.001	=	Mass conversion factor (tonne/kg).
MF_{CH4}	=	Weighted average mole fraction of methane in the combined flare gas at a flare in the reporting period ($kmol_{CH4}/kmol_{GAS}$).
CE_{FL}	=	Flaring combustion efficiency (%).
44.01	=	Molecular weight of CO_2 (kg/kmol).
16.04	=	Molecular weight of CH_4 (kg/kmol).

(3) Data requirements

- For facilities subject to the expansion requirements prescribed by ECCC's GHGRP, the facility should follow measurement frequencies prescribed by ECCC's GHGRP.
- The flare gas must be measured at a point after the flare gas streams are combined and before flaring. The measured flow volumes and gas composition must be used to calculate emissions from the flare source.
- The volume and gas composition measurements must be taken daily if there is online instrumentation (i.e. flow meter and gas analyzer) or weekly if no online instrumentation is available.
- A weighted gas composition must be used in calculating emissions and is based on the minimum frequency of measurements that the facility is conducting.
- If flare gas volumes and/or gas composition measurements are missing in a reporting period, the missing data procedures outlined in Section 17.5.2 of Chapter 17 should be followed.
- The facility may select a default flare combustion efficiency that best represents the flare technology that is applied at the facility. The selection must be supported by manufacturer specification or test data. The default flare combustion efficiencies are described in Section 2.2.
- Flare gas volume and composition must be measured using:
  - A analytical methods required by AER Directives and other applicable regulatory requirement; or
  - The most appropriate method published by a consensus-based standards organization.

2.4. Nitrous Oxide

2.4.1. Introduction

For all flare types, the mass of N_2O emissions for the reporting period is calculated using a default emission factor methodology.

2.4.2. Method 2-4: Default Emission Factor Method

(1) Introduction

Default N_2O emission factors are assumed to remain unchanged with different flare combustion efficiencies and HHVs for different types of flare gases.

(2) Equations

For each flare source, calculate the N_2O mass emissions using Equation 2-7a or Equation 2-7b.

$$N_2O = \sum_{F}^{N} V_{FL,F} \times EF_{vol,F} \times 10^{-6}$$ Equation 2-7a

$$N_2O = \sum_{F}^{N} ENE_{FL,F} \times EF_{ENE,F} \times 10^{-6}$$ Equation 2-7b

Where:

N_2O	=	N_2O mass emissions from a flare source for the reporting period (tonnes of N_2O).
F	=	Flare gas stream.
N	=	Total number of flare gas streams.
$V_{FL,F}$	=	Volume of the flare gas stream, F, at a flare source (sm^3) at standard conditions for the reporting period. Volumes for pure fuel types such as ethane, propane and butane are measured in gas phase.
$ENE_{FL,F}$	=	Energy of the flare gas stream, F, at a flare source (MJ) for the reporting period.
$EF_{vol,F}$	=	Default N_2O emission factor, selected from Table 2-4 (g/m^3).
$EF_{ENE,F}$	=	Default N_2O emission factor, selected from Table 2-4 (g/MJ).

Table 2-4: Default N_2O Emission Factors for Different Flare Gas Types

Flare Gas Type	HHV	N_2O	
	MJ/m[3]	(g/m[3])	(g/MJ)
Hydrocarbon gas (sales gas, lean to rich gas)[1]	38.02	0.033	0.00087
Field gas or process vent gas[2]	45.79	0.0044	0.000095
100% Ethane (C2)[3]	66.065	0.00050	0.0063
100% Propane (C3)[3]	93.936	0.00035	0.0043
100% Butane (C4)[3]	121.600	0.00027	0.0038
Still gas[4]	34.02	0.02	0.0006
Landfill gas[4]	18.85	0.0064	0.00034

1. Natural gas combustion emission factor for the industrial sector adapted from ECCC Canada's Greenhouse Gas Quantification Requirements (December 2019).
2. Emission factors are adapted from the Western Climate Initiative (WCI) Final Essential Requirements of Mandatory Reporting 2011 Amendment.
3. Natural gas combustion emission factor for the industrial sector adapted from ECCC Canada's Greenhouse Gas Quantification Requirements (December 2019) and adjusted by the HHV of the fuel for an energy-based emission factor.
4. Emission factors adapted from Canada's National Inventory Report (NIR) 2016.

(3) Data requirements

- For facilities subject to the expansion requirements prescribed by ECCC's GHGRP, the facility should apply measurement frequencies prescribed by ECCC's GHGRP.
- For all other facilities:
  - For emergency flaring and facilities using level 1 methodologies, the volume or energy of the flare gas may be estimated using engineering estimates, fuel mass balance, manufacturer specifications, and operating time.
  - For routine flaring and facilities using levels 2 and 3 methodologies, the following requirements apply:
    - The volume and/or high heating value measurements must be taken daily if there is online instrumentation or weekly if no online instrumentation is available.
    - If measuring the HHV, the HHV must be weighted based on the maximum sampling frequency that the facility is conducting. If the sampling frequency is higher than the

prescribed frequency, the facility must apply the higher frequency in the weighted average. Energy should be measured in accordance with Section 17.3.2 of Chapter 17 and Appendix C.5.

  - If flare gas volumes and/or HHV measurements are missing in a reporting period, the missing data procedures outlined in Section 17.5.2 of Chapter 17 should be followed.

- For a flare gas stream where the volume is not measured, but the flare gas is from a controlled venting emission source, the venting volume may be quantified using quantification methodologies provided in Chapter 4 Venting. Refer to the data requirements in Section 2.3.2 (Method 2-1).

- Based on the facility's knowledge of the flare gas composition and flare technology, select the fuel gas type that would best align with the flare gas and the appropriate emission factor from Tables 2-2 or 2-3. If the HHV of the flare gas falls between two HHVs in the tables, choose the emission factor with the higher HHV.