NETL Life Cycle Inventory Data
Process Documentation File

Process Name:	Natural Gas Well Venting and Flaring
Reference Flow:	1 kg of Natural Gas, Vented or Flared
Brief Description:	This unit process quantifies the carbon dioxide and select criteria air pollutant emissions associated with the flaring and venting of natural gas at a generic natural gas well.

Section I: Meta Data

Geographical Coverage:	United States	**Region:**	N/A
Year Data Best Represents:	2010		
Process Type:	Auxiliary Process (AP)		
Process Scope:	Gate-to-Gate Process (GG)		
Allocation Applied:	No		
Completeness:	All Relevant Flows Captured		

Flows Aggregated in Data Set:

☒ Process ☐ Energy Use ☐ Energy P&D ☐ Material P&D

Relevant Output Flows Included in Data Set:

Releases to Air:	☒ Greenhouse Gases	☐ Criteria Air Pollutants	☒ Other
Releases to Water:	☐ Inorganic Emissions	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Flare_rate	*Fraction of vented natural gas that is flared (dimensionless)*

Tracked Input Flows:

Vented or Flared Natural Gas [Intermediate product]	*Reference flow; vented gas from well construction, workovers, liquid unloading, dehydration, venting, sweetening, and other venting processes*

Tracked Output Flows:

N/A

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NG_Flaring_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers flaring and venting in support of natural gas extraction activities, as described in greater detail below. Venting and flaring may occur during well preparation, during emergency operations, as a result of fugitive leaks along fittings and other components, and when it is otherwise not financially preferable to recover natural gas and/or other hydrocarbons. Limited data were available regarding the proportion of natural gas that is vented, rather than flared. Therefore, this proportion was included as an adjustable parameter. The process is based on the reference flow of 1 kg of natural gas, vented or flared, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #1 and can be used to model the flaring of gas at natural gas extraction and processing sites. This unit process is combined with other relevant equipment for LC Stage #1 in a separate operations assembly process, DF_Stage1_O_Assembly_Natural_Gas _2011.01.doc. The assembly process quantifies the relevant flows and emissions associated with each portion of the natural gas extraction profile being modeled, in order to complete extraction and in-field processing of 1 kg of natural gas.

Boundary and Description

Venting and Flaring are frequently intermittent operations, necessary in situations where a natural gas (or other hydrocarbons) stream cannot be safely or economically recovered. Venting is defined as the release of natural gas or other hydrocarbons directly into the environment. Flaring is the direct combustion of natural gas and/or other hydrocarbons, and the release of combustion products to the environment. The combustion products of flaring include carbon dioxide, methane, and nitrous oxide. Using a 98% flaring efficiency, the flaring of 1 kg of natural gas results in air emissions of 1.8E-02 kg of CH_4 per kg of flared natural gas (API 2009). This analysis assumes that, in comparison to the other activities of natural gas extraction, the flaring emissions of criteria air pollutants and other air emissions, aside from GHG emissions, are insignificant.

The input to this unit process is combination of all vented gas streams from other unit processes in NETL's natural gas model. This includes vented gas from well completion (which is a part of the construction and installation unit process), liquids unloading, well workovers, centrifugal compressor venting, and venting from oil and gas separation (which is used only when modeling associated natural gas production).

Recent data indicate that only 51 percent of vented natural gas from natural gas operations is flared and the remaining 49 percent is released to the atmosphere (EPA 2011). The flaring rate of vented natural gas is a significant variable because it determines the split between CO_2 and CH_4 emissions at the wellhead. Changing the flaring rate from 100 percent to 51 percent increases the GWP of flaring and venting operations, per MMBTU of delivered natural gas. Data on venting and flaring rates incorporated into this unit process should be further refined as additional data become available.

Figure 1 provides an overview of the boundary of this unit process. As shown, vented natural gas from upstream unit processes are input to venting and flaring operations, quantified in parallel. Air emissions from venting and flaring are then evaluated, in order to quantify overall carbon dioxide, methane, nitrous oxide, and non-methane volatile organic carbon emissions to the atmosphere. This unit process is then combined with other natural gas extraction operations unit processes in a downstream natural gas operations assembly unit process.

Figure 1: Unit Process Scope and Boundary
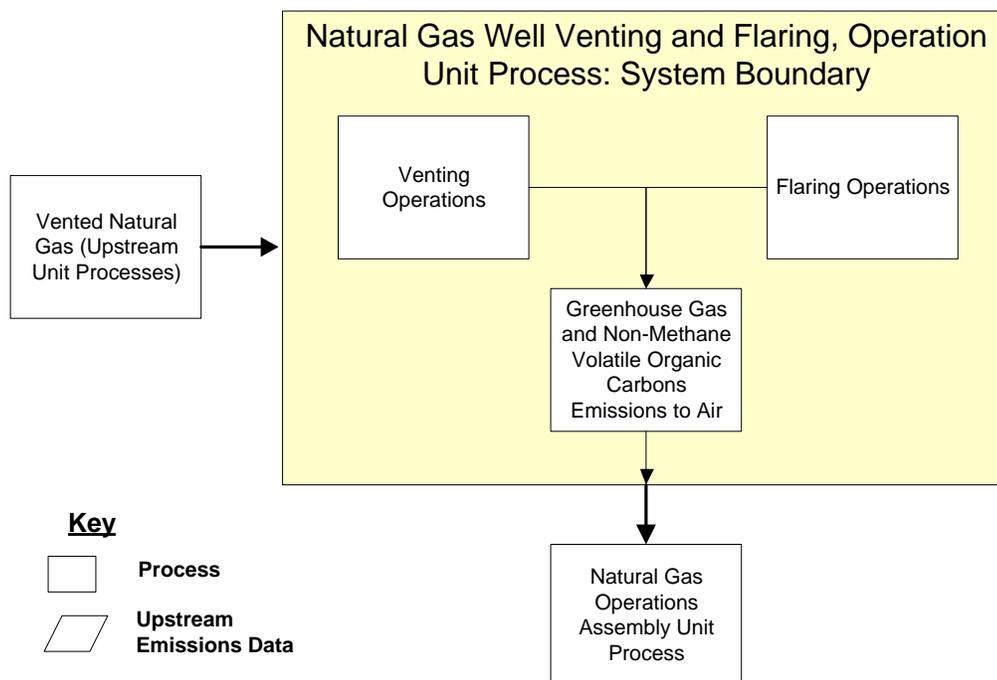
Table 1 summarizes natural gas flaring emissions and associated calculations that are applied within this unit process. **Table 2** provides a summary of modeled input and

output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Natural Gas Flaring Air Emission Factors

Emission	Production NG	Pipeline NG	Units	Reference
Natural Gas Composition				
CH_4	78.8%	93.4%	% mass	EPA, 2011
CO_2	1.52%	0.47%	% mass	EPA, 2011
Nitrogen	1.78%	0.55%	% mass	EPA, 2011
NMVOC	17.90%	5.57%	% mass	EPA, 2011
Flaring Emissions				
CO_2	2.67	2.69	lb CO_2/lb Flared NG	calculated
N_2O	8.95E-05	2.77E-05	lb N_2O/lb Flared NG	calculated
CH_4	1.53E-02	1.81E-02	lb CH_4/lb Flared NG	calculated
NMVOC	3.47E-03	1.08E-03	lb NMVOC/lb Flared NG	calculated

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Vented or Flared Natural Gas [Intermediate product]	**1.00**	**kg**
Outputs		
Carbon dioxide [Inorganic emissions to air]	1.37	kg
Methane [Organic emissions to air (group VOC)]	3.94E-01	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	4.56E-05	kg
NMVOC (unspecified) [Group NMVOC to air]	8.95E-02	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using GaBi modeling software, as shown in Figure 1.

Embedded Unit Processes

None.

References

API 2009   American Petroleum Institute. 2009. "Compendium of Greenhouse Gas Emissions for the Oil and Natural Gas Industry." 2009. Available at:

http://www.api.org/ehs/climate/new/upload/2009_GH
G_COMPENDIUM.pdf (Accessed May 18, 2010).

EPA 2011   United States Environmetal Protection Agency. 2011.
                    Greenhouse Gas Emissions Reporting from the
                    Petroleum and Natural Gas Industry; Background
                    Technical Support Document. Available at
                    http://www.epa.gov/climatechange/emissions/downloa
                    ds10/Subpart-W_TSD.pdf (Accessed April 4, 2011).

Section III: Document Control Information

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