NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Natural Gas Well, Venting from Liquid Unloading

Reference Flow: 1 kg of Natural Gas

Brief Description: This unit process quantifies the mass of vented natural gas that is anticipated to occur during liquid unloading at a natural gas well.

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2012

Process Type: Extraction Process (EP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: All Relevant Flows Recorded

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:

Vent_episode	*Amount of methane vented during liquid unloading of a natural gas (NG) well*
Freq_episode	*Number of times, per year, of liquid unloading of a NG well*

Tracked Input Flows:

None.

Tracked Output Flows:

Natural Gas	*Reference flow; amount of natural gas produced after gas is vented during liquid unloading*
Vented gas [intermediate product]	*Intermediate product; amount of gas vented to the atmosphere during liquid unloading (only necessary in conventional gas wells)*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NGWell_LiqUnloading_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers natural gas that is vented during liquid unloading at a conventional natural gas site. It is considered to be applicable to all conventional natural gas well installations, both onshore and offshore, as relevant. Liquid unloading is necessary for conventional gas wells, but is unnecessary for unconventional gas wells or associated gas wells. The process is based on the reference flow of 1 kg of natural gas, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #1 to account for methane emissions from liquid unloading at a gas well. Liquid unloading is a routine operation for conventional gas wells. Liquid unloading is a step in the extraction process that occurs several times each year during well activities. This process is combined with other relevant equipment for LC Stage #1 in a separate operation 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

Liquid unloading is necessary for conventional gas wells, but is unnecessary for unconventional wells or associated gas wells. The methane emissions from the unloading of liquid from conventional wells are based on emission factors developed by EPA (2011). In 2007, conventional wells produced 223 BCF/year (EPA 2011), which is

equivalent to 4.25 million metric tons per year using a natural gas density of 0.042 lb/scf. There were approximately 389,000 unconventional wells in 2007. When the annual emissions are divided the total number of wells, the resulting emission factor is 10.9 metric tons/well-year.

Liquid unloading is a routine operation for conventional gas wells. The frequency of liquid unloading was calculated using EPA's assessment of two producers and the unloading activities for their wells (EPA 2011). From this sampling, EPA calculated that there are 31 liquid unloading episodes per well-year (EPA 2011). When the emission factor for liquid unloading is divided by the average number of unloading episodes, the resulting methane emission factor is 352 kg/episode.

Figure 1 provides an overview of the boundary of this unit process. As shown, natural gas from upstream unit processes is input into the natural gas well venting from liquid unloading operations. Methane air emissions from liquid unloading are quantified and results are exported to a downstream methane venting and flaring unit process. This unit process is then combined with other natural gas extraction operations unit processes in a downstream natural gas operations assembly unit process. The amount of methane vented during a single liquid unloading episode and the frequency of liquid unloading episodes are the two adjustable parameters included in this unit process. These parameters affect the amount of vented gas in the production of 1 kg of natural gas.

Figure 1: Unit Process Scope and Boundary

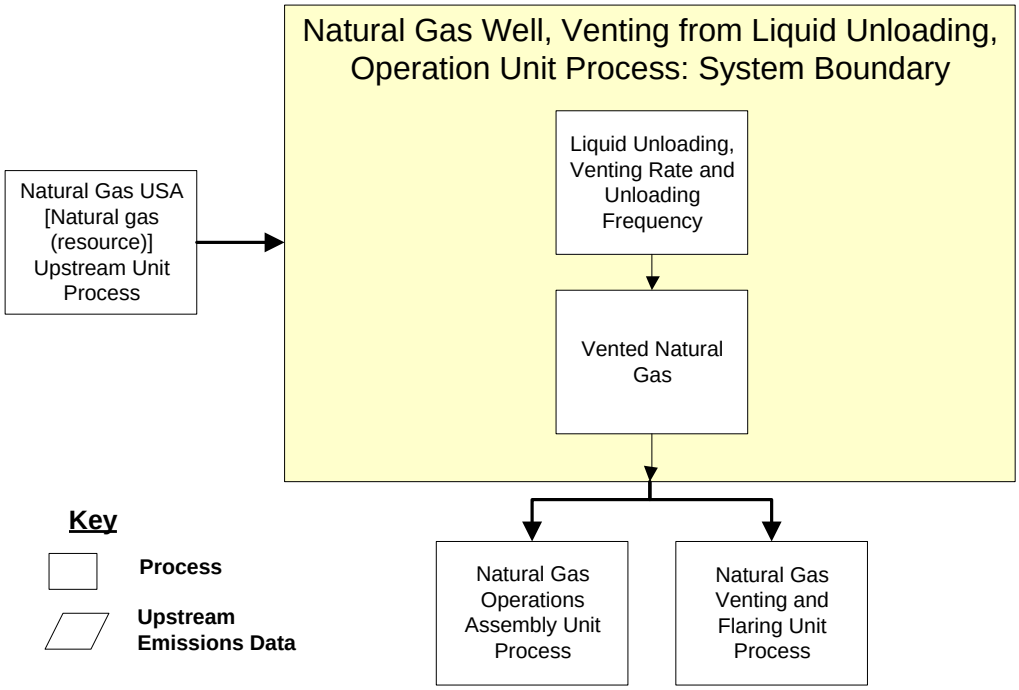

Table 1 summarizes vented gas emissions and associated calculations that are applied within this unit process. **Table 2** provides a summary of modeled input and output

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

Table 1: Properties of Liquid Unloading Process

Property	Value	Units	Reference
Conventional well natural gas production, 2007	223	Billion cubic feet	EPA 2011
Number of conventional wells, 2007	389,000	wells	EPA 2011
Average liquid unloading episodes, 2007 (unloading frequency)	31	episodes per well	EPA 2011
Natural gas emission factor (venting from unloading)	448	kg/episode	NETL engineering calculation

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Natural Gas USA [Natural gas (resource)]	3.02E-02	kg
Outputs		
Natural Gas	**1.00**	**kg**
Vented gas [intermediate product]	**3.02E-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. This table shows input and output values for conventional onshore natural gas production. Values for other natural gas profiles can be calculated by adjusting the appropriate parameter values within the associated DS.

Embedded Unit Processes

None.

References

EPA 2011 — US Environmental Protection Agency. 2011. *Background Technical Support Document - Petroleum and Natural Gas Industry.* Washington, D.C.: U.S. Environmental Protection Agency, Climate Change Division, 2011.

Section III: Document Control Information

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Revision History:

Original/no revisions

How to Cite This Document: This document should be cited as:

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Natural Gas Well, Venting from Liquid Unloading.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: April 2011 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

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