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:** Northeast, Mid-Continent, Southwest, Gulf Coast, and Rocky Mountains

Year Data Best Represents: 2012

Process Type: Extraction Process (EP)

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	☑ Other
Releases to Water:	☐ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☐ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

Vent_episode	*[Vents/well] Total number of unloading events per well*
Internal_diam	*[in] Casing or Tubing Internal Diameter for non-plunger wells and plunger wells, respectively*

Well_Depth	*[ft] Well depth*
Pressure	*[psia] Shut-in pressure or surface pressure for wells with tubing production, or casing pressure for each well with no packers*
Flow_Rate_NG	*[ft3/hr] Average flow-line rate of natural gas for well*
Conv_Coeff	*[kg/scf] kg natural gas per standard cubic foot of natural gas*
Hour_Vent	*[hr] Hours of unloading event*
Plunger_Switch	*1=Plunger; 0=Without Plunger. Calculation for total emissions for well venting for liquid unloading differs for wells with and without plunger lift system*

Tracked Input Flows:

Natural gas USA [Natural gas (resource)]

Tracked Output Flows:

Natural Gas Extraction, liquid unloading	*Reference flow*
Vented gas	*Intermediate flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NGWell_LiqUnloading_2011.02.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process accounts for natural gas that is vented during liquid unloading at a natural gas extraction site. This unit process includes multiple scenarios to account for parameterization differences. The scenarios discern between region (i.e. Northeast, Mid-Continent, Southwest, Gulf Coast, and Rocky Mountains),

conventional vs. unconventional well type (unconventional considered to be shale gas, coal bed, and tight sand), the application of a plunger lift system, and the corresponding expected, minimum, and maximum parameter values. The reference flow of this unit process is: 1 kg of Natural Gas

Boundary and Description

Liquid unloading is a routine operation for gas wells. The accumulation of fluids in the well can impede gas production. To maintain gas flow, fluids are removed by several treatment methods, such as venting the well to the atmosphere. However, fluid removal may result in substantial methane emissions to the atmosphere (EPA, 2006).

Some well operations install a plunger lift system that uses gas pressure buildup in a well to lift a column of accumulated fluid out of the well, which helps maintain gas production and reduce methane emissions. While vented methane emissions during liquid unloading events vary as a result of the use of a plunger lift system, other factors include local geology, hydrology, and state law.

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. Natural gas 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 U.S. Environmental Protection Agency's *Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems* provides a method for calculating emissions from each sub-basin venting to the atmosphere for liquids unloading with or without plunger lift assist (EPA, 2014). The parameters utilized in this calculation are shown and described in **Table 1**. Furthermore, **Equation 1** and **Equation 2** shown below are used for calculating emissions without a plunger lift system and with a plunger lift system, respectively.

Equation 1. Without Plunger Lift Assist (EPA, 2014)

$$E_{s,n} = \sum_{p=1}^{W}\left[V_p \times \left(\left(0.37\times10^{-3}\right)\times CD_p^2 \times WD_p \times SP_p\right) + \sum_{q=1}^{V_p}\left(SFR_q \times \left(HR_{p,q} - 1.0\right)\times Z_{p,q}\right)\right]$$

Equation 2. With Plunger Lift Assist (EPA, 2014)

$$E_{s,n} = \sum_{p=1}^{W}\left[V_p \times \left(\left(0.37\times10^{-3}\right)\times TD_p^2 \times WD_p \times SP_p\right) + \sum_{q=1}^{V_p}\left(SFR_q \times \left(HR_{p,q} - 0.5\right)\times Z_{p,q}\right)\right]$$

Table 1: Parameters for Well Venting Emissions Calculation

Parameter	Definition	Units
V	Total number of unloading events per well	Events/well
TD	Tubing internal diameter for each well	in
CD	Casing internal diameter for each well	in
WD	Well depth	ft
SP	Shut-in pressure or surface pressure for wells with tubing production, or casing pressure for each well with no packers	psia
SFR	Average flow-line rate of gas for well	ft^3/hr
HR	Hours of unloading event	hr
Z	If HR is less than 0.5 then Z is equal to 0. If HR is greater than or equal to 0.5 then Z is equal to 1.	dimensionless
E	Annual natural gas emissions for each sub-basin at standard conditions	ft^3/yr

Ultimately, this unit process includes multiple scenarios to account for parameterization differences. The scenarios discern between Oil and Gas Supply Model Regions (OGSM) utilized in the survey report by API and ANGA (i.e. Northeast, Mid-Continent, Southwest, Gulf Coast, and Rocky Mountains), conventional vs. unconventional well type (unconventional considered to be shale gas, coal bed, and tight sand), the application of a plunger lift system, and the corresponding expected, minimum, and maximum parameter values. The parameter values are derived from the API and ANGA Natural Gas Production Survey (API & ANGA, 2012).

In the data sheet (DS) *DS_Stage1_O_NGWell_LiqUnloading_2011.02.xls*, the adjustable parameter, Plunger_Switch, is a binary input where 1=Plunger and 0=Without Plunger. The choice of each scenario will require the user to subsequently "switch" this parameter on or off. For example, if the scenario, *Conventional, Northeast, Plunger, Expected*, is selected, Plunger_Switch must be set to 1; similarly, if the scenario, *Conventional, Northeast, NO Plunger, Expected*, is selected, Plunger_Switch must be set to 0. This switch results in the use of either **Equation 1** or **Equation 2**.

Figure 1: Unit Process Scope and Boundary

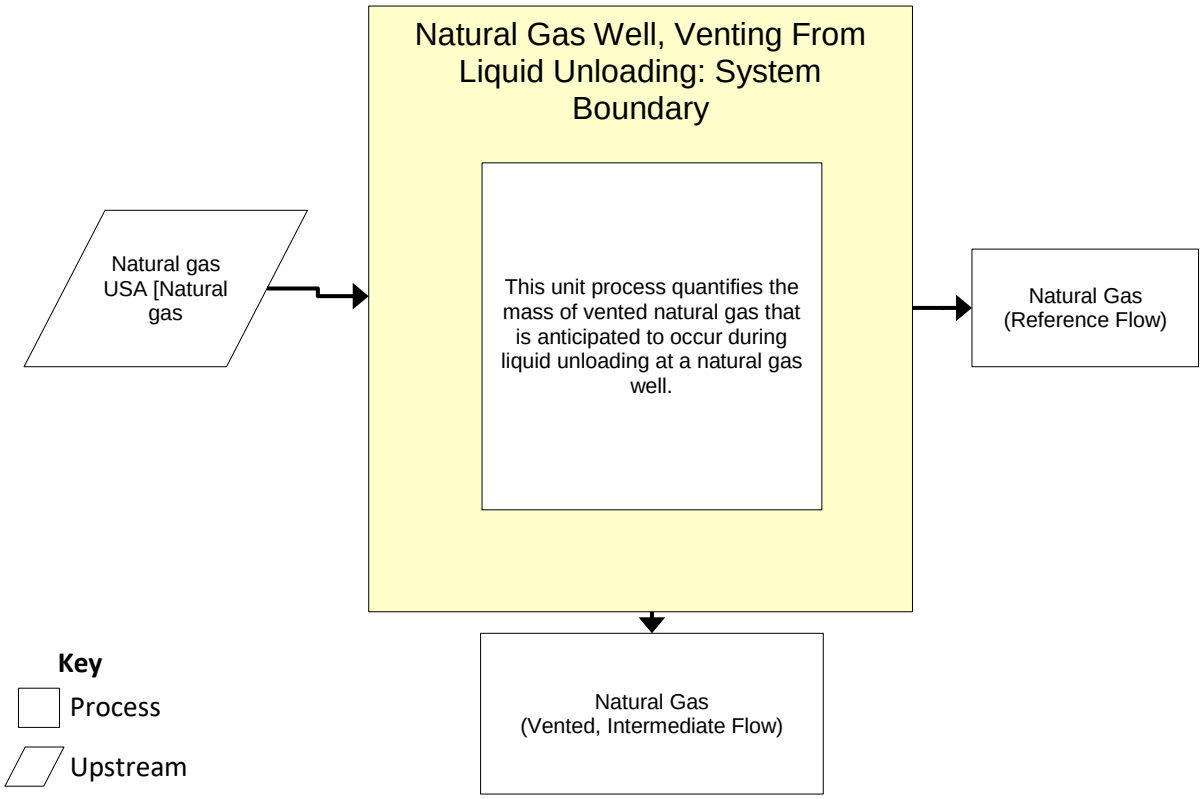

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Natural gas USA [Natural gas (resource)]	**1.01E+00**	**kg**
Outputs		
Natural Gas	**1.00E+00**	**kg**
Vented Gas	**5.86E-03**	**kg**

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

API & ANGA, 2012 — American Petroleum Institute and America's Natural Gas Alliance (2012). Characterizing Pivotal Sources of Methane Emissions from Natural Gas Production. API, ANGA.

EPA, 2006 — U.S. Environmental Protection Agency (2006). Installing Plunger Lift Systems in Gas Wells. Lessons Learned from Natural Gas STAR Partners. EPA.

EPA, 2014 — U.S. Environmental Protection Agency (2014). Greenhouse Gas Reporting Rule: Revisions and Confidentiality Determinations for Petroleum and Natural Gas Systems; Proposed Rule. EPA.

Section III: Document Control Information

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