NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Natural Gas Well Workovers

Reference Flow: 1 kg of Natural Gas

Brief Description: This unit process quantifies the mass of vented gas that is anticipated to result from natural gas well workovers, associated with the production of natural gas from conventional and unconventional wells.

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 gas vented from well during workover*

Freq_episode   *Frequency of well workovers, number per year; default = 0.1 episodes/year*

Tracked Input Flows:

None.

Tracked Output Flows:

Natural Gas   *Reference flow; 1 kg of natural gas (NG) product*

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Vented gas [intermediate product]	*Intermediate product; amount of natural gas vented as emission to air during well workover, based on reference flow of 1 kg NG*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NGWell_Workovers_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the fraction of gas that is vented during the workover of a natural gas well. It is considered to be applicable to workovers for all completed natural gas wells, both conventional and unconventional. 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 assist in the extraction of natural gas. It 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, in order to complete extraction and in-field processing of 1 kg of natural gas.

Boundary and Description

The methane emissions from the workover of conventional and unconventional wells are based on emission factors developed by EPA (EPA 2011). Conventional wells produce 2.454 MCF/workover and unconventional wells produce 9,175 MCF/workover. (Note that the workover emission factor for unconventional wells is the same as the completion emission factor for unconventional wells.) This analysis tracks flows on a mass basis, so it is necessary to convert these emission factors from a volumetric to a mass basis. Using a natural gas density of 0.042 lb/scf (API 2009) and the conversion factor of 2.205 lb/kg, the methane emissions from well workovers are 46.7 and 175,000 kg/workover for conventional and unconventional wells, respectively.

Well workovers occur more than one time during the life of a well. The frequency of well workovers was calculated using EPA's accounting of the total number of natural gas wells in the U.S. and the total number of workovers performed per year (all data representative of 2007). For conventional wells, there were approximately 389,000 wells and 14,600 workovers in 2007 (EPA 2011), which translates to 0.037 workovers per well-year. Similarly, for unconventional wells, there were approximately 35,400

wells and 4,180 workovers in 2007 (EPA 2011), which translates to 0.118 workovers per well-year.

Figure 1 provides an overview of the boundary of this unit process. Natural gas resources are input into natural gas workover operations. Gas emissions as a result of the workover are quantified on the basis of 1 kg of natural gas produced. This unit process is then combined with other natural gas extraction operations unit processes in a downstream natural gas operations assembly unit process. Two adjustable parameters are taken into account for this unit process. One is the total amount of gas vented during a single workover episode, with a default value of 175,000 kg gas per workover. The second is the frequency of workover episodes, with a default value of one workover every ten years, or 0.1 workover per year. Output from this unit process feeds into a downstream assembly unit process for natural gas, and to a separate natural gas venting and flaring unit process.
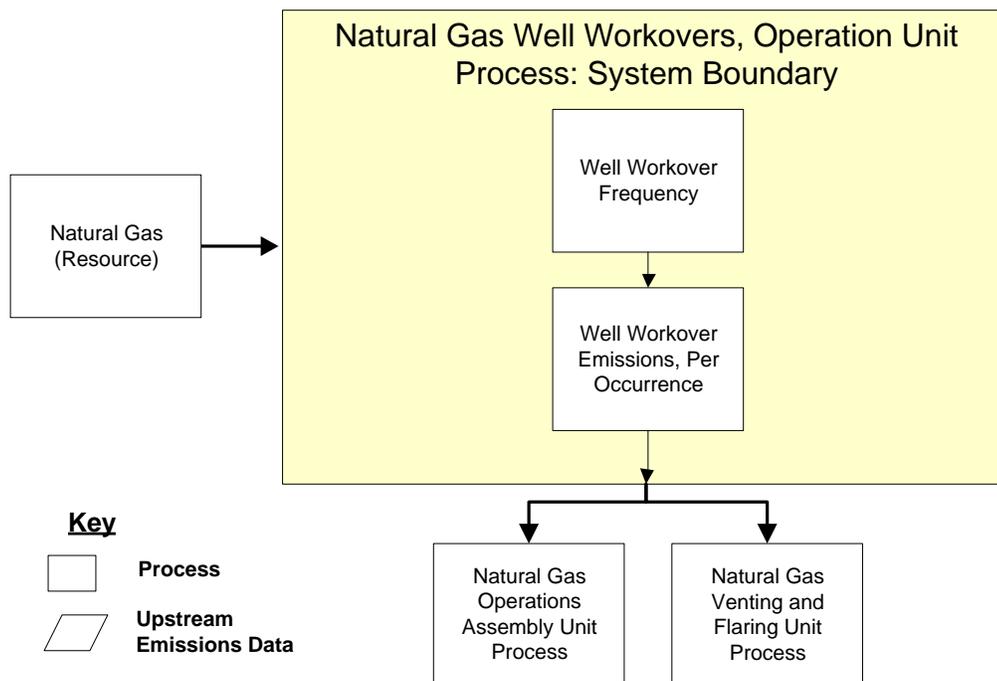
Figure 1: Unit Process Scope and Boundary

Table 1 summarizes the relevant properties and assumptions used to calculate the vented gas emissions during a natural gas well workover. **Table 2** provides a summary of modeled input and output flows and is representative of workover emissions for onshore conventional natural gas wells. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

DF_Stage1_O_NGWell_Workovers_2011.01.doc

Table 1: Workover Emission Factors and Frequency

Properties and Natural Gas Emissions for Well Workovers			
Property	**Value**	**Units**	**Reference**
Onshore Conventional Natural Gas	46.7	kg/workover	EPA 2011
Associated Natural Gas	46.7	kg/workover	EPA 2011
Offshore Natural Gas	46.7	kg/workover	EPA 2011
Tight Gas	69,900	kg/workover	EPA 2011
Barnett Shale	175,000	kg/workover	EPA 2011
Marcellus Shale	175,000	kg/workover	EPA 2011
Coal Bed Methane	945	kg/workover	EPA 2011
Conventional Well Workover Frequency	0.037	workovers/yr	EPA 2011
Unconventional Well Workover Frequency	0.118	workovers/yr	EPA 2011

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Natural Gas USA [Natural gas (resource)]	3.77E-06	kg
Outputs		
Natural Gas	**1**	**kg**
Vented gas [intermediate product]	**3.77E-06**	**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. The values shown above are relevant to conventional onshore natural gas extraction. To determine input and output flows relevant to other natural gas extraction profiles, please update the appropriate adjustable parameters within the associated DS.

Embedded Unit Processes

None.

References

API 2009   American Petroleum Institute. 2009. *Compendium of Greenhouse Gas Emissions for the Oil and Natural Gas Industry.* 2009. http://www.api.org/ehs/climate/new/upload/2009_GHG_COMPENDIUM.pdf (accessed May 18, 2010).

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.

DF_Stage1_O_NGWell_Workovers_2011.01.doc

Section III: Document Control Information

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