NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Wellhead Compressor, Gas-Powered Reciprocating, 200 HP

Reference Flow: 1 kg of Natural Gas

Brief Description: This unit process quantifies the amount of natural gas required for the operation of a 200 horsepower, gas-powered reciprocating wellhead compressor for natural gas wells.

Section I: Meta Data

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

Year Data Best Represents: 2010

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:

None.

Tracked Input Flows:

Natural gas [intermediate product]	*[Intermediate Product] Natural gas to be compressed*
Internal Combustion Engines, Commercial/Institutional, Natural Gas, Reciprocating, Uncontrolled [Intermediate product]	*[Intermediate Product] Natural gas combusted in a reciprocating compressor*

Tracked Output Flows:

Natural gas [Intermediate product]	*Reference flow of natural gas, pressurized and ready for pipeline distribution*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NG_WellCompression_Recip_2011.02.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the wellhead compression of natural gas using a 200 horsepower, natural gas-powered reciprocating compressor. This unit process is applicable to all natural gas well types considered, and the proportion of this versus other compressor types are identified in a separate unit process. 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. 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_Compressors_2011.02. The assembly process quantifies the relevant flows and emissions associated with each portion of the natural gas extraction profile being modeled. From this process, the natural gas product is prepared for distribution, while excess natural gas (including fugitive emissions) is vented and flared.

Boundary and Description

Compressors are used at the natural gas wellhead to increase the gas pressure for pipeline distribution. The performance of a compressor depends on the natural pressure at the wellhead, which varies from reservoir to reservoir and decreases with increasing well life. This analysis assumes that the inlet pressure to a wellhead compressor is 50 psig and the outlet pressure is 800 psig. The inlet pressure depends on the pressure of the natural gas reservoir and thus introduces uncertainty into the natural gas model. On the other hand, the outlet pressure of 800 psig is a standard pressure for pipeline transport of natural gas.

The energy required for compressor operations is based on manufacturer data that compares power requirements to compression ratio (the ratio of outlet to inlet pressures). A two-stage compressor with an inlet pressure of 50 psig and an outlet pressure of 800 psig has a power requirement of 187 horsepower per MMCF of natural

gas (GE Oil and Gas 2005). Using a natural gas density of 0.042 lb/scf and converting to SI units gives a compression energy intensity of 1.76E-04 MWh per kg of natural gas. This energy rate represents the required *output* of the compressor shaft; the *input* fuel requirements for compression vary according to compression technology. Reciprocating compressors are discussed below.

Reciprocating compressors used for industrial applications are driven by a crankshaft that can be powered by 2- or 4-stroke diesel or natural gas engines. Reciprocating compressors are not as efficient as centrifugal compressors and are typically used for small scale extraction operations that do not justify the increased capital requirements of centrifugal compressors. The natural gas fuel requirements for a gas-powered, reciprocating compressor used for natural gas extraction are based on a compressor survey conducted for natural gas production facilities in Texas (HARC 2006). The average energy intensity of a gas-powered turbine is 8.74 Btu/hp-hr (HARC 2006). Using a natural gas heating value of 1,027 Btu/scf (API 2009), a natural gas density of 0.042 lb/scf (API 2009), and converting to SI units translates to 217 kg of natural gas per MWh of centrifugal, gas-powered turbine output. This fuel factor represents the mass of natural gas that is combusted per compressor energy output.

Figure 1 provides an overview of the boundary of this unit process. Natural gas, extracted and ready to be pressurized, is the sole input to this unit process. Within the system boundary, compressor energy use is determined as a function of engine power and the energy needed to run the compressor. Output from this unit process feeds into a downstream assembly unit process for natural gas. The external unit process linking this unit process to natural gas emissions is also included.

Figure 1: Unit Process Scope and Boundary

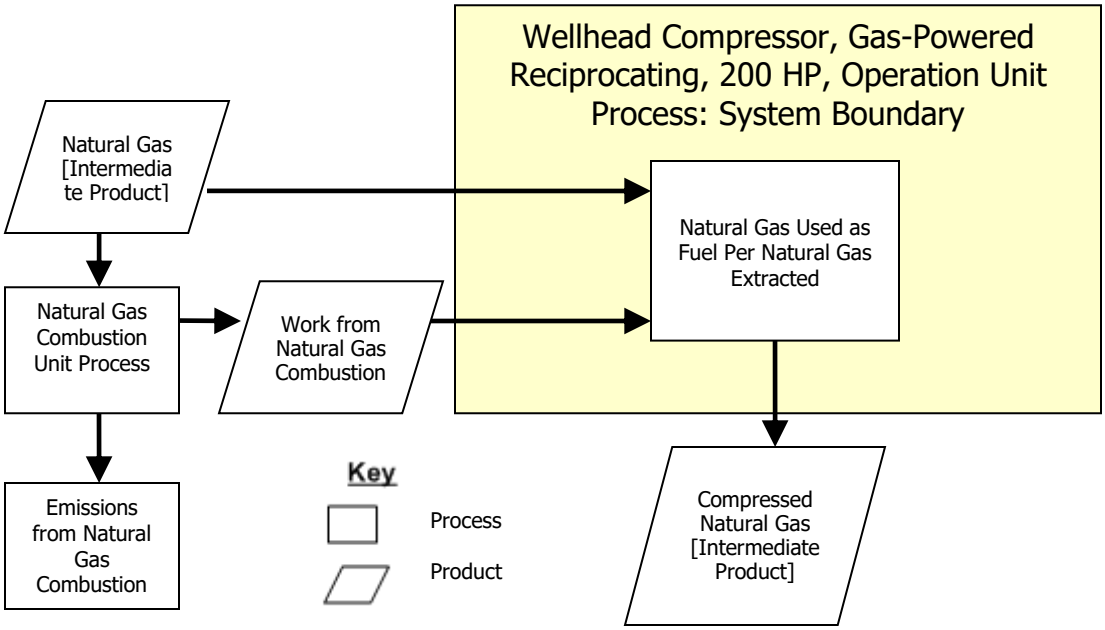

Table 1 summarizes the relevant properties and assumptions used to calculate the natural gas output and scale of emissions for the Internal Combustion Engines, Commercial/Institutional, Natural Gas, Reciprocating, Uncontrolled [Intermediate product] from the operation of a reciprocating, gas-powered 200 horsepower compressor. **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: Wellhead Compressions for a Gas-Powered Reciprocating Compressor

Energy inputs and outputs			
Flow Name	**Value**	**Units**	**Reference**
Output shaft energy	1.76E-04	MWh/kg	GE 2005
Heat rate	217	kg NG/MWh	HARC 2006
Fuel input[1]	3.82E-02	kg NG/kg NG	NETL Engineering Calculation

[1] The fuel input is the product of output shaft energy and heat rate.

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)	DQI
Inputs			
Natural Gas [Intermediate product]	**1.0**	**kg**	**2,2**
Internal Combustion Engines, Commercial/Institutional, Natural Gas, Reciprocating, Uncontrolled [Intermediate product]	**0.04**	**kg**	**2,2**
Outputs			
Natural Gas [Intermediate product]	**1**	**kg**	**2,2**

* **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

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).

GE Oil and Gas 2005 — GE Oil and Gas. Reciprocating Compressors. Florence, Italy: General Electric Company, 2005.

HARC 2006 — Houston Advanced Research Center. 2006. *Natural Gas Compressor Engine Survey for Gas Production and Processing Facilities, H68 Final Report.* Houston Advanced Research Center. 2006. http://www.utexas.edu/research/ceer/GHG/files/ConfCallSupp/H068FinalReport.pdf (accessed May 18, 2010).

Section III: Document Control Information

Date Created: April 07, 2011

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

Revision History:

19DECEMBER2014	Combustion emissions removed and linked to external UP. Added inventory item level DQI data to the data summary tab.

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