NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Wellhead Compressor, Electrically-Powered Centrifugal, 500 HP

Reference Flow: 1 kg of Natural Gas

Brief Description: This unit process quantifies the amount of electricity required and methane emissions associated with the operation of a 500 horsepower, 95% efficiency electric centrifugal 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 (GG)

Allocation Applied: No

Completeness: All 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:

Motor_eff — *Efficiency of electric motor*

Tracked Input Flows:

Natural gas (intermediate product) — *Natural gas from NG dehydration*

Power — *Electricity from ERCOT region to power compressor*

Tracked Output Flows:

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

Vented gas — *Intermediate product to venting and flaring*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_NG_WellCompression_ElecCentrif_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process encompasses the energy inputs and material outputs for the operation of a 500 horsepower, 95% efficiency electric centrifugal wellhead compressor for natural gas wells. It is applicable to all natural gas well types considered, and the proportion of this versus other compressor types are identified in a separate assembly unit process. The unit process is based on the reference flow of 1 kg of natural gas (NG). The relevant flows of this unit process are described below and shown in **Figure 1.**

The inputs to this unit process are natural gas (as an intermediate product) and power. The outputs of this unit process are natural gas ready for pipeline transport and natural gas that is an intermediate product for venting and flaring.

Boundary and Description

This unit process characterizes the operation of an electric centrifugal compressor for natural gas wells. The boundaries of this unit process start with the receipt of natural gas at the wellhead and ends with natural gas (NG) compressed to a pressure sufficient for pipeline distribution.

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 to 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 ratios (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.

Electrically-powered centrifugal compressors account for an estimated 25 percent of wellhead compression in the Barnett Shale gas play, and are also utilized within other natural gas extraction profiles. An electric centrifugal compressor uses the same compression principles as a gas-powered centrifugal compressor, but its shaft energy is provided by an electric motor instead of a gas-fired turbine. If the natural gas extraction site is near a source of electricity, it has traditionally been financially preferable to use electrically-powered equipment instead of gas-powered equipment. This is the case for extraction sites for Barnett Shale located near Dallas-Fort Worth. The use of electric equipment is also an effective way of reducing the noise of extraction operations, which is encouraged when an extraction site is near a city. The average power range of electrically-driven compressor in the U.S. natural gas transmission network is greater than 500 horsepower. This analysis assumes that compressors of this size have an efficiency of 95 percent (DOE 1996). This efficiency is the ratio of mechanical power output to electrical power input. Thus, approximately 1.05 MWh of electricity is required per MWh of compressor energy output. The upstream emissions associated with the generation of electricity are modeled with the fuel mix of the ERCOT grid, which is representative of electricity generation in Texas (the location of Barnett Shale). There is no data that suggest that other gas plays (either conventional or unconventional) have electrically-powered compressors at the wellhead, and thus this version of the unit process does not allow for adjustments to the grid mix used by electric wellhead compressors. Electric compressors have negligible methane emissions because they do not require a fuel line for the combustion of product natural gas and incomplete combustion of natural gas is not an issue (EPA 2010). In fact, electric compressors are recommended by EPA's Natural Gas STAR program as a strategy for reducing system emissions of methane (EPA 2010).

Figure 1 provides an overview of the boundary of this unit process. As shown, extracted natural gas and electric power are input to the compressor operation unit process. Within the process boundary, compressor energy use is quantified based on compressor energy efficiency, and fugitive methane venting emissions from compressor seals are also quantified. This unit process is then combined with other natural gas extraction unit processes in a downstream natural gas assembly unit process. Output from this unit process also 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

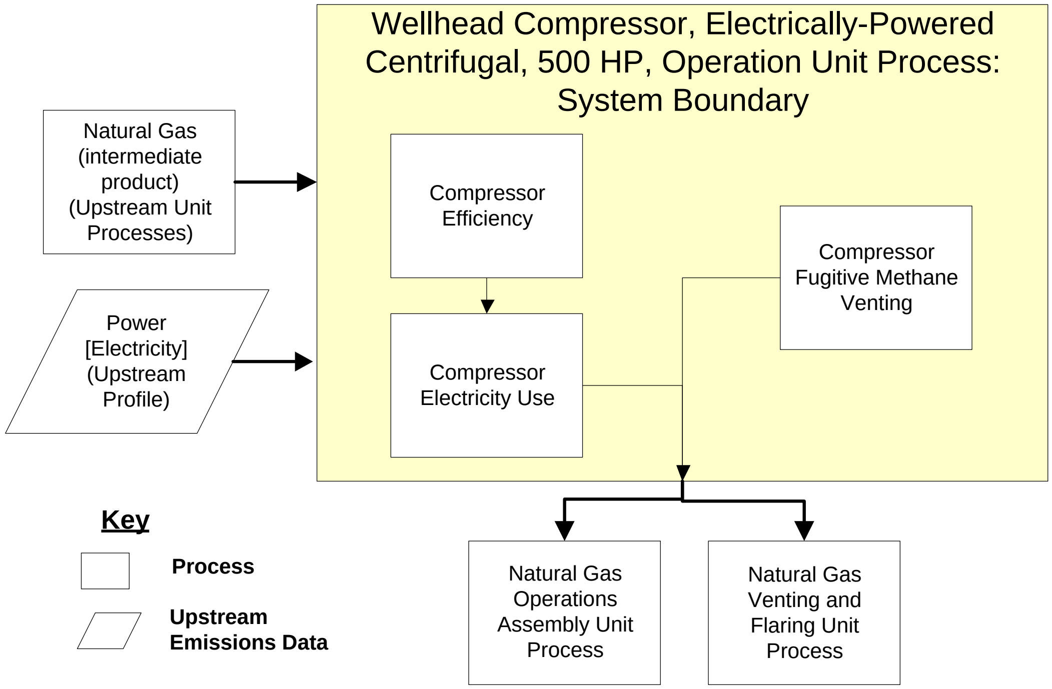

Table 1 summarizes vented gas emissions and associated calculations that are applied within this unit process. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Electrically-Powered Centrifugal Compressor Properties

Property	Value	Units	Reference
Compressor motor efficiency	95	Percent	DOE 1996
Compressor shaft efficiency	1.76E-04	MWH/kg	GE Oil and Gas 2005

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Natural gas (intermediate product)	**1.0069**	**kg**
Power [Electricity]	**1.85E-04**	**MWh**
Outputs		
Natural Gas	**1.00**	**kg**
Vented gas [intermediate product]	**6.90E-03**	**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 2.

Embedded Unit Processes

None.

References

DOE 1996 — US Department of Energy. 1996. "Buying an Energy-Efficient Electric Motor." U.S. Department of Energy, Industrial Technologies Program. 1996. http://www1.eere.energy.gov/industry/bestpractices/pdfs/mc-0382.pdf (accessed May 18, 2010).

EPA 2010 — US Environmental Protection Agency. 2010. *"Natural Gas STAR Recommended Technologies and Practices - Gathering and Processing Sector."* U.S. Environmental Protection Agency. 2010. http://www.epa.gov/gasstar/documents/gathering_and_processing_fs.pdf (accessed March 2, 2011).

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

Section III: Document Control Information

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