NETL Life Cycle Inventory Data
Process Documentation File

Process Name: CO_2 Pressure Boosting

Reference Flow: 1 kg of carbon dioxide

Brief Description: The operating requirements CO_2 pressure boosting in a CO_2 pipeline.

Section I: Meta Data

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

Year Data Best Represents: 2012

Process Type: Transport Process

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 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:

CO2_flow — *Flow rate of CO_2 through pipeline*

EF_CO2 — *CO_2 emissions per output of 1 kg of CO_2*

Tracked Input Flows:

Carbon Dioxide — *Captured CO_2 from an energy conversion facility*

Electricity — *Electricity used for powering a CO_2 pump*

Tracked Output Flows:

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_CO2_Pressure_Boosting_2012.01.doc*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides a summary of relevant input and output flows associated with the operation of a carbon dioxide pumping system that boosts the pressure in a CO_2 pipeline. The key emission of this unit process is CO_2 that leaks from pumps.

The tracked inputs are electricity and CO_2, and the key outputs are compressed CO_2 and CO_2 emissions to air. The reference flow of this unit process is the pumping of one kilogram of CO_2 as described below and shown in **Figure 1**. This unit process is used within Life Cycle (LC) Stage #3 of NETL's energy conversion models.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with the operation of a pump that boosts the pressure in a CO_2 pipeline. The tracked inputs are electricity and CO_2, and the key outputs are liquid CO_2 and CO_2 emissions to air. The reference flow of this unit process is the output of one kilogram of CO_2.

At pipeline conditions, liquid carbon dioxide forms at a pressure of 7.38 MPa. The pipeline pressure is maintained above this critical point to ensure that all CO_2 remains in the liquid state. The power to pressurize supercritical CO_2 from its critical point (7.38 MPa) to its maximum pipeline pressure (15.2 MPa) is described by **Equation 1**. This equation is based on a performance curve for CO_2 pumping and is a function of CO2 flow rate.

*Power (MW) = 0.0001867*x, where x = CO_2 flow rate (tonnes/day)* **(Equation 1)**

This unit process models CO_2 pressure boosting using an electrically–powered pump. The power requirements calculated by **Equation 1** represent a pump with an efficiency of 75 percent (McCollum, 2006).

Boost pressurization is required when the length and flow rate of a CO_2 pipeline are too high to maintain CO_2 above its critical pressure (7.38 MPa). The maximum pipeline distance for CO_2 flow rates ranging from 2,000 to 20,000 short tons/day were calculated using NETL's CO_2 pipeline transport, storage, and modeling tool, which is the same tool used by NETL's quality guidelines for CO_2 pipeline costing (NETL, 2010). At flow rates less than 10,000 short tons/day and pipeline diameters of 24 inches or less, boost pressurization is not required for distances less than 1,000 miles. Boost pressurization is required for higher flow rates. For example, at a flow rate of 11,000 short tons/day and a pipeline diameter of 24 inches, boost pressurization is required for distances longer than 855 miles.

To convert to a basis of CO_2 throughput, the power input (MW) is multiplied by the operating time at full capacity (24 hours/day) and divided by CO_2 throughput at full capacity (in tonnes/day).

The operation of CO_2 pumps results in fugitive emissions of CO_2. The low, mid-range, and high emission factors for CO_2 from pumps are 9,960, 33,200, and 166,000 cubic meters (m^3) of CO_2 per megawatt-year (MW-yr). These factors are based on natural gas pipeline data that the Intergovernmental Panel on Climate Change (IPCC) collected and adapted to CO_2 pipelines using the relative densities of natural gas and CO_2 (Holloway, 2006). Using a CO_2 density of 1.98 kg/m^3 (the density of CO_2 at standard temperature and pressure), these emission factors are 19,700, 65,700, and 329,000 kg/(MW-yr). On a daily basis, this is equivalent to 54.0, 180, and 900 kg CO_2/MW-day. This unit process applies these emission factors to the calculated pump power output to determine the fugitive CO_2 emissions from CO_2 pumps.

Figure 1 provides an overview of the boundary of this unit process. There are two inputs to this unit process: electricity used for powering pumps and pipeline CO_2. The fugitive emission of CO_2 is accounted for in this unit process. There is one tracked output for this unit process: 1 kg of CO_2 that has been pressurized to maximum pipeline pressure.

Figure 1: Unit Process Scope and Boundary

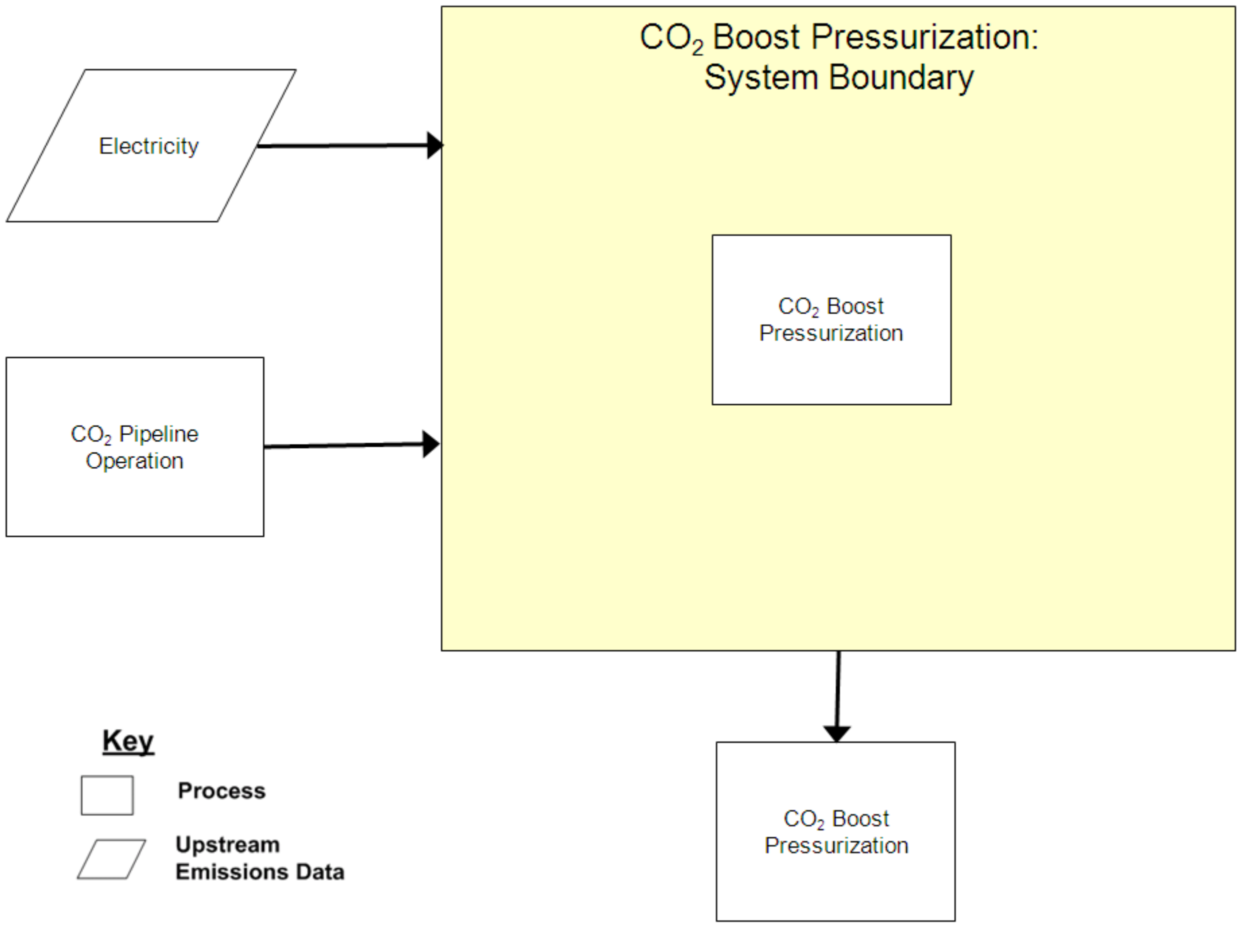

Table 1 summarizes emission factors and other parameters that are relevant to this unit process. **Table 2** provides a summary of modeled input and output flows and shows all inputs and outputs on the basis of the reference flow (the boost pressurization of one kilogram of CO_2). Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Emission Factors and Other Relevant Parameters

Flow Name	Value	Units
Pipeline Distance	500	miles
CO_2 emission factor	180	kg/(MW-day)
CO_2 flow	16,000	short ton/day

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Carbon dioxide	1.0000336	kg
Electricity	1.093E-06	MWh
Outputs		
Carbon dioxide	1.000	kg
Carbon dioxide [Inorganic emissions to air]	3.360E-05	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.

Embedded Unit Processes

None.

References

Holloway, 2006 — Holloway, S., 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2: Energy, Chapter 5: Carbon Dioxide Transport, Injection, and Geological Storage, Intergovernmental Panel on Climate Change (IPCC). Accessed on July 25, 2012 at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_5_Ch5_CCS.pdf.

McCollum, 2006. — McCollum, D.L, 2006. Techno-Economic Models for Carbon Dioxide Compression, Transport, and Storage & Correlations for Estimating Carbon Dioxide Density and Viscosity, Institute of Transportation Studies, University of California, Davis, Davis, California. Accessed on July 26, 2012 at http://pubs.its.ucdavis.edu/publication_detail.php?id=1047.

NETL, 2010. — Quality Guidelines for Energy System Studies: Estimating Carbon Dioxide Transport and Storage Costs, Department of Energy, National Energy Technology Laboratory, Pittsburgh, PA. Accessed on September 11, 2012 at http://www.netl.doe.gov/energy-analyses/pubs/QGESStransport.pdf.

Section III: Document Control Information

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