NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Natural Gas CO2 Recovery

Reference Flow: 1 kg of Recovered CO2

Brief Description: Operation of an amine-based CO2 recovery system for production natural gas

Section I: Meta Data

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

Year Data Best Represents: 2010

Process Type: Auxiliary Process (AP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: Individual 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:

Solvent	*[kg/kg] Makeup rate of amine solvent for CO2 recovery, in kg of solvent per kg of CO2 recovered*
NG	*[kg/kg] Combusted natural gas input for steam generation per unit of CO2 captured*

Water_in	*[kg/kg] Water withdrawal per unit of CO2 captured; uncertainty range based on differences shown by NETL cases for NGCC, PC, and SCPC*
Swater_share	*[dimensionless] Share of water withdrawn from surface water sources*
CO2_start	*[dimensionless] CO2 share of incoming stream*
H2S_start	*[dimensionless] H2S share of incoming stream*
NLG_start	*[dimensionless] NGL share of incoming stream*
CO2_pipeline	*[dimensionless] Fixed share of CO2 in pipeline quality natural gas. Used to calculate removal rate.*
H2S_removal	*[dimensionless] Removal rate of H2S*

Tracked Input Flows:

Water (ground water) [Water]	*[Resource] Groundwater withdrawal for amine-based gas removal process*
Water (surface water) [Water]	*[Resource] Surface water withdrawal for amine-based gas removal process*
Natural gas production [Valuable substance]	*[Resource] Natural gas stream from the production well; includes input for fuel for steam generation*
Monoethanolamine [Valuable substanc	*[Technosphere] Makeup of solvent (MEA)*

Tracked Output Flows:

CO2 recycle stream	*Reference flow*
Pipeline natural gas stream	*Pipeline natural gas stream*
NMVOC (unspecified) [Group NMVOC to air]	*Emission to air (MEA solvent losses)*
Sales NGL stream	*Sales NGL stream*
Waste H2S stream	*Waste H2S stream*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_CO2_Removal_Natural_Gas_Plant_2012.01.xls*, 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 an amine-based CO2 recovery system. The inlet stream represents natural gas from a produciton well. The outlet streams are recovered CO2, hydrocarbon sales gas, natural gas liquids, and H2S for waste treatment. The reference flow of this unit process is: 1 kg of Recovered CO2.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with the operation of an amine-based CO_2 recovery system. The inlet stream represents natural gas from a produciton well. The outlet streams are recovered CO_2, hydrocarbon sales gas, natural gas liquids, and H_2S for waste treatment. The reference flow of this unit process is: 1 kg of Recovered CO_2.

The energy consumed by the amine reboiler accounts for the majority of energy consumed by the CO_2 removal process. Reboiler energy consumption is a function of the amine flow rate, which, in turn, is related to the amount of CO_2 removed from the inlet stream. Approximately 3.4 MJ of steam are required for the removal of 1 kg of CO_2 (NETL, 2010). This energy is in the form of steam. This unit process requires the input of combusted natural gas. The upstream fuel acquisition requirements and air emissions for steam generation are not in the boundary of this unit process, but are accounted for in an upstream unit process.

The solvent flow rate is based on data for an amine-based CO_2 removal system modeled by NETL's bituminous baseline (NETL, 2010). The reaction between the amine and CO_2 is reversible, allowing regeneration of the amine. A small amount of amine escapes to the atmosphere during amine regeneration. This unit process categorizes this amine loss as VOC emission to air. The amine input flow to this unit process accounts for the amine required to make up for this loss. Approximately 0.0001 kg of amine are lost per kg of CO_2 captured (NETL, 2010).

The amine is mixed with water. The water input to this unit process represents the amount of water required to make up for the water lost to the air during amine regeneration. The make up rate of water is approximately 0.015 kg of water per kg of CO_2 captured (NETL, 2010).

The incoming stream to this unit process has the same composition as the outlet stream from a membrane separation unit. The outlet streams include captured CO_2 and a hydrocarbon stream. In the context of the operation of an enhanced oil recovery (EOR) facility, the outlet CO_2 stream is combined with the CO_2 from the membrane process and sent to re-injection processes, and the outlet hydrocarbon stream can be sold. The outlet hydrocarbon stream has an expected CO2 composition of 5 percent CO_2, but this unit process uses CO_2 compositions of 2 percent and 10 percent to account for uncertainty in the composition of the outlet hydrocarbon stream. The stream compositions for the default case (5 percent CO_2 in the outlet hydrocarbon stream) are shown in **Table 1**.

Figure 1 shows the boundary of this unit process and **Table 2** shows values for the input and output flows.

Figure 1: Unit Process Scope and Boundary

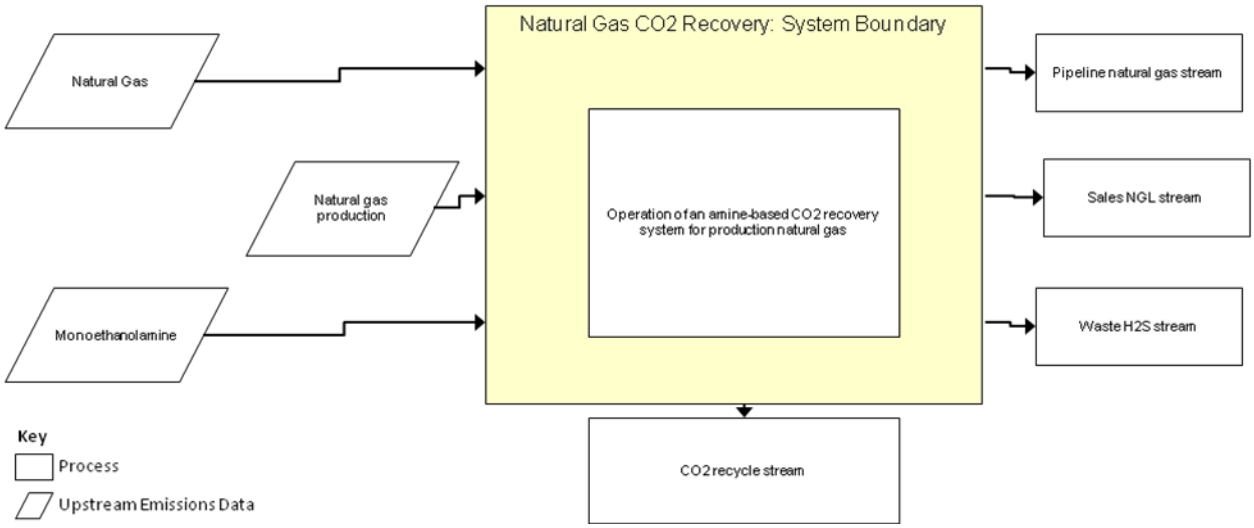

Table 1: Default Parameters for CO_2 Removal from Natural Gas

Parameter	Value	Unit
Solvent make up	1.00E-04	kg/kg
Natural gas for steam	6.64E-02	kg/kg
Water withdrawal	1.49E-02	kg/kg
Surface water share	5.00E-01	dimensionless
Incoming CO_2 share	1.51E-02	dimensionless
Incoming H_2S share	5.00E-03	dimensionless
Incoming NGL share	1.50E-01	dimensionless
Production CO_2 share	4.70E-03	dimensionless
H_2S removal rate	9.80E-01	dimensionless

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Water (ground water) [Water]	7.46E-03	kg
Water (surface water) [Water]	7.46E-03	kg
Natural gas production [Valuable substance]	96.22	kg
Monoethanolamine [Valuable substance]	1.00E-04	kg
Outputs		
Carbon dioxide [Valuable substance]	1.00	kg
Pipeline natural gas [Valuable substance]	80.26	kg
NMVOC (unspecified) [Group NMVOC to air]	1.00E-04	kg
Natural gas liquids [Valuable substance]	14.42	kg
Waste H_2S stream [Waste]	4.71E-01	kg

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

Embedded Unit Processes

None.

References

NETL. (2010). *Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity Report*. (DOE/NETL-2010/1397). Pittsburgh, PA: National Energy Technology Laboratory Retrieved June 5, 2012, from http://www.netl.doe.gov/energy-analyses/pubs/BitBase_FinRep_Rev2.pdf

Section III: Document Control Information

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