NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Post Membrane CO_2 Recovery

Reference Flow: 1 kg of Recovered CO_2

Brief Description: Operation of an amine-based CO_2 recovery system for post-membrane acid gas removal

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 CO_2 recovery, in kg of solvent per kg of CO_2 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 CO_2 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Swater_share	*[dimensionless] Share of water withdrawn from surface water sources*
Input	*[kg/kg] Input gas stream per kg of CO_2 outlet stream. Min and max values represent 2% and 10% CO_2 compositions in hydrocarbon sales stream.*
Output	*[kg/kg] Outlet hydrocarbon stream per kg of CO_2 outlet stream. Min and max values represent 2% and 10% CO_2 compositions in hydrocarbon sales stream.*

Tracked Input Flows:

Natural Gas	*Technosphere] Combusted natural gas input used for steam generation for reboiler duty*
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*
Retentate from Membrane Separation	*[Technosphere] Mixed hydrocarbon/CO_2 stream from upstream membrane separation unit*
Monoethanolamine	*[Technosphere] Makeup of solvent (MEA)*

Tracked Output Flows:

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

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_CO2_Recovery_Post_Membrane_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 CO_2 recovery system. The inlet stream is the retentate from a membrane separation unit and is a mix of CO_2 and hydrocarbons. Other inputs include amine (used for absorbing acid gas) and steam (used to regenerate amine). The outlet streams are recovered CO_2 and hydrocarbon sales gas. The reference flow of this unit process is: 1 kg of recovered CO_2.

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 is the retentate from a membrane separation unit and is a mix of CO_2 and hydrocarbons. Other inputs include amine (used for absorbing acid gas) and combusted natural gas which is used to produce steam (used to regenerate amine). The outlet streams are recovered CO_2 and hydrocarbon sales gas. 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

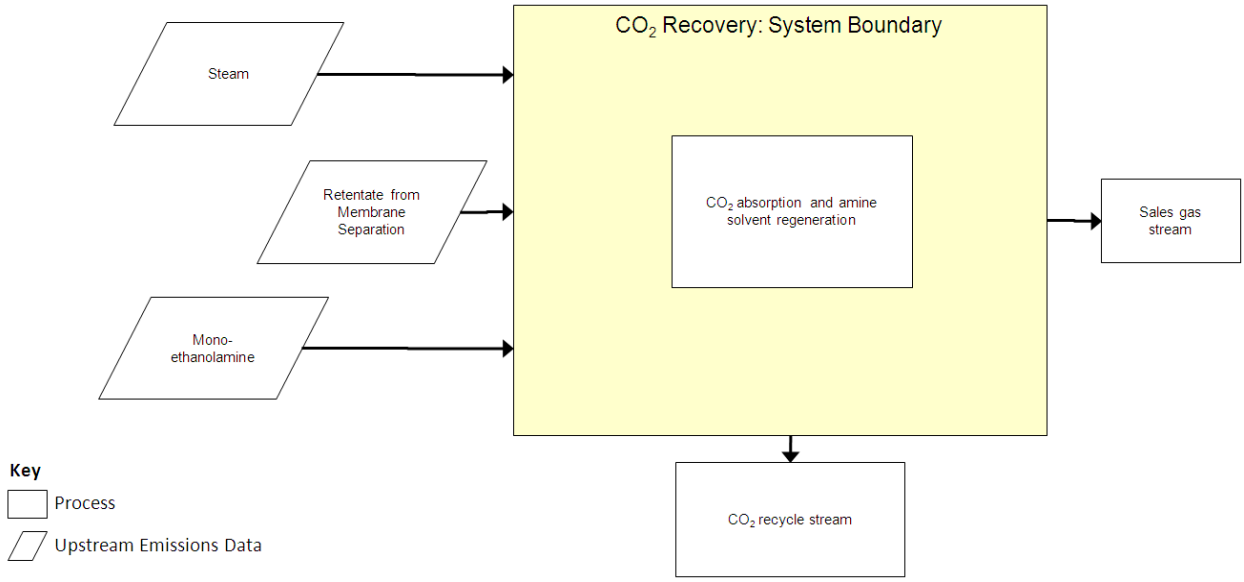

Table 1: Inlet and Outlet Stream Compositions

Flow	Input: Retentate from Membrane (Hydrocarbons and CO_2)	Output: Recovered CO_2	Output: Hydrocarbon Sales Gas
H_2	0.0%	0.0%	0.0%
N_2	0.4%	0.0%	5.0%
CO_2	91.8%	99.5%	10.0%
H_2S	0.5%	0.5%	0.0%
C1	0.7%	0.0%	8.3%
C2	1.2%	0.0%	13.7%
C3	2.0%	0.0%	23.5%
iC4	0.5%	0.0%	5.5%
C4	1.2%	0.0%	14.1%
iC5+	1.7%	0.0%	19.8%
Total	100.0%	100.0%	100.0%

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Natural Gas	6.64E-02	kg
Water (ground water) [Water]	7.46E-03	kg
Water (surface water) [Water]	7.46E-03	kg
Retentate from Membrane Separation	1.09	kg
Monoethanolamine	1.00E-04	kg
Outputs		
CO2 recycle stream	1.00	kg
Sales gas stream	0.09	kg
NMVOC (unspecified) [Group NMVOC to air]	1.00E-04	kg

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

Embedded Unit Processes

None.

References

NETL, 2010 — NETL, 2010. Cost and Performance Baseline for Fossil Energy Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity, National Energy Technology Laboratory, Pittsburgh, PA. Accessed on July 30, 2012 at http://www.netl.doe.gov/energy-analyses/pubs/BitBase_FinRep_Rev2.pdf.

Section III: Document Control Information

Date Created: November 29, 2012

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

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