NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Gas Stream Chilling

Reference Flow: 1 kg of carbon dioxide and hydrocarbon gas

Brief Description: Energy requirements for the chilling of a carbon dioxide/hydrocarbon stream

Section I: Meta Data

Geographical Coverage: United States **Region:** National

Year Data Best Represents: 2012

Process Type: Basic Process (BP)

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	☐ 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:

Energy	*[MWh/kg] Energy output from a chiller used for cooling a gas stream.*
Eff	*[dimensionless] Electric to mechanical efficiency of chiller system*
Share_cooling	*[dimensionless] Share of cooling provided by chiller, with balance of cooling provided by heat exchange*

	between inlet stream and permeate/retentate streams
Electricity	*[MWh/kg] Electricity input to chiller*

Tracked Input Flows:

Electricity	*[Technosphere] Electricity used for powering the refrigeration system for a gas stream chiller*
Carbon dioxide and hydrocarbon gas	*[Technosphere] Mixed gas stream received from a dehydration process*

Tracked Output Flows:

Carbon dioxide and hydrocarbon gas	*Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_Chiller_2012.01.xlsx*, 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 chiller used for cooling a stream of carbon dioxide and hydrocarbon gases. It is based on a refrigeration system that uses propane as a refrigerant. The load of this chiller is representative of the cooling requirements for a gas stream before it enters a membrane separation unit. The reference flow of this unit process is: 1 kg of carbon dioxide and hydrocarbon gas.

Boundary and Description

This unit process provides a summary of relevant input and output flows associated with the operation of a chiller used for cooling a stream of carbon dioxide and hydrocarbon gases. It is based on a refrigeration system that uses propane as a refrigerant. The load of this chiller is representative of the cooling requirements for a gas stream before it enters a membrane separation unit.

This unit process uses the energy balance for a propane-refrigerated chiller (Vargas, 2010) used by a refrigerated separation column to calculate the energy requirements for chilling a feed stream for membrane separation (Callison and Davidson, 2007). The energy requirements were scaled according to the flow rates and temperature drops of the two applications (refrigerated separation vs. cooling of membrane feed). The two applications (refrigerated separation vs. cooling of membrane feed) have identical stream compositions, so it is not necessary to account for differences in heat capacity.

The cooling requirements are provided by two sources: a propane-based refrigeration system powered by purchased and heat exchange between heat exchange with the cold stream exiting the downstream membrane process. The loss rate of propane (the refrigerant) is negligible with respect to the electricity requirements and other environmental burdens of this unit process. The efficiency of the refrigeration system (i.e., the energy input per unit of cooling duty provided) is parameterized, using 95 percent as the default efficiency.

There is no loss of the process stream (carbon dioxide and hydrocarbon gases) in this process.

Figure 1 illustrates the boundaries of this unit process.

Figure 1: Unit Process Scope and Boundary

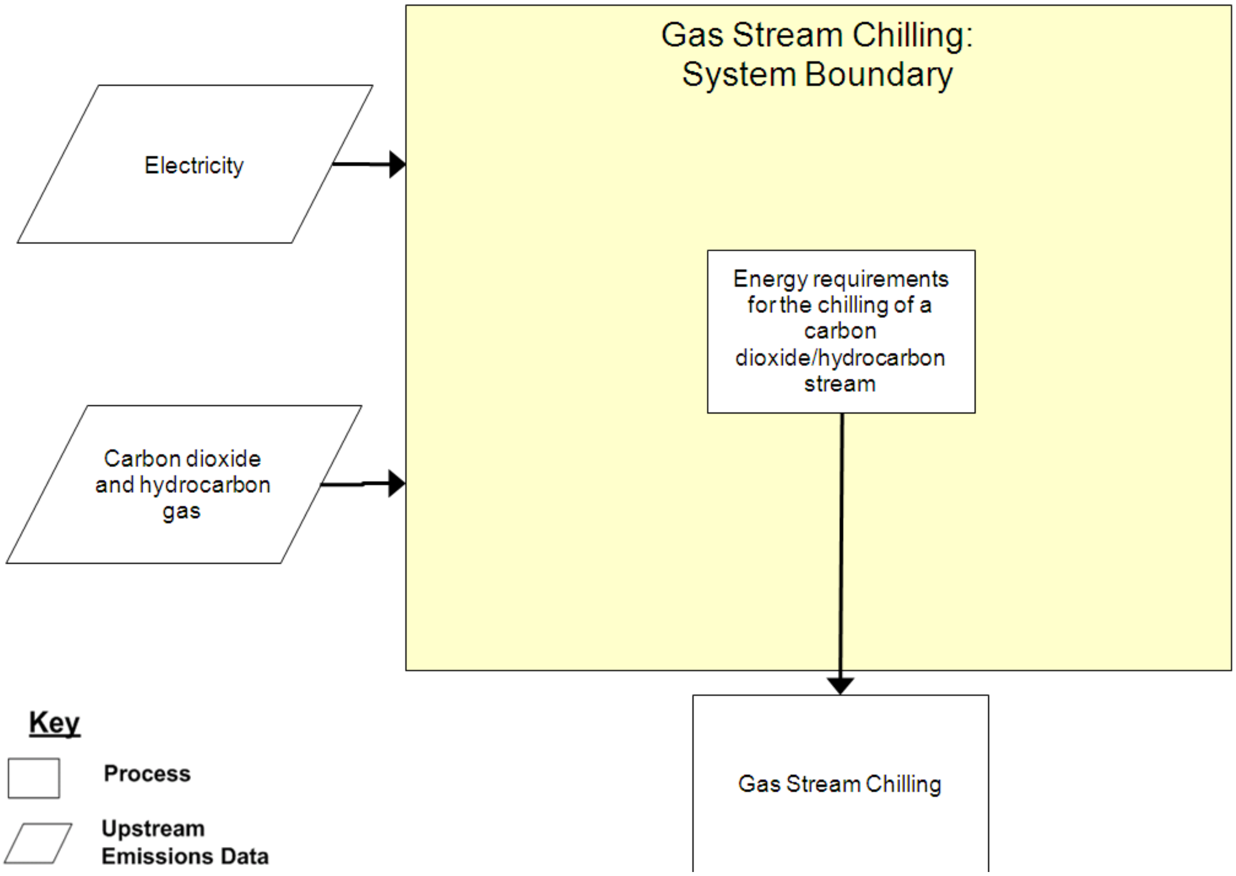

Table 1 shows the properties of the process stream used for refrigerated separation and the process stream for the cooling of membrane feed. The process stream that is used for refrigerated separation (Vargas, 2010) does not represent the application of this unit process, but uses the same type of cooling technology, so it is used as the basis for estimating the refrigeration load for the chilling of membrane feed gas. **Table 2** shows the inputs and outputs for this unit process.

Table 1: Properties of the Process Streams for Two Cooling Applications

Flow	Units	Refrigerated Separation (Vargas, 2010)	Cooling of Membrane Feed (Callison and Davidson, 2007)
Refrigeration Compressor Load	MW	3.4	7.1
Mass Flow Rate of Gas Stream	kg/s	70.7	1
Inlet Temperature	Kelvin	300	288
Outlet Temperature	Kelvin	244	275
Temperature Delta	Kelvin	56	13

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Electricity	1.67E-06	MWh
Carbon dioxide and hydrocarbon gas	1.00	kg
Outputs		
Carbon dioxide and hydrocarbon gas	1.00	kg

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

Embedded Unit Processes

None.

References

Callison and Davidson, 2007	Callison, A. and Davidson, G. (2007). Offshore Processing Plant Uses Membranes for CO2 Removal. Oil & Gas Journal. PennWell Corporation. http://www.ogj.com/articles/print/volume-105/issue-20/processing/offshore-processing-plant-uses-membranes-for-cosub2-sub-removal.html (Accessed October 25, 2012)
Vargas, 2010	Vargas, K. J. (2010). Refrigeration provides economic process for recovering NGL from CO2-EOR recycle gas. Oil & Gas Journal, 108(2).

Section III: Document Control Information

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