NETL Life Cycle Inventory Data
Process Documentation File

Process Name: NGL Extraction from EOR Gas - Refrigeration

Reference Flow: 1 kg of EOR reinjection gas

Brief Description: Natural gas liquids extraction from gas recovered from enhanced oil recovery (EOR) operations using refrigeration and distillation

Section I: Meta Data

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

Year Data Best Represents: 2010

Process Type: Extraction Process (EP)

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:

refine_NGLs	*[dimensionless] Parameter to determine whether additional NGL refinement is performed (0 - do not refine NGLs; 1 - refine NGLs)*

Tracked Input Flows:

Gas recovered from EOR	*[Technosphere] Mass of EOR gas recovered from well*
Natural gas free customer USA [Natural Gas Products]	*[Technosphere] Mass of natural gas combusted for process heat*
Power [Electric Power]	*[Technosphere] Electricity usage for process*

Tracked Output Flows:

EOR reinjection gas [Intermediate Flow]	*Reference flow*
Propane [Organic intermediate products]	*Co-product*
Butane (n-butane) [Organic intermediate products]	*Co-product*
Pentane [Organic intermediate products]	*Co-product*
Combined NGLs [Organic intermediate products]	*Co-product*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *Stage3_O_NGL_production_from_EOR_gas_2012.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

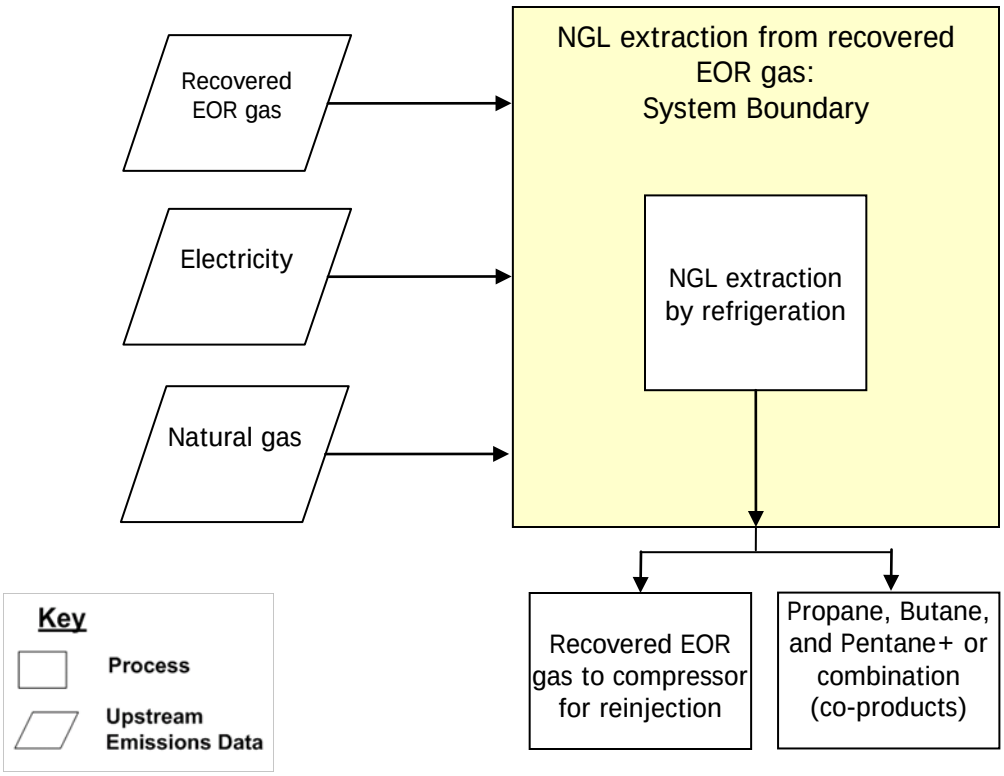
Goal and Scope

This unit process provides a summary of relevant input and output flows associated with separating natural gas liquids (NGLs) from recovered enhanced oil recovery (EOR) gas that is primarily carbon dioxide (CO_2) using propane refrigeration and optional distillation processes. The reference flow of this unit process is: 1 kg of EOR reinjection gas.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while trapezoidal boxes indicate upstream data that are outside of the boundary of this unit process. As shown, the upstream emissions from electricity, natural gas, and recovered EOR gas are calculated in another unit process which should be added to this to provide an accurate inventory value. The methods for calculating these operating activities are described below.

Figure 1: Unit Process Scope and Boundary



This unit process is based on a theoretical process that uses propane refrigeration to chill the CO_2-rich recovered EOR gas stream, allowing the separation of CO_2 from ethane (C_2) and higher hydrocarbons (Vargas, 2010). The NGLs are then separated using a series of distillation columns to provide three saleable streams: Propane, Butane, and Pentane plus higher hydrocarbons. This unit process provides the option to bypass distillation columns, providing a mix of all three streams, shown in **Table 1**, which discounts the reboiler heat loads downstream of the de-ethanizer reboiler. Hydrogen sulfide (H_2S) is separated from the bottoms of the de-ethanizer using a molecular sieve. For simplicity the heat load of the molecular sieve is ignored in this unit process, but the sieve is assumed to capture all H_2S from the product stream. In Vargas, the ethane is recombined with the CO_2-rich injection stream and then sent to two compressor trains for reinjection. The boundaries of this unit process do not include compression needed for reinjection, so the reinjection stream needs to be sent to a separate unit process to provide an accurate inventory. The inlet and reinjection streams were normalized based on the EOR gas composition of an average well in the Permian Basin (NETL, 2010). The three saleable streams were also scaled so that they are representative of the change to the inlet composition.

The electrical and heat requirements and the process yields for this refrigeration process are dependent on the various flow rates through the system and thus chemical composition of the inlet gas. For simplicity, this unit process simply scales the electrical and heat requirements and yields based on the mass flow rate of the output EOR gas

for reinjection, rather than accounting for changes in gas composition and the non-linear changes in loads that would accompany changes in flow rates.

Also as modeled in Vargas, the saleable streams contain small amounts of other hydrocarbons (e.g., the propane stream contains some ethane). As another simplification, the saleable streams are treated as 100% propane, butane, or pentane+.

Table 2 provides a summary of modeled input and output flows and shows all inputs and outputs on the basis of the reference flow. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Composition by % Weight of Saleable Combined Stream

Component	% Mass
H_2	0.0000%
N_2	0.0000%
CO_2	0.0034%
H_2S	0.0000%
C1	0.0000%
C2	0.0003%
C3	12.2599%
C4	31.7932%
C5+	55.9433%
Total	100.0000%

Table 2: Unit Process Input and Output Flows

Flow Name	Refined NGLs Case	Combined NGLs Case	Units (Per Reference Flow)
Inputs			
Gas recovered from EOR	1.01	1.01	kg
Natural gas free customer USA [Natural Gas Products]	1.91E-06	1.45E-06	kg
Power [Electric Power]	1.38E-05	1.38E-05	MWh
Outputs			
EOR reinjection gas [Intermediate Flow]	1.00	1.00	kg
Propane [Organic intermediate products]	1.32-03	0.00E+00	kg
Butane (n-butane) [Organic intermediate products]	3.60E-03	0.00E+00	kg
Pentane [Organic intermediate products]	6.29E-03	0.00E+00	kg
Combined NGLs [Organic intermediate products]	0.00E+00	1.12E-02	kg

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

Embedded Unit Processes

None.

References

NETL. (2010). *An Assessment of Gate-to-Gate Environmental Life Cycle Performance of Water-Alternating-Gas CO_2-Enhanced Oil Recovery in the Permian Basin*. (DOE/NETL-2010/1433). Pittsburgh, PA: National Energy Technology Laboratory Retrieved October 18, 2012, from http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubId=333

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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