NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Conventional Offshore Natural Gas, Water Use and Water Quality

Reference Flow: 1 kg of Natural Gas, Conventional Offshore

Brief Description: This unit process quantifies water use and water quality emissions resulting from the production of natural gas from a conventional offshore natural gas well.

Section I: Meta Data

Geographical Coverage: United States **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 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:

N/A

Tracked Input Flows:

N/A

Tracked Output Flows:

Natural Gas, Conventional Offshore *Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_Water_Conventional_Offshore _2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers produced water and water quality emissions associated with produced water in support of conventional offshore natural gas extraction activities, as described in greater detail below. This unit process considers only water and water quality related flows. For an evaluation of energy, materials, and airborne emissions associated with conventional offshore natural gas extraction, please refer to separate unit processes for natural gas extraction and on-site processing. The calculations presented for this unit process are based on the reference flow of 1 kg of natural gas, conventional offshore, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #1 in support of the extraction of conventional offshore natural gas. Water use and water quality emissions for other natural gas profiles are contained in separate unit processes. This unit process is combined with other relevant equipment for LC Stage #1 in a separate operations assembly process, DF_Stage1_O_Assembly_Natural_Gas _2011.01.doc. The assembly process quantifies the relevant flows and emissions associated with each portion of the natural gas extraction profile being modeled, in order to complete extraction and in-field processing of 1 kg of natural gas.

Boundary and Description

According to ANL (2009), in 2007, approximately 49 million bbl of water was injected offshore in support of natural gas production. However, the original source of this water was produced water that derived from NG wells. Therefore, this 49 million bbl was not extracted from the ocean or from a potable water aquifer or other source -- instead, it was simply taken from the gas-bearing formation and re-injected back into that formation. Therefore, the 49 million bbl of water does not constitute a net water consumption. Many other data sources were reviewed and no additional water consumption data for offshore wells were found to be available. Additionally, no discussion was found indicating that additional water use might occur for offshore NG production. Therefore, this analysis assumes that offshore drilling does not use additional water beyond produced water that is re-injected, which constitutes a net zero water use. The remaining produced water is derived from the NG formation and discharged to the surface or to a separate injection well. Produced water derives from the NG formation and would not otherwise be available for beneficial use. Therefore, use of produced water for discharge does not deplete water resources that would

otherwise be used for human or environmental benefit, and therefore is not considered further.

In addition to reinjection, additional produced water is also generated by natural gas wells. This additional produced water is either managed via injection into a deep well, or by treatment to reduce oil/hydrocarbon content and discharge to the ocean. **Table 1** provides a summary of the volumes of produced water that were reinjected for enhanced recovery, injected into a deep well for disposal, or treated and discharged to the ocean. As shown, nearly 92% of all produced water is discharged to the ocean, equivalent to approximately 0.66 kg water discharged to the ocean per kg of natural gas produced.

Water quality data were also available from surveys conducted by Argonne National Laboratory (ANL 2005). Data were available for biochemical oxygen demand (BOD), total organic carbon (TOC) including oil and grease, total nitrogen, total phosphorous, and salinity, as shown in **Table 2**.

Figure 1 provides an overview of the boundary of this unit process. As shown, no inputs to the unit process are considered. Produced water occurs as a result of natural gas extraction operations, and therefore is considered within the boundary of the unit process. Also within the system boundary, produced water volume data are used to calculate produced water emissions to the ocean, and also pollutant loading rates for each of the water quality constituents considered. This unit process is combined with other natural gas extraction unit processes in a natural gas operations assembly unit process.

Figure 1: Unit Process Scope and Boundary

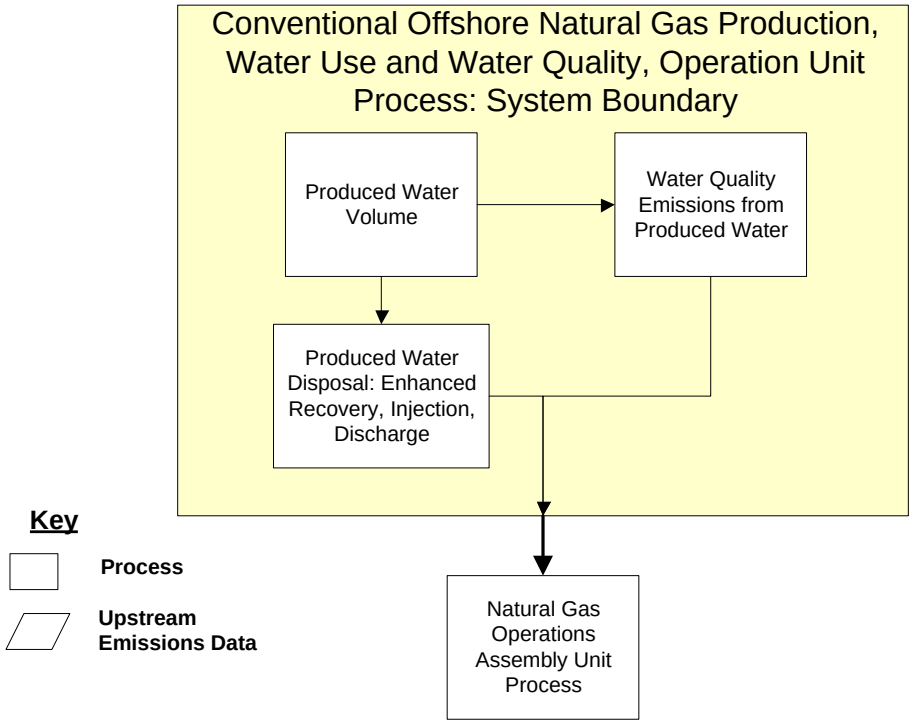

Table 1 summarizes conventional offshore natural gas produced water generation, reinjection, deep well disposal, and discharges that are applied within this unit process. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Water Consumption and Produced Water: Conventional Offshore Natural Gas

Flow Name	Value	Units	Reference
Surface Water and Groundwater Consumption	0	kg water/kg NG	ANL 2009
Total volume of produced water managed via injection for enhanced recovery (2007)	48,673,102	bbl/yr	ANL 2009
Total volume of offshore produced water managed via deep well injection for disposal	1,298,417	bbl/yr	ANL 2009
Total volume of offshore produced water managed via treatment and discharge	537,381,327	bbl/yr	ANL 2009
Proportion of total offshore produced water that was discharged to the ocean	91.5%	Percent	NETL Engineering Calculation
Produced water volume discharged per kg natural gas produced	0.657	kg water/kg natural gas	NETL Engineering Calculation

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
N/A	N/A	N/A
Outputs		
Natural Gas, Conventional Offshore	1.00	kg
Water (wastewater) [Water]	0.66	kg
Biochemical Oxygen Demand (BOD) [Inorganic emissions to water]	9.48E-04	kg
Total Organic Carbon (TOC) [Organic emissions to water]	5.83E-04	kg
Total Nitrogen [Inorganic emissions to water]	4.27E-05	kg
Total Phosphorous [Inorganic emissions to water]	5.65E-07	kg
Salinity (dissolved salts) [Inorganic emissions to water]	4.50E-02	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

ANL 2005 Argonne National Laboratory. 2005. Characteristics of Produced Water Discharged to the Gulf of Mexico Hypoxic Zone. http://www.evs.anl.gov/pub/doc/ANL-hypoxia-report.pdf (Accessed July 7, 2010)

ANL 2009 Argonne National Laboratory. 2009. Produced Water Volumes and Management Practices in the United States. http://www.netl.doe.gov/technologies/coalpower/ewr/water/pdfs/anl%20produced%20water%20volumes%20sep09.pdf (Accessed April 12, 2011)

Section III: Document Control Information

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