NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Marcellus Shale Water Treatment with Crystallization

Reference Flow: 1 kg of Flowback Water to Crystallization

Brief Description: This unit process models the transport and treatment of flowback water produced from the hydraulic fracturing of a natural gas well in the Marcellus Shale, with treatment via crystallization.

Section I: Meta Data

Geographical Coverage: United States **Region:** Northeast, U.S.

Year Data Best Represents: 2011

Process Type: Waste Treatment (WT)

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:

dist_crystal	*[km] Distance by truck from NG well to crystallizer plant for treatment.*

Tracked Input Flows:

Diesel Combustion, Mobile Sources, Truck [Refinery products]	*Amount of diesel combusted within the mobile source*
Flowback Water to Crystallization [kg]	*Mass of wastewater input (Reference flow)*
Power [kWh]	*Electricity used by a crystallization plant*

Tracked Output Flows:

Solid waste	[kg] *Solid waste from crystallization sent to a landfill*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_MarcellusWaterQuality_Crystalized_2011.02.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 transport and treatment of flowback water from a natural gas well in the Marcellus Shale. The inputs to this unit process include flowback water, electricity, and diesel. (Electricity is used to power the water treatment plant and diesel is used by a tanker truck that transports flowback water from the Marcellus Shale natural gas well site to a wastewater treatment process that uses crystallization.) The calculations presented for this unit process are based on the reference flow of 1 kg of wastewater from a Marcellus Shale gas well, 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 Marcellus Shale natural gas. 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 _2011.02.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

This unit process provides a summary of relevant input and output flows associated with transport and treatment of flowback water from a natural gas well in the Marcellus Shale. The inputs to this unit process include flowback water and diesel used by a tanker truck that transports flowback water from the Marcellus Shale natural gas well site to a wastewater treatment process that uses crystallization. The calculations presented for this unit process are based on the reference flow of 1 kg of wastewater from a Marcellus Shale gas well. The quantity of electricity consumed by the crystallization plant is accounted for in this unit process, but the upstream emissions from electricity generation are accounted for by upstream unit processes.

Crystallization is necessary when flowback water contains pollutants in concentrations that are too high to be treated by a municipal wastewater treatment. Crystallization is

an energy-intensive process that evaporates wastewater, leaving residual solids behind. The residual solids can then be disposed of in a landfill or other facility, according to local regulations and requirements. A crystallizer unit sufficient to treat flowback water volumes has a typical energy requirement of approximately 205 kWh per 1,000 gallons of water treated (Colorado School of Mines, 2009). When converting to a mass basis, this electricity requirement is 0.05416 kWh per kg water.

Figure 1 provides an overview of the boundary of this unit process. Within the boundary of this unit process, water is transported by a truck and water is purified using crystallization. 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

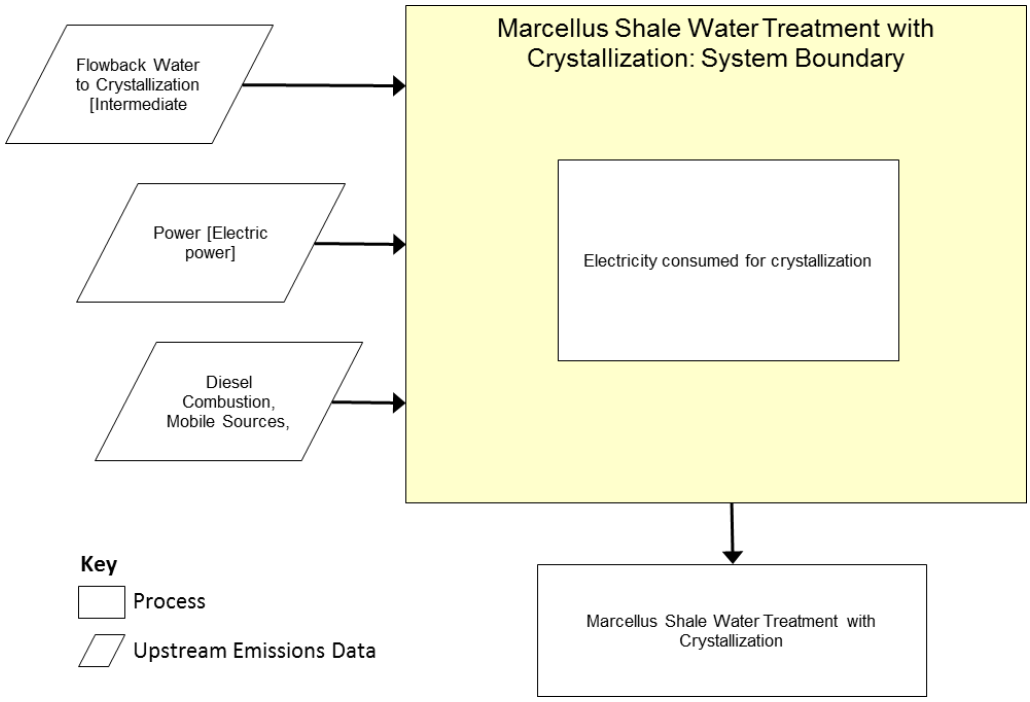

Table 1 summarizes water sources related to the treatment of Marcellus Shale flowback water using crystallization. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Default Parameters for Unit Process Waste Water Crystallization

Flow Name	Value	Units	Reference
Transportation distance from well to crystallization WWTP (waste water treatment plant)	100	km	study assumption
Crystallization WWTP electricity use	0.0542	kWh/kg water	Colorado School of Mines 2009
Total dissolved solids in flowback water	0.196	kg/kg	Hayes 2009
Water recovery rate from flowback water	0.95	kg/kg	Colorado School of Mines 2009

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units	DQI
Inputs			
Diesel Combustion, Mobile Sources, Truck [Refinery products]	**2.416E-03**	**kg**	2,2
Flowback Water to Crystallization [Intermediate Product]	**1.000**	**kg**	1,2
Power [Electric power]	**5.416E-02**	**kWh**	1,2
Outputs			
Crystallizer Water Outflow	9.500E-01	kg	2,2
Solid waste (crystal)	1.961E-01	kg	2,2

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows for bolded values were added during the modeling process using GaBi modeling software, as shown in **Figure 1**.

Embedded Unit Processes

None.

References

Colorado School of Mines 2009 — Colorado School of Mines. 2009. *An Integrated Framework for Treatment and Management of Produced Water*.. http://aqwatec.mines.edu/produced_water/treat/docs/Tech_Assessment_PW_Treatment_Tech.pdf (Accessed February 21, 2011)

Hayes 2009 — Hayes, Thomas. (2009). *Sampling and Analysis of Water Streams Associated with the Development of Marcellus Shale gas*.

Section III: Document Control Information

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Revision History:

28DECEMBER2014 — Updated to reflect combustion removal. Diesel combustion is now an input.

Added inventory item level DQI data

How to Cite This Document: This document should be cited as:

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Water Use for Marcellus Shale Gas Extraction.* U.S. Department of Energy, National Energy Technology

Laboratory. Last Updated: December 2014 (version 02). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

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