NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Advanced Ethanol Dry Mill Plant w/CCS, Construction

Reference Flow: 1 pcs Advanced Ethanol Dry Mill Plant w/CCS per kg Fuel Produced

Brief Description: Calculates the amount of materials (including concrete, steel plate, and stainless steel) needed to construct an individual Advanced Dry Mill plant with CCS. Data based on construction of a conventional dry mill plant.

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest

Year Data Best Represents: 2006

Process Type: Manufacturing Process (MP)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: No

Completeness: Individual Relevant Flows Recorded

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:

Tracked Input Flows:

Concrete, ready mix, R-5-0 [Concrete_Cement]	*Concrete needed in the construction of the ethanol plant, normalized to the reference flow*
Stainless steel, 316 2B, 80% Recycled [Metals]	*Summation of stainless steel needed in the construction of the ethanol plant, normalized to the reference flow*

Steel plate, BF (85% Recovery Rate) [Metals]	*Summation of steel plate needed in the construction of the ethanol plant, normalized to the reference flow*

Tracked Output Flows:

Advanced Ethanol Dry Mill Plant/ Fuel Produced	*Reference flow, one piece of plant per kg of fuel produced*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS), DS_Stage3_C_Advanced_Dry_Mill_CCS_2010.01.xls, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this unit process covers the materials required for the construction of a single Advanced Dry Mill Ethanol Plant with Carbon Capture and Sequestration (CCS) for the production of ethanol. Inventory results based on this scope have been normalized to the production of a single kg of ethanol, as described below. The materials included in the plant construction are concrete, carbon steel, and stainless steel. The process is based on the reference flow of 1 piece of plant per kg fuel produced, as described below and shown in **Figure 1**.

This unit process is used under Life Cycle (LC) Stage #3 to construct an ethanol plant with a carbon capture system fed by either corn or corn stover for the production of transportation fuel, which will be blended with gasoline and transported (LC Stage #4) to a refueling station for use by an end user (LC Stage#5). It is combined with other relevant unit processes for LC Stage #3, including plant operation including carbon transport and sequestration along with plant commissioning and decommissioning.

Boundary and Description

The flows calculated in this unit process are based on a reference flow of 1 piece (pcs) Advanced Ethanol Dry Mill Plant w/CCS per kg Fuel Produced. Within this unit process, “piece” is used to refer to a single, constructed/completed Advanced Ethanol Dry Mill Plant w/CCS.

Because no data of sufficient quality were available for the construction of an Advance Dry Mill Ethanol Plant with CCS equipment, this unit process is based on the assumption that it would be similar to a conventional Dry Mill Ethanol Plant. As there are additional components needed (beyond the components specified for a conventional dry mill ethanol plant) for the removal of corn oil from the biomass to be sold as a co-product and the CCS equipment, it is assumed that an additional 10 percent by weight of materials, 5 percent for the equipment for the

corn oil removal and 5 percent for the CCS equipment, will be needed for these components. The relatively low increase in equipment requirements due to the additional oil extraction and CO_2 capture systems is supported by manufacturer specifications (Watkins 2009) that show that the retrofit of a corn oil extraction unit is a relatively low expense to ethanol producers and the fact that the CO_2 output from a dry mill does not require the solvent separation or dehydration systems that are typical of CCS equipment used by fossil energy plants (McAloon *et al.* 2008). These types of systems have not gained broad commercial acceptance and thus there is limited primary data for corn oil extraction and CCS systems used by ethanol dry mills. This is a data limitation on the actual material weights for the construction of the facility. All values are normalized per kg of ethanol being produced in the plant.

The total construction mass for the dry mill ethanol plant is reported by Hill (2006) and references therein. This source cites an assumed plant life of 20 years. The time frame of this unit process is 30 years. This difference in assumed time frames does not affect the validity of the construction requirements; the total material requirements for the construction of a facility are not affected by the assumed lifetime of the facility.

Figure 1 provides an overview of the boundary of this unit process. Emissions related to the physical assembly of the plant (e.g., emitted while constructing the plant or while transporting the components for the construction) are not considered in this study. Upstream emissions from the production of raw materials used for the construction of the plant (e.g., concrete, stainless steel, and carbon steel) are calculated outside of the boundary of this unit process, based on proprietary profiles available in the GaBi model. As shown in Figure 1 and discussed above, the plant constructed in this unit process is incorporated under LC Stage #3 along with plant operation including carbon transport and sequestration along with plant commissioning and decommissioning.

Table 1 summarizes the relevant properties and assumptions used to calculate the amount of concrete, stainless steel, and carbon steel contained in a single Advanced Dry Mill Ethanol Plant with CCS. **Table 2** provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

Figure 1: Unit Process Scope and Boundary

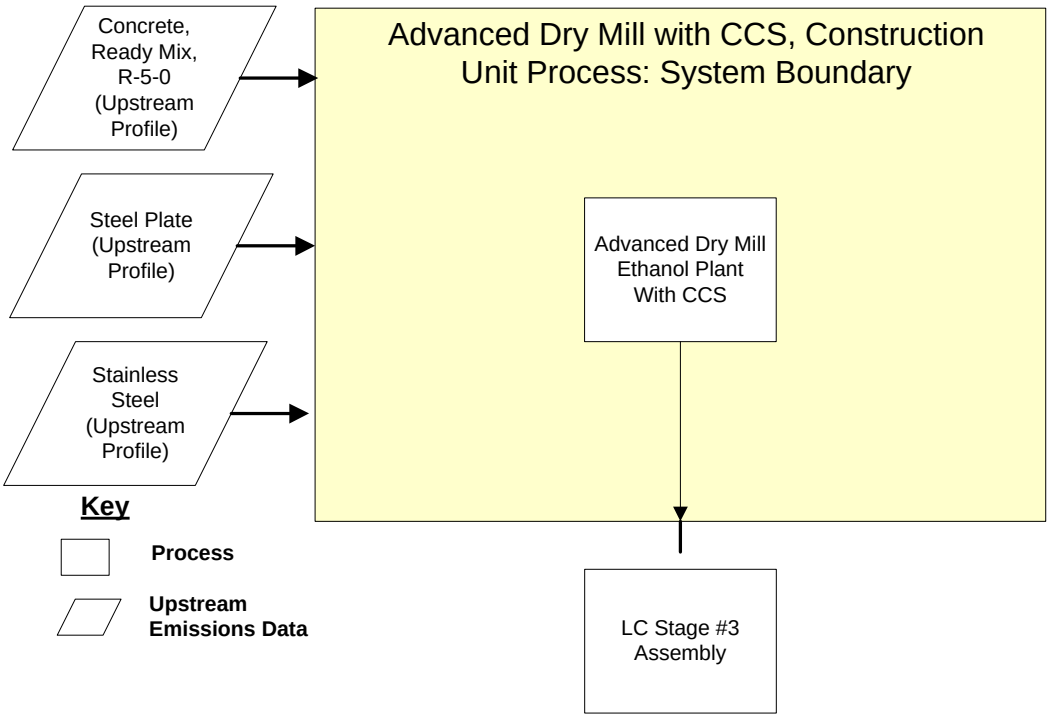

Table 1: Commissioning and Decommissioning Information

Data Point	Value	Unit	Reference
Plant Life	30	years	NETL Engineering Judgment
Total Plant Ethanol Output	2.6984E+09	kg	NETL Engineering Calculation
Total Concrete	1.3420E+07	kg	Hill 2006 (and references cited therein)
Total Stainless Steel	6.4900E+05	kg	Hill 2006 (and references cited therein)
Total Carbon Steel	1.0230E+06	kg	Hill 2006 (and references cited therein)

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Concrete, ready mix, R-5-0 [Concrete_Cement]	**5.7887E-03**	**kg**
Stainless steel, 316 2B, 80% Recycled [Metals]	**2.4051E-04**	**kg**
Steel plate, BF (85% Recovery Rate) [Metals]	**3.7912E-04**	**kg**
Outputs		
Plant per kg of Fuel Produced [Construction]	1.00E+00	kg/kg fuel produced

* Text in **Bold face** font 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

Hill 2006 — Hill, J. Nelson, E. Tilman, D. Polasky, S. et al. Proceedings of the National Academy of Sciences. Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels. Vol 103, No 30. www.pnas.org/content/103/30/11206.full.pdf+html (Accessed September 26, 2009)

McAloon et al. 2008 — McAloon, A., Taylor, F. *Shelled Corn to Ethanol Process Analysis: Dry Grind Starch Fermentation.* USDA. 2008.

Watkins 2009 — Watkins, C. (2009). Two Fuels from One Kernel. International News on Fats, Oils and Related Materials (INFORM). AOCS Press. November 1, 2007 http://www.greenshift.com/pdf/EPM_One_Kernel_Two_Fuels.pdf (Accessed September 28, 2009)

Section III: Document Control Information

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