NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Ethanol Plant, Thermochemical, Construction

Reference Flow: 1 pcs Thermochemical Ethanol Plant per kg Ethanol Produced

Brief Description: Materials required for the construction of an ethanol plant that uses direct gasification of cellulosic biomass followed by catalyzed synthesis of ethanol.

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest

Year Data Best Represents: 2007

Process Type: Installation Process (IP)

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:

None.

Tracked Input Flows:

Steel Plate, BF (85% Recovery Rate) [Metals] — *Steel plate from blast furnace (BF), assumes 85% recovered/recycled steel*

316 Stainless Steel Cold Rolled [Metals] — *316 cold-rolled stainless steel*

Concrete, ready mix, R-5-0 [Concrete_Cement] — *Concrete used in construction of an ethanol plant*

Tracked Output Flows:

Pcs/kg Ethanol — *Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_C_Thermochemical_Ethanol_Plant_2010.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the materials required for the construction of a thermochemical ethanol plant, the energy conversion facility under LC Stage #3. This unit process is combined with other LC Stage #3 processes (installation and operation) under an assembly process for the total effects of the stage. Carbon steel (steel plate), stainless steel, and concrete (ready mix) are considered to be the sole input flows for the construction of the indicated plant. All other material inputs are assumed to be negligible.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Emissions related to the physical assembly of the plant (including transport of those components) are considered to be outside of the boundary of this unit process. Upstream emissions from the production of raw materials used for the construction of the plant (e.g., carbon steel and stainless steel) are calculated outside the boundary of this unit process, based on proprietary profiles available within the GaBi model. As shown in Figure 1 and discussed above, the plant constructed in this unit process is incorporated into the assembly process for LC Stage #3.

Phillips et al. (2007) describe the design of a plant that produces ethanol and higher alcohols from biomass via thermochemical conversion. The installed costs of main plant components are given in 2005 dollars. The installed costs are calculated by applying cost scaling factors to equipment costs as fabricated. By using the factors in the report one can calculate the equipment costs. The cost of each main plant component includes ancillary equipment and piping, since these are not detailed in the cost table.

Phillips et al. provides a table (Table 14) with the general cost factors between total purchased equipment cost (TPEC) and total installed cost (TIC) for each component type (piping, electrical components, buildings, etc). The total TIC for all components is given to be 247 percent of the TPEC. The TPEC is 3 times the costs of materials used to construct the equipment (labor, sales, and delivery account for the balance of purchased cost). In order to calculate the total mass of steel material used, the total material cost (1/3 of TPEC) is divided by the 2005 price of steel per kg

(Steelonthenet.com 2009). This total steel weight is assumed to be composed of 50 percent carbon steel and 50 percent stainless steel. This is an engineering assumption based on the recognition that some fraction of the steel will need to be stainless, while some fraction may require less corrosion resistance.

The material requirements of the plant is scaled to the reference flow of one kg of ethanol by dividing them by the estimated cumulative quantity of fuel output from the plant over its lifetime. This calculation assumes an 85 percent capacity factor, which accounts for plant downtime due to interruptions in biomass delivery and routine maintenance. A 30 year plant life is also assumed for consistency with other NETL Power/Fuel LCAs. Therefore, operating at an 85% capacity factor over the 30-year life of the plant, a total of 1.56 billion gallons of ethanol would be produced (52.5 million gallons per year). Construction requirements of the plant are apportioned between ethanol and higher alcohols according to their relative masses of production.

The concrete requirements of a thermochemical ethanol plant are assumed to be comparable to those of a dry mill ethanol plant. Hill et al (2006) find the concrete material weight to be 14,200 Mg. This value is scaled per kg ethanol output using the total ethanol output over the plant lifetime, as explained above; this is considered to be a data limitation.

Table 1 shows relevant properties and assumptions used to calculate the amount of carbon steel, stainless steel, and concrete contained in a single ethanol plant per kg ethanol output.

Applying the calculations and assumptions described to the plant design of Phillips et al. (2007), the plant materials fractions can be obtained from the product shown in **Table 2**. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS.

Figure 1: Unit Process Inputs, Outputs, and Boundaries

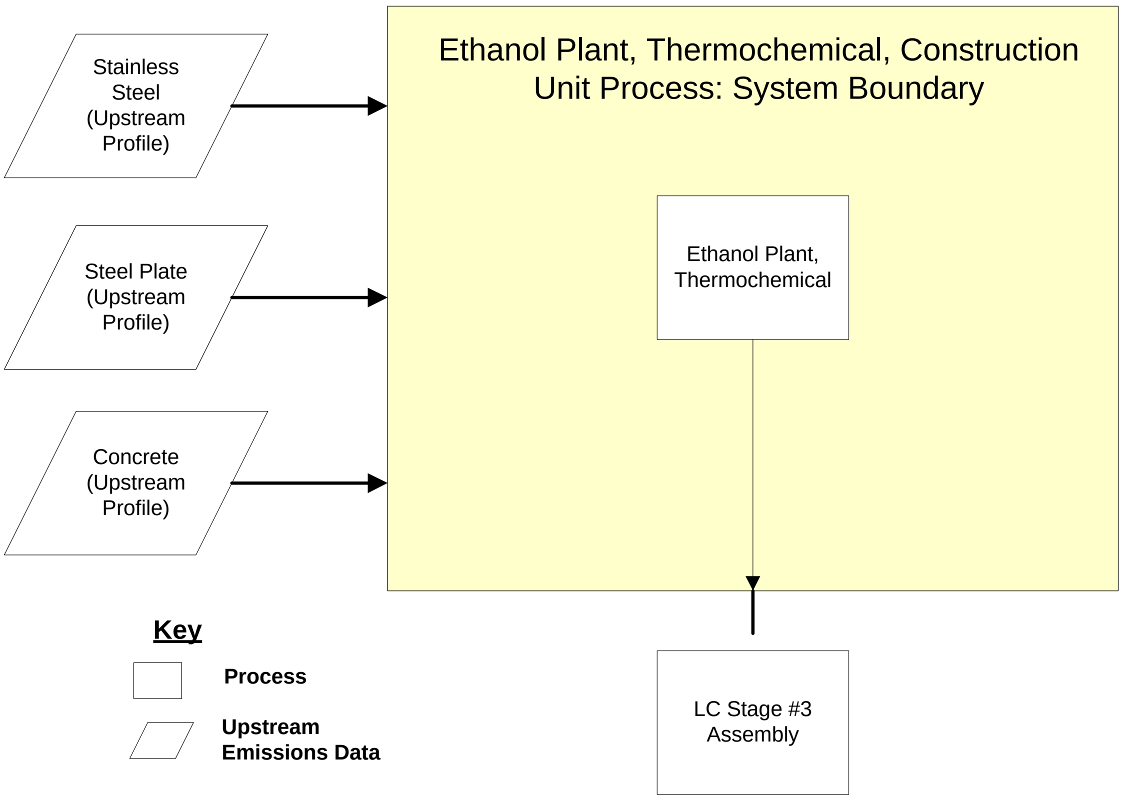

Table 1: Properties of the Ethanol Plant

Property	Value	Reference
Annual capacity million m^3/year (million gal/year)	0.234 (61.8)	NETL Engineering Judgment
Capacity factor	85%	NETL Engineering Judgment
Plant lifetime years	30	NETL Engineering Judgment

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Steel plate, BF (85% Recovery Rate) [Metals]	**8.81198E-04**	**kg**
316 Stainless steel cold rolled [Metals]	**8.81198E-04**	**kg**
Concrete, ready mix, R-5-0 [Concrete_Cement]	**3.0173E-03**	**kg**
Outputs		
Ethanol	1.00	pcs/kg

* **Bold faced font** clarifies that the value shown *does not* include upstream environmental flows. Upstream environmental flows were added during the modeling process using separate modeling software, as shown in Figure 1.

Embedded Unit Processes

None.

References

Hill et al. 2006 — Hill, J. Nelson, E. Tilman, D. Polasky, S. et al. 2006. "Environmental, economic, and energetic costs and benefits of biodiesel and ethanol biofuels." Proceedings of the National Academy of Sciences. Vol 103, No 30. www.pnas.org/content/103/30/11206.full.pdf+html (Accessed September 26, 2009); Table 6

Phillips et al. 2007 — Phillips, S. D., Aden, Andy, Jechura, J., et al. 2007. Thermochemical Ethanol via Indirect Gasification and Mixed Alcohol Sythesis of Lignocellulosic Biomass.

Steelonthenet 2009 — Steelonthenet.com. http://www.steelonthenet.com/prices.html (Accessed September 22, 2009).

Section III: Document Control Information

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