NETL Life Cycle Inventory Data
Process Documentation File

Process Name: CTL, CBTL, BTL Plant, Construction

Reference Flow: 1 piece (pcs) of Plant per kg Diesel Produced

Brief Description: Quantifies the amount of materials needed to construct an individual CTL, CBTL, or BTL plant. Data based on construction of an IGCC plant.

Section I: Meta Data

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

Year Data Best Represents: 1998

Process Type: Manufacturing Process (MP)

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

Allocation Applied: No

Completeness: Individual 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:

Kg coal per MWh Plant Output	*kg of coal required per MWh of electricity produced at an IGCC plant.*

Tracked Input Flows:

Concrete, ready-mix, R-5-0 [Concrete_Cement]	*Estimated amount of concrete for plant construction, normalized to the reference flow*
Steel cold rolled (St) [Metals]	*Estimated amount of steel for plant construction, normalized to the reference flow*

Steel, pipe welded, BF (85% Recovery Rate) [Metals]	*Estimated amount of steel piping for plant construction, normalized to the reference flow*
Cast iron part [Metal parts]	*Estimated amount of iron for plant construction, normalized to the reference flow*
Aluminum sheet [Metals]	*Estimated amount of aluminum for plant construction, normalized to the reference flow*

Tracked Output Flows:

Plant per kg Diesel Produced	*Reference flow, one piece of plant per kg of diesel produced at plant.*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_C_CTL_CBTL_BTL_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 single, CTL, CBTL, or BTL plant for the production of diesel fuel and naphtha, normalized to the production of a single kg of diesel fuel, as described below. The materials included in plant construction include concrete, cold rolled steel, steel piping, iron, and aluminum. The process is based on the reference flow of 1 piece of plant per kg diesel produced, as described below and shown in **Figure 1**. The term “piece”, in this unit process, refers to fraction of materials required to produce 1 kg of transport fuel over the 30-year study period.

This unit process is used under Life Cycle (LC) Stage #3 to construct a plant for the production of transportation fuel. It is combined with other relevant equipment for LC Stage #3, including biomass drying, plant operation, plant installation, and a CO_2 (carbon dioxide) pipeline (for cases with CCS (carbon capture and sequestration)).

Boundary and Description

Because no data of sufficient quality were available for the construction of a CTL, CBTL, or BTL plant, the amount of materials required was estimated based on the construction profile for an IGCC (integrated gasification combined cycle) plant. The IGCC generates electricity, so the materials required to build an IGCC are expressed as mass per MW of

power that the IGCC is rated to produce. The rated power depends on whether or not the IGCC includes CCS. CCS requires energy so the rated power decreases for an IGCC with CCS as compared to a comparable IGCC without CCS. An IGCC, like a CTL/CBTL/BTL, can use different feedstocks (i.e., coal and/or biomass). To simplify the analysis, this evaluation was done for the situation where coal is the only feedstock for the IGCC and CTL/CBTL/BTL (actually CTL). For an IGCC without CCS, the power rating is 640 MW and it takes 347 kg of coal to generate 1 MWh of electricity (NETL 2007). For an IGCC with CCS, the power rating is 556 MW and it takes 408 kg of coal to generate 1 MWh of electricity (NETL 2007). The default values are 556 MW and 408 kg coal/MWh. For the CTL/CBTL/BTL, an NETL report (NETL 2009) examines different plant capacities that use different feedstocks for a total of 24 cases. For this evaluation, case 1 was used which is a CTL that generates 50,000 barrels of fuel each day, with 34,253 barrels being diesel and the remainder being naphtha. For case 1, 21,719 tonnes of coal is needed each day. Assuming there are 0.85 kg of diesel in each liter (or 7.1 pounds per gallon), this works out to 4.69 kg coal for each kg of diesel fuel produced.

The materials necessary for the construction of an IGCC plant (and, by assumption, to build a CTL/CBTL/BTL plant) include concrete, cold rolled steel, steel piping, iron, and aluminum. Data for the amount of each material necessary to construct a plant were taken from a total of 5 sources. The values for concrete were taken from 4 representative plants, with amounts of approximately 111 yd^3/MW (Duke Energy 2008), 87 yd^3/MW, 108 yd^3/MW, and 140 yd^3/MW (ConocoPhillips 2005). These 4 values were averaged and then converted to kg/MW, for a total amount of concrete of approximately 235,039 kg/MW.

The amount of cold rolled steel required was taken from a representative IGCC plant with CCS (Fiaschi and Lombardi 2002). A value of 46.04 short tons/MW was converted to approximately 41,771 kg/MW.

Steel piping totals were obtained by taking the average of five representative plants. Amounts of 3.00 short tons/MW (Duke Energy 2008), 5.97 short tons/MW (ELCOGAS 2000), 2.36 short tons/MW, 4.47 short tons/MW, and 3.92 short tons/MW (ConocoPhillips 2005) averaged out to 3.94 short tons/MW. This value was converted to 3,579 kg/MW of steel piping.

The fourth material included in the construction of a plant was iron. A single value from the representative IGCC with CCS plant was used for this data, 0.752 short tons/MW (Fiaschi and Lombardi 2002). This was converted to 681 kg/MW.

The final material for the plant was aluminum. The amount of aluminum was taken from a 1999 NREL study (Spath, Mann and Kerr 1999). This study gave a value of 0.462 short tons/MW, which was converted to 419 kg/MW of aluminum.

To determine the amount of each material required for the construction of the CTL/CBTL/BTL plant per kg of diesel fuel produced (the reference flow), the following procedure was used. First, the total amount of each material needed per MW was divided by the capacity factor of the plant (0.80, NETL 2007) and the life of the plant in

hours (30 years x 365 days/year x 24 hours/day). This converts the mass of each material per MW to the mass of each material per MWh of electricity generated in the 30 year plant lifetime. Second, the amount of each material per MWh was divided by the amount of coal required per MWh of IGCC plant output (either 347 kg/MWh for an IGCC without CCS or 408 kg/MWh for an IGCC with CCS, as explained above). This converts the mass of each material per MWh to the mass of each material per kg of coal used in the IGCC over the 30 year plant lifetime. Third, the amount of each material per kg of coal was multiplied by the kg of coal needed in the CTL to generate a kg of diesel (4.69 kg coal/kg diesel, as discussed above). This converts the mass of each material per kg of coal used in the IGCC over the 30 year plant lifetime to the mass of each material per kg of diesel produced by the CTL/CBTL/BTL. Using this procedure, the mass of each construction material needed to generate 1 kg of diesel were estimated to be 0.0128 kg concrete, 0.00228 kg cold rolled steel, 0.000195 kg steel piping, 3.718E-05 kg iron, and 2.287E-05 kg aluminum.

The amount of coal required by the IGCC per MWh of output is the only adjustable parameter in this process. This parameter allows the user to vary the amount of coal depending on whether the plant includes CCS equipment or not. The default value is 408 kg/MWh, which is for a plant with CCS. For a plant without CCS, the value would be 347 kg/MWh, as discussed above.

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 assembling the components of a plant, including transport of those components) are not considered in this study. Upstream emissions from the production of raw materials used for the construction of the plant (e.g., concrete, cold rolled steel, steel piping, iron and aluminum) are calculated outside of the boundary of this unit process, based on profiles obtained elsewhere, such as from the proprietary 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 biomass drying, plant operation, plant installation, and a CO_2 pipeline.

Table 1 summarizes the relevant properties and assumptions used to calculate the amount of concrete, cold rolled steel, steel piping, iron, and aluminum contained in a single CTL, CBTL, or BTL plant. **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.

Figure 1: Unit Process Scope and Boundary

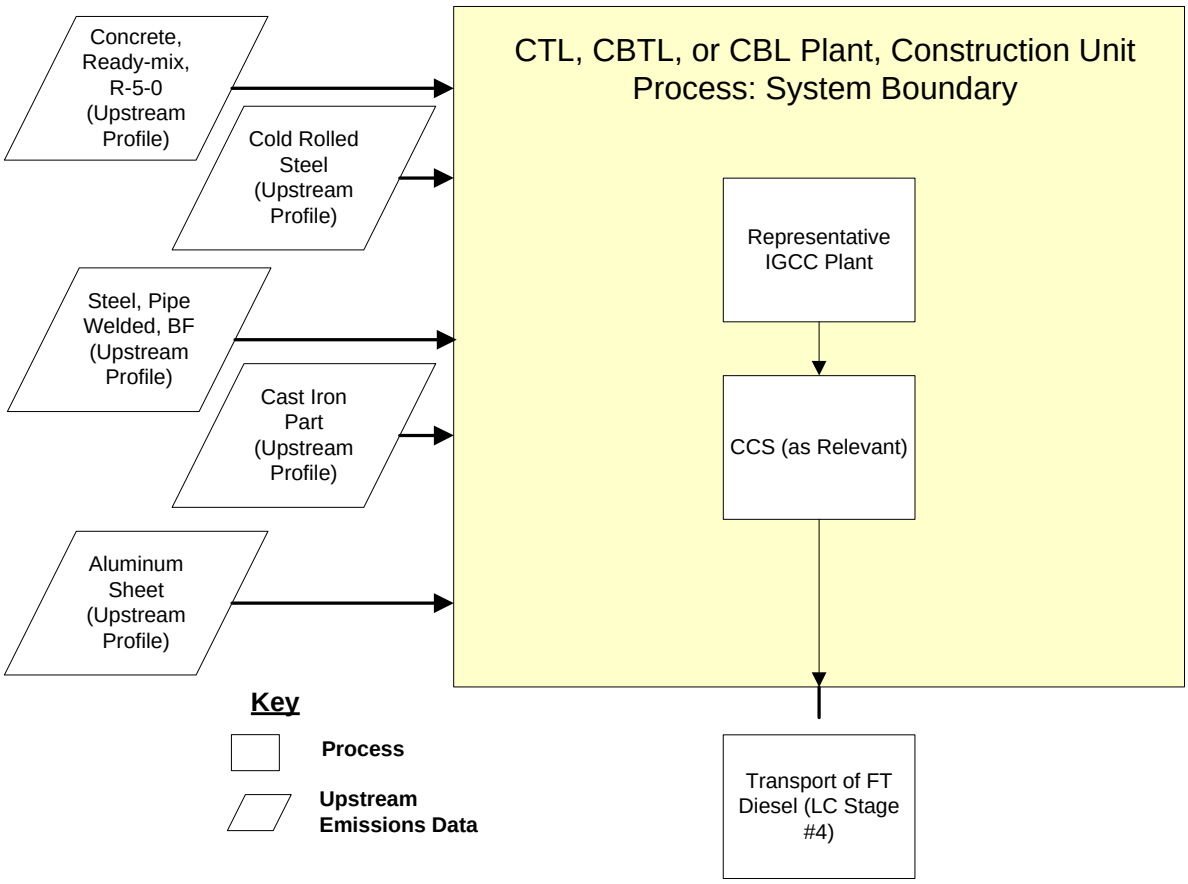

Table 1: Properties of a Single CTL, CBTL, or BTL Plant

Properties and Values			
Property	**Value**	**Units**	**Reference**
Kg coal required per kg fuel produced	4.69	kg coal/kg fuel	NETL 2009
Net MW output of representative IGCC plant	556	MW	NETL 2007
IGCC plant capacity factor	0.80	[dimensionless]	NETL 2007
Life of plant	30	years	NETL 2007
Kg coal required per MW plant output	408	kg coal/MWh	NETL 2007
Total concrete	235,039	kg/MW	ConocoPhillips 2005; Duke Energy 2008
Total cold rolled steel	41,771	kg/MW	Fiaschi and Lombardi 2002
Total steel piping	3,579	kg/MW	ConocoPhillips 2005; ELCOGAS 2000; Duke Energy 2008
Total iron	681	kg/MW	Fiaschi and Lombardi 2002
Total aluminum	419	kg/MW	Spath, Mann and Kerr 1999

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Concrete, ready-mix, R-5-0 [Concrete_Cement]	**1.28E-02**	**kg**
Steel cold rolled (St) [Metals]	**2.28E-03**	**kg**
Steel, pipe welded, BF (85% Recovery Rate) [Metals]	**1.95E-04**	**kg**
Cast iron part [Metal parts]	**3.72E-05**	**kg**
Aluminum sheet [Metals]	**2.29E-05**	**kg**
Outputs		
Plant per kg Diesel Produced	1.97E-11	pcs/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

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Spath, Mann and Kerr 1999	Spath, P.L., Mann, M.K., Kerr, D.R. 1999. *Life Cycle Assessment of Coal-fired Power Production*. NREL/TP-570-25119. NREL. Golden, CO.

Section III: Document Control Information

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Revision History:

Original/no revisions

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

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: CTL,CBTL, BTL Plant, Construction.* U.S. Department of Energy, National Energy Technology Laboratory. Last

Updated: October 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

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