NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Illinois No. 6 Underground Coal Mine Assembly, Construction

Reference Flow: 1 kg of Illinois No. 6 Bituminous Coal

Brief Description: Calculates the number of each piece of equipment included in an underground, Illinois No. 6 bituminous coal mine. Includes life expectancy and replacement rates for longwall mining system, continuous miner, conveyor system, and shuttle car.

Section I: Meta Data

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

Year Data Best Represents: 2006

Process Type: Basic Process (BP)

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:

Coal Feedrate	*Estimated required feedrate of coal-to-energy conversion facility (plant) in Life Cycle (LC) Stage #3, in metric tonnes per day. Default value is from Case #1 of NETL study (NETL 2009)*

Tracked Input Flows:

Longwall Mining System [Installation]	*Total number of longwall mining systems needed over the lifetime of the energy conversion facility (plant), including replacements, to produce 1 kg of Illinois No. 6 bituminous coal*
Continuous Miner, 755 Horsepower (HP) [Installation]	*Total number of 755-HP continuous miners needed over the lifetime of the energy conversion facility (plant), including replacements, to produce 1 kg of Illinois No. 6 bituminous coal*
Conveyor System, 48 Inch [Installation]	*Total number of 48-inch wide conveyor systems needed over the lifetime of the energy conversion facility (plant), including replacements, to produce 1 kg of Illinois No. 6 bituminous coal*
Shuttle Car, 95 Horsepower [Installation]	*Total number of 95-HP shuttle cars needed over the lifetime of the energy conversion facility (plant), including replacements, to produce 1 kg of Illinois No. 6 bituminous coal*

Tracked Output Flows:

Hard Coal (Illinois No. 6) [Hard Coal Products]	*Amount of Illinois No. 6 bituminous coal output from the underground coal mine facilities (reference flow)*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_C_Assembly_I6_Coal_Underground_Mine_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 elements required for the construction of a single underground coal mine used to extract Illinois No. 6 bituminous coal under LC Stage #1. Once the coal has been conveyed to the surface, it will be crushed and cleaned, then loaded into railcars for transport (LC Stage #2) to the power plant (LC Stage #3) over the 30-year study period, as described below and in **Figure 1**. Input flows for the underground coal mine construction include longwall mining systems, continuous miners, shuttle cars, and a conveyor system. This unit process estimates the number of each type of equipment included in the underground coal mine, and calculates the fraction of each type of equipment needed as inputs to extract 1 kg of Illinois No. 6 bituminous coal, based on the parameters shown above and in the DS.

Construction data, including the mass of raw materials required to construct a single longwall mining system, continuous miner, shuttle car, and conveyor system are calculated in separate unit processes. Therefore, the following unit processes are considered to be embedded in this assembly unit process: DF_Stage1_C_Assembly_Longwall_Mining_System_2010.01.doc, DF_Stage1_C_Continuous_Miner_755_HP_2010.01.doc, DF_Stage1_C_Conveyor_System_48_Inch_2010.01.doc, and DF_Stage1_C_Shuttle_Car_95_Horsepower_2010.01.doc. For a discussion of environmental emissions associated with the manufacture of raw materials used in the construction of these components, as well as other pertinent information, please refer to these separate unit processes.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process. Specifications for the number of longwall mining systems and continuous miners at the underground coal mine were taken from the Illinois Department of Natural Resources' 2006 Annual Statistical Report (Illinois DNR 2006). These values are from the Galatia mine in southern Illinois, a representative underground mine extracting Illinois No. 6 bituminous coal. This source indicated a total of three longwall mining units and nine continuous miners in use at this mine, and these values were used for this unit process. In an e-mail communication, the expected lifetime of longwall system components was given as 10–15 years (Bruniany

2008). The average of these values (12.5 years) was assumed for the life expectancy of both the longwall mining system and the continuous miner. The lifetime of the plant (30 years) was divided by the life expectancy of the longwall system and continuous miner for a replacement rate of 2.4 for both the longwall system and continuous miner over the lifetime of the plant.

It was assumed that the conveyor system construction unit process was modeled so that a single conveyor system would be adequate to carry as much coal to the surface as required. The conveyor belt has an expected lifetime of 20 years (Goodyear 2008), and it was assumed that the same lifetime would apply to the conveyor system as a whole. Dividing the plant lifetime by the conveyor lifetime resulted in a replacement rate of 1.5 conveyor systems over the study period.

To determine the number of shuttle cars required in the underground coal mine, it was assumed that there was a 2-to-1 ratio between the continuous miners and the shuttle cars, so that there would be 18 shuttle cars. Each shuttle car has an expected lifetime of 12 years (Australian Tax Office 2008). This lifetime results in a replacement rate of 2.5 shuttle cars over the 30-year lifetime of the plant.

To determine the portion of each piece of equipment constructed per kg of coal, a coal feedrate value was taken from a previous NETL study (NETL 2009). The coal feedrate is included as an adjustable parameter that indicates the total amount of coal required by the plant in LC Stage #3, in metric tonnes per day. The default value for this parameter is 21,719 tonnes/day, taken from the table shown in **Figure 2** under Case #1 (NETL 2009). This variable can be adjusted as needed to reflect assumptions regarding the amount of coal required.

To determine the fraction of a single piece of each type of equipment required over the lifetime of the plant to produce 1 kg of Illinois No. 6 bituminous coal, the coal feedrate (tonnes/day) was converted to kg/year, then multiplied by the plant lifetime (30 years) to get the kilograms of coal produced over the entire study period. Finally, the number of each type of equipment was multiplied by the replacement rate of that equipment, and then divided by the total amount of coal required over the study period.

Relevant properties of a single underground coal mine used for the calculation of input and output flows for this unit process are shown in **Table 1**. **Table 2** provides a summary of modeled input and output flows. Additional details showing calculation methods for input and output flows, and other relevant information, are contained in the associated DS.

Figure 1: Unit Process Scope and Boundary

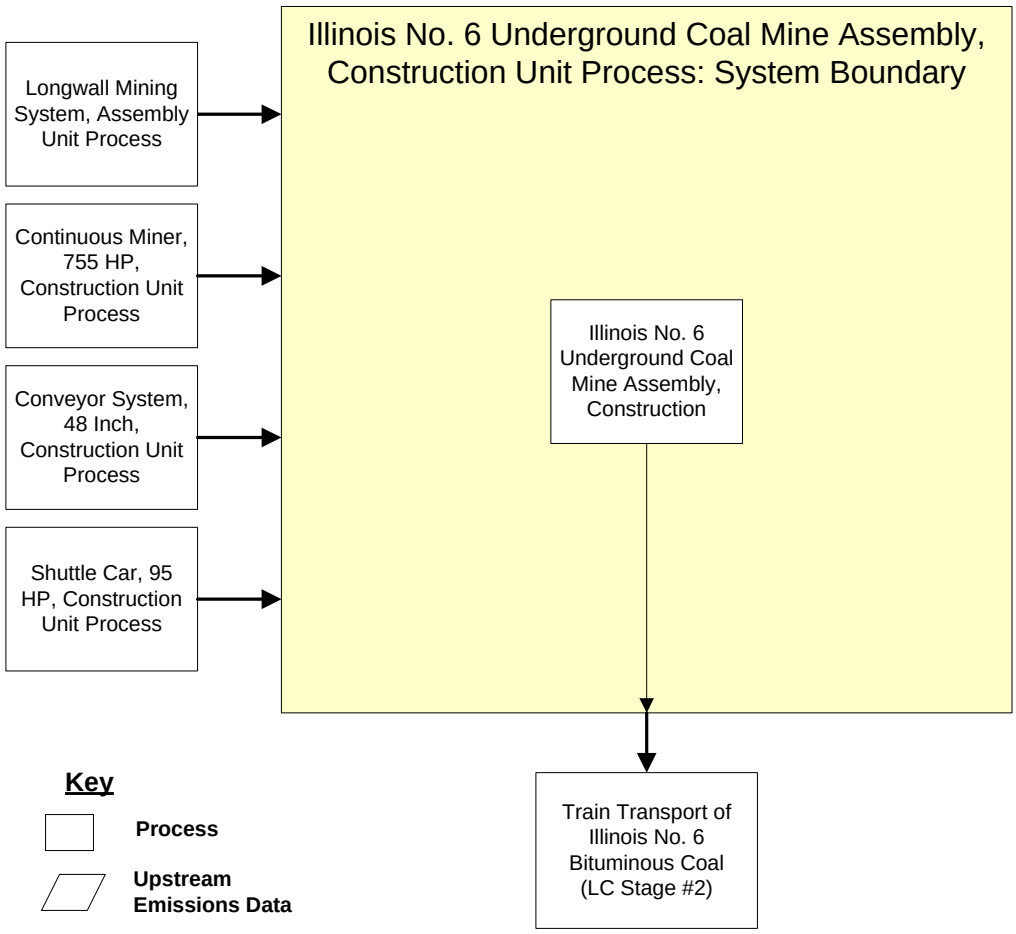

Figure 2: Overall Performance for CBTL Plants (NETL, 2009)

Table D-1: Overall Performance for CBTL Plants

	Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9	Case 10	Case 11
Plant Description	CTL w/o CCS	CTL w/ CCS	CTL w/ CCS + ATR	7.7 wt% CBTL w/ CCS	15wt% CBTL w/CCS	15wt% CBTL w/ CCS + ATR	30wt% CBTL w/ CCS	30wt% CBTL w/ CCS + ATR	BTL w/o CCS	BTL w/ CCS	BTL w/ CCS + ATR
Coal Feed (as-received TPD, 100% CF)	21,719	21,214	23,035	19,948	18,923	20,667	9,893	10,843	0	0	0
Biomass Feed (as-received TPD, 100% CF)	0	0	0	1,657	3,339	3,647	4,240	4,647	4,084	4,136	4,350
Biomass Mass %	0.0%	0.0%	0.0%	7.7%	15.0%	15.0%	30.0%	30.0%	100.0%	100.0%	100.0%
Biomass Energy % (HHV)	0.0%	0.0%	0.0%	4.9%	9.9%	9.9%	21.0%	21.0%	100.0%	100.0%	100.0%
Total Liquids (BPD)	50,000	50,000	50,000	50,000	50,000	50,000	30,000	30,000	5,000	5,000	5,000
Diesel (BPD)	34,253	34,270	34,296	34,292	34,292	34,295	20,575	20,575	3,425	3,434	3,431
Naphtha (BPD)	15,747	15,730	15,704	15,708	15,708	15,705	9,425	9,425	1,575	1,566	1,569
Gasifier	11 train, entrained	11 train, entrained	11 train, entrained	11 train, entrained	11 train, entrained	12 train, entrained	8 train, entrained	8 train, entrained	6 train, CFB	6 train, CFB	6 train, CFB
FT Reactor	10 trains	10 trains	10 trains	10 trains	10 trains	10 trains	6 trains	6 trains	2 trains	2 trains	2 trains
Internal Power (MW)	415.6	450.7	544.8	447.8	451.8	550.3	272.2	333.4	60.2	69.0	78.7
Export Power (MW)	35.2	0.0	0.0	0	0	0	0	0	0.0	0.0	0.0
HHV Efficiency (%)	52.4	53.0	48.8	53.6	53.6	49.0	53.9	49.1	44.3	43.7	41.6
CO_2 Capture (%)	n/a	91.0%	96.6%	91.6%	91.3%	96.5%	91.5%	96.7%	n/a	87.5%	95.6%
Carbon Sequestered (tpd CO_2eq, 100% CF)	n/a	26,646	32,248	26,470	26,646	32,402	15,983	19,576	n/a	3,821	4,503
LCA Effective Carbon (gCO_2E/MMBtu LHV)	**235,000**	**90,200**	**83,700**	**76,000**	**63,400**	**55,300**	**35,100**	**23,800**	**-8,760**	**-210,430**	**-244,800**
LCA Carbon – Comparison to Petroleum Diesel	**+147%**	**-5%**	**-12%**	**-20%**	**-33%**	**-42%**	**-63%**	**-75%**	**-109%**	**-322%**	**-358%**

[1] The coal used in all cases is a bituminous, high-sulfur coal from the Illinois Basin: Illinois #6.
[2] The biomass used in all cases is Switchgrass.

Table 1: Properties of a Single Illinois No. 6 Underground Coal Mine

Construction and Replacement Properties		
Property	**Value**	**Units**
Number of Longwall Miners	3	longwall miners
Number of Continuous Miners	9	continuous miners
Number of Conveyors	1	conveyor systems
Number of Shuttle Cars	18	shuttle cars
Plant Lifetime	30	years
Longwall Miner Replacement Rate	2.4	longwall miners
Continuous Miner Replacement Rate	2.4	continuous miners
Conveyor Replacement Rate	1.5	conveyor systems
Shuttle Car Replacement Rate	2.5	shuttle cars
Coal Feedrate	21,719 (23,941)	tonnes/day (tons/day)
Total Coal over Plant Lifetime	237,823,050,000 (524,310,076,000)	kg (lbs)

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Longwall Mining System [Installation]	**3.03E-11**	**pcs**
Continuous Miner, 755 HP [Installation]	**9.08E-11**	**pcs**
Conveyor System, 48 Inch [Installation]	**6.31E-12**	**pcs**
Shuttle Car, 95 Horsepower [Installation]	**1.89E-10**	**pcs**
Outputs		
Hard Coal (Illinois No.6) [Hard Coal Products]	1	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows. See also the documentation for embedded unit processes, as shown below.

Embedded Unit Processes

DF_Stage1_C_Assembly_Longwall_Mining_System_2010.01.doc;

DF_Stage1_C_Continuous_Miner_755_HP_2010.01.doc;

DF_Stage1_C_Conveyor_System_48_Inch_2010.01.doc;

DF_Stage1_C_Shuttle_Car_95_Horsepower_2010.01.doc

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U.S. Department of Energy, National Energy Technology Laboratory. Pittsburgh, PA.

Section III: Document Control Information

Date Created: January 29, 2010

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

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