NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Underground Mine, Southern Appalachia Bituminous Coal, Operation

Reference Flow: 1 kg of Southern Appalachia Bituminous Coal

Brief Description: Based on the Illinois No. 6 underground, bituminous coal mine unit process. Assumes all underground mining to be similar; 61.4 cubic feet/short ton coal mine CH4 (CMM) emissions, adjustable CMM capture rates; LHV=12,760 Btu/lb.

Section I: Meta Data

Geographical Coverage: US **Region:** Central East

Year Data Best Represents: 2004

Process Type: Extraction Process (EP)

Process Scope: Cradle-to-Gate Process (CG)

Allocation Applied: No

Completeness: All 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:

Coal mine methane emissions (CMM)	*Emissions of coal mine methane (CMM) from the coal mine and from mined coal*

Tracked Input Flows:

Diesel [Crude oil products]	*Diesel (from crude oil) usage for mine operations*
Power [Electric power]	*Electricity usage for mine operations*

Tracked Output Flows:

Hard Coal (Southern Appalachia) [Hard Coal Products]	*Coal mine production flow for Southern Appalachia bituminous coal*

Section II: Process Description

Associated Documentation

This unit process is comprised of this document, as well as the data sheet (DS) *DS_Stage1_O_Underground_Coal_Mine_SouthAppBit_2011.01.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this process covers the production of coal during operation of an underground coal mine, from resource extraction to the boundary for Life Cycle (LC) Stage #2 (e.g., transport of coal). The process is based on the reference flow of 1 kg of cleaned, crushed (to approximately 3 inches) Southern Appalachia bituminous coal, as described below, and in **Figure 1.** Considered are the consumption of electricity, consumption of diesel, emissions of methane associated with off-gassing from the coal/coal mine, particulate matter emissions associated with fugitive coal dust, water input flows required for mining and cleaning operations, wastewater flows including stormwater, emissions of criteria air pollutants, and air emissions of mercury and ammonia.

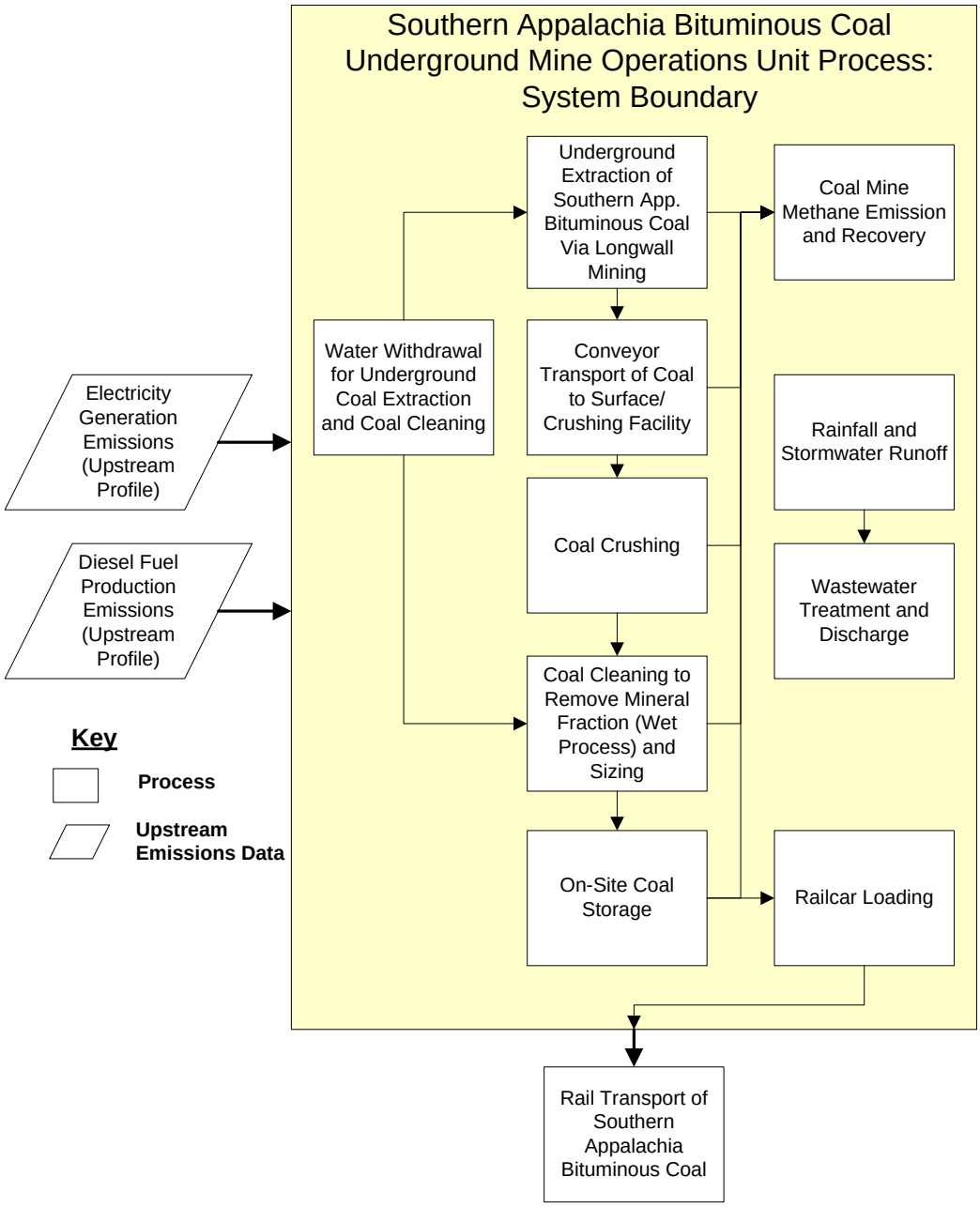
Boundary and Description

This unit process is a screening level data set. It was created using a previously created unit process with specific adjustments for the coal properties. The adjustments include the specific region and coal type's CMM and energy content values. This unit process is based on the Illinois No. 6 underground mining of bituminous coal. It is assumed that all underground mines have similar operation profiles.

Operations of the coal mine are based on operation of a representative mine, the Galatia Mine, an underground, bituminous Illinois No. 6 coal mine, having an average production rate of approximately 6.6 million short tons per year. The Galatia Mine is operated by the American Coal Company and is located in Saline County, IL. Sources reviewed in assessing coal mine operations include Galatia mine facilities and equipment, production rates, electricity usage, particulate air emissions, methane emissions, wastewater discharge permit monitoring reports, and communications with Galatia mine staff. When data from the Galatia mine were not available, surrogate data were taken from other underground mines, as relevant. It is assumed that the underground mine operations of a Southern Appalachia bituminous coal mine are similar to those at the Galatia Mine.

Figure 1 provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while trapezoidal boxes indicate upstream data that are outside of the boundary of this unit process. As shown, upstream emissions associated with the production and delivery of electricity and diesel fuel are accounted for outside of the boundary of this unit process.

Figure 1: Unit Process Scope and Boundary



Coal is extracted from the underground Illinois No. 6 coal seam with wet-head longwall and continuous miners using a longwall mining process. It is assumed that the Southern Appalachia underground mines operate similarly. Coal is then loaded onto a conveyor for transport to the surface. At the surface, the coal continues along a conveyor to the

crushing facility, where the coal is crushed to approximately 3 inch sizing. Coal then continues to the cleaning facility, where the mineral fraction (approximately 45% of total coal mass) of the run-of-the mine coal is removed via a water-based cleaning and sorting process. The coal is then temporarily stored, until it is eventually loaded onto a railcar for rail transport. Stormwater, which generates on-site runoff from coal stockpiles and other facilities, is treated at a wastewater treatment plant, which discharges to a river. The wastewater treatment plant does not treat mining or coal cleaning process water. These systems are closed-loop in terms of water use, and generate no wastewater discharge.

Coal mine methane emissions from the coal mine, and from the extracted coal during processing and storage, were estimated based on U.S. EPA estimates of methane release for coal mines (U.S. EPA 2011). A 40% methane capture rate was used based on data for existing and potential recovery rates (U.S. EPA 2008), which resulted in a coal mine methane emission factor of 36.84 standard cubic feet per short ton of coal. For a sensitivity analysis, one may assume that no coal mine methane capture method was employed, by updating the appropriate adjustable parameter. It was assumed that all emitted methane was released to the atmosphere. The average Southern Appalachia coal deposit has 61.4 standard cubic feet of methane per short ton of coal. Other types of coal may have up to 360 standard cubic feet of methane per short ton of coal. Southern Appalachia bituminous coal has a lower heating value of 12,760 Btu/lb (U.S. EPA 2008).

Electricity use was estimated based on previous estimates made by U.S. EPA for electricity use for underground mining and coal cleaning at the Galatia Mine (U.S. EPA 2008). Diesel use was estimated for the Galatia mine from 2002 U.S. Census data for bituminous coal underground mining operations and associated cleaning operations (U.S. Census Bureau 2004).

Emissions of criteria pollutants were based on emissions associated with the use of diesel. U.S. EPA Tier 4 diesel standards for non-road diesel engines were used, since these standards would go into effect within a couple years of commissioning of the mine for this study (U.S. EPA 2004). Diesel is assumed to be ULSD (15 ppm sulfur). Emissions of particulate matter included those due to the combustion of diesel, as well as fugitive coal dust from the mining process. Total coal dust emissions from the Galatia Mine were used based on data for the mine (U.S. EPA 2005), and were normalized to the reference flow.

Water use was estimated by Galatia Mine staff (Personal Communication 2009). Water emissions data, including flows and concentrations of relevant inorganic constituents and biological oxygen demand, were taken from available National Pollutant Discharge Elimination System permit reporting documentation for Galatia Mine from 2005-2008 (NPDES 2008).

Properties of Southern Appalachia and Illinois No. 6 bituminous coal relevant to this screening level UP are indicated in **Table 1**. **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.

Table 1: Properties of Southern Appalachia and Illinois No. 6 Underground Coal (NETL 2007; EPA 2011; EPA 2008)

Rank	Bituminous	Bituminous
Seam	Illinois No. 6	Southern Appalachia
LHV, Btu/lb	11,252	12,760
CMM, scf/ton	360	61.4

Table 2: Unit Process Input and Output Flows

Flow Name*	**Value**	**Units (Per Reference Flow)**
Inputs		
Power [Electric power]	**3.31E-02**	**kWh**
Hard Coal (Southern Appalachia) [Hard coal (resource)]	1.00E+00	kg
Diesel [Crude oil products]	**3.10E-04**	**L**
Water (ground water) [Water]	3.45E-01	L
Outputs		
Hard Coal (Southern Appalachia) [Hard Coal Products]	1.00E+00	kg
Carbon dioxide [Inorganic emissions to air]	8.29E-04	kg
VOC (unspecified) [Organic emissions to air (group VOC)]	2.38E-07	kg
Methane [Organic emissions to air (group VOC)]	1.29E-03	kg
Nitrogen oxides [Inorganic emissions to air]	5.10E-07	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	2.13E-08	kg
Sulphur oxide [Inorganic emissions to air]	7.82E-09	kg
Particulate Matter, unspecified [Other emissions to air]	1.25E-06	kg
Carbon monoxide [Inorganic emissions to air]	4.44E-06	kg
Mercury (+II) [Heavy metals to air]	4.08E-14	kg
Ammonia [Inorganic emissions to air]	3.40E-08	kg
Water (storm runoff) [Water]	9.92E-01	L
Total suspended solids [Particles to fresh water]	8.71E-06	kg
Iron [Heavy metals to fresh water]	1.02E-07	kg
Alkalinity [Inorganic emissions to fresh water]	8.30E-05	kg
Acidity [Inorganic emissions to fresh water]	0.00E+00	kg
Chloride [Fresh water]	2.27E-03	kg
Sulphate [Inorganic emissions to fresh water]	1.60E-04	kg
Biological oxygen demand (BOD) [Analytical measures to fresh water]	2.24E-08	kg

* **Bold face** clarifies that the value shown *does not* include upstream environmental flows.

Embedded Unit Processes

None.

References

NPDES 2008	Galatia Mine. 2005 through 2008. *NPDES Permit No. IL061727, Required Reports*. Galatia Mine, IL.
NETL 2007	National Energy Technology Laboratory. 2007. *Cost and Performance Baseline for Fossil Energy Plants: Volume 1*. National Energy Technology Laboratory, U.S. DOE, Pittsburgh, PA. Report Number DOE/NETL-2007/1281.
Personal Communication 2009	Personal communication with Galatia Mine chief engineer, March 13, 2009.
U.S. Census Bureau 2004	U.S. Census Bureau. 2004. *Bituminous Coal Underground Mining: 2002*. U.S. Department of Commerce. http://www.census.gov/prod/ec02/ec0221i212112.pdf (Accessed March 18, 2009).
U.S. EPA 2011	U.S. Environmental Protection Agency. 2011. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2009. Annex 3*. US EPA, Washington, DC. April 15, 2011. EPA 430-R-11-005. http://epa.gov/climatechange/emissions/downloads11/US-GHG-Inventory-2011-Annex_Complete_Report.pdf (accessed July 25, 2011).
U.S. EPA 2008	U.S. Environmental Protection Agency. 2008. *Identifying Opportunities for Methane Recovery at U.S. Coal Mines: Profiles of Selected Gassy Underground Coal Mines 2002-2006.* U.S. Environmental Protection Agency, Coalbed Methane Outreach Program. Report Number: EPA 430-K-04-003.
U.S. EPA 2005	U.S. Environmental Protection Agency. 2005. *National Emission Inventory Database - Galatia Mine, IL*. EPA. http://www.epa.gov/oar/data/neidb.html (Accessed March 18, 2009).
U.S. EPA 2004	U.S. Environmental Protection Agency. 2004. *Regulatory Announcement: Clean Air Nonroad Diesel Rule*. EPA 420-F-04-032. May 2004.

Section III: Document Control Information

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