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# NETL Life Cycle Inventory Data

## Process Documentation File

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Light Fuel Oil [Crude Oil Products]

*Light fuel oil (from crude oil) needed for ANFO explosives*

### Tracked Output Flows:

Northwest Subbituminous Coal

*Coal mine production flow for Northwest subbituminous coal*

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## Section II: Process Description

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### Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS\_Stage1\_O\_Surface\_Coal\_Mine\_NorthwestSubbit\_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 a surface mine for Northwest subbituminous coal, 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) Northwest 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.

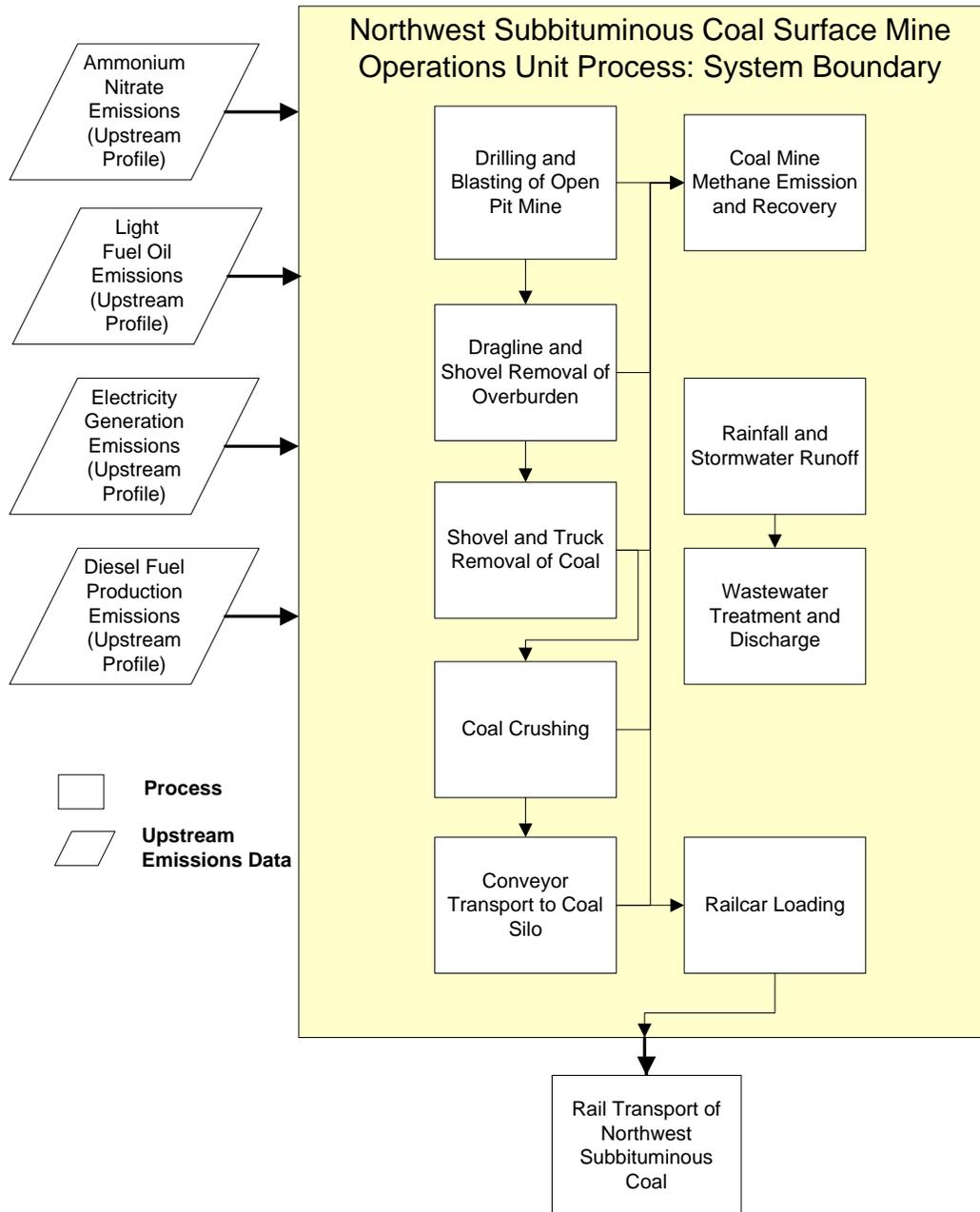
### Boundary and Description

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 Powder River Basin surface mining of subbituminous coal. It is assumed that all surface mines have similar operation profiles.

Operations of the coal mine are based on operations from a compilation of the three largest producers of Powder River Basin coal (Peabody Energy's North Antelope-Rochelle mine, Arch Coal, Inc.'s Black Thunder Mine, and Kennecott Energy's Cordero Rojo Operation) to produce an average annual rate of 60.8 billion kilograms (NMA 2009). The Powder River Basin is located in the southeast portion of Montana and the northeast portion of Wyoming. Sources reviewed in assessing coal mine operations include facility and equipment needs, production rates, electricity usage, particulate air emissions, methane emissions, explosives usage, and additional governmental publications on coal and mines. It is assumed that the surface mine operations of a Northwest subbituminous coal mine are similar to those in the Powder River Basin.

**Figure 1** provides an overview of the boundary of this unit process. As shown, upstream emissions associated with the production and delivery of electricity and diesel fuel, ammonium nitrate, and light fuel oil are accounted for outside of the boundary of this unit process.

**Figure 1: Unit Process Scope and Boundary**



Coal is extracted from a surface PRB coal seam through an open pit mining process. It is assumed that the Northwest surface mines operate similarly. Blasting with ammonium nitrate fuel oil (ANFO) explosives occurs in drilled holes to remove the overburden and

expose the coal seam for extraction. The removal of the overburden occurs with the use of draglines, powered by electricity, which pile the overburden in a different location to enable extraction of the coal. After the dragline has removed as much as possible, large electric shovels are used for the removal of the remaining overburden. The coal is removed using a truck and shovel approach. The trucks move the coal 3.2 km (2 miles) to the preparation facility for grinding and crushing to the proper size for transport. No cleaning of the coal occurs based on the coal properties. A conveyor belt carries the crushed coal from the preparation facility to the loading silo. The coal is then loaded into rail cars for transport (LC Stage #2) to the plant (LC Stage #3).

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). An 80 percent 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 3.2 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 Northwest coal deposit has 16.0 standard cubic feet of methane per short ton of coal. Other types of coal may have up to 360 standard cubic feet per short ton of emissions. Northwest subbituminous coal has a lower heating value of 7,500 Btu/lb (U.S. EPA 2008).

Electricity and diesel use were based on data points published by Peabody Energy in reference to their North Antelope Rochelle Mine in Wyoming (Burley 2008 and Peabody 2005). The data were scaled such that they were applicable to the size of the mine being modeled.

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 few years of commissioning of the mine for this study (U.S. EPA 2004). Diesel is assumed to be ultra low sulfur diesel (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 were obtained from the EPA's AP 42's Mineral Products Industry section (EPA 2009).

Water use was estimated based on an environmental impact study completed on West Antelope II mine located in the Powder River Basin of Wyoming (BLM 2008). Water emissions, including flows and concentrations of relevant inorganic constituents and solids entering the waterstream, were taken from available National Pollutant Discharge Elimination System permit reporting documentation (NPDES 2009).

Properties of Northwest and PRB subbituminous coal relevant to this screening level unit process 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 Northwest and Powder River Basin Subbituminous Surface Mined Coal (NETL in press; EPA 2011; EPA 2008)**

| <b>Rank</b>  | Subbituminous      | Subbituminous |
|--------------|--------------------|---------------|
| <b>Seam</b>  | Powder River Basin | Northwest     |
| LHV, Btu/lb  | 11,096             | 7,500         |
| CMM, scf/ton | 30-40              | 16.0          |

**Table 2: Unit Process Input and Output Flows**

| <b>Flow Name*</b>   | <b>Value</b> | <b>Units (Per Reference Flow)</b> |
|---|--------------|-----------------------------------|
| <b>Inputs</b>   |              |                                   |
| Ammonium nitrate [Inorganic intermediate products]          | 1.4544E-03   | kg                                |
| Diesel [Crude oil products]                                 | 8.9284E-04   | kg                                |
| Light fuel oil [Crude oil products]                         | 1.0111E-04   | kg                                |
| Power [Electric power]                                      | 1.4028E-03   | kWh                               |
| Water (ground water) [Water]                                | 3.0347E-02   | L                                 |
| <b>Outputs</b>  |              |                                   |
| Northwest Subbituminous Coal                                | 1            | kg                                |
| Carbon dioxide [Inorganic emissions to air]                 | 2.8092E-03   | kg                                |
| Carbon monoxide [Inorganic emissions to air]                | 6.9709E-12   | kg                                |
| Methane [Organic emissions to air (group VOC)]              | 6.7936E-05   | kg                                |
| Nitrogen dioxide [Inorganic emissions to air]               | 2.4900E-05   | kg                                |
| Sulphur dioxide [Inorganic emissions to air]                | 2.6757E-11   | kg                                |
| Particulate Matter, unspecified [Other emissions to air]    | 9.4546E-05   | kg                                |
| Volatile Organic Carbons [Organic emissions to air]         | 3.4765E-07   | kg                                |
| Mercury - Heavy Metals to Air                               | 1.3962E-13   | kg                                |
| Ammonia - Emissions to Air                                  | 1.1560E-07   | kg                                |
| Ammonium / ammonia [Inorganic emissions to fresh water]     | 3.0005E-05   | kg                                |
| Nitrogen [Inorganic emissions to fresh water]               | 9.0388E-05   | kg                                |
| Phosphorus [Inorganic emissions to fresh water]             | 8.9395E-07   | kg                                |
| Aluminium [Heavy metals to fresh water]                     | 2.4790E-06   | kg                                |
| Selenium [inorganic emissions to fresh water]               | 1.1151E-07   | kg                                |
| Sulfate [inorganic emissions to fresh water]                | 4.2008E-02   | kg                                |
| Total Dissolved Solids [inorganic emissions to fresh water] | 8.7516E-02   | kg                                |
| Total Suspended Solids [inorganic emissions to fresh water] | 2.5672E-03   | kg                                |
| Arsenic [Heavy metals to fresh water]                       | 1.3244E-07   | kg                                |
| Copper [Heavy metals to fresh water]                        | 1.3447E-07   | kg                                |
| Iron [Heavy metals to fresh water]                          | 4.3199E-05   | kg                                |
| Lead [Heavy metals to fresh water]                          | 5.3484E-08   | kg                                |
| Manganese [Heavy metals to fresh water]                     | 1.2115E-05   | kg                                |
| Nickel [Heavy metals to fresh water]                        | 4.8900E-07   | kg                                |
| Water (wastewater) [Water]                                  | 4.8900E-02   | L                                 |

\* **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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U.S. EPA 2009

EPA. 2009. *National Pollutant Discharge Elimination System Permit, Water Quality Reporting Documentation*. U.S. Environmental Protection Agency. [http://www.epa-echo.gov/echo/compliance\\_report\\_water.html](http://www.epa-echo.gov/echo/compliance_report_water.html) (Accessed December 21, 2009).

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**Section III: Document Control Information**

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July 23, 2011

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**Revision History:**

Original/no revisions

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

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Surface Mine, Northwest Subbituminous Coal, Operation*. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: July 2011 (version 01). [www.netl.doe.gov/energy-analyses](http://www.netl.doe.gov/energy-analyses) (<http://www.netl.doe.gov/energy-analyses>)

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