NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Rosebud Surface Subbituminous Coal Mine, Operations

Reference Flow: 1 kg of Rosebud Subbituminous Coal

Brief Description: Based on a compilation of mines, a surface mine for Rosebud subbituminous coal in Montana, producing ~11 billion kg of coal per year. Assumes ~40 scf/ton coalbed methane (CBM) emissions, adjustable CBM capture rates.

Section I: Meta Data

Geographical Coverage: US **Region:** Rosebud

Year Data Best Represents: 2008

Process Type: Extraction Process (EP)

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

Allocation Applied: No

Completeness: All 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:

Coalbed methane emissions (CBM)	*Emissions of coalbed methane (CBM) from the coal mine and from mined coal*

Tracked Input Flows:

Diesel Combustion, Mobile Sources, Truck [Refinery products]	*Diesel from crude oil, combusted in trucks*
Power [Electric Power]	*Electricity usage for mine operations*
Ammonium Nitrate [Inorganic Intermediate Products]	*The amount of ammonium nitrate needed for ammonium nitrate fuel oil (ANFO) explosives*

Light Fuel Oil [Crude Oil Products]	*Light fuel oil (from crude oil) needed for ANFO explosives*

Tracked Output Flows:

Rosebud Coal [Hard Coal Products]	*Coal mine production flow for Rosebud subbituminous coal*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_CoalMine_Rosebud_2012.02.xlsx*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

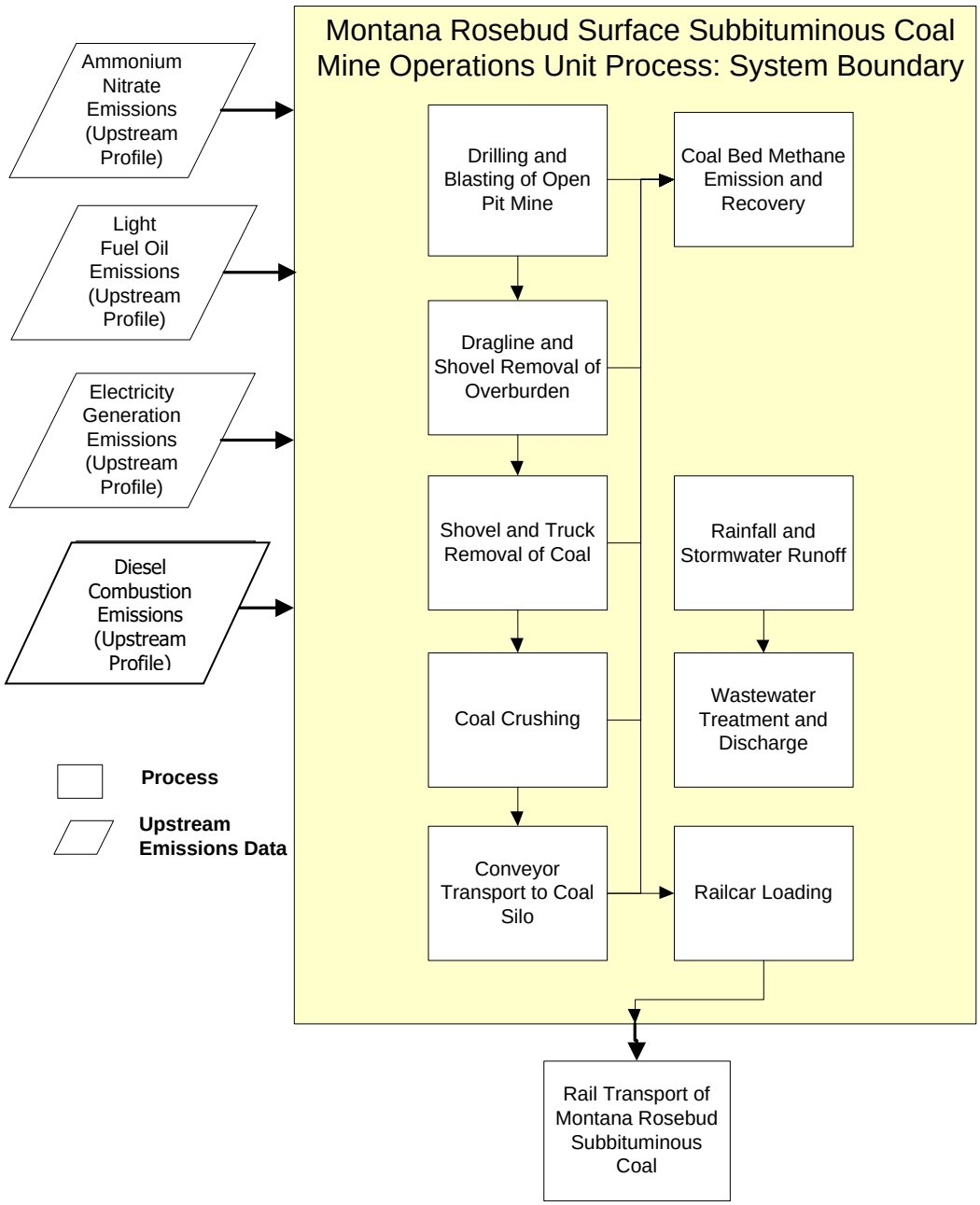
The scope of this process covers the production of coal during operation of a surface mine for Rosebud subbitumious coal, from resource extraction to the boundary for LC Stage #2 (e.g., transport of coal). The process is based on the reference flow of 1 kg of cleaned, crushed (to approximately 3 inches) Rosebud 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. The consumption of diesel is modeled as a tracked input flow in which the associated emissions from diesel combustion are accounted for in an externally linked unit process.

Boundary and Description

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), of which Rosebud is a coal seam. The Rosebud is located in Montana. Sources reviewed in assessing coal mine operations include facility and equipment needs, production raters, electricity usage, particulate air emissions, methane emissions, explosives usage, and additional governmental publications on coal and mines.

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 Rosebud coal seam through an open pit mining process. 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).

Coalbed 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 the Rosebud coal mine (U.S. EPA 2008). No methane is capture from the Rosebud coal mine prior to coal mining (U.S. EPA 2008). It is assumed that all emitted methane is released to the atmosphere. The Rosebud mine has 39-40 standard cubic feet per short ton (U.S. EPA 2008). Other types of coal may have up to 360 standard cubic feet per short ton of emissions.

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.

Diesel is assumed to be ultra low sulfur diesel (ULSD; 15 ppm sulfur). The emissions associated with the combustion of diesel are accounted for in an externally linked unit process.

Emissions to air from ammonium nitrate and fuel oil (ANFO) based explosives were calculated using Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges (NPI, 1999). A combustion efficiency of 98 percent was assumed. Unspecified VOCs were calculated as the difference in accounted for VOCs and total VOCs using the weighted average molecular weight of accounted for VOCs for the molecular weight of unspecified VOCs. CO_2 emissions from ANFO combustion were determined by assuming that all unaccounted for carbon in combusted ANFO become CO_2.

Emissions of particulate matter included those due to fugitive coal dust from the mining process are calculated as PM10 and PM2.5. Total coal dust emissions were obtained from the EPA's AP 42's Mineral Products Industry section (EPA 2009). A PM2.5/PM10 ratio was not available for fugitive dust from storage piles so it was assumed to be the same ratio as that of truck loading. It was further assumed that there was an 85 percent reduction of fugitive waste emissions due to remediation efforts.

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 Rosebud coal relevant to this 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 Rosebud Coal (NETL 2011)

Proximate Analysis	Dry Basis, %	As Received, %
Moisture	0	25.77
Ash	11.04	8.19
Volatile Matter	40.87	30.34
Fixed Carbon	48.09	35.7
Total	100	100
Ultimate Analysis	**Dry Basis, %**	**As Received, %**
Carbon	67.45	50.07
Hydrogen	4.56	3.38
Nitrogen	0.96	0.71
Sulfur	0.98	0.73
Chlorine	0.01	0.01
Ash	11.03	8.19
Moisture	0	25.77
Oxygen (Note A)	15.01	11.14
Total	100	100
Heating Value	**Dry Basis, (Dulong Calc.)**	**As Received, %**
HHV, kJ/kg	26,787	19,920
HHV, Btu/lb	11,516	8,564
LHV, kJ/kg	25,810	19,195
LHV, Btu/lb	11,096	8,252

Notes: (A) the proximate analysis assumes sulfur as volatile matter; (B) by difference.

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)	DQI
Inputs			
Ammonium nitrate [Inorganic intermediate products]	**1.4544E-03**	**kg**	2,2
Diesel Combustion, Mobile Sources, Truck [Refinery products]	**8.9284E-04**	**kg**	2,2
Light fuel oil [Crude oil products]	**1.0111E-04**	**kg**	2,2
Power [Electric power]	**1.4028E-03**	**kWh**	2,2
Water (ground water) [Water]	3.0347E-02	kg	2,2
Outputs			
Rosebud Subbituminous Coal [Resource]	1.00	kg	2,3
Carbon dioxide [Inorganic emissions to air]	2.356E-04	kg/kg coal	1,1
Carbon monoxide [Inorganic emissions to air]	5.289E-05	kg/kg coal	1,1
Sulphur dioxide [Inorganic emissions to air]	9.333E-08	kg/kg coal	1,1
Methane [Organic emissions to air (group VOC)]	8.489E-04	kg/kg coal	1,2
Nitrogen dioxide [Inorganic emissions to air]	1.244E-05	kg/kg coal	1,1
NMVOC (unspecified) [Group NMVOC to air]	2.287E-07	kg/kg coal	1,1
Hexane [Group NMVOC to air]	3.111E-08	kg/kg coal	1,1
Benzene [Group NMVOC to air]	3.111E-09	kg/kg coal	1,1
Toluene [Group NMVOC to air]	9.333E-09	kg/kg coal	1,1
Ethylbenzene [Group NMVOC to air]	3.111E-09	kg/kg coal	1,1
Xylene [Group NMVOC to air]	3.111E-08	kg/kg coal	1,1
Cumene [Group NMVOC to air]	6.689E-08	kg/kg coal	1,1
Dust (PM10) [Particles to air]	1.217E-04	kg/kg coal	1,1
Dust (PM2.5) [Particles to air]	1.703E-05	kg/kg coal	1,1
Ammonium / ammonia [Inorganic emissions to fresh water]	3.000E-05	kg/kg coal	2,2
Nitrogen [Inorganic emissions to fresh water]	9.039E-05	kg/kg coal	2,2
Phosphorus [Inorganic emissions to fresh water]	8.940E-07	kg/kg coal	2,2
Aluminum [Heavy metals to fresh water]	2.479E-06	kg/kg coal	2,2
Selenium [inorganic emissions to fresh water]	1.115E-07	kg/kg coal	2,2
Sulfate [inorganic emissions to fresh water]	4.201E-02	kg/kg coal	2,2
Total Dissolved Solids [inorganic emissions to fresh water]	8.752E-02	kg/kg coal	2,2
Total Suspended Solids [inorganic emissions to fresh water]	2.567E-03	kg/kg coal	2,2

Arsenic [Heavy metals to fresh water]	1.324E-07	kg/kg coal	2,2
Copper [Heavy metals to fresh water]	1.345E-07	kg/kg coal	2,2
Iron [Heavy metals to fresh water]	4.320E-05	kg/kg coal	2,2
Lead [Heavy metals to fresh water]	5.348E-08	kg/kg coal	2,2
Manganese [Heavy metals to fresh water]	1.211E-05	kg/kg coal	2,2
Nickel [Heavy metals to fresh water]	4.890E-07	kg/kg coal	2,2
Water (wastewater) [Water]	4.890E-02	kg/kg coal	2,2

* **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.

Inventory items not included are assumed to be zero based on best engineering judgment or assumed to be zero because no data was available to categorize them for this unit process at the time of its creation.

Embedded Unit Processes

None.

References

BLM 2008 — BLM. 2008. *Draft Environmental Impact Study, West Antelope II Coal Lease Application, Chapter 4: Cumulative Environmental Consequences*. U.S. Department of the Interior, Bureau of Land Management. WYW163340. http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/westantelope.Par.18077.File.dat/008ch4.pdf (Accessed December 21, 2009).

Burley 2008 — Burley, J.B. 2008. *Reclamation and Restoration Newsletter, Winter 2008*. ASLA. http://www.asla.org/ppn/article.aspx?id=21152 (Accessed February 9, 2010)

NETL 2011 — NETL. 2011. *Quality Guidelines for Energy System Studies, Section 1: Specifications for Selected Feedstocks. Draft Report*. NETL, U.S. Department of Energy. February 7, 2011. DOE/NETL-401/012111.

NMA 2009 — National Mining Association. 2009. *2008 Coal Producer Survey*. National Mining Association. Washington, D.C. May, 2009. http://www.nma.org/pdf/members/coal_producer_survey2008.pdf (Accessed December 18, 2009).

NPI 1999 — *Emission Estimation Technique Manual for Explosives Detonation and Firing Ranges*. Department of the Environment, Water, Heritage and the Arts. First published March, 1999.

Peabody 2005	Peabody Energy Company. 2005. *Mine Energy Assessment, Supplemental Report, Peabody Energy Company, Gillette, Wyoming*. Peabody Energy Company.
U.S. EPA 2006	US EPA. 2006. AP 42, Fifth Edition, Volume I, Chapter 13: Miscellaneous Sources. U.S. Environmental Protectin Agency. http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s0204.pdf (Accessed January 23, 2015).
U.S. EPA 2008	EPA. 2008. *U.S. Surface Coal Mine Methane Recovery Project Opportunities*. U.S. EPA. EPA430-R-08-001. http://www.epa.gov/cmop/docs/cmm_recovery_opps_surface.pdf (Accessed January 9, 2012).
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 (Accessed December 21, 2009).

Section III: Document Control Information

Date Created: May 3, 2012

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

Revision History:

20JAN2014

- Combustion emissions removed and diesel input replaced by "Diesel Combustion, Mobile Source, Truck"
- Speciated fugitive dust emissions by size using PM2.5/PM10 ratio from existing source
- Air emissions from ANFO combustion were added to the Air Emissions Factors and Data Summary tabs
- Added inventory level DQI to Data Summary tab

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

NETL (2015). *NETL Life Cycle Inventory Data – Unit Process: Coal Mine Operation – Rosebud – Surface Mining.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: July 2015 (version 02). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses).

Section IV: Disclaimer

Neither the U.S. Department of Energy (DOE) National Energy Technology Laboratory (NETL) nor any person acting on behalf of these organizations:

A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this document, or that the use of any information, apparatus, method, or process disclosed in this document may not infringe on privately owned rights; or

B. Assumes any liability with this report as to its use, or damages resulting from the use of any information, apparatus, method, or process disclosed in this document.

Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by NETL. The views and opinions of the authors expressed herein do not necessarily state or reflect those of NETL.