NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Rosebud Surface Sub-Bituminous Coal Mine Assembly, Construction

Reference Flow: 1 piece (pcs) of Rosebud Surface Coal Mine per kg Coal Produced

Brief Description: This unit process calculates the quantity of each piece of equipment needed to extract and produce coal at a large western surface mine, mining Montana Rosebud sub-bituminous coal, over a 30-year study period.

Section I: Meta Data

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

Year Data Best Represents: 2009

Process Type: Auxillary Process (AP)

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:

Annual Mine Production	*Estimated amount of Rosebud sub-bituminous coal produced by mine over a single year*
Mine Lifetime	*Assumed life of the study period, same as lifetime of plant in LC Stage #3*
Dragline Lifetime	*Expected lifetime of a single dragline, in years*
Shovel Lifetime	*Expected lifetime of a single shovel, in years*
Loader Lifetime	*Expected lifetime of a single loader, in years*
Conveyor Lifetime	*Expected lifetime of a single conveyor, in years*
Drill Lifetime	*Expected lifetime of a single drill, in years*
Crusher Lifetime	*Expected lifetime of a single crusher, in years*
Silo Lifetime	*Expected lifetime of a single silo, in years*
Truck Lifetime	*Expected lifetime of a single truck, in years*
Number of Draglines	*Estimated number of draglines required at one time at the mine*
Number of Shovels	*Estimated number of shovels required at one time at the mine*
Number of Loaders	*Estimated number of loaders required at one time at the mine*
Number of Conveyors	*Estimated number of conveyors required at one time at the mine*
Number of Drills	*Estimated number of drills required at one time at the mine*
Number of Crushers	*Estimated number of crushers required at one time at the mine*
Number of Silos	*Estimated number of silos required at one time at the mine*
Number of Trucks	*Estimated number of trucks required at one time at the mine*

Tracked Input Flows:

Dragline, 8,200 Ton [Installation]	*Total fraction of a single dragline needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Electric Shovel, 120 Tons Payload [Installation]	*Total fraction of a single shovel needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Track Loader, 239 HP [Installation]	*Total fraction of a single loader needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Steel Cord Conveyor System, 72 In [Installation]	*Total fraction of a single conveyor needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Blasthole Drill, 250,000 lbs [Installation]	*Total fraction of a single drill needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Coal Crusher, 254,000 lbs [Installation]	*Total fraction of a single crusher needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*
Steel Coal-Loading Silo, 12000 Tons, Rosebud [Installation]	*Total fraction of a single silo needed over the life of the mine, including replacements, to produce 1 kg of Rosebud sub-bituminous coal*

Mining Truck, 623690 kg [Installation]	*Total fraction of a single truck needed over the life of the mine, including replacements, per 1 kg coal produced*

Tracked Output Flows:

Rosebud Surface Mine per kg Coal Produced [Installation]	*Construction of a single surface coal mine used to produce Rosebud sub-bituminous coal under LC Stage #1, per kg coal produced over the study period (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_Rosebud_Coal_Surface_Mine_2012.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process assembles the types and pieces of equipment required for the construction of a surface coal mine used to extract and produce Rosebud sub-bituminous coal under Life Cycle (LC) Stage #1. The coal produced is transported by rail (LC Stage #2) to an energy conversion facility (LC Stage #3) over a 30 year study period, as described below and outlined in **Figure 1**. Draglines, shovels, loaders, a conveyor system, drills, crushers, silos, and trucks are the included input flows for the assemblies of a single Rosebud surface mine. This assembly process sums the necessary equipment for construction of the surface mine by using the expected equipment lifetimes in comparison to the 30 year study period. Inputs calculated in this way are scaled to produce 1 kg of Rosebud sub-bituminous coal.

Construction data, including the mass of raw materials required to construct a single piece of each type of equipment, are calculated in separate unit processes. Therefore, the following unit processes are considered to be embedded in this assembly unit process: DF_Stage1_C_Dragline_8200ton_2010.02.doc, DF_Stage1_C_Electric_Shovel_120_Tons_Payload_2010.02.doc, DF_Stage1_C_Track_Loader_239_HP_2010.02.doc, DF_Stage1_C_Steel_Cord_Conveyor_System_72in_2010.02.doc,

DF_Stage1_C_Blasthole_Drill_250000lb_2010.02.doc, DF_Stage1_C_Coal_Crusher_254000lb_2010.02.doc, DF_Stage1_C_Steel_Coal_Loading_Silo_Rosebud_2011.01.doc, and DF_Stage1_C_Mining_Truck_623690kg_2010.02.doc. For a discussion of environmental emissions associated with the manufacture of raw materials used in the construction of Rosebud western coal surface mine 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. The total annual production of the representative Rosebud coal surface mine was taken from the Western Energy Company's Rosebud Mine near Colstrip, Montana (WEC 2012). This mine's annual production, 11,158,372,302 kg/year, was multiplied by the length of the study period (default value of 30 years) for a total of 334,751,169,060 kg over the life of the mine.

Data for the number of draglines, electric shovels, and mining trucks used at the mine site were also taken from the representative Rosebud Mine (WEC 2012). There were 4 draglines, 1 shovel/excavator, and 12 trucks; the draglines and shovels were assumed to have a 15-year life expectancy while the trucks had an assumed lifetime of 10 years.

For the track loader, it was assumed that 10 pieces were required at the mine. Each loader was assumed to have a 15 year life expectancy. Specifications for a Goodyear conveyor belt stated that their belts could be expected to last 20 years (Goodyear 2009), so that was assumed to be the lifetime of the entire conveyor system. The conveyor system itself was sized from specifications for a system in use at a Powder River Basin coal mine, so it was assumed that there would only be a single conveyor system constructed.

The SME Mining Engineering Handbook stated that three rotary drills were required during cast blasting of overburden, so it was assumed that the study mine would also require three pieces (SMME 1992). Each of the drills is assumed to have a 15 year lifetime. Manufacturer specifications gave a capacity of 10,000 short tons of coal per hour for a Gundlach coal crusher (Gundlach 2009). This value was converted to kg coal/year, and then the estimated annual mine production was divided by the total, which came out to be a single crusher. This single crusher was assumed to be the only one required to crush coal at the mine, and was also assumed to have a 15 year life expectancy.

BNSF publications listed the number of coal loading silos in use at four Powder River Basin mines, which were used to determine the number of silos required (BNSF 2009). Records for 3 of the 4 stated that some additional slot storage capacity was unaccounted for in the number of silos, and this was taken into account when calculating the number of silos at the study mine. The number of silos averaged out to 5.5, so this number was rounded up to 6 total silos to

account for additional slot storage capacity. Each of the silos was assumed to last the entire length of the 30 year study period.

For each type of equipment, the replacement rate was calculated by dividing the mine lifetime (default value of 30 years) by the expected lifetime of that type of equipment. This resulted in replacement rates of 1.0 pieces/study-period for the silos; 2.0 pieces/study-period for the draglines, shovels, loaders, drills, and crushers; 1.5 pieces for the conveyor system, and 3.0 pieces for the trucks. The final calculation was to multiply the number of each type of equipment required by the replacement rate for the same type of equipment, then divide that value by the estimated total production of the mine over the duration of the study period. These values, in pcs/kg coal produced, are for the fraction of a single piece of each type of equipment required over the life of the study to produce 1 kg of Rosebud sub-bituminous coal.

The annual mine production adjustable parameter is the total amount of Rosebud sub-bituminous coal estimated to be produced at the mine over the life of the mine. This parameter was based on the average yearly production of Western Energy's Rosebud Mind. This variable can be adjusted to reflect a larger or smaller scale surface mine.

The mine lifetime adjustable parameter indicates the temporal boundary of the study. In this case, the default value is 30 years, which can be adjusted to reflect a longer or shorter study period based on mine life expectancy.

The equipment lifetime adjustable parameters give the estimated or assumed life expectancy of a single piece of a given type of equipment. Each of these values was assumed, and can be adjusted to reflect longer or shorter equipment life expectancies.

The final group of adjustable parameters was for the number of each type of equipment required to be in operation at the mine at any given point in time. The default number of track loaders and conveyor systems were assumed values. The number of draglines, shovels, crushers, silos, and trucks was based on data from the representative mine or calculated using data from previous study mines. The number of any type of equipment can be adjusted to reflect assumptions reflecting larger or smaller scale mine operations.

Relevant properties of a single Rosebud coal surface 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

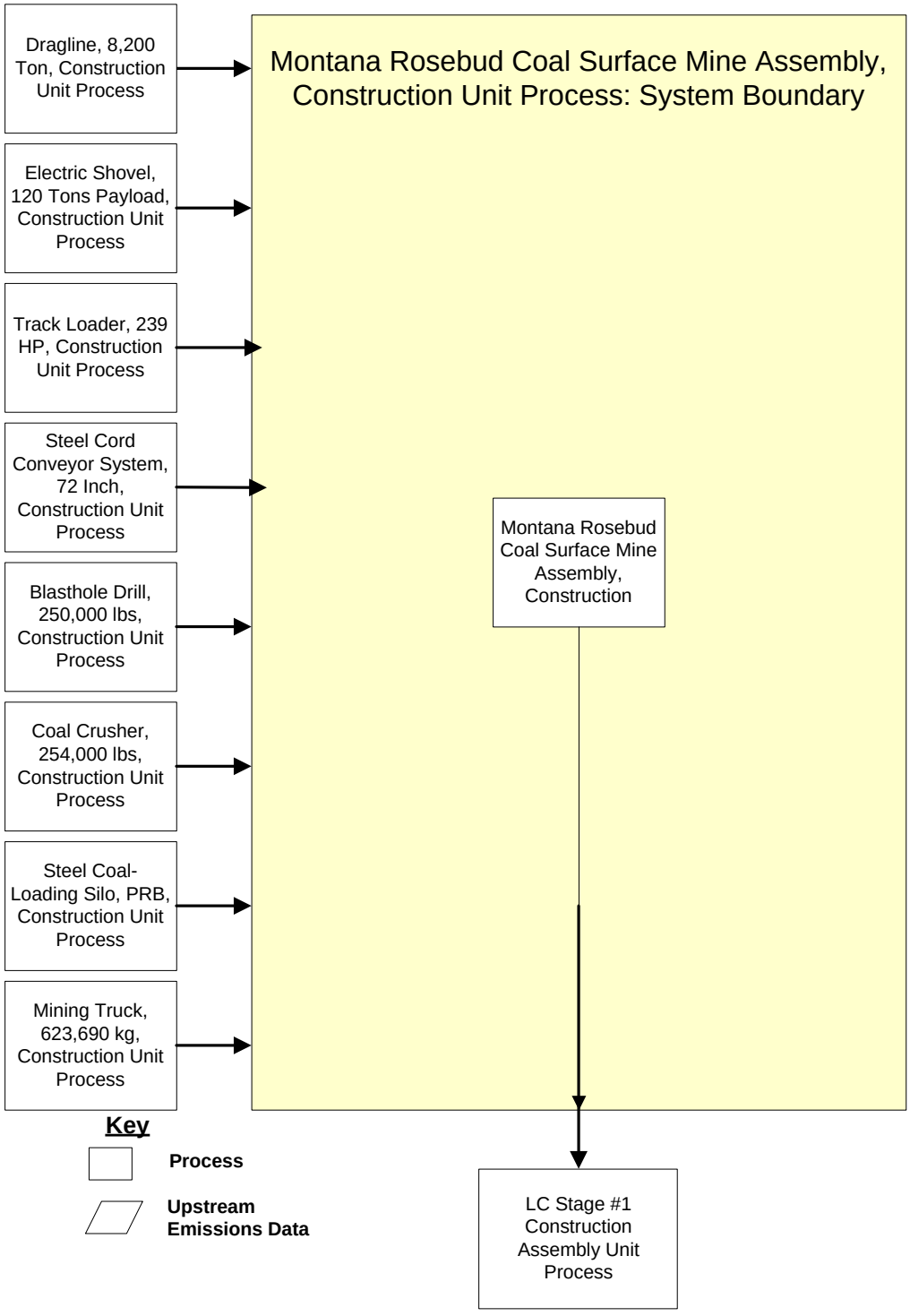

Table 1: Properties of a Single Rosebud Coal Surface Mine

Construction and Life Expectancy Properties		
Property	**Value**	**Units**
Annual mine production	11,158,372,302	kg/yr
Mine lifetime (study period)	30	years
Total amount of Rosebud coal produced over mine lifetime	334,751,169,060	kg
Dragline lifetime	15	years
Shovel lifetime	15	years
Loader lifetime	15	years
Conveyor lifetime	20	years
Drill lifetime	15	years
Crusher lifetime	15	years
Silo lifetime	30	years
Truck lifetime	10	years
Number of draglines	4.0	draglines
Number of shovels	1.0	shovels
Number of loaders	10	loaders
Number of conveyors	1.0	conveyors
Number of drills	3,0	drills
Number of crushers	1.0	crushers
Number of silos	6.0	silos
Number of trucks	12	trucks
Dragline replacement rate	2.0	draglines
Shovel replacement rate	2.0	shovels
Loader replacement rate	2.0	loaders
Conveyor replacement rate	1.5	conveyors
Drill replacement rate	2.0	drills
Crusher replacement rate	2.0	crushers
Silo replacement rate	1.0	silos
Truck replacement rate	3.0	trucks

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Dragline, 8,200 Ton [Installation]	**2.38983E-11**	**pcs**
Electric Shovel, 120 Tons Payload [Installation]	**5.97459E-12**	**pcs**
Track Loader, 239 HP [Installation]	**5.97459E-11**	**pcs**
Steel Cord Conveyor System, 72 In [Installation]	**4.48094E-12**	**pcs**
Blasthole Drill, 250,000 lbs [Installation]	**1.79238E-11**	**pcs**
Coal Crusher, 254,000 lbs [Installation]	**5.97459E-12**	**pcs**
Steel Coal-Loading Silos, 12000 Tons [Installation]	**1.79238E-11**	**pcs**
Mining Truck, 623690 kg [Installation]	**1.07543E-10**	**pcs**
Outputs		
Rosebud Coal Surface Mine per kg Coal Produced [Installation]	1	pcs/kg coal produced

* **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

DF_Stage1_C_Dragline_8200ton_2010.02.doc;

DF_Stage1_C_Electric_Shovel_120_Tons_Payload_2010.02.doc;

DF_Stage1_C_Track_Loader_239_HP_2010.02.doc;

DF_Stage1_C_Steel_Cord_Conveyor_System_72in_2010.02.doc;

DF_Stage1_C_Blasthole_Drill_250000lb_2010.02.doc;

DF_Stage1_C_Coal_Crusher_254000lb_2010.02.doc;

DF_Stage1_C_Steel_Coal_Loading_Silo_Rosebud_2011.01.doc; and

DF_Stage1_C_Mining_Truck_623690kg_2010.02.doc

References

BNSF 2009 — BNSF Railway. 2009. *Guide to Coal Mines: Mines Served by BNSF Railway*. BNSF Railway. http://www.bnsf.com/markets/coal/pdf/mineguide.pdf (Accessed December 18, 2009).

Gundlach 2009 — Gundlach Equipment Corporation. 2009. *Gundlach Breakers*. Gundlach Equipment Corporation. http://www.gundlachcrushers.com/PDF_download/BreakerBrochure.cfm (Accessed December 18, 2009).

SMME 1992 — Society for Mining, Metallurgy, and Exploration, Inc. 1992. *SME Mining Engineering Handbook, 2nd Edition, Volume 2*. Hartman, R.L. Society for Mining, Metallurgy, and Exploration, Inc. http://books.google.com/books?id=DsSmPKEOWDcC&pg=PA1417&lpg=PA1417&dq=number+of+drills+cast+blasting&source=bl&ots=2Nx2t1dJKk&sig=fbJjLoiHnjrLR0rnag-RZMdQrXA&hl=en&ei=xwrvSt_zI5SolAffrpGABQ&sa=X&oi=book_result&ct=result&resnum=2&ved=0CBIQ6AEwAQ#v=onepage&q=number%20of%20drills%20cast%20blasting&f=false (Accessed December 18, 2009).

WEC 2012 — Westmoreland Coal Company. 2012. *Western Energy Company: Rosebud Mine*. Infront Webworks. http://www.westmoreland.com/rosebud (Accessed January 5, 2012).

Section III: Document Control Information

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Section IV: Disclaimer

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