NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Coal Fly Ash Disposal

Reference Flow: 1 kg of fly ash, disposal

Brief Description: Coal fly ash disposed of in a landfill.

Section I: Meta Data

Geographical Coverage: United States **Region:** N/A

Year Data Best Represents: 2010-2013

Process Type: Waste Treatment Process (WT)

Process Scope: Gate-to-Grave (End-of-Life) Process (GE)

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	☐ Other
Releases to Water:	☑ Inorganic	☐ Organic Emissions	☐ Other
Water Usage:	☑ Water Consumption	☐ Water Demand (throughput)	
Releases to Soil:	☐ Inorganic Releases	☐ Organic Releases	☐ Other

Adjustable Process Parameters:

coaltype	*[binary] 0 = bituminous (Illinois #6), 1 = sub-bituminous (PRB)*
waste_to_env	*[kg/kg] kg of leachate that is emitted to fresh water per kg of total leachate*

Tracked Input Flows:

Diesel, combusted in engine	*[Resource]*
Water (ground water) [Water]	*[Resource]*

Fly ash, transported to disposal	*Reference flow*

Tracked Output Flows:

Fly Ash Dust (PM10) [Particles to air]	*Emission to air*
Fly Ash Dust (PM2.5) [Particles to air]	*Emission to air*
Silver [Inorganic emissions to fresh water]	*Emissions to water*
Barium [Inorganic emissions to fresh water]	*Emissions to water*
Cadmium [Inorganic emissions to fresh water]	*Emissions to water*
Chromium [Inorganic emissions to fresh water]	*Emissions to water*
Lead [Inorganic emissions to fresh water]	*Emissions to water*
Mercury [Inorganic emissions to fresh water]	*Emissions to water*
Arsenic [Inorganic emissions to fresh water]	*Emissions to water*
Selenium [Inorganic emissions to fresh water]	*Emissions to water*
Antimony [Inorganic emissions to fresh water]	*Emissions to water*
Beryllium [Inorganic emissions to fresh water]	*Emissions to water*
Nickel [Inorganic emissions to fresh water]	*Emissions to water*
Thallium [Inorganic emissions to fresh water]	*Emissions to water*
Silver [Deposited goods]	*Deposited or treated waste*
Barium [Deposited goods]	*Deposited or treated waste*
Cadmium [Deposited goods]	*Deposited or treated waste*
Chromium [Deposited goods]	*Deposited or treated waste*
Lead [Deposited goods]	*Deposited or treated waste*
Mercury [Deposited goods]	*Deposited or treated waste*
Arsenic [Deposited goods]	*Deposited or treated waste*
Selenium [Deposited goods]	*Deposited or treated waste*
Antimony [Deposited goods]	*Deposited or treated waste*
Beryllium [Deposited goods]	*Deposited or treated waste*
Nickel [Deposited goods]	*Deposited or treated waste*
Thallium [Deposited goods]	*Deposited or treated waste*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_fly_ash_disposal_2014.01.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

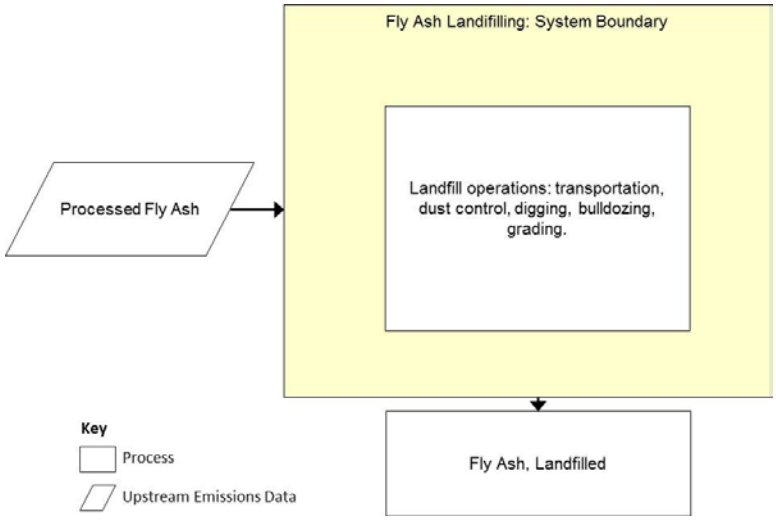
Goal and Scope

This unit process provides a summary of relevant input and output flows associated with disposing of fly ash in a landfill. Earth moving equipment, such as bulldozers, compactors, graders, backhoes, and water trucks are the pieces of equipment used to landfill the fly ash. The process also accounts for the air emissions and leachate incurred during and after the landfilling process. The reference flow of this unit process is: 1 kg of fly ash, disposal.

Boundary and Description

Figure 1 provides an overview of the boundary of this unit process.

Figure 1: Unit Process Scope and Boundary



Coal fly ash landfilling is performed to dispose of the fly ash waste streams transported from other facilities. The amount and type of materials in the fly ash is dependent on the particular coal that was combusted.

The landfilling process and energy requirements are based on the data provided in Section 5 of the Life Cycle Assessment of Coal-fired Power Production developed by the National Renewable Energy Laboratory (NREL) (Spath et al., 1999). The process therein serves as a generic fly ash landfill for a typical U.S. landfill, and contains equipment required to spread and compact landfilled material, maintain haul roads, and provide water for moisture control and dust suppression. NREL developed the data by utilizing results from a study by GAI Consultants, Inc. for the Electric Power Research Institute Coal Ash Disposal Manual: Third Edition. The equipment was used to determine the diesel fuel and water use; however, no additional materials were included for equipment manufacture, and no credits were applied for decommissioning the equipment (Spath et al., 1999).

The default course and fine waste flows are based on a typical landfilling process for coal fly ash. Dry fly ash disposal involves dumping ash from a truck and the movement of a grader and/or other earth moving equipment across the ash surface which produces fugitive particulate emissions. The fugitive air emissions were calculated using data from a 2013 study titled Fugitive particulate emission factors for dry fly ash disposal (Mueller et al., 2013). The study measured hourly airborne mass concentrations for particles smaller than 2.5 micron (PM2.5) and 10 micron (PM10) along with meteorological conditions and atmospheric turbidity at high temporal resolution to characterize and quantify fugitive fly ash emissions. The researchers then computed fugitive fly ash transport and dispersion using the on-site meteorological data and a regulatory air pollutant dispersion model (AERMOD) (Mueller et al., 2013).

When ash is placed into a landfill, the resulting leachate depends on conditions such as precipitation, leachability of the fly ash, type of fly ash, and soil factors such as source (urban or rural location), age, mineral compositions, as well as the degree to which the soil is weathered. The residence time at the landfill also affects the amount of leachate generated. Summing all these factors makes it extremely difficult to predict process-level leachability (Spath et al., 1999). The data utilized in this unit process is derived from a US EPA Microsoft Access Database developed for EPA's Proposed Rule "Hazardous and Solid Waste Management System: Identification and Listing of Special Wastes; Disposal of Coal Combustion Residuals from Electric Utilities" (75 FR 35128) (EPA, 2010). The data was down-selected for toxicity characteristic leaching procedure (TCLP) values closest to the representative coal fly ash types utilized in this process, Illinois No. 6 and Powder River Basin. All values for chemical constituents were then averaged and converted to amounts per kg fly ash using the TCLP dilution factor of 1:20 by mass (EPA, 1992). These values represent conservative upper limits on the total leachable amount of each chemical constituent.

Because landfills may be required to control emissions by treating leachate water prior to discharge, a parameter was added to provide the ability to divert flows as simply deposited waste rather than being discharged to fresh water. This method discounts any energy required to process leach water and is also applied to all of the leachates when it may be possible to treat for only specific flows.

Table 1 shows the input and output flows of this unit process. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

Table 1: Unit Process Input and Output Flows

Flow Name	Illinois #6	PRB	Units (Per Reference Flow)
Inputs			
Diesel, combusted in engine	1.01E-03	1.01E-03	kg
Water (ground water) [Water]	7.60E-02	7.60E-02	kg
Fly ash, transported to disposal	1.00E+00	1.00E+00	kg
Outputs			
Fly Ash Dust (PM10) [Particles to air]	9.60E-05	9.60E-05	kg/kg
Fly Ash Dust (PM2.5) [Particles to air]	1.80E-05	1.80E-05	kg/kg
Silver [Inorganic emissions to fresh water]	8.90E-07	1.00E-07	kg/kg
Barium [Inorganic emissions to fresh water]	5.07E-06	7.90E-06	kg/kg
Cadmium [Inorganic emissions to fresh water]	4.50E-07	1.00E-07	kg/kg
Chromium [Inorganic emissions to fresh water]	6.75E-06	5.00E-07	kg/kg
Lead [Inorganic emissions to fresh water]	1.22E-06	1.00E-06	kg/kg
Mercury [Inorganic emissions to fresh water]	2.00E-08	2.00E-08	kg/kg
Arsenic [Inorganic emissions to fresh water]	5.70E-07	8.20E-07	kg/kg
Selenium [Inorganic emissions to fresh water]	1.14E-06	2.00E-06	kg/kg
Antimony [Inorganic emissions to fresh water]	5.20E-06	0.00E+00	kg/kg
Beryllium [Inorganic emissions to fresh water]	8.00E-07	0.00E+00	kg/kg
Nickel [Inorganic emissions to fresh water]	1.14E-05	0.00E+00	kg/kg
Thallium [Inorganic emissions to fresh water]	2.00E-07	0.00E+00	kg/kg
Silver [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Barium [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Cadmium [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Chromium [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Lead [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Mercury [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Arsenic [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Selenium [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Antimony [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Beryllium [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Nickel [Deposited goods]	0.00E+00	0.00E+00	kg/kg
Thallium [Deposited goods]	0.00E+00	0.00E+00	kg/kg

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

Embedded Unit Processes

None.

References

Mueller *et al.* 2013	Mueller, Stephen F., et al. "Fugitive particulate emission factors for dry fly ash disposal." Journal of the Air & Waste Management Association 63.7 (2013): 806-818
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Spath *et al.* 1999	P.L. Spath, M.K. Mann, D.R. Kerr, Life Cycle Assessment of Coal-fired Power Production, National Renewable Energy Laboratory, Golden, CO, 1999.
EPA 1992	EPA Test Method 1311 Toxicity Characteristic Leaching Procedure July 1992 http://www.epa.gov/osw/hazard/testmethods/sw846/pdfs/1311.pdf Accessed 22 May 2014
EPA 2010	USEPA Office of Resource Conservation and Recovery (ORCR) Coal Combustion Residuals (CCR) Constituent Database 2010. Docket ID EPA-HQ-RCRA-2009-0640 http://www.regulations.gov/#!documentDetail;D=EPA-HQ-RCRA-2009-0640-0028 Accessed 16 April 2014
EPA 2014	EPA (2014). A-400 DRAFT Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2012. EPA. Washington, DC. http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Annex-6-Additional-Information.pdf

Section III: Document Control Information

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