NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Coal Energy Conversion U.S. Fleet Average

Reference Flow: 1 MWh of Electricity

Brief Description: The operations of the U.S. fleet average Coal power generation facilities.

Section I: Meta Data

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

Year Data Best Represents: 2007

Process Type: Energy Conversion (EC)

Process Scope: Gate-to-Gate (GG)

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:

Carbon_Factor   *Amount of carbon (in kg) per MJ of coal feed to the power plant*

Heat_in   *Heat rate of power plant (in MJ/MWh)*

Tracked Input Flows:

Coal   *Coal extraction and delivery to the fleet average power plant*

Tracked Output Flows:

Electricity   *Reference flow; 1 MWh of electricity generation*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_Coal_Fleet_Average_2012.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

This unit process provides fleet average, minimum, and maximum values for various air emissions for representative U.S. coal-fired power plant operations based on 1 MWh of electricity production. The scope of this process is restricted to the direct emissions that result from conversion of coal to electricity (LC Stage 3 Operations). Key outputs include electricity, greenhouse gas emissions to air, and other air pollutant emissions, specifically mercury, carbon monoxide (CO), nitrogen oxides (NO_X), and sulfur dioxide (SO_2). The water consumption and withdrawal values are also reported.

Boundary and Description

The Emissions & Generation Resource Integrated Database (eGRID) provides an inventory of operating data and emissions for U.S. power plants (EPA 2011a). The latest edition is eGRID 2010, which contains operating and emissions data for 2007. The Microsoft Excel based version of eGRID allows the user to select several different parameters to sort the list of power generation facilities as desired. In the 2010 version, there were a total of 5,172 plants generating electricity from coal, natural gas, oil, nuclear, hydro, biomass, wind, and solar.

The eGRID data file was filtered to generate a list of facilities that are representative of an average coal power facility in the U.S. The first level of filtering involved setting the "primary fuel generation" category to coal. More than one type of coal is reported in eGRID, and thus the "plant primary fuel" selections were chosen as bituminous coal, subbituminus coal, and lignite. Other filtering criteria include nameplate capacity, capacity factor, biomass co-firing, and combined heat and power (CHP). **Table 1** lists the criteria applied for this analysis along with the number of plants that remained after each filter level. Each filtering criteria is discussed below.

Table 1: eGRID Coal Power Plant Filtering Levels

Filter Level	Number of Plants
0 – Primary Fuel Generation = Coal	572
1 – Plant Nameplate Capacity ≥ 250 MW	332
2 – Plant Capacity Factor ≥ 0.4	287
3 – No Use of Biogas/Biomass	284
4 – Not Operated as Combined Heat and Power (CHP)	272
5 – 95% or Greater Annual Power Gen from Coal	256

The first level of filtering was based on the plant nameplate capacity. As shown in **Table 2**, 42 percent of the coal fired power plants in the U.S. have a capacity of less than 250 MW and combined generate only 4.3 percent of the total coal-based electricity. For this reason, plants with nameplate capacities less than 250 MW were excluded from this analysis. The second level of filtering was based on the plant capacity factor. Coal-fired power plants primarily support the base power load, so they have higher capacity factors than other types of fossil fuel-based electricity generation facilities. The cut off capacity factor chosen for this analysis was 0.4. **Table 3** shows that the 23.4 percent of coal power plants with a capacity factor of less than 0.4 are responsible for only 5.4 percent of the total coal-based electricity.

Table 2: U.S. Coal Power Plant Size and Output for 2007

Plant Nameplate Capacity (MW)	Number of Plants	Percent of Total Plants	2007 Power Gen (MWh)	Percent of Total Generation
0 – 100	163	28.5%	2.98E+07	1.4%
100 – 250	77	13.5%	5.97E+07	2.9%
250 – 500	83	14.5%	1.51E+08	7.3%
500 – 1,000	101	17.7%	3.63E+08	17.6%
1,000 – 1,500	63	11.0%	4.18E+08	20.3%
1,500 – 2,000	50	8.7%	4.89E+08	23.7%
2,000 – 2,500	18	3.1%	2.50E+08	12.1%
2,500 – 3,000	11	1.9%	1.67E+08	8.1%
3,000 – 3,500	3	0.5%	6.61E+07	3.2%
3,500 – 4,000	3	0.5%	6.81E+07	3.3%
Total	572	100.0%	2.06E+09	100.0%

Table 3: U.S. Coal Power Plant Capacity Factor and Output for 2007

Plant Capacity Factor	Number of Plants	Percent of Total Plants	2007 Power Gen (MWh)	Percent of Total Generation
0.0 – 0.1	17	3.0%	2.58E+06	0.1%
0.1 – 0.2	24	4.2%	3.52E+06	0.2%
0.2 – 0.3	41	7.2%	4.24E+07	2.1%
0.3 – 0.4	52	9.1%	6.11E+07	3.0%
0.4 – 0.5	66	11.5%	1.26E+08	6.1%
0.5 – 0.6	76	13.3%	2.74E+08	13.3%
0.6 – 0.7	116	20.3%	4.78E+08	23.2%
0.7 – 0.8	106	18.5%	6.44E+08	31.2%
0.8 – 0.9	63	11.0%	3.78E+08	18.3%
0.9 – 1.0	11	1.9%	5.13E+07	2.5%
Total	572	100.0%	2.06E+09	100.0%

The next two levels of filtering criteria were based on the co-firing of biogas/biomass long with coal and the operation as a combined heat and power facility (CHP) or co-generation facility. CHP, or co-generation facilities, generate both electricity and heat or steam for industrial or commercial purposes (EPA 2011a). As the purpose of this emissions estimate is to characterize the typical coal power plant, it was decided to remove those facilities that

DF_Stage3_O_Coal_Fleet_Average_2012.01.doc

implement biogas/biomass co-firing and those that operate as CHP facilities. As indicated by **Table 1**, these two levels of filtering remove 15 plants from the analysis. The majority of coal power plants that operate as CHP facilities are typically those that have a much smaller capacity. The final level of filtering was related to the percentage of annual power generation that is attributed to coal at the facility. All of the coal power plants co-fired some amount of oil or natural gas. To ensure that the emissions values were indicative of coal power plants, any facility that generated more than 5 percent of its annual power from oil or natural gas was excluded from the analysis. This final level of filtering removed 16 plants from the list. After all of the filters have been applied, the number of coal-powered electricity generation facilities was reduced from 572 to 256 plants.

The latest edition of eGRID does not contain values for carbon monoxide and mercury emissions. Carbon monoxide emissions were based on the value from the EXPC LCA (NETL 2010). It was assumed that the CO emissions would not vary significantly based on the feed since CO is controlled. The Toxics Release Inventory (TRI) was used to determine the mass of mercury emissions to air from coal power plants (EPA 2011b). The most recent data available in the TRI is for 2009 operations. Data in the TRI is accessed by selecting the corresponding North American Industry Classification System (NAICS) code for the desired industry. For this analysis, the appropriate NAICS code is 221112, which represents Fossil Fuel Electric Power Generation. It was assumed that all mercury emissions for this NAICS code were from coal power production. To find the appropriate emission factor with respect to the reference flow, the annual coal power production output for 2009 was calculated from EIA data (2011).

Carbon dioxide emissions were calculated using the heat rate of the plant and a carbon emission factor for coal. The heat rate of the plant, in MJ/MWh was determined based on the plants survey in eGRID (EPA 2011a). The carbon emission factor for coal was calculated from the results of a study which surveyed lignite, bituminous, and sub-bituminous coal samples from over 200 counties in the United States (Quick 2010).

Table 4 shows the average, minimum, and maximum air emissions associated with the 256 representative coal power plants identified in **Table 1**. For each air emission other than mercury, potential outliers were removed from the data set by discarding the top and bottom 5 percent of the individual emissions values when calculating the average, minimum, and maximum. Entire plants were not excluded based on this 5 percent rule as there was no evidence of a correlation between emissions. For example, a potential outlier in the NO_X category may not be associated with the same plant as a potential outlier in the SO_2 category.

Table 4 shows the water withdrawal and consumption values to be used for the fleet average coal power plant. These values are based on the NETL evaluation of freshwater needs for thermoelectric generation requirements updated in 2011 (NETL 2011). The weighted average water withdrawal and consumption values were calculated based on the breakdown of boiler type (subcritical, supercritical) and cooling technology (wet recirculation, once-through, dry, cooling pond).

Table 4: Unit Process Flows

Flow Name	Average eGRID[1]	Minimum eGRID[1]	Maximum eGRID[1]	Units (Per Reference Flow)
Inputs				
Coal	11,244	9,756	13,072	MJ
Water (surface water)	20,654	20,654	20,654	kg
Water (ground water)	20,654	20,654	20,654	kg
Outputs				
Electricity [Reference flow]	1	1	1	MWh
Carbon dioxide [Inorganic emissions to air]	1,013	879	1,178	kg
Carbon monoxide [Inorganic emissions to air]	0.11	0.11	0.11	kg
Methane [Inorganic emissions to air]	0.0113	0.0098	0.0131	kg
Nitrous oxide [Inorganic emissions to air]	0.0169	0.0146	0.0195	kg
Nitrogen oxides [Inorganic emissions to air]	1.435	0.521	2.728	kg
Sulfur dioxide [Inorganic emissions to air]	3.986	0.475	11.867	kg
Mercury [Inorganic emissions to air]	2.41E-05	2.41E-05	2.41E-05	kg
Water (wastewater) [Water]	804	804	804	kg

[1]eGRID average, minimum, and maximum scenarios involve changes in heat rate, methane, nitrous oxide, NO_X and SO_2 only. Mercury and carbon monoxide emissions are constant for all scenarios. Carbon dioxide is production a function of heat rate and carbon factor. The values presented in this table for carbon dioxide assume the average carbon factor, with varying heat rates based on eGRID data.

Embedded Unit Processes

None.

References

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DF_Stage3_O_Coal_Fleet_Average_2012.01.doc

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Section III: Document Control Information

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Section IV: Disclaimer

DF_Stage3_O_Coal_Fleet_Average_2012.01.doc