



NETL Life Cycle Inventory Data

Process Documentation File

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_Biomass_Firing_Stoker_Boiler_Retrofit_2011.02.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers the conversion of dried or torrefied biomass to electricity via a stoker boiler power plant that was originally designed for coal-fired power production. This unit process assumes that the facility has been modified so as to be able to handle ground and dried, or ground and torrefied biomass. The use of torrefied versus dried biomass is accounted for via alteration of the feed rate for biomass (in kg), assuming energy required must remain constant for cofiring, and that the mass of required biomass must be adjusted to maintain the required energy input. Heating values used for the calculation of feed rates account for moisture content of the incoming biomass.

This unit process considers biomass consumption, water use, wastewater production, and airborne emissions of carbon dioxide and criteria pollutants for which emissions data were available. Electricity produced within this unit process is presumed to be delivered to end users under subsequent life cycle stages or via other additional environmental modeling. The calculations presented for this unit process are based on the reference flow of 1 MWh of electricity, as described below and shown in **Figure 1**. This unit process is used under Life Cycle (LC) Stage #3 to assist in the conversion of biomass to electricity.

Boundary and Description

This unit process is applicable to the following types of biomass: short rotation woody crops (SRWC), corn stover, and switchgrass. Depending on the type of biomass that is used, the user of this unit process must insert the appropriate biomass feed rate into the "Biom_Feed" parameter. Feed rates are determined based on the heating content of each type of biomass, such that an equivalent amount of energy is input into the process for each type of biomass utilized. Parameter values for each type of biomass are shown in **Table 1**.

Energy inputs within the scope of the unit process are limited to the consumption of biomass input to the stoker boiler. Other energy requirements, such as electricity required for feedstock handling and other parasitic loads, are accounted for as reduced overall net generation capacity of the plant. Parasitic loads of the plant are not explicitly quantified within the unit process, but are instead considered within the biomass electricity production data source (EERE 1997) that serves as a basis for this unit process.

Table 1: Parameter Values for Biomass (NETL 2007, 2010a, b, c, 2012)

Biomass Type	Cultivation CO ₂ Uptake (kg CO ₂ /kg biomass)	Heating Value (HHV) at 0% moisture (Btu/lb)	Moisture Content, as harvested (%)
Short Rotation Woody Crops	0.96	8438	50%
Switchgrass	1.33	7787	15%
Corn Stover	1.39	7528	15%

Air quality emissions resulting from combustion of biomass in the stoker boiler are quantified using emission factors from an investigation of standalone biomass firing and coal-biomass cofiring, which was completed in 1997 (EERE, 1997). The data contained in this source was nearly 15 years old at the time of publication of this document. However, the analysis contained in EERE (1997) is comprehensive in that it provides feed rates and airborne emissions data for biomass combustion within a coal fired stoker boiler. Therefore, while EERE (1997) was selected as the best available data source for some of the calculations contained in this unit process, its vintage is a data limitation, and additional data development should be completed in the event that newer data become available.

The biogenic CO₂ emissions resulting from the combustion of biomass in the stoker boiler were based on existing NETL unit processes that describe the uptake of CO₂ during the cultivation stage of the biomass (NETL 2010a, b, c). These values are adjusted according to the change in moisture content across the biomass dryer to ensure that the biogenic CO₂ balances between cultivation and combustion.

Figure 1 provides an overview of the boundary of this unit process. As shown, biomass that is produced, transported, and dried or torrefied within upstream unit processes is input to this energy conversion process. Within the boundary of the unit process, biomass feed rates needed to support energy conversion are identified, and air emissions, water use from groundwater and surface water, solid waste generation, and wastewater production are quantified. This unit process is aggregated with other life cycle stage #3 unit processes in order to evaluate total input and emission flows, prior to the distribution of electricity to the end user.

Figure 1: Unit Process Scope and Boundary

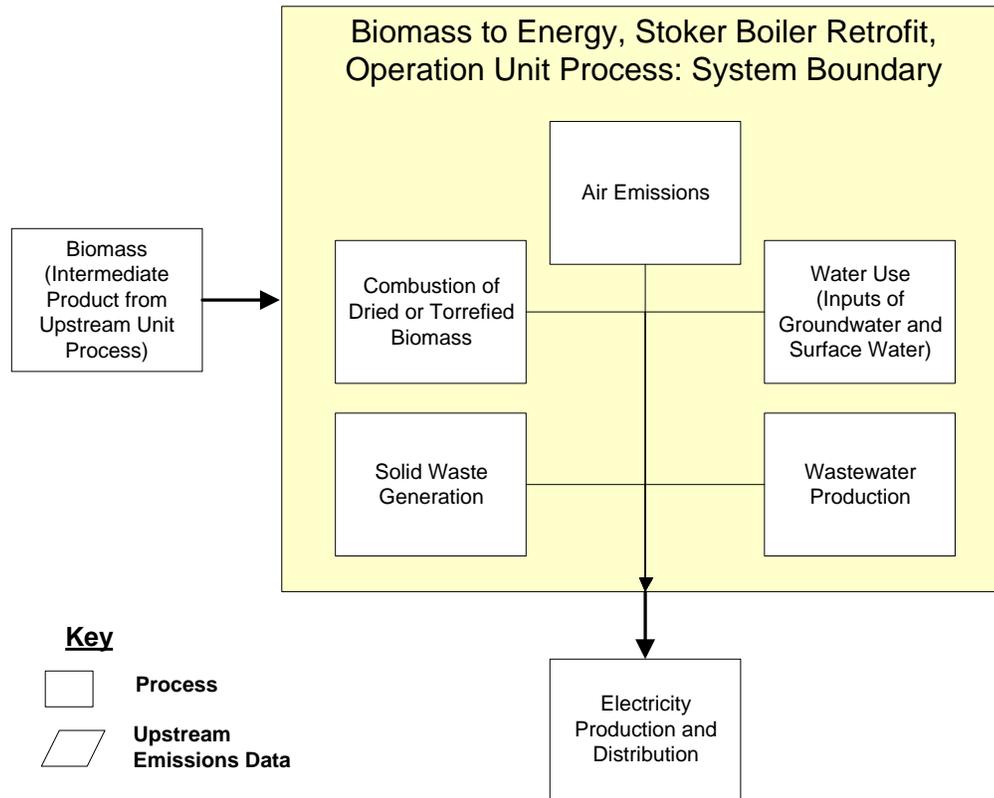


Table 1 summarizes biomass feed rate values for each of the four biomass types that are applied within this unit process. **Table 2** provides a summary of modeled input and output flows for a stoker boiler firing SRWC. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)
Inputs		
Biomass [Intermediate Product]	7.36E+02	kg
Water (surface water) [Water]	1.26E+03	kg
Water (groundwater) [Water]	1.26E+03	kg
Outputs		
Electricity	1.00E+00	MWh
Carbon dioxide, biogenic [Inorganic emissions to air]	1.18E+03	kg
Nitrogen oxides [Inorganic emissions to air]	3.22E-01	kg
Sulphur oxides [Inorganic emissions to air]	1.47E-01	kg
Carbon monoxide [Inorganic emissions to air]	2.66E-01	kg
Dust (PM10) [Particles to air]	7.95E-02	kg
Solid Waste (unspecified) [Solid Waste]	5.01E+00	kg
Water (returned to receiving body) [Water]	5.66E+02	kg

* **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

- EERE 1997 United States Department of Energy, Energy Efficiency and Renewable Energy. 1997. Renewable Energy Technology Characterizations. Available at: http://www1.eere.energy.gov/ba/pba/pdfs/entire_document.pdf Accessed on May 1, 2011.
- NETL 2007 NETL. 2007. *Increasing Security and Reducing Carbon Emissions of the U.S. Transportation Sector: A Transformational Role for Coal with Biomass*. (DOE/NETL-2007/1298). Pittsburgh, PA: National Energy Technology Laboratory
- NETL 2010a NETL (2010a). *NETL Life Cycle Inventory Data – Unit Process: Corn Stover Cultivation, Operation*. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: June 2012 (version 02). www.netl.doe.gov/energy-analyses (<http://www.netl.doe.gov/energy-analyses>)
- NETL 2010b NETL (2010b). *NETL Life Cycle Inventory Data – Unit Process: SRWC Cultivation, Operation*. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: June 2012 (version 02). www.netl.doe.gov/energy-analyses (<http://www.netl.doe.gov/energy-analyses>)

- NETL 2010c NETL (2010c). *NETL Life Cycle Inventory Data – Unit Process: Switchgrass Cultivation, Operation*. U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: June 2012 (version 02). www.netl.doe.gov/energy-analyses (<http://www.netl.doe.gov/energy-analyses>)
- NETL 2012 NETL. (2012). *Greenhouse Gas Reductions in the Power Industry Using Domestic Coal and Biomass Volume 2: Pulverized Coal Plants*. (DOE/NETL-2012/1547). Pittsburgh, PA: National Energy Technology Laboratory, from <http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&SourSo=Main&PubId=426>

Section III: Document Control Information

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