NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Biomass Drying for Coal-Biomass Cofiring

Reference Flow: 1 kg of Dried Biomass

Brief Description: This unit process quantifies the energy requirements and airborne emissions that are expected to result from the biomass drying process, where the biomass type being dried is short rotation woody crop (SRWC) biomass.

Section I: Meta Data

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

Year Data Best Represents: 2006

Process Type: Auxiliary Process (AP)

Process Scope: Gate-to-Gate Process (GG)

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:

Wood_Moisture	*Proportion of moisture in incoming wood biomass feedstock, by mass*
Wood_Moisture_D	*Proportion of moisture in dried wood biomass feedstock, by mass*
Drying_NG	*Mass of natural gas to required to remove 1 kg of water during biomass drying process*

Tracked Input Flows:

Biomass [Intermediate product]	*Biomass generated and transported within the boundary of the study*
External Combustion Boilers, Industrial, Natural Gas, > 100 Million Btu/hr, SCR	*Amount of natural gas combusted.*

Tracked Output Flows:

Dried Biomass [Intermediate Product]	*Reference flow*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage3_O_Biomass_Drying _2011.03.xlsx*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers drying of moist biomass, in support of coal-biomass cofiring, as described in greater detail below. Biomass drying is the process of removing excess water from moist biomass, as delivered to the energy conversion facility, in order to make it suitable for combustion and power production. This unit process considers energy use (natural gas) as well as emissions of non-methane VOCs from the dried wood. Combustion emissions are calculated in a upstream unit process. Dried biomass produced within this unit process is routed into additional processing and/or energy conversion facilities downstream. The calculations presented for this unit process are based on the reference flow of 1 kg of dried biomass, 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 via coal-biomass cofiring.

Boundary and Description

Biomass drying is necessary to remove water from raw short rotation woody crop (SRWC) biomass, which is presumed to have a moisture content of 25% (varying from 5% to 50%) as it arrives from biomass production and transport. Natural gas is presumed to be the sole source of heat energy used for biomass drying. Energy use within the scope of the unit process is therefore limited to the consumption of natural gas, as it is burned for heating. Other energy requirements, such as electricity or diesel fuel required for loading and biomass handling, or process requirements such as conveyors and other electrically powered processes, are assumed to be negligible, and were not quantified.

The drying process for SRWC biomass releases non-methane VOCs directly, as the biomass is heated and water is driven off. Volatile emissions are quantified based on

Banerjee et al (2006), and account for 2.19E-04 kg NMVOC per kg of dried biomass, which is nearly double the NMVOC emissions associated with natural gas combustion.

Figure 1 provides an overview of the boundary of this unit process. As shown, biomass that is produced and transported within upstream unit processes is input to biomass drying operations. Natural gas combustion is input to the system using an upstream emissions profile. Other energy use is presumed to be negligible. Volatile emissions from the wood biomass as it is heated are quantified. This unit process then feeds into a separate unit process used for evaluating coal-biomass or biomass to electricity within an energy conversion facility.

Figure 1: Unit Process Scope and Boundary

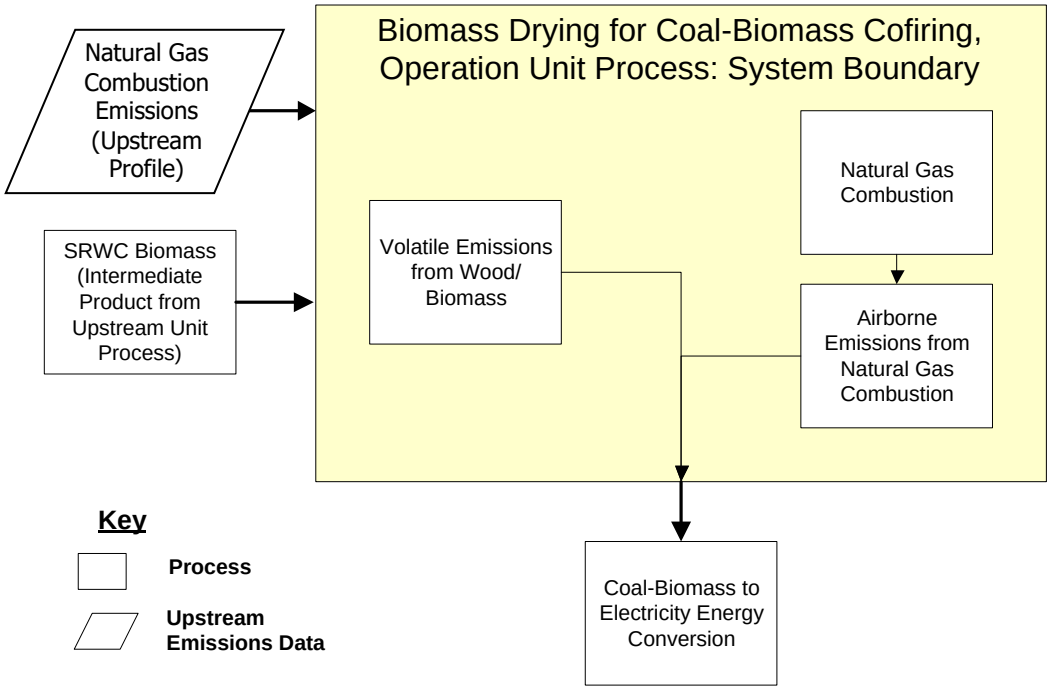

Table 1 summarizes airborne emissions factors and energy inputs and outputs that are applied within this unit process. **Table 2** provides a summary of modeled input and output flows. Additional detail regarding input and output flows, including calculation methods, is contained in the associated DS.

Table 1: Relevant Emission Factors

Flow Name	Value	Units (Per Reference Flow)
NMVOC emissions from wood drying	2.192E-04	kg/kg biomass

Table 2: Unit Process Input and Output Flows

Flow Name	Value	Units (Per Reference Flow)	DQI
Inputs			
Biomass [Intermediate Product]	**1.22**	**kg**	**2,2**
External Combustion Boilers, Industrial, Natural Gas, > 100 Million Btu/hr, SCR	**2.32E-02**	**kg**	**2,2**
Outputs			
Dried Biomass [Intermediate product]	1.00E+00	kg	2,2
NMVOC (unspecified) [Group NMVOC to air]	2.19E-04	kg	1,1

* **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

Banerjee et al. 2006 — Banerjee, S., et al. 2006. "Process-Based Control of HAPs Emissions from Drying Wood Flakes." Environmental Science and Technology 40(7): 2438-2441.

Battye et al. 1994 — Battye R., et al. 1994. Development and Selection of Ammonia Emissions Factors, Final Report. US Environmental Protection Agency, Washington, D.C. http://www.epa.gov/ttn/chief/old/efdocs/ammonia.pdf (Accessed December 16, 2009).

Ciolkosz and Wallace 2011 — Ciolkosz and Wallace. 2011. A review of torrefaction for bioenergy feedstock production. Biofuels, Bioproducts, and Biorefining: 10.1002/bbb275. Available at http://onlinelibrary.wiley.com/doi/10.1002/bbb.275/full (Accessed April 27, 2011).

FEMP 2004 — Federal Energy Management Program. 2004. Biomass Cofiring in Coal-Fired Boilers. DOE/EE-0288 Federal Technology Alert. Available at http://www.nrel.gov/docs/fy04osti/33811.pdf (Accessed on April 9, 2012)

Section III: Document Control Information

Date Created:	July 28, 2011
Point of Contact:	Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV
Revision History:	
03MAY2012	Added mercury emissions; updated incoming biomass moisture content.
29DECEMBER2014	Updated to reflect combustion removal. Natural gas combustion is now an input. Added inventory item level DQI data to the data summary tab.

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

> NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Biomass Drying for Coal-Biomass Cofiring, Operation.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: December 2014 (version 03). 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.