NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Switchgrass, Land Preparation, Operation

Reference Flow: 1 kg Switchgrass

Brief Description: Operations for land preparation for switchgrass, including an inputs of combusted diesel and required land area, and outputs of fugitive dust emissions.

Section I: Meta Data

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

Year Data Best Represents: 2008

Process Type: Installation Process (IP)

Process Scope: Cradle-to-Gate Process (CG)

Allocation Applied: No

Completeness: Individual 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:

Biomass_yield_y	*Annual yield rate of switchgrass (kg/acre-year)*
Study_period	*The number of years in the study period*

Tracked Input Flows:

Diesel Combustion, Mobile Sources, Truck [Refinery products]	*Amount of diesel combusted within the mobile source.*
Equipment Assembly per kg Biomass [Valuable substances]	*Amount of farm equipment required for 1 kg of biomass.*

Tracked Output Flows:

Switchgrass [biomass] | *Land preparation production flow for switchgrass.*

Section II: Process Description

Associated Documentation

This unit process is comprised of this document, as well as the data sheet (DS) *DS_Stage1_O_SGLandprep_2011.03.xlsx*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

This unit process accounts for the operating activities for the preparation of land for switchgrass production. The process is based on the reference flow of 1 kg of switchgrass production. The inputs to the process include diesel and land use. Diesel is used as fuel for the land preparation equipment (a motor grader and a track bulldozer); the energy and material flows for the upstream production and delivery of diesel are not included in the boundaries of this process. Diesel combustion is handled in a linked upstream unit process which accounts for the associated combustion emissions. Land use, expressed in terms of acres per unit production of switchgrass, is considered a resource that involves no upstream operating or construction activities. The fugitive dust from the use of land preparation equipment are included in this unit process. Fugitive dust is categorized as particulate matter (PM10 and PM2.5) emissions to air. Water use and emissions to water are not characterized in this process, because they are assumed to comprise a negligible contribution to the direct operations of land preparation.

Boundary and Description

Operations for the preparation of land for switchgrass production are based on the estimated diesel consumption of farming equipment, fugitive dust emissions caused by surface dust that is disturbed by land preparation equipment, and the annual yield rate of switchgrass. **Figure 1** provides an overview of the boundary of this unit process. Rectangular boxes represent relevant sub-processes, while trapezoidal boxes indicate upstream data that are outside of the boundary of this unit process. As shown, upstream emissions associated with the production and delivery of electricity and diesel fuel are accounted for outside of the boundary of this unit process. The methods for calculating these operating activities are described below.

There are two adjustable parameters in this unit process: the annual yield of switchgrass and the study period. The annual yield of switchgrass (kg/acre-year) is used to translate the values for diesel consumption, land use, and fugitive dust emissions from a basis of quantity per acre to a basis of quantity per kilogram of

switchgrass production. NETL currently recommends a default value of 3,569 kg/acre–year for this parameter based on the Calculating Uncertainty in Biomass Emissions (CUBE) model (NETL 2011). The study period is used to determine the amount of land needed to produce one kg of switchgrass.

Diesel is consumed by a track bulldozer and a motor grader. A track bulldozer consumes an average of 12 gallons of diesel per hour (BAH 2005). Based on equipment specifications published by a heavy equipment manufacturer, the width of a bulldozer bucket is 177 inches (14.75 feet) (Caterpillar 2009c). Assuming that the bulldozer operates in second gear, the manufacturer specifications for the bulldozer show an operating speed of 4.2 miles per hour (Caterpillar 2010). By multiplying the width of the blade by the operating speed of the bulldozer, the land coverage rate of the bulldozer is estimated at 7.5 acres per hour. Multiplying this land coverage rate by the fuel consumption rate, the estimated diesel consumption for is 1.60 gal/acre. This calculation assumes that the bulldozer makes a single pass over the site.

Similarly, the motor grader consumes an average of 17.5 gallons per hour (BAH 2005). The scraper blade of the motor grader is 14 feet wide (Caterpillar 2009). Assuming the motor grader operates in third gear, the speed of the motor grader has an average operating speed of 5 miles per hour (Caterpillar 2009). The width and speed of the motor grader translate to a land coverage rate of 8.48 acres per hour, which, when factored with the fuel consumption rate, results in consumption rate of 2.06 gal of diesel per acre. This unit process assumes that the motor grader must make two passes of the land site, which doubles the total fuel consumption of the motor grader to 4.12 gal/acre.

The combined diesel consumption of the track bulldozer and motor grader is the sum of 1.60 gal/acre and 4.12 gal/acre, which equals 5.72 gal/acre (21.7 L/acre). This unit process assumes that the engines of the track bulldozer and motor grader are greater than 175 horsepower. The emissions for the required amount of diesel combusted for this process are accounted for in an upstream diesel combustion process. That process is pulled as an input to this process.

The impacts associated with the manufacturing of the farm equipment are accounted for in a separate unit process. This process scales the manufacturing processes based on the amount of biomass demanded.

Fugitive dust emissions are generated by the disturbance of surface soil land preparation. Fugitive dust emissions from land preparation are estimated using an emission factor specified by Western Regional Air Program (WRAP) (Countess Environmental 2004), which conducted air sampling studies on ripping and subsoiling practices used for breaking up soil compaction. The emission factor for fugitive dust is 4.6 lb PM10/acre-pass. The track bulldozer makes one pass of the site and thus has a fugitive dust emission factor of 4.6 lbs PM10/acre; the motor grader makes two passes on the site and thus has a fugitive dust emission factor of 9.2 lbs PM10/acre. The total emissions of fugitive dust are 13.8 lbs PM10/acre,

which is the sum of the emission factors for the track bulldozer and motor grader. Dividing this by the 30 year horizon time of the study, the emission factor is 0.21 kg PM10/acre-yr. The ratio of PM2.5 to PM10 utilized for this study is 0.15 kg PM2.5/kg PM10.

Properties of switchgrass relevant to this unit process are indicated in **Table 1**. **Table 2** provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

Figure 1: Unit Process Scope and Boundary

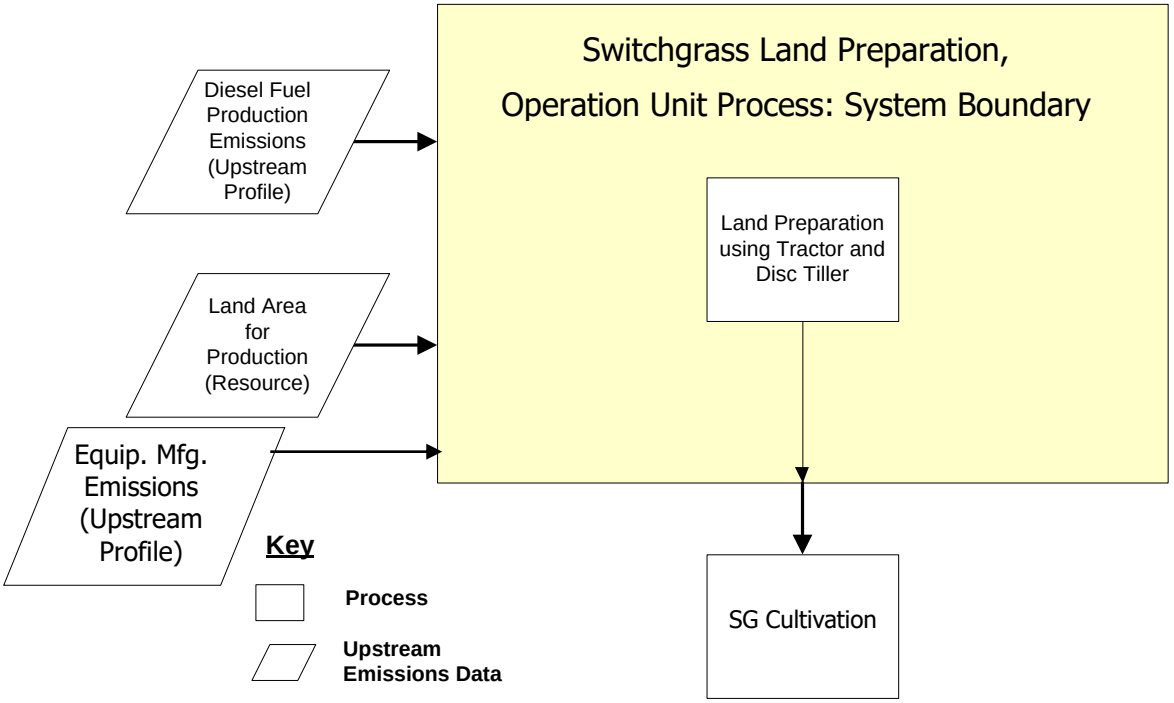

Table 1: Properties of Switchgrass (NETL 2012)

Physical Component/Property	Value (as received)
Ash (%)	6.33
Carbon (%)	36.21
Hydrogen (%)	5.57
Nitrogen (%)	1.11
Oxygen (%)	35.77
Sulfur (%)	0.01
Moisture (%)	15.00
HHV at 15% moisture (Btu/lb)	6,619
LHV at 15% moisture (Btu/lb)	5,935

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)	DQI
Inputs			
Diesel Combustion, Mobile Sources, Truck [Refinery products]	**1.72E-04**	**kg**	**1,1**
Equipment Assembly per kg Biomass [Valuable substances]	**1.00E+00**	**Pieces**	**2,2**
Area of Production Land	**9.34E-06**	**acres**	**2,3**
Outputs			
Switchgrass [biomass]	1	kg	2,3
Dust (PM10) [Particles to air]	1.95E-06	kg	2,3
Dust (PM2.5) [Particles to air]	2.92E-07	kg	2,3

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

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

BAH 2005 — Booz Allen Hamilton, South Coast Air Quality Management District, and California Air Resources Board, 2005. *Demonstration of Particulate Trap Technologies on Existing Off-Road Heavy-Duty Construction Equipment: Final Report*. SCAQMD and CARB. July, 2005.

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Countess Environmental 2004	Countess Environmental, 2004. *WRAP Fugitive Dust Handbook.* WGA Contract No. 30204-83. Western Regional Air Partnership.
NETL 2011	NETL. (2011). *Calculating Uncertainty in Biomass Emissions Model, Version 2.0 (CUBE 2.0): Model and Documentation*. (DOE/NETL-2012/1538). Pittsburgh, PA: National Energy Technology Laboratory, from http://www.netl.doe.gov/energy-analyses/refshelf/PubDetails.aspx?Action=View&PubIP=409
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
SunGrant Initiative 2007	SunGrant Initiative, 2007. *Management Guide for Biomass Feedstock Production From Switchgrass in the Northern Great Plains.* South Dakota State University.
USDA 2009	USDA, 2009. *Fact Sheet: Management and Lifecycle Assessment of Bioenergy Crop Production.* U.S. Department of Agriculture.

Section III: Document Control Information

Date Created: May 24, 2011

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Revision History:

13JUNE2012	Updated to revised parameter values.
29DECEMBER2014	Updated to reflect combustion removal. Diesel combustion is now an input. Added inventory item

DQI data to the data summary tab. Speciated PM emissions by size.

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