NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Corn Stover Land Preparation, Operation

Reference Flow: 1 kg Corn Stover Land Preparation

Brief Description: This unit process includes operations for land preparation for corn stover including diesel use, dust emissions, and a calculation of required land area. Includes co-product allocation between grain and stover.

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest

Year Data Best Represents: 2008

Process Type: Extraction Process (EP)

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

Allocation Applied: Yes

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:

Stover yield (STOVER_YIELD_Y)	*The yield of corn stover, in kg/acre-yr*
Corn yield (CORN_YIELD_Y)	*The yield of corn grain, in kg/acre-yr*
Allocation (ALLOCATE_ENERGY)	*If using energy allocation, use value = 1 else use value = 0.*

Tracked Input Flows:

Diesel [Crude oil products]	*Diesel (from crude oil) usage for biomass cultivation operations.*

Tracked Output Flows:

Biomass Operation [Installation]	*This unit process is assembled with the biomass cultivation operation unit process in series, therefore the reference flow is assumed to be 1 kg biomass operation.*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_CS_Land_Preparation_2010.02.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this unit process covers the operation of farming activities used for land area preparation for corn stover biomass in Life Cycle (LC) Stage #1. This unit process is based on the reference flow of 1 kg of corn stover land preparation operation, as described below, and in **Figure 1.** The operation activities are assumed to occur every year. Inputs to the unit process include diesel consumption and land use. Diesel is used as fuel for the land preparation equipment (a disk tiller and a tractor); the energy and material flows for the upstream production and delivery of diesel are not included in the boundary of this process. Land use, expressed in terms of acres per unit production of corn stover, is considered a resource that involves no upstream operating or construction activities. The air emissions from diesel combustion and fugitive dust from the use of land preparation equipment are included in this unit process boundary. Fugitive dust is categorized as PM (particulate matter) 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

The LC boundary of this unit process starts with farming activities to prepare land for seeding and ends with a unit of land area ready to seed. This unit process is the first unit process in a sequence of four operations processes required for the acquisition of corn stover. The LC Stage #1 unit processes that follow this unit process are corn stover cultivation, corn stover harvesting, and corn stover collection and baling.

Operations for the preparation of land for corn stover production are based on the estimated diesel consumption of farming equipment, the direct emissions from diesel combustion, fugitive dust emissions caused by surface dust that is disturbed by land preparation equipment, and the annual yield rates of corn grain and corn stover. **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 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 three adjustable parameters in this unit process: the annual yield of corn stover ("STOVER_YIELD_Y"), the annual yield of corn grain ("CORN_YIELD_Y"),and the calculation of co-product allocation based on energy ("ALLOCATE_ENERGY") basis. The annual yields of corn grain and stover(kg/acre-year) are used to translate the values for diesel consumption, diesel combustion and fugitive dust emissions from a basis of quantity per acre to a basis of quantity per kg of biomass production. NETL currently recommends a default value of 3,829 kg/acre-yr for corn yield based on a survey of national data from 2004 to 2009 (Iowa State 2009, USDA 2010). The recommendation for stover yield is 1,001 kg/acre year (NETL 2011, Petrolia 2009).

The parameter for energy-based co-product allocation allows the unit process to allocate inputs and outputs between co-products on an energy or mass basis. If the value for "ALLOCATE_ENERGY" is 1, then energy-based co-product allocation is used; if the value for "ALLOCATE_ENERGY" is 0, then mass-based co-product allocation is used and a ratio of the yield rates is used to apportion emissions.

Diesel is consumed by the tractor as it pulls the disc tiller and the seeding equipment. A tractor consumes an average of 10.26 gallons of diesel per hour (John, 2009a). The diesel consumption of equipment used in farming cultivation activities was calculated based on specifications of a 1,953 rpm tractor consuming 10.26 gal/hour diesel fuel and a disc tiller of 4.78 m (188 inches) width (John 2009a, John 2009b). Assuming that the tractor operates at 5.8 miles per hour (mph), an average operating speed, and by multiplying the width of the disk tiller by the operating speed of the tractor, the land coverage rate is estimated at 11 acres per hour [Caterpillar, 2010]. Multiplying this land coverage rate by the fuel consumption rate, the estimated diesel consumption is 0.93 gal/acre prepared. This calculation assumes that the tractor makes a single pass over the site.

The combustion of diesel results in the direct emission of GHGs (greenhouse gases) and CAPs (criteria air pollutants). The emissions factors for GHGs are based on DOE instructions for the voluntary reporting of GHGs (DOE 2007). Emissions factors for PM (particulate matter), NO_x (nitrogen oxides), and VOCs (volatile organic compounds) are based on EPA documentation on air emissions from non-road diesel engines. These emissions factors are expressed in terms of the mass of emissions per bhp (brake horsepower-hour), which requires a determination of the bhp of the tractor. This unit process uses a conversion factor of 0.066 gal/bhp-hr (SCAQMD 2005) to apply the emissions factors for PM, NO_x, and VOC to a basis of gallons of diesel combusted in non-road heavy equipment.

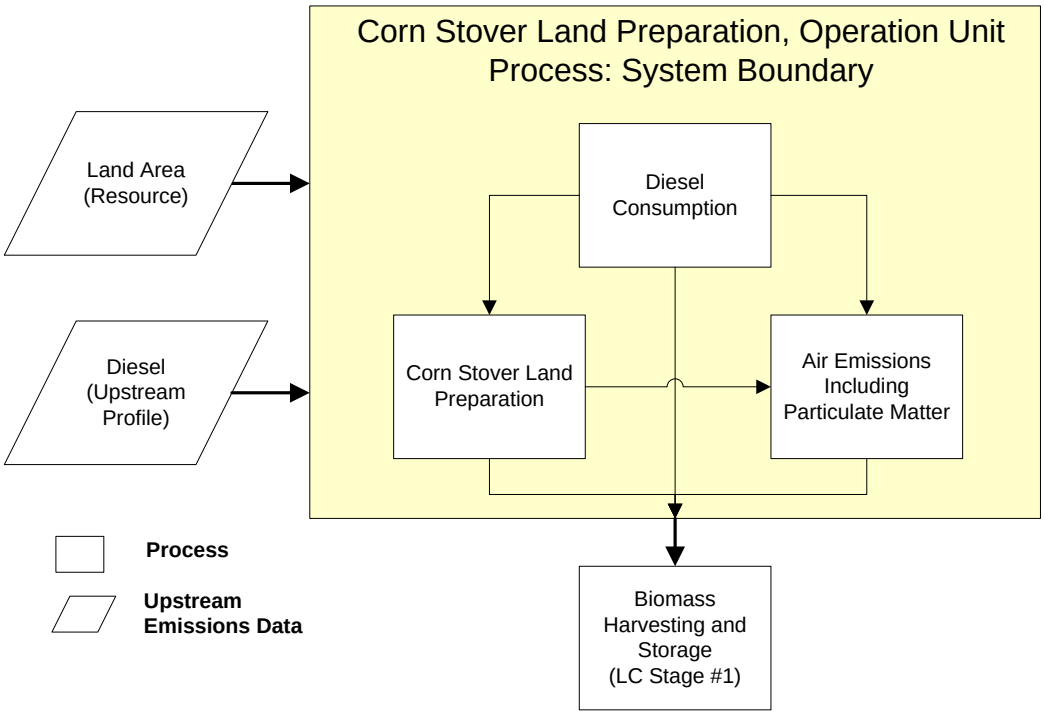
Emissions of SO_2 (sulfur dioxide) are calculated by assuming that diesel has a sulfur content of 15 ppm (DieselNet 2009a) and that all sulfur in diesel is converted to SO_2 upon combustion. The calculated emissions factor for diesel is 2.52677×10^{-5} kg SO_2/L.

The emissions factors for CO (carbon monoxide) are based on Tier 4 emissions standards, which specify an array of CO emissions factors across a range of engine

sizes (DieselNet 2009b). This unit process assumes that the engine of the tractor is greater than 175 horsepower, and the calculated emissions factor for diesel is 0.010 kg CO/L.

Fugitive dust emissions are generated by the disturbance of surface soil during land preparation. Fugitive dust emissions from land preparation are estimated using an emissions factor specified by WRAP (Western Regional Air Program) (Countess Environmental 2004), which conducted air sampling studies on ripping and sub-soiling practices used for breaking up soil compaction. The emissions factor for fugitive dust is 1.2 lb PM/acre-pass. The tractor makes two passes of the site and thus has a fugitive dust emissions factor of 2.4 lbs PM/acre. The total emissions of fugitive dust are 1.088 lbs PM/acre (0.2875 kg/kg biomass).

Figure 1: Unit Process Scope and Boundary



Properties of corn stover and corn grain 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.

Table 1: Properties of land preparation operation activities

Property	Value
Corn stover yield, (kg/acre-year)	1001
Corn grain yield, (kg/acre-year)	3829
HHV corn stover, (Btu/lb) at 15% moisture	6399
HHV corn grain, (Btu/lb) at 15% moisture	6970

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Diesel [Crude oil products]	**7.94E-06**	**kg**
Area of Production Land	6.90E-06	acres
Outputs		
Biomass Operation [Installation]	1	kg
Carbon dioxide [Inorganic emissions to air]	2.50E-05	kg
Carbon monoxide [Inorganic emissions to air]	9.80E-08	kg
Methane [Organic emissions to air (group VOC)]	3.58E-09	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	6.47E-10	kg
Nitrogen dioxide [Inorganic emissions to air]	1.13E-08	kg
Sulphur dioxide [Inorganic emissions to air]	2.38E-10	kg
Particulate Matter, unspecified [Other emissions to air]	1.45E-06	kg
Volatile Organic Carbons [Organic emissions to air]	5.28E-09	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

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Section III: Document Control Information

Date Created: February 02, 2010

Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

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