



NETL Life Cycle Inventory Data

Process Documentation File

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 comprised of this document, as well as the data sheet (DS) *DS_Stage1_O_CG_Land_Preparation_2011.02.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

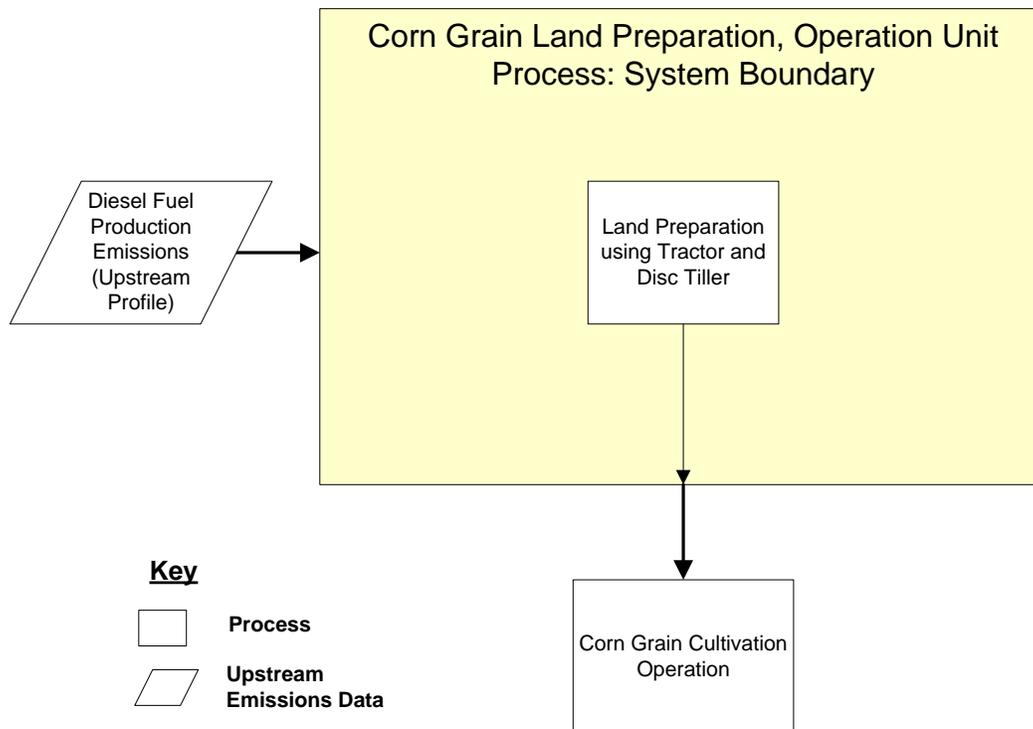
The scope of this unit process covers the operation of farming activities used for land area preparation for corn grain biomass in life cycle (LC) Stage #1. This unit process is based on the reference flow of 1 kg of biomass operation to prepare land, as described below, and in **Figure 1**. The operation activities are assumed to occur once when the land is transformed into a corn field. The inputs to the unit process include diesel consumption (technosphere) and land use (resource). Diesel is used as fuel for the land preparation equipment (a tractor); the energy and material flows for the upstream production and delivery of diesel as well as life cycle emissions of diesel production are not included in the boundary of this process. Land use, expressed in terms of acres per unit production of corn grain, 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 the unit process boundary. Fugitive dust is categorized as particulate matter (PM) 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. Operations for the preparation of land for corn grain 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 rate of corn grain. **Figure 1** provides an overview of the boundary of this unit process including a schematic of operations considered within 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.

Figure 1: Unit Process Scope and Boundary



There are two adjustable parameters in this unit process: the annual yield of corn grain and time horizon of the study. These adjustable parameters are designed to allow modeling flexibility to enable the modeler to update the unit process to meet specific assumptions and study criteria, as relevant. Additionally, these values may be updated as needed to incorporate newer or revised data sources. Corn grain yield per year indicates the annual yield of corn grain per acre and is 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 kilogram of biomass production NETL currently recommends a default value of 3,829 kg/acre-yr for this parameter based on a survey of national data from 2004 to 2009 (Iowa State 2009, USDA 2010). The horizon time indicates the study period such that the initial conversion of the land into a corn field is allocated over every kilogram of corn which is produced. This conversion only occurs once during the study period.

Diesel is consumed by the tractor as it pulls the disc tiller. The diesel consumption of equipment used in farming cultivation activities was calculated based on specifications of a 1953 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 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 two passes over the site; the total diesel consumption is 1.86 gal/acre.

The combustion of diesel results in the direct emission of greenhouse gases (GHGs) and criteria air pollutants (CAPs). The emission factors for GHGs are based on DOE instructions for the voluntary reporting of GHGs (DOE 2007). Emission factors for PM, nitrogen oxides (NO_x), and volatile organic compounds (VOCs) are based on EPA documentation on air emissions from nonroad diesel engines. These emission factors are expressed in terms of the mass of emission per brake horsepower-hour (bhp), 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 emission factors for PM, NO_x, and VOC to a basis of gallons of diesel combusted in nonroad heavy equipment.

Emissions of sulfur dioxide (SO₂) are calculated by assuming that diesel has a sulfur content of 15 ppm (DieselNet 2009a) and that all sulfur in diesel is converted to SO₂ upon combustion. The calculated emission factor for diesel is 2.52677×10^{-5} kg SO₂/L.

The emission factors for carbon monoxide (CO) are based on Tier 4 emission standards, which specify an array of CO emission 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 emission 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 emission factor specified by Western Regional Air Program (WRAP) (Countess Environmental 2004), which conducted air sampling studies on ripping and sub-soiling practices used for breaking up soil compaction. The emission 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 emission factor of 2.4 lbs PM/acre. The total emissions of fugitive dust are 1.088 lbs PM/acre (0.2875 kg/kg biomass).

Properties of corn grain biomass land preparation operation activities relevant to this unit process are illustrated 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	Units
Corn grain yield	3829	kg/acre-year
HHV corn grain	6970	Btu/lb
LHV corn grain	6545	Btu/lb

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Diesel [Crude oil products]	5.18E-05	kg
Area of Production Land	8.71E-06	acres
Outputs		
Biomass Operation [Installation]	1	kg
Carbon dioxide [Inorganic emissions to air]	1.63E-04	kg
Carbon monoxide [Inorganic emissions to air]	6.39E-07	kg
Methane [Organic emissions to air (group VOC)]	2.34E-08	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	4.22E-09	kg
Nitrogen dioxide [Inorganic emissions to air]	7.37E-08	kg
Sulphur dioxide [Inorganic emissions to air]	1.55E-09	kg
Particulate Matter, unspecified [Other emissions to air]	9.48E-06	kg
Volatile Organic Carbons [Organic emissions to air]	3.44E-08	kg

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

Embedded Unit Processes

None.

References

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Section III: Document Control Information

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