NETL Life Cycle Inventory Data
Process Documentation File

Process Name: SRWC Southern Pine Land Preparation, Operation

Reference Flow: 1 kg of Biomass Operation

Brief Description: This unit process includes operations for land preparation for short rotation woody crops (SRWC) (from Southern Pine) including diesel use, dust emissions, and a calculation of required land area.

Section I: Meta Data

Geographical Coverage: US **Region:** US Midwest

Year Data Best Represents: 2011

Process Type: Extraction Process (EP)

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

Allocation Applied: No

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:

SRWC yield (Biomass_yield_y)	*Represents the SRWC biomass annual yield*
SRWC rotation period (Biomass_Rot)	*Represents the SWRC rotation period between harvest*

Tracked Input Flows:

Diesel [Crude oil products]	*Diesel (from crude oil) usage for biomass land preparation 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_SouthernPine_Land_Preparation_2012.01.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this unit process covers the operations of farming activities used for land area preparation for short rotation woody crops (SRWC) biomass (from Southern Pine) in Life Cycle (LC) Stage #1. This unit process is based on the reference flow of 1 kg of biomass operation, as described below, and in **Figure 1.** The input to the unit process includes diesel consumption (technosphere). Diesel is used as fuel for the land preparation equipment (a tractor used to pull a disk tiller); 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. 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 area for seeding of biomass and ends with a unit land area ready to seed. Land preparation is assumed to occur once during (at the very beginning of) the study period. Operations for the preparation of land for SRWC 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 SRWC. Figure 1 provides an overview 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 two adjustable parameters in this unit process: the annual yield of SRWC and the SWRC rotation period. These 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. SRWC per year indicates the annual yield of SRWC per acre. NETL currently recommends a default value of 6,350 kg/acre-yr for this parameter. The annual yield of SRWC (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 kg of SRWC biomass production. Biomass rotation period indicates the time period between harvests of an unit area. NETL currently recommends a default value of 13 years for this parameter.

Diesel is consumed by the tractor as it pulls the disk tiller. A tractor consumes an average of 10.26 gallons of diesel per hour (John Deere, 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 of diesel fuel and a disk tiller of 4.78 m (188 inches) width (John Deere 2009a, John Deere 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-pass. This calculation assumes that the tractor makes two passes over the site and the total diesel consumption is 1.86 gal/acre calculated.

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 2010). 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-hr (brake horsepower-hour), which requires a determination of the bhp-hr 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.

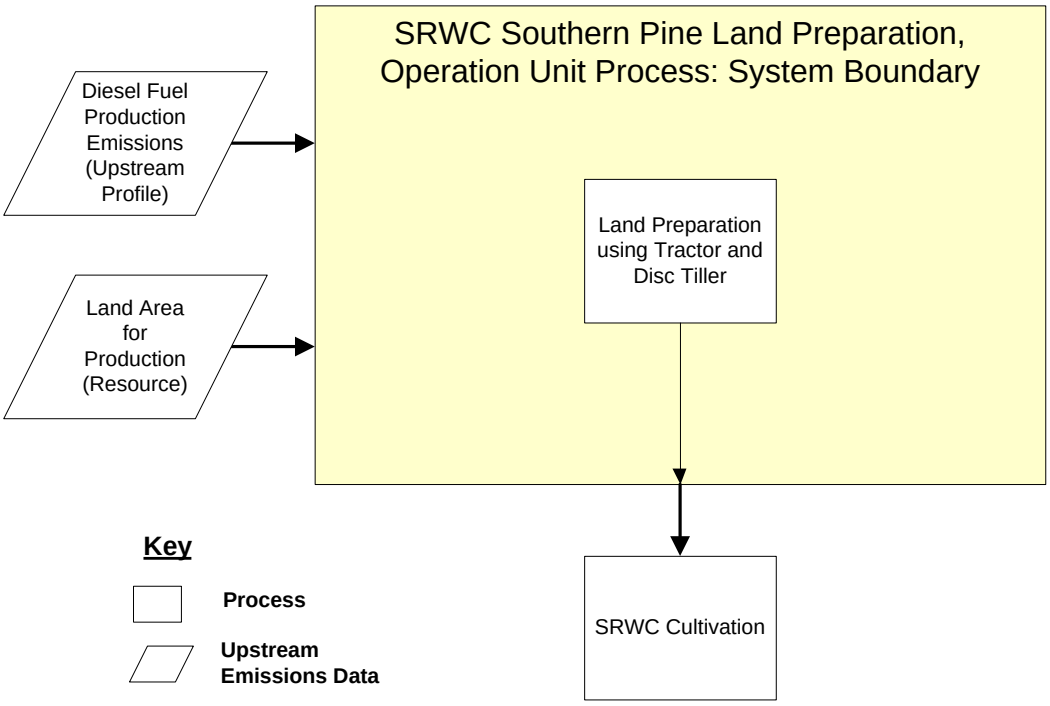
Emissions of SO_2 (sulfur dioxide) are calculated stoichiometrically by assuming that diesel has a sulfur content of 15 ppm (DieselNet 2009) and that all sulfur in diesel is converted to SO_2 upon combustion. The calculated emissions factor for diesel is 2.53×10^{-5} kg SO_2/L.

The emissions factors for CO (carbon monoxide) are based on Tier 4 emission standards, which specify an array of CO emissions factors across a range of engine sizes (DieselNet 2009). This unit process assumes that the engine of the tractor is greater than 175 horsepower, and the calculated emissions factor for diesel is 1.04×10^{-2} 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 total emissions of fugitive dust are 6.53 kg PM/acre (0.0025 kg/kg biomass).

The yield rate of SRWC is based on a review of several sources, with the primary sources being U.S. DOE (2011) and Kline and Coleman (2010). Based on data available therein for southern pine biomass yields, an annualized yield of 6,350 kg/acre-year was estimated for use as the default yield value for this study.

Figure 1: Unit Process Scope and Boundary



Properties of SRWC relevant to this unit process are indicated in **Table 1**. Heating values for SRWC are provided as a reference point to document assumptions and for comparison with other biomass types applied outside of this unit process, as relevant. **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	Reference
SRWC yield	6,350	kg/acre-year	DOE 2011; Kline and Coleman 2010
Harvest Frequency	13	Years	Study Value

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)
Inputs		
Diesel [Crude oil products]	**7.20E-05**	**kg**
Outputs		
Biomass Operation [Installation]	1	kg
Carbon dioxide [Inorganic emissions to air]	2.27E-04	kg
Carbon monoxide [Inorganic emissions to air]	8.89E-07	kg
Methane [Organic emissions to air (group VOC)]	3.24E-08	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	5.76E-09	kg
Nitrogen oxides [Inorganic emissions to air]	1.03E-07	kg
Sulphur dioxide [Inorganic emissions to air]	2.16E-09	kg
Particulate Matter, unspecified [Other emissions to air]	1.32E-05	kg
Volatile Organic Carbons [Organic emissions to air]	4.79E-08	kg
Mercury (+II) [Heavy metals to air]	1.13E-20	kg
Ammonia [Inorganic emissions to air]	9.40E-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

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