NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Southern Pine Harvesting & Storage, Operation

Reference Flow: 1 kg of Southern Pine Biomass

Brief Description: This unit process includes farming operations (activities) for harvesting and storage for short rotation woody crop (SRWC) biomass production (from Southern Pine) including an input of combusted diesel, direct dust emissions, and a calculation of yield.

Section I: Meta Data

Geographical Coverage: US **Region:** U.S. Southeast

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:

Southern Pine yield (Biomass_yield_r)	*The annual yield rate of Southern Pine biomass production*
Southern Pine harvest loss (LossRate)	*The assumed loss rate of Southern Pine biomass during production*
Southern Pine chip type (ChipType)	*The type of Southern Pine chips generated by field grinding*

Tracked Input Flows:

Biomass Operation [Installation]	*This unit process is assembled with*

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

Tracked Output Flows:

SRWC Biomass [Biomass Fuels]	*This reference flow represents mass of SRWC.*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_SouthernPine_Harvesting_Storage_2012.02.xlsx*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this unit process covers the harvesting and storage operations for SRWC biomass in Life Cycle (LC) Stage #1. This unit process is based on the reference flow of 1 kg of short rotation woody crop (SRWC) biomass production (from Southern Pine), as described below, and in **Figure 1.** The inputs to the unit process include combusted diesel consumption (technosphere) and biomass (resource). Diesel is used as fuel for crop harvesting equipment (a tree harvester); the energy and material flows for the upstream production and delivery of diesel as well as LC emissions of diesel production and combustion are not included in the boundary of this process. The fugitive dust emissions from harvesting equipment are included in the 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 harvesting trees.

Boundary and Description

The LC boundary of this unit process starts with the harvesting of SRWC and ends with SRWC biomass ready for delivery to the fuel production facility. The harvesting operations for SRWC biomass production are based on the estimated diesel consumption of harvesting operations equipment, the direct emissions from diesel combustion, fugitive dust emissions caused by surface dust that is disturbed by harvesting equipment, and the annual yield rate of SRWC. **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 SRWC, the loss rate of SWRC biomass during harvest, and the type of SWRC chips produced. This is 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. NETL currently recommends a harvest loss rate of 0.05 and a conventional chip type.

Diesel is consumed by the tree harvester to harvest and chip trees. The diesel consumption by harvesting equipment was calculated based on specifications of a 440 hp diesel engine consuming 0.15 kg diesel/hp-hour (0.35 lb/hp-hour) (John Deere. 2012). Assuming that harvesting operations produce approximately 3 tons SRWC/hour (Gaffney and Yu 2003), header operating speed is 2,721 kg/hour. By multiplying the replanting time by the annual yield rate of the biomass, and dividing by the header operating speed, the coverage area by harvester is 0.2142 acres/hour. By dividing biomass production per hour by a harvesting coverage area, the fuel per coverage area is 386.62 L/acre-pass. By dividing the annual yield rate of the biomass, the estimated diesel consumption is 0.03044 L/kg biomass. The diesel engine of the harvester is 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 harvesting 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 when harvesting. Fugitive dust emissions from harvesting activities are estimated using an emission factor and PM2.5/PM10 ratio 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 emissions factor for fugitive dust is 40.8 lb PM10/acre-pass, with one assumed pass per harvest (Gaffney and Yu 2003). Harvesting is assumed to take place every 13 years and horizon time of the study is assumed to be 30 years. Multiplying the harvesting frequency (30/13) and dividing by the horizon time, the total emissions of fugitive dust are 1.42 kg PM10/acre/year calculated. The ratio of PM2.5 to PM10 utilized for this study is 0.15 kg PM2.5/kg PM10.

The yield rate of SRWC from Southern Pine is based on independent studies on loblolly pine in the Southeastern United States. The best estimate yield is calculated based on

data from multiple sources collected by NETL, which represents a variety of site prep, fertilizer, and management practices. The best estimate yield for SRWC yield is 6,350 kg/acre-yr, which is used for this study.

Figure 1: Unit Process Scope and Boundary

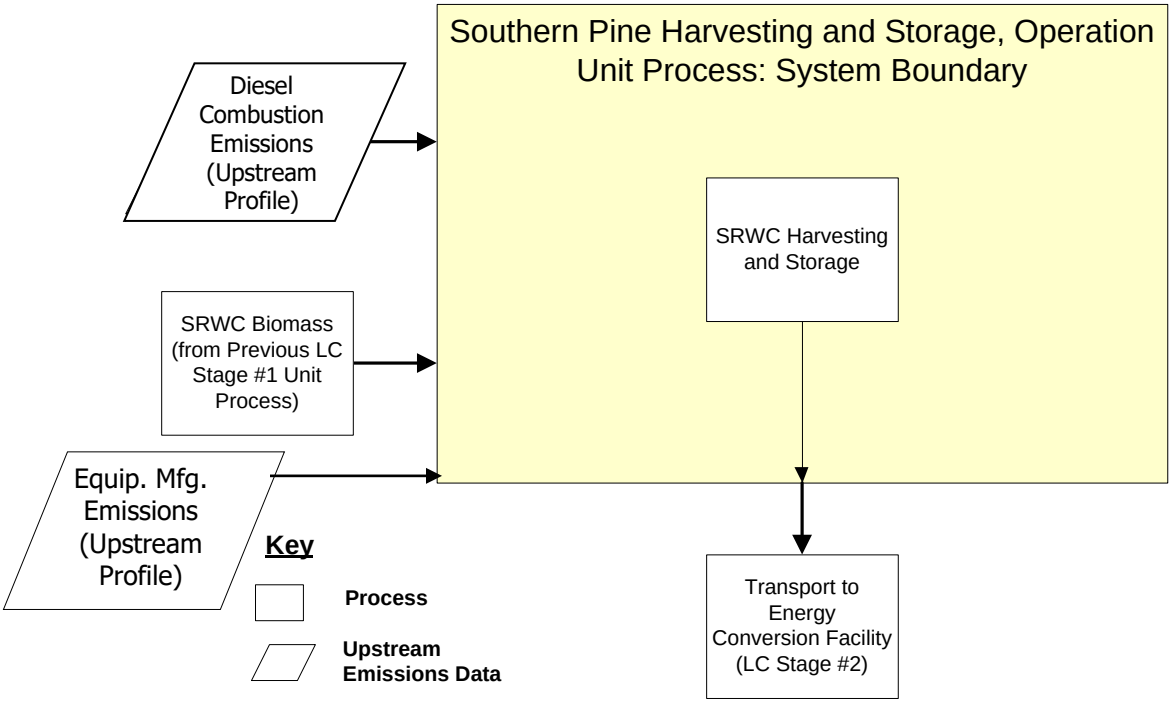

Table 1 provides a summary of modeled input and output flows. Additional details regarding input and output flows, including calculation methods, are contained in the associated DS sheet.

Table 1: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)	DQI
Inputs			
Biomass Operation [Installation]	**1**	**kg**	**2,2**
SRWC Biomass [Resource]	**1**	**kg**	**1,1**
Equipment Assembly per kg Biomass [Valuable substances]	**1.00E+00**	**Pieces**	**2,2**
Diesel [Crude oil products]	**1.97E-03**	**kg**	**2,2**
Outputs			
Biomass Operation [Installation]	**1**	**kg**	**1,1**
Dust (PM10) [Particles to air]	2.36E-04	kg	1,2
Dust (PM2.5) [Particles to air]	3.54E-05	kg	1,2

* **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

Countess Environmental 2004 — Countess Environmental, 2004. *WRAP Fugitive Dust Handbook.* WGA Contract No. 30204-83. Western Regional Air Partnership.

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John Deere 2012 — John Deere. 2012. PowerTech 6135H Diesel Engine Specifications. Deere & Company. http://www.deere.com/en_US/docs/engines_and_drivetrain/specsheet/IGS/6135HF485_T.pdf (Accessed April 2, 2012).

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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:	April 2, 2012
Point of Contact:	Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV
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29DECEMBER2014	Updated to reflect combustion removal. Diesel combustion is now an input.

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