NETL Life Cycle Inventory Data
Process Documentation File

Process Name: SRWC Harvesting & Storage, Operation

Reference Flow: 1 kg of SRWC Biomass

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

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest

Year Data Best Represents: 2007

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)	*The annual yield rate of short rotation woody crop (SRWC) biomass production*

Tracked Input Flows:

Biomass Operation [Installation]	*This unit process is assembled with SRWC cultivation operations unit process in series*
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:

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_SRWC_Harvesting_Storage_2010.03.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, as described below, and in **Figure 1.** The inputs to the unit process include 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 are not included in the boundary of this process. The fugitive dust 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 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 is one adjustable parameter in this unit process: the annual yield of SRWC. 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, this value may be updated as needed to incorporate newer or revised data sources. SRWC

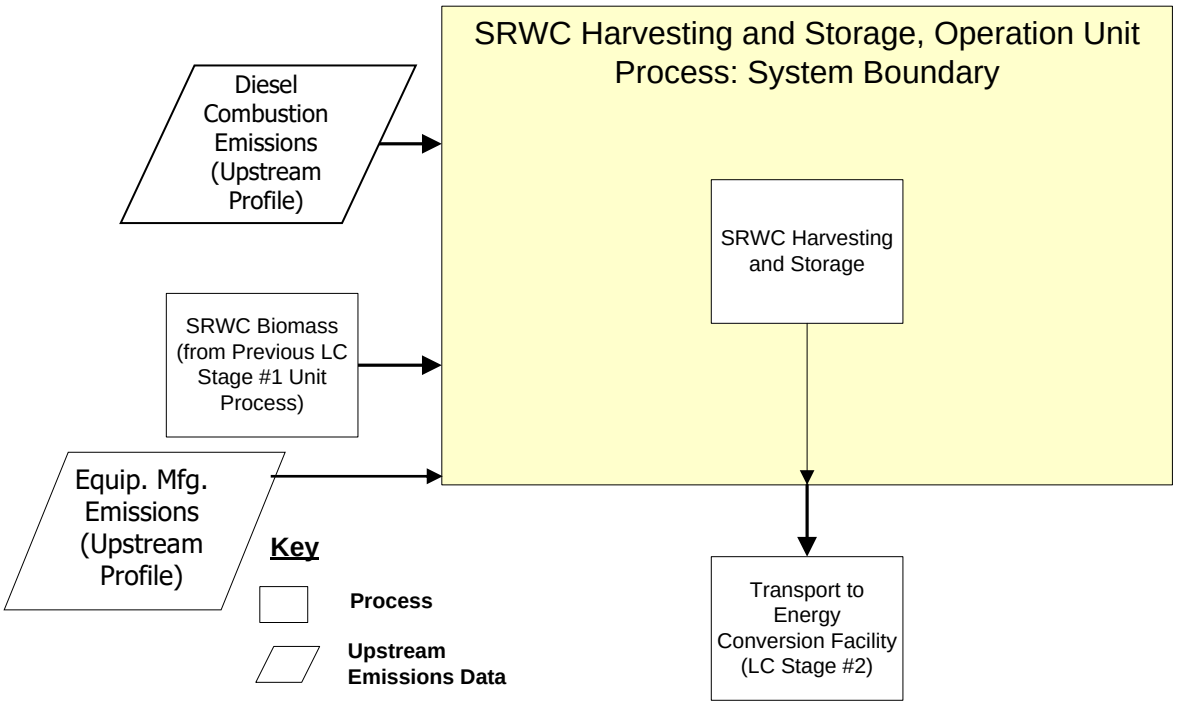
per year indicates the annual yield of SRWC per acre. NETL currently recommends a default value of 6,214 kg/acre-year for this parameter (NETL 2011).The annual yield of SRWC (kg/acre-year) is used to translate the values for diesel consumption, land use, and fugitive dust emissions from a basis of quantity per acre to a basis of quantity per kg of SRWC biomass production.

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. 2008). 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. 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 emissions 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 emissions factor for fugitive dust is 40.8 lb PM10/acre-pass (Gaffney and Yu 2003). Harvesting is assumed to take place every 5 years and horizon time of the study is assumed to be 30 years. Multiplying the harvesting frequency (30/5) and dividing by the horizon time, the total emissions of fugitive dust are 3.08 kg PM10/acre/year calculated. The ratio of PM2.5 to PM10 utilized for this study is 0.15 kg PM2.5/kg PM10.

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 SRWC (NETL 2011, 2012)

Property	Value	Units
SRWC yield	6214	kg/acre-year
SRWC LHV at 50% moisture	3969	Btu/lb
SRWC HHV at 50% moisture	4219	Btu/lb

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)	DQI
Inputs			
Biomass Operation [Installation]	**1**	**kg**	**2,2**
Diesel Combustion, Mobile Sources, Truck [Refinery products]	**2.57E-02**	**kg**	**2,2**
Equipment Assembly per kg Biomass [Valuable substances]	**1.00E+00**	**Pieces**	**2,2**
SRWC Biomass [Resource]	1	kg	2,2
Outputs			
SRWC Biomass [Biomass Fuels]	**1**	**kg**	**2,2**
Dust (PM10) [Particles to air]	4.96E-04	kg	1,2
Dust (PM2.5) [Particles to air]	7.45E-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.

Gaffney and Yu 2003 — Gaffney, P. and Yu, H. 2003. *Computing Agricultural PM10 Fugitive Dust Emissions Using Process Specific Emissions Rates and GIS*. US EPA Annual Emission Inventory Conference. April, 2003.

John 2008 — John Deere. 2008. *PowerTech 6135H Diesel Engine Specifications*. Deere & Company.

Miller and Bender 2008 — Miller, R. and Bender, B. 2008. *Growth and Yield of Willow and Poplar Hybrids in the Central Upper Peninsula of Michigan*. Michigan State University. August, 2008.

NETL 2009	NETL. 2009. *Life Cycle Inventory and Life Cycle Costing (LCI&C) of Illinois No. 6 Coal and Biomass-to-Liquids Fuel Pathways*. Draft Final Report. August 2009.
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

Section III: Document Control Information

Date Created:	February 04, 2010
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Revision History:	
13JUNE2012	Updated to revised parameter values.
29DECEMBER2014	Updated to reflect combustion removal. Diesel combustion is now an input. Corrected error in PM calculations. Speciated PM emissions. Added DQI data to data summary tab.

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