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 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 [Crude oil products] — *Diesel (from crude oil) usage for biomass harvesting operations*

Tracked Output Flows:

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_2010.02.xls*, which provides additional details regarding calculations, data quality, and references as relevant.

Goal and Scope

The scope of this unit process covers the 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 air emissions from diesel combustion and 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 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 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

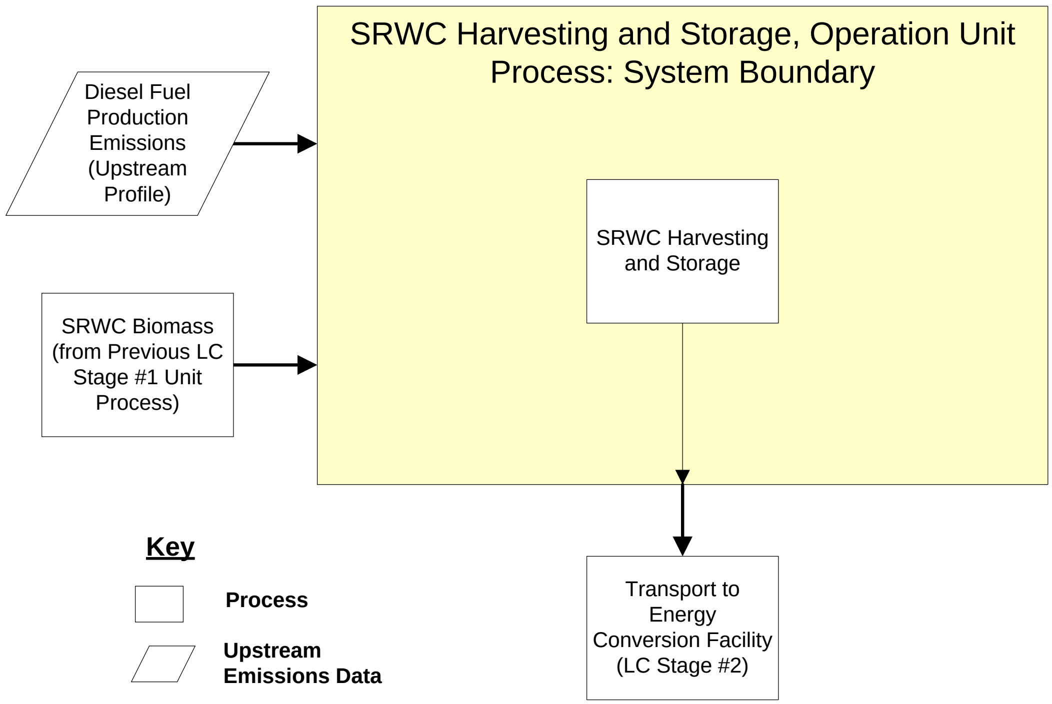
The combustion of diesel results in the direct emission of greenhouse gases (GHGs) and criteria air pollutants (CAPs). The emissions factors for GHGs are based on DOE instructions for the voluntary reporting of GHGs (DOE 2007). Emissions factors for PM, nitrogen oxides (NO_x), and volatile organic compounds (VOCs) 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 harvester/chipper. 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 sulphur dioxide (SO_2) are calculated stoichiometrically by assuming that diesel has a sulphur content of 15 ppm (DieselNet 2009a) and that all sulphur 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 2009b). The diesel engine of the harvester is greater than 175 horsepower, and the calculated emissions factor for diesel is 0.0104 kg CO/L.

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 PM/acre-pass (Gaffney and Yu 2003).

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)
Inputs		
Biomass Operation [Installation]	**1**	**kg**
Diesel [Crude oil products]	**2.57E-02**	**kg**
SRWC Biomass [Resource]	1	kg
Outputs		
SRWC Biomass [Biomass Fuels]	**1**	**kg**
Carbon dioxide [Inorganic emissions to air]	8.08E-02	kg
Carbon monoxide [Inorganic emissions to air]	3.17E-04	kg
Methane [Organic emissions to air (group VOC)]	1.16E-05	kg
Nitrous oxide (laughing gas) [Inorganic emissions to air]	2.05E-06	kg
Nitrogen oxides [Inorganic emissions to air]	3.66E-05	kg
Sulfur dioxide [Inorganic emissions to air]	7.69E-07	kg
Particulate Matter, unspecified [Other emissions to air]	5.97E-04	kg
Volatile Organic Carbons [Organic emissions to air]	1.71E-05	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

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

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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
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Section III: Document Control Information

Date Created:	February 04, 2010
Point of Contact:	Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV
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13JUNE2012	Updated to revised parameter values.

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Section IV: Disclaimer