NETL Life Cycle Inventory Data
Process Documentation File

Process Name:	Corn Grain Harvesting & Storage, Operation
Reference Flow:	1 kg of Corn Grain Biomass
Brief Description:	This unit process includes operations for harvesting and storage of corn grain including the input of combusted diesel and emissions. Corn stover is left on the field and is thus not a coproduct in this case.

Section I: Meta Data

Geographical Coverage:	US	**Region:**	Midwest
Year Data Best Represents:	2008		
Process Type:	Extraction Process (EP)		
Process Scope:	Cradle-to-Gate Process (CG)		
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:

Corn yield (Corn_yield_y)	*Represents the weight of corn grain per acre year.*

Tracked Input Flows:

Biomass Operation [Installation]	*Flow from cultivation of biomass, unit process is assembled, in series, with cultivation process.*
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:

Corn Grain Biomass (15% Moisture) [Biomass Fuels]	*This reference flow represents mass of corn and corn stover.*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_Stage1_O_CG_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 operations of farming activities used for the harvesting of corn grain biomass in life cycle (LC) Stage #1. This unit process is based on the reference flow of 1 kg of corn grain biomass production, as described below, and in **Figure 1.** The inputs to the unit process include diesel consumption. Diesel is used as fuel for crop harvesting equipment (a combine with corn header); 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. Diesel combustion and the associated emissions are a upstream process linked as in input. The air emissions from fugitive dust from harvesting equipment are included in this unit process boundary. Fugitive dust is categorized as PM10 and PM 2.5 (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 harvesting crops.

Boundary and Description

The LC boundary of this unit process begins with the harvesting of corn grain and ends with corn grain biomass ready for delivery to the fuel production facility, and leaves stover biomass on the ground. The harvesting operations for corn grain biomass production are based on the estimated diesel consumption of farming equipment, the fugitive dust emissions caused by surface dust that is disturbed by harvesting 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.

There is one major adjustable parameter in this unit process: the annual yield of corn grain. This adjustable parameter is designed to allow modeling flexibility, enabling the

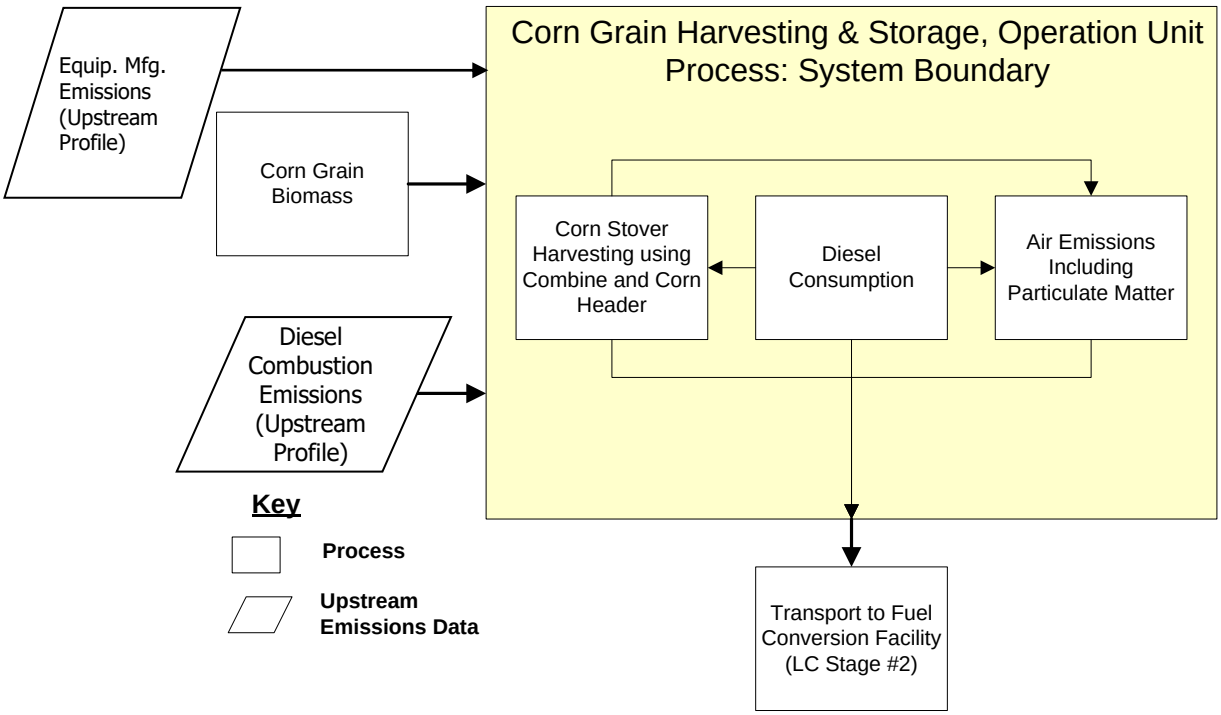
modeler to update the unit process to meet specific assumptions and study criteria, as relevant. Additionally, adjustable values may be updated as needed to incorporate newer or revised data sources. Corn grain yield per year indicates the annual yield of corn grain per acre and it is used to translate the values for diesel consumption 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).

Diesel is consumed by the combine to rotate the corn header. This calculation assumes that the combine makes a single pass over the site. The diesel consumption of the harvesting combine was calculated based on specifications of a 360 horsepower (hp) combine consuming 0.154 kg diesel/hp-hour (0.34 lb/hp-hour) rotating a corn header of 2.40 m (7.91 ft) width (John 2008a, John 2009h). Assuming that the combine operates at 5.5 miles per hour (mph), an average operating speed, and by multiplying the width of the corn header by the operating speed of the combine, the land coverage rate is estimated at 5.27 acres per hour. Dividing this land coverage rate by the fuel consumption rate, the estimated diesel consumption is 12.47 L/acre-pass calculated.

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 during harvesting. Fugitive dust emissions from harvesting activities 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 5.8 lb PM10/acre-pass (Gaffney, P. and Yu, H. 2003). The total emissions of fugitive dust are 2.63 kg PM10/acre-year based on the assumption of a 30-year study period and annual harvesting. 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 corn grain biomass cultivation 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 Corn Grain (NETL, 2009)

Physical Component/Property	Value	Units
Ash	9.82 – 13.51	%
Carbon	44.7 - 48.02	%
Hydrogen	5.41 – 6.14	%
Nitrogen	0.59 – 0.74	%
Oxygen	36.99 – 41.42	%
Sulfur	0.06 – 0.10	%
HHV Moisture Free	7,697 – 7,967	Btu/lb
LHV Moisture Free	7,197 – 7,467	Btu/lb
Na_2O	1.47	% composition of ash
Corn grain yield	3829	kg/acre-yr
HHV corn grain	6970	Btu/lb
LHV corn grain	6545	Btu/lb
K_2O	20.22	% composition of ash
Ash Fusion Temperature	884 (reducing atmosphere), 1054 (oxidizing atmosphere)	°C

Table 2: Unit Process Input and Output Flows

Flow Name*	Value	Units (Per Reference Flow)	DQI
Inputs			
Biomass Operation [Installation]	**1**	**kg**	**1,1**
Diesel Combustion, Mobile Sources, Truck [Refinery products]	**2.75E-03**	**kg**	**3,1**
Equipment Assembly per kg Biomass [Valuable substances]	**1.00E+00**	**Pieces**	**2,2**
Corn Grain Biomass [Renewable Resource]	1	kg	1,1
Outputs			
Corn Grain Biomass (15% Moisture) [Biomass Fuels]	1	kg	3,3
Dust (PM10) [Particles to air]	6.87E-04	kg	2,3
Dust (PM2.5) [Particles to air]	1.03E-04	kg	2,3

* **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

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USDA 2010	USDA. 2010. *2009 Crop Year is One for the Record Books, USDA Reports.* U.S. Department of Agriculture. Washington D.C. http://www.nass.usda.gov/Newsroom/2010/01_12_2201.asp (Accessed June 13, 2012).
NETL 2009	NETL. 2009. *Personal Communication with NETL OSAP*. May 2009.

Section III: Document Control Information

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Revision History:

13JUNE2012	Updated to revised parameter values.
26DECEMBER2014	Updated to reflect combustion removal. Combustion is now an input to this process.

How to Cite This Document: This document should be cited as:

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: Corn Grain Harvesting & Storage, Operation.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: December 2014 (version 03). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

Section IV: Disclaimer