NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Switchgrass, Production

Reference Flow: 1 kg of Switchgrass

Brief Description: This process includes all inputs for the raw material acquisition for 1 kg of cultivated and harvested switchgrass.

Section I: Meta Data

Geographical Coverage: US **Region:** N/A

Year Data Best Represents: 2008

Process Type: Extraction Process (EP)

Process Scope: Cradle-to-Gate Process (CG)

Allocation Applied: No

Completeness: Individual Relevant Flows Captured

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:

acres_yr	*The area of land needed to produce the quantity of biomass*
biomass_yield	*The amount of biomass produced by each acre of farming area each year*

Tracked Input Flows:

Tracked Output Flows:

Switchgrass	*Switchgrass delivered to the energy conversion facility*

Section II: Process Description

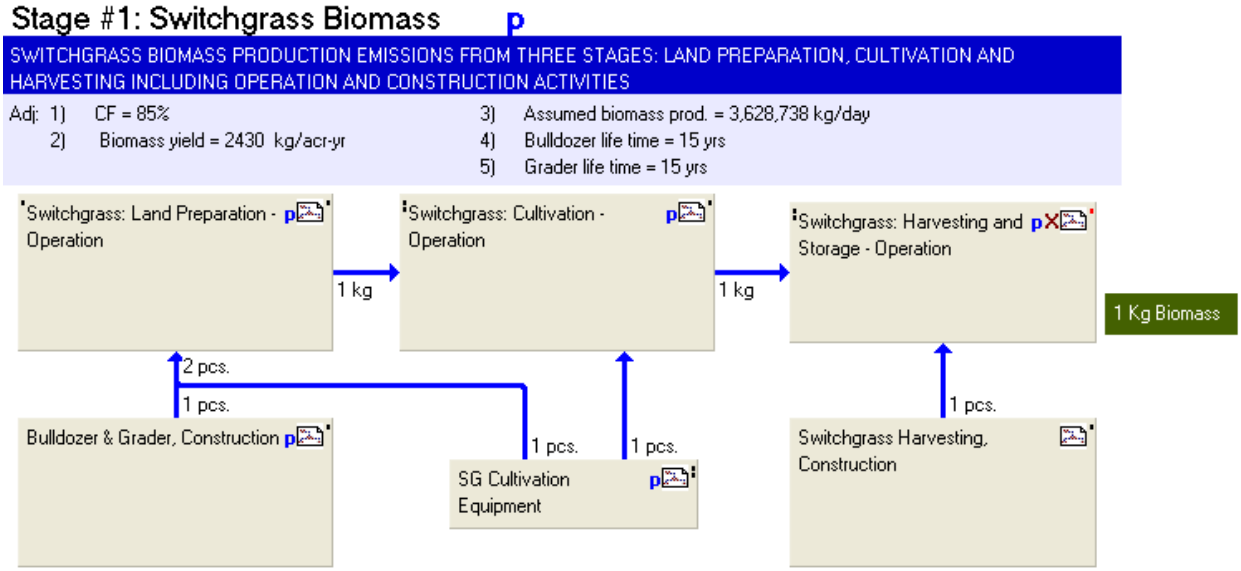
Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_RMA_Biomass_Switchgrass_2011.02.xls*, which provides additional details regarding relevant calculations, data quality, and references.

Goal and Scope

The scope of this unit process covers all aspects of raw material acquisition (RMA) as seen in **Figure 1**. At the end, one kilogram of switchgrass is harvested and cultivated and harvested, stopping at the life cycle (LC) Stage #2 boundary.

Figure 1: Plan for RMA of Switchgrass, Including Land Preparation, Cultivation and Harvesting and Storage



Boundary and Description

LC Stage #1, RMA of switchgrass, includes land preparation for the switchgrass production, cultivation of switchgrass, and the harvesting and storing of the switchgrass. Most of the data used in the formation of the operation processes are from states in the U.S. Midwest.

The RMA of switchgrass includes the construction of the machinery needed for RMA operation processes. Within the machinery construction, upstream processes (for example, steel or rubber) are included. The plan for RMA of switchgrass is provided in **Figure 1**.

The biomass processes are set up slightly differently than some of the other feedstocks. Unlike other RMA pathways, biomass has a set order of operations for its production. The product from one process is the input to another process, which then lends itself to assembly of the model in series. Each of the operations uses a distinct set of machinery, and each piece is constructed as many times as needed during the study period. For the operation processes, each requires diesel fuel and calculates the emissions based on the diesel consumed. The cultivation process also includes the production and application of different fertilizers (potassium, nitrogen, and phosphorus).

The construction processes for machinery contain all of the machinery needed for the initial clearing of the site, cultivation, and harvesting of the switchgrass. The machinery includes:

- Bulldozer, 410 Horsepower
  (DS/DF_Stage1_C_Diesel_Track_Bulldozer_410_HP_2010.01.doc)
- Diesel Motor Grader
  (DS/DF_Stage1_C_Diesel_Motor_Grader_213_HP_2010.01.doc)
- Tiller
  (DS/DF_Stage1_C_Tiller_5015_lbs_TractorPropelled_2009.01.doc)
- Tractor
  (DS/DF_Stage1_C_Diesel_Tractor_165_HP_2009.01.doc)
- Seeder
  (DS/ DF_Stage1_C_Seeder_21900_lbs_TractorPropelled_2009.01.doc)
- Harvester
  (DS/ DF_Stage1_C_Diesel_Forage_Harvester_615_HP_2010.01.doc)
- Baler
  (DS/ DF_Stage1_C_Baler_3110_lbs_TractorPropelled_2009.01.doc)

Each piece of equipment is scaled to the production of one kilogram of switchgrass accounting for the lifetime of each piece of equipment, as relevant. The profiles and processes included in RMA are provided in **Table 1**. Those shown in bold face were developed by NETL.

Table 1: Profiles and Processes Included in RMA for Switchgrass

Stage #1: Switchgrass Biomass

- Bulldozer & Grader, Construction
  - US: Diesel Motor Grader, 213 Horsepower, Construction NETL <u-so>
  - US: Diesel Track Bulldozer, 410 Horsepower, Construction NETL <u-so>
  - US: Switchgrass Land Preparation Assembly, Construction NETL <u-so>
  - WOR: Steel Plate, BF, Manufacture NETL <u-so>
- SG Cultivation Equipment
  - Seeder, Construction

US: Seeder, 21900 lbs, Tractor-Propelled, Construction NETL <u-so>
WOR: Steel Plate, BF, Manufacture NETL <u-so>
Tiller, Construction
US: Tiller, 5015 lbs, Tractor-Propelled, Construction NETL <u-so>
WOR: Steel Plate, BF, Manufacture NETL <u-so>
Tractor, Construction
US: Diesel Tractor, 165 Horsepower, Construction NETL <u-so>
WOR: Steel Plate, BF, Manufacture NETL <u-so>
US: Switchgrass Cultivation Assembly, Construction NETL <u-so>
Switchgrass Harvesting, Construction
Switchgrass Baler, Construction
US: Baler, 3110 lbs, Tractor-Propelled, Construction NETL <u-so>
WOR: Steel Plate, BF, Manufacture NETL <u-so>
Switchgrass Harvester, Construction
US: Diesel Forage Harvester, 615 Horsepower, Construction NETL <u-so>
WOR: Steel Plate, BF, Manufacture NETL <u-so>
US: Switchgrass Harvesting Assembly, Construction NETL <u-so>
Switchgrass: Cultivation - Operation
Average K Fertilizer
EU-15: Average K Fertilizer NETL
North American Average Electricity Mix, 2007 NETL
Average N Fertilizer
DE: Ammonia (NH3) PE
DE: Nitric acid (98%) PE
EU-15: Average N Fertilizer NETL
North American Average Electricity Mix, 2007 NETL
Average P Fertilizer
DE: Sulphuric acid (96%) PE
EU-15: Average P Fertilizer NETL
North American Average Electricity Mix, 2007 NETL
US: Phosphate NETL
US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>
US: Switchgrass Cultivation, Operation NETL <u-so>
Switchgrass: Harvesting and Storage - Operation
US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>
US: Switchgrass Harvesting & Storage, Operation NETL <u-so>
Switchgrass: Land Preparation - Operation
US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>
US: Switchgrass: Land Preparation Operation NETL <u-so>

Parameters and Balances

The parameters for the highest level modeling plans for RMA of switchgrass are shown in **Table 2**. These parameters may or may not include the adjustable parameters shown previously, depending on how the model was created. **Table 3** presents the input and output balances for resources and emissions of interest for the RMA plan.

Table 2: Adjustable Parameters for RMA of Switchgrass

Plan	Parameter	Value	Comment
LC Stage #1			
Stage #1: Switchgrass Biomass	acres_yr	500	[acre/yr] Assumed size of farm is 500 acres (just to cal. individual stage results).
Stage #1: Switchgrass Biomass	biomass_yield	3569	[kg/acre-year] Adjustable parameter.

Table 3: Inputs and Output Balances for RMA of Switchgrass (kg/kg produced)

\	Cradle to Gate (RMA)
Inputs	
Flows	7.729E+02
Resources	7.729E+02
Energy resources	4.138E-02
Non renewable energy resources	4.138E-02
Crude oil (resource)	7.892E-03
Crude oil	2.874E-03
Crude oil Algeria	1.552E-04
Crude oil Angola	1.623E-04
Crude oil Argentina	3.330E-07
Crude oil Australia	3.010E-06
Crude oil Austria	1.250E-07
Crude oil Bolivia	1.636E-12
Crude oil Brazil	2.820E-06
Crude oil Brunei	3.009E-12
Crude oil Bulgaria	1.227E-11
Crude oil Cameroon	1.570E-06
Crude oil Canada	7.113E-04
Crude oil Central Africa	0.000E+00
Crude oil Central America	0.000E+00
Crude oil Chile	7.319E-11
Crude oil China	8.730E-07

\	Cradle to Gate (RMA)
Crude oil CIS	2.822E-04
Crude oil Colombia	9.101E-07
Crude oil Czech Republic	1.506E-08
Crude oil Denmark	1.624E-05
Crude oil Ecuador	1.021E-04
Crude oil Egypt	6.409E-07
Crude oil France	2.335E-07
Crude oil Gabon	6.784E-07
Crude oil Germany	2.390E-05
Crude oil Greece	2.480E-08
Crude oil Hungary	3.878E-09
Crude oil India	5.932E-12
Crude oil Indonesia	1.344E-06
Crude oil Iran	6.408E-06
Crude oil Iraq	1.606E-04
Crude oil Ireland	7.876E-13
Crude oil Italy	1.831E-06
Crude oil Japan	1.085E-13
Crude oil Kuwait	1.018E-04
Crude oil Libya	6.462E-05
Crude oil Malaysia	1.559E-12
Crude oil Mexico	3.775E-04
Crude oil Middle East	0.000E+00
Crude oil Netherlands	4.904E-06
Crude oil New Zealand	1.809E-07
Crude oil Nigeria	3.368E-04
Crude oil North Africa	0.000E+00
Crude oil Norway	1.734E-04
Crude oil Oman	4.129E-07
Crude oil Poland	8.341E-07
Crude oil Qatar	7.506E-07
Crude oil Romania	5.000E-08
Crude oil Saudi Arabia	3.777E-04
Crude oil Slovakia	2.422E-10
Crude oil South Africa	2.467E-12
Crude oil Spain	4.143E-08

\	Cradle to Gate (RMA)
Crude oil Syria	6.863E-11
Crude oil Trinidad and Tobago	2.369E-07
Crude oil Tunisia	2.143E-06
Crude oil Turkey	8.126E-16
Crude oil United Arab Emirates	1.604E-06
Crude oil United Kingdom	1.052E-04
Crude oil USA	1.486E-03
Crude oil Venezuela	3.487E-04
Hard coal (resource)	3.717E-03
Hard coal	1.258E-03
Hard Coal (Illinois No 6)	3.946E-04
Hard coal Australia	7.674E-05
Hard coal Belgium	1.554E-08
Hard coal Bosnia and Herzegovina	4.118E-09
Hard coal Brazil	1.141E-08
Hard coal Canada	3.306E-05
Hard coal Chile	7.631E-09
Hard coal China	1.030E-05
Hard coal CIS	4.625E-05
Hard coal Colombia	6.403E-05
Hard coal Czech Republic	2.339E-05
Hard coal France	4.587E-07
Hard coal Germany	4.859E-04
Hard coal India	4.355E-10
Hard coal Indonesia	8.973E-06
Hard coal Italy	2.156E-10
Hard coal Japan	8.603E-14
Hard coal Malaysia	5.524E-14
Hard coal Mexico	4.451E-08
Hard coal New Zealand	6.285E-09
Hard coal Poland	1.536E-04
Hard coal Portugal	2.726E-11
Hard coal South Africa	1.549E-04
Hard coal Spain	8.286E-08
Hard coal Turkey	3.532E-12
Hard coal United Kingdom	3.326E-06

\	Cradle to Gate (RMA)
Hard coal USA	9.988E-04
Hard coal Venezuela	2.410E-06
Hard coal Vietnam	2.789E-06
Hard Coal, Pure, Fuel	9.238E-09
Hard Coal, Raw, Fuel	7.233E-08
Powder River Basin Subbituminous Coal	0.000E+00
Lignite (resource)	3.415E-03
Lignite	3.351E-07
Lignite Australia	1.551E-06
Lignite Austria	1.286E-08
Lignite Bosnia and Herzegovina	9.510E-09
Lignite Bulgaria	4.361E-09
Lignite Canada	1.072E-06
Lignite CIS	1.306E-06
Lignite Czech Republic	4.511E-05
Lignite France	1.059E-07
Lignite Germany	2.894E-07
Lignite Germany (Central Germany)	3.764E-04
Lignite Germany (Lausitz)	1.092E-03
Lignite Germany (Rheinisch)	1.887E-03
Lignite Greece	1.354E-07
Lignite Hungary	7.501E-09
Lignite India	8.712E-11
Lignite Macedonia	4.190E-09
Lignite Poland	5.132E-06
Lignite Romania	4.413E-10
Lignite Serbia and Montenegro	1.833E-08
Lignite Slovakia	2.310E-09
Lignite Slovenia	1.739E-08
Lignite Spain	1.737E-07
Lignite Turkey	1.007E-13
Lignite USA	4.482E-06
Natural gas (resource)	2.636E-02
Natural gas	2.982E-07
Natural gas Algeria	1.411E-05
Natural gas Angola	1.990E-05

\	Cradle to Gate (RMA)
Natural gas Argentina	7.000E-08
Natural gas Australia	3.555E-07
Natural gas Austria	1.460E-08
Natural gas Bolivia	3.287E-09
Natural gas Brazil	2.012E-07
Natural gas Brunei	2.622E-08
Natural gas Bulgaria	1.506E-12
Natural gas Cameroon	3.912E-07
Natural gas Canada	8.954E-05
Natural gas Chile	1.741E-08
Natural gas China	5.044E-08
Natural gas CIS	4.484E-03
Natural gas Colombia	9.664E-08
Natural gas Czech Republic	1.300E-08
Natural gas Denmark	2.646E-04
Natural gas Ecuador	6.235E-06
Natural gas Egypt	5.639E-08
Natural gas France	8.700E-08
Natural gas Gabon	9.998E-08
Natural gas Germany	2.798E-03
Natural gas Greece	1.636E-09
Natural gas Hungary	6.576E-10
Natural gas India	3.338E-11
Natural gas Indonesia	8.510E-08
Natural gas Iran	5.972E-07
Natural gas Iraq	6.688E-06
Natural gas Ireland	1.773E-09
Natural gas Italy	1.531E-07
Natural gas Japan	3.745E-10
Natural gas Kuwait	3.865E-06
Natural gas Libyan	1.672E-06
Natural gas Malaysia	2.656E-08
Natural gas Mexico	2.121E-05
Natural gas Netherlands	2.559E-03
Natural gas New Zealand	1.193E-08
Natural gas Nigeria	5.982E-05

\	Cradle to Gate (RMA)
Natural gas Norway	2.942E-03
Natural gas Oman	5.562E-08
Natural gas Poland	7.201E-08
Natural gas Qatar	4.148E-07
Natural gas Romania	3.122E-09
Natural gas Saudi Arabia	1.472E-05
Natural gas Slovakia	3.518E-11
Natural gas South Africa	8.125E-10
Natural gas Spain	5.113E-09
Natural gas Syria	7.375E-12
Natural gas Trinidad and Tobago	1.619E-06
Natural gas Tunisia	2.763E-07
Natural gas Turkey	8.218E-17
Natural gas United Arab Emirates	7.626E-08
Natural gas United Kingdom	2.697E-04
Natural gas USA	3.733E-04
Natural gas Venezuela	1.536E-05
Natural Gas, Fuel	1.209E-02
Natural gas, Raw Material	3.097E-04
Pit gas	4.297E-09
Pit Methane	1.507E-05
Uranium (resource)	9.235E-08
Nuclear energy	0.000E+00
Uranium natural	9.235E-08
Renewable energy resources	1.266E-07
Biomass	3.779E-10
Energy, gross calorific value, in biomass, primary forest	0.000E+00
Primary energy from geothermics	0.000E+00
Primary energy from hydro power	0.000E+00
Primary energy from solar energy	0.000E+00
Primary energy from waves	0.000E+00
Primary energy from wind power	0.000E+00
Renewable fuels	1.665E-10
Wood	1.261E-07
Unspecified	0.000E+00
Energy unspecified (APME)	0.000E+00

\	Cradle to Gate (RMA)
Land use	0.000E+00
Hemerobie ecoinvent	0.000E+00
Transformation, from unknown	0.000E+00
Transformation, to mineral extraction site	0.000E+00
Occupation	0.000E+00
Biotic Production	0.000E+00
Erosion Resistance	0.000E+00
Groundwater Replenishment	0.000E+00
Mechanical Filtration	0.000E+00
Physicochemical Filtration	0.000E+00
Transformation	0.000E+00
Biotic Production	0.000E+00
Erosion Resistance	0.000E+00
Groundwater Replenishment	0.000E+00
Mechanical Filtration	0.000E+00
Physicochemical Filtration	0.000E+00
Material resources	7.728E+02
Non renewable elements	5.727E-07
Aluminum	2.923E-11
Chromium	1.430E-14
Copper	2.392E-14
Iron	5.695E-07
Lead	7.248E-15
Magnesium	1.610E-17
Mercury	4.652E-15
Nickel	6.077E-17
Phosphorus	1.609E-12
Sulphur	1.131E-11
Zinc	3.151E-09
Non renewable resources	6.014E-02
Barium sulphate	2.164E-17
Basalt	3.047E-07
Bauxite	4.298E-07
Bentonite	5.489E-05
Calcium carbonate (CaCO3)	9.549E-03
Calcium chloride	2.216E-15

\	Cradle to Gate (RMA)
Chalk (Calciumcarbonate)	7.789E-41
Chromium ore (39%)	5.075E-08
Clay	7.518E-06
Colemanite ore	9.772E-09
Copper - Gold - Silver - ore (1,0% Cu; 0,4 g/t Au; 66 g/t Ag)	1.258E-07
Copper - Gold - Silver - ore (1,1% Cu; 0,01 g/t Au; 2,86 g/t Ag)	7.666E-08
Copper - Gold - Silver - ore (1,16% Cu; 0,002 g/t Au; 1,06 g/t Ag)	4.327E-08
Copper - Molybdenum - Gold - Silver - ore (1,13% Cu; 0,02% Mo; 0,01 g/t Au; 2,86 g/t Ag)	3.927E-08
Copper ore (0.14%)	1.913E-06
Copper ore (1.2%)	1.305E-08
Copper ore (4%)	2.365E-17
Copper ore (sulphidic, 1.1%)	1.304E-08
Dolomite	1.096E-05
Feldspar (aluminum silicates)	1.134E-12
Ferro manganese	2.519E-15
Fluorspar (calcium fluoride; fluorite)	2.653E-09
Granite	3.394E-22
Gravel	4.140E-07
Gypsum (natural gypsum)	2.226E-06
Heavy spar (BaSO4)	1.328E-04
Ilmenite (titanium ore)	1.940E-12
Inert rock	4.773E-02
Iron ore (56,86%)	9.755E-04
Iron ore (65%)	1.197E-08
Kaolin ore	1.753E-08
Lead - zinc ore (4.6%-0.6%)	1.079E-05
Limestone (calcium carbonate)	5.032E-04
Magnesit (Magnesium carbonate)	4.451E-11
Magnesium chloride leach (40%)	1.166E-05
Manganese ore	9.822E-09
Manganese ore (R.O.M.)	4.260E-07
Molybdenite (Mo 0,24%)	2.398E-08
Molybdenum ore (0.1%)	1.353E-10
Natural Aggregate	6.559E-05
Nickel ore (1,5%)	1.748E-10
Nickel ore (1.6%)	1.510E-06

\	Cradle to Gate (RMA)
Olivine	2.626E-14
Peat	8.963E-08
Phosphate ore	9.555E-04
Phosphorus minerals	1.037E-05
Phosphorus ore (29% P2O5)	8.846E-16
Potassium chloride	4.166E-11
Precious metal ore (R.O.M)	1.443E-09
Quartz sand (silica sand; silicon dioxide)	1.416E-05
Raw pumice	1.703E-09
Rutile (titanium ore)	8.585E-16
sand	3.849E-12
Slate	4.838E-14
Sodium chloride (rock salt)	8.252E-05
Sodium nitrate	4.330E-21
Sodium sulphate	7.867E-10
Soil	2.138E-05
Sulphur (bonded)	2.230E-12
Talc	3.103E-10
Tin ore	1.877E-18
Titanium ore	1.633E-07
Zinc - copper ore (4.07%-2.59%)	1.947E-06
Zinc - lead - copper ore (12%-3%-2%)	8.335E-07
Zinc - lead ore (4.21%-4.96%)	8.077E-18
Zinc ore (4%)	-7.006E-06
Zinc ore (sulphidic, 4%)	1.578E-16
Renewable resources	7.728E+02
Water	7.724E+02
Water	6.481E-03
Water (feed water)	6.194E+02
Water (ground water)	7.645E+01
Water (lake water)	9.570E-07
Water (municipal)	8.528E-07
Water (rain water)	0.000E+00
Water (river water)	0.000E+00
Water (sea water)	5.054E-05
Water (surface water)	7.655E+01

\	Cradle to Gate (RMA)
Water (well water)	1.155E-08
Water (well-produced water)	3.332E-04
Water (with river silt)	6.728E-15
Water,turbine use, unspecified natural origin	0.000E+00
Air	3.197E-01
Carbon dioxide	2.138E-05
Nitrogen	3.008E-10
Oxygen	0.000E+00
Unspecified	8.387E-09
Unspecified minerals	1.908E-09
Unspecified resources	6.479E-09
Area of Production Land	0.000E+00
Output	
Flows	1.902E+01
Resources	1.992E+01
Energy resources	0.000E+00
Non renewable energy resources	0.000E+00
Hard coal (resource)	0.000E+00
Hard Coal (Illinois No 6)	0.000E+00
Powder River Basin Subbituminous Coal	0.000E+00
Non Renewable Energy	0.000E+00
Renewable energy resources	0.000E+00
Feedstock Energy	0.000E+00
Renewable Energy	0.000E+00
Total Primary Energy	0.000E+00
Land use	0.000E+00
Hemeroby	0.000E+00
Occup. as Forest land	0.000E+00
Material resources	1.992E+01
Renewable resources	1.992E+01
Water	1.992E+01
Water	0.000E+00
Water (feed water)	0.000E+00
Water (rain water)	1.970E+01
Water (river water)	2.119E-01
Water (sea water)	0.000E+00

\	Cradle to Gate (RMA)
Water (wastewater)	3.371E-04
Water (wastewater)	1.878E-03
Nitrogen	0.000E+00
Oxygen	1.061E-05
Ecoinvent	8.869E-07
Long-term emission	8.869E-07
Fresh water	8.869E-07
Chloride	8.869E-07
Dissolved organic carbon, DOC (Ecoinvent)	3.465E-13
Total organic carbon, TOC (Ecoinvent)	0.000E+00
Emissions to air	-9.061E-01
Heavy metals to air	5.200E-08
Antimony	4.653E-11
Arsenic (+V)	3.010E-10
Arsenic trioxide	7.370E-15
Cadmium (+II)	1.526E-10
Chromium (+III)	1.729E-12
Chromium (+VI)	3.036E-16
Chromium (unspecified)	1.943E-09
Cobalt	8.415E-11
Copper (+II)	2.409E-10
Heavy metals to air (unspecified)	3.914E-12
Hydrogen arsenic (arsine)	6.117E-13
Iron	3.347E-10
Lanthanides	1.666E-14
Lead (+II)	6.133E-09
Manganese (+II)	7.744E-10
Mercury (+II)	5.424E-10
Molybdenum	2.434E-11
Nickel (+II)	5.965E-10
Palladium	6.133E-20
Rhodium	5.921E-20
Selenium	9.411E-10
Silver	3.356E-19
Tellurium	2.306E-13
Thallium	1.741E-12

\	Cradle to Gate (RMA)
Tin (+IV)	2.925E-10
Titanium	1.093E-12
Vanadium (+III)	4.312E-09
Zinc (+II)	3.528E-08
Inorganic emissions to air	-1.140E+00
Ammonia	1.163E-04
Ammonium	2.402E-13
Ammonium nitrate	1.311E-14
Argon	5.764E-13
Barium	8.517E-08
Beryllium	6.212E-12
Boron compounds (unspecified)	1.777E-08
Bromine	4.266E-09
Carbon dioxide	1.083E-01
Carbon dioxide (biotic)	2.495E-09
Carbon dioxide (biotic)	-1.328E+00
Carbon disulphide	9.969E-14
Carbon monoxide	1.202E-04
Carbon monoxide (biotic)	9.820E-14
Chloride (unspecified)	3.281E-09
Chlorine	1.091E-10
Cyanide (unspecified)	8.145E-11
Fluoride	3.987E-09
Fluorides	2.928E-11
Fluorine	5.723E-13
Helium	9.179E-11
Hydrogen	6.655E-08
Hydrogen bromine (hydrobromic acid)	3.459E-11
Hydrogen chloride	1.260E-06
Hydrogen cyanide (prussic acid)	2.626E-12
Hydrogen fluoride	1.752E-08
Hydrogen iodide	3.652E-14
Hydrogen phosphorous	3.890E-15
Hydrogen sulphide	1.506E-07
Lead dioxide	4.268E-13
Nitrogen (atmospheric nitrogen)	3.326E-06

\	Cradle to Gate (RMA)
Nitrogen (N-compounds)	1.127E-13
Nitrogen dioxide	7.172E-06
Nitrogen monoxide	3.876E-13
Nitrogen oxides	2.807E-04
Nitrous oxide (laughing gas)	6.901E-04
Oxygen	5.149E-06
Scandium	7.831E-15
Steam	7.788E-02
Strontium	3.128E-13
Sulphur dioxide	1.426E-04
Sulphur hexafluoride	7.262E-10
sulphur oxide	3.433E-06
Sulphuric acid	4.219E-11
Tin oxide	1.861E-16
Unspecified Particles	1.562E-08
Zinc oxide	3.723E-16
Zinc sulphate	1.541E-11
Organic emissions to air (group VOC)	1.577E-04
Group NMVOC to air	1.762E-05
Group PAH to air	1.195E-08
Anthracene	1.780E-12
Benzo{a}anthracene	8.955E-13
Benzo{a}pyrene	4.446E-11
Benzo{ghi}perylene	7.989E-13
Benzofluoranthene	1.598E-12
Chrysene	2.200E-12
Dibenz(a)anthracene	4.978E-13
Indeno[1,2,3-cd]pyrene	5.945E-13
Naphthalene	1.869E-10
Phenanthrene	5.871E-11
Polycyclic aromatic hydrocarbons (PAH)	1.165E-08
Halogenated organic emissions to air	1.894E-09
Dichloroethane (ethylene dichloride)	1.185E-14
Dichloromethane (methylene chloride)	2.516E-16
Dioxins (unspec.)	-9.398E-15
Halogenated hydrocarbons (unspecified)	2.447E-14

\	Cradle to Gate (RMA)
Halon (1301)	0.000E+00
Polychlorinated biphenyls (PCB unspecified)	1.344E-12
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	6.192E-16
R 11 (trichlorofluoromethane)	6.744E-10
R 114 (dichlorotetrafluoroethane)	6.906E-10
R 116 (hexafluoroethane)	9.076E-13
R 12 (dichlorodifluoromethane)	1.450E-10
R 13 (chlorotrifluoromethane)	9.104E-11
R 22 (chlorodifluoromethane)	1.585E-10
Tetrafluoromethane	1.268E-11
Vinyl chloride (VCM; chloroethene)	1.197E-10
Acetaldehyde (Ethanal)	1.824E-09
Acetic acid	7.422E-09
Acetone (dimethylcetone)	1.614E-09
Acrolein	1.256E-11
Aldehyde (unspecified)	1.278E-10
Alkane (unspecified)	1.902E-08
Alkene (unspecified)	1.758E-08
Aromatic hydrocarbons (unspecified)	1.518E-10
Benzene	2.005E-08
Butadiene	2.332E-13
Butane	1.396E-06
Butane (n-butane)	4.686E-08
Caprolactam	2.056E-17
Cumene (isopropylbenzene)	7.553E-21
Cyclohexane (hexahydro benzene)	2.221E-12
Diethylamine	5.929E-18
Ethane	4.784E-06
Ethanol	1.200E-09
Ethene (ethylene)	4.068E-10
Ethyl benzene	1.773E-08
Fluoranthene	5.797E-12
Fluorene	1.839E-11
Formaldehyde (methanal)	1.305E-07
Heptane (isomers)	1.403E-08
Hexamethylene diamine (HMDA)	1.372E-14

\	Cradle to Gate (RMA)
Hexane (isomers)	2.100E-08
Mercaptan (unspecified)	1.584E-09
Methanethiol	3.971E-10
Methanol	7.598E-10
NMVOC (unspecified)	6.272E-06
Octane	7.720E-09
Pentane (n-pentane)	6.640E-07
Phenol (hydroxy benzene)	1.631E-14
Propane	4.099E-06
Propene (propylene)	1.591E-09
Propionic acid (propane acid)	1.213E-13
Styrene	2.465E-15
Toluene (methyl benzene)	8.699E-09
Trimethylbenzene	1.813E-15
Xylene (dimethyl benzene)	7.376E-08
Hydrocarbons (unspecified)	1.496E-09
Methane	1.342E-04
Methane (biotic)	1.131E-11
Organic chlorine compounds	3.502E-14
Unspecified Organic Compounds	1.085E-14
VOC (unspecified)	5.915E-06
Other emissions to air	2.338E-01
Aldehydes, unspecified	5.427E-15
Exhaust	7.414E-02
non used primary energy from wind power	0.000E+00
Particulate Matter, unspecified	2.133E-07
Sand (Silica) (SiO2)	1.035E-10
Unused primary energy from solar energy	0.000E+00
Used air	1.596E-01
Waste heat	0.000E+00
Particles to air	1.162E-04
Dust (PM10)	1.123E-07
Dust (PM2,5 - PM10)	2.173E-07
Dust (PM2.5)	4.094E-07
Dust (Portland cement kiln)	7.012E-09
Dust (unspecified)	1.155E-04

\	Cradle to Gate (RMA)
Metals (unspecified)	3.600E-13
Unspecified Organic Chlorine Compounds	7.161E-14
Wood (dust)	6.870E-14
Radioactive emissions to air	7.840E-10
Antimony (Sb124)	0.000E+00
Argon (Ar41)	0.000E+00
Carbon (C14)	0.000E+00
Cesium (Cs134)	0.000E+00
Cesium (Cs137)	0.000E+00
Cobalt (Co58)	0.000E+00
Cobalt (Co60)	0.000E+00
Hydrogen (H3)	0.000E+00
Iodine (I129)	0.000E+00
Iodine (I131)	0.000E+00
Krypton (Kr85)	0.000E+00
Krypton (Kr85m)	0.000E+00
Plutonium (Pu alpha)	0.000E+00
radionuclides	0.000E+00
Radon (Rn222)	0.000E+00
Uranium (total)	7.840E-10
Uranium (U234)	0.000E+00
Uranium (U235)	0.000E+00
Uranium (U238)	0.000E+00
Xenon (Xe131m)	0.000E+00
Xenon (Xe133)	0.000E+00
Xenon (Xe133m)	0.000E+00
Xenon (Xe135)	0.000E+00
Xenon (Xe135m)	0.000E+00
Xenon (Xe137)	0.000E+00
Xenon (Xe138)	0.000E+00
Unspecified Heavy Metals	5.593E-18
Emissions to fresh water	9.773E-03
Analytical measures to fresh water	3.257E-05
Adsorbable organic halogen compounds (AOX)	1.278E-08
Biological oxygen demand (BOD)	3.980E-07
Chemical oxygen demand (COD)	4.761E-06

\	Cradle to Gate (RMA)
Nitrogenous Matter (unspecified, as N)	1.263E-07
Solids (dissolved)	2.491E-05
Total Biochemical Oxygen Demand	0.000E+00
Total dissolved organic bounded carbon	2.338E-08
Total Dissolved Solids	2.188E-06
Total organic bounded carbon	1.492E-07
Total Suspended Solids	0.000E+00
Heavy metals to fresh water	1.645E-05
Aluminium	4.895E-10
Antimony	1.823E-08
Arsenic (+V)	7.705E-08
Cadmium (+II)	1.867E-08
Chromium (+III)	2.014E-10
Chromium (+VI)	5.462E-14
Chromium (unspecified)	1.667E-07
Cobalt	2.394E-12
Copper (+II)	1.587E-07
Heavy metals to water (unspecified)	1.856E-10
Iron	1.016E-05
Lead (+II)	2.537E-07
Manganese (+II)	1.648E-08
Mercury (+II)	1.159E-07
Molybdenum	1.989E-09
Nickel (+II)	1.855E-06
Selenium	4.011E-10
Silver	1.778E-08
Strontium	1.924E-08
Thallium	2.613E-13
Tin (+IV)	4.244E-13
Titanium	2.077E-10
Unspecified Substance	4.838E-14
Uranium	7.202E-07
Vanadium (+III)	6.290E-10
Zinc (+II)	2.853E-06
Inorganic emissions to fresh water	9.591E-03
Acid (calculated as H+)	7.438E-10

\	Cradle to Gate (RMA)
Acidity	0.000E+00
Aluminum (+III)	2.119E-06
Aluminum ion (+III)	5.378E-16
Ammonia	2.235E-05
Ammonia, as N	6.151E-14
Ammonium (total N)	5.296E-09
Ammonium / ammonia	3.361E-05
Barium	9.542E-08
Beryllium	2.377E-12
Boron	2.150E-08
Bromate	3.325E-16
Bromine	3.936E-12
Calcium (+II)	3.635E-03
Carbonate	5.444E-03
Chlorate	2.760E-13
Chloride	1.057E-04
Chlorine (dissolved)	9.804E-08
Copper ion (+II/+III)	6.107E-15
Cyanide	1.655E-07
Fluoride	2.117E-04
Fluorine	1.000E-10
Hydrogen chloride	1.846E-12
Hydrogen fluoride (hydrofluoric acid)	4.899E-12
Hydrogen Ions (H+)	1.080E-11
Hydroxide	2.131E-10
Inorganic salts and acids (unspecified)	1.037E-17
Iron ion (+II/+III)	6.798E-13
Magnesium (+III)	6.869E-07
Magnesium chloride	1.668E-14
Metal ions (unspecific)	3.207E-13
Neutral salts	1.867E-11
Nickel ion (+III)	3.530E-14
Nitrate	3.395E-07
Nitrate (as total N)	1.735E-13
Nitrogen	1.419E-05
Nitrogen (as total N)	1.712E-09

\	Cradle to Gate (RMA)
Nitrogen organic bounded	1.786E-08
Phosphate	5.269E-08
Phosphorus	5.647E-05
Potassium	1.922E-09
Silicate particles	1.048E-10
Sodium (+I)	2.837E-05
Sodium chloride (rock salt)	1.805E-06
Sodium hypochlorite	4.351E-11
Sulfates	1.435E-07
Sulphate	3.436E-05
Sulphide	5.309E-08
Sulphite	6.459E-09
Sulphur	1.017E-11
Sulphur dioxide	0.000E+00
Sulphuric acid	2.380E-10
Unspecified Iron Oxides	1.239E-13
Unspecified Oil	4.389E-13
Unspecified Organic Chlorine compounds	9.946E-16
Unspecified Salt	3.979E-12
Unspecified Solids (Suspended)	1.545E-11
Organic emissions to fresh water	3.194E-05
Halogenated organic emissions to fresh water	5.726E-12
1,2-Dibromoethane	5.218E-16
Chlorinated hydrocarbons (unspecified)	6.042E-14
Chloromethane (methyl chloride)	5.660E-12
Dichloroethane (ethylene dichloride)	4.963E-16
Dichloropropane	1.101E-17
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	1.616E-18
Vinyl chloride (VCM; chloroethene)	3.752E-15
Hydrocarbons to fresh water	3.178E-05
Acenaphthene	7.961E-13
Acenaphthylene	3.321E-13
Acetic acid	1.562E-09
Acrylonitrile	8.051E-13
Anthracene	1.368E-12
Aromatic hydrocarbons (unspecified)	1.291E-09

\	Cradle to Gate (RMA)
Benzene	2.378E-09
Benzo{a}anthracene	9.700E-14
Benzofluoranthene	2.985E-14
Chrysene	3.899E-13
Cresol (methyl phenol)	2.634E-13
Ethyl benzene	9.581E-11
Fluoranthene	1.339E-13
Hexane (isomers)	2.889E-14
Hydrocarbons (unspecified)	3.286E-09
Methanol	3.091E-05
Oil (unspecified)	8.567E-07
Phenol (hydroxy benzene)	1.725E-09
Polycyclic aromatic hydrocarbons (PAH, unspec.)	6.127E-10
Toluene (methyl benzene)	1.247E-09
Xylene (isomers; dimethyl benzene)	6.900E-10
Carbon, organically bound	1.673E-07
Naphthalene	5.484E-11
N-unspecified (N)	3.435E-13
Organic chlorine compounds (unspecified)	1.031E-14
Organic compounds (dissolved)	3.729E-13
Organic compounds (unspecified)	5.069E-13
Unspecified wastewater	2.597E-10
Other emissions to fresh water	0.000E+00
Detergent (unspecified)	0.000E+00
non used primary energy from water power	0.000E+00
Unused primary energy from geothermal	0.000E+00
Waste heat	0.000E+00
Waste water	0.000E+00
Particles to fresh water	1.012E-04
Metals (unspecified)	2.439E-12
Silicon dioxide (silica)	1.871E-12
Soil loss by erosion into water	9.326E-11
Solids (suspended)	1.010E-04
Suspended solids, unspecified	2.221E-07
Unspecified Oxides	1.030E-13
Radioactive emissions to fresh water	0.000E+00

\	Cradle to Gate (RMA)
Americium (Am241)	0.000E+00
Antimony (Sb124)	0.000E+00
Antimony (Sb125)	0.000E+00
Carbon (C14)	0.000E+00
Cesium (Cs134)	0.000E+00
Cesium (Cs137)	0.000E+00
Cobalt (Co58)	0.000E+00
Cobalt (Co60)	0.000E+00
Curium (Cm alpha)	0.000E+00
Hydrogen (H3)	0.000E+00
Iodine (I129)	0.000E+00
Iodine (I131)	0.000E+00
Manganese (Mn54)	0.000E+00
Plutonium (Pu alpha)	0.000E+00
Radionuclides	0.000E+00
Radium (Ra226)	0.000E+00
Ruthenium (Ru106)	0.000E+00
Silver (Ag110m)	0.000E+00
Strontium (Sr90)	0.000E+00
Thorium (Th234)	0.000E+00
Uranium	0.000E+00
Bromide	0.000E+00
Radionuclide	0.000E+00
Sulfite	0.000E+00
Unspecified Solids (Dissolved)	2.978E-11
Uranium (total)	6.691E-14
Emissions to sea water	1.178E-04
Analytical measures to sea water	6.260E-07
Adsorbable organic halogen compounds (AOX)	4.166E-14
Biological oxygen demand (BOD)	4.595E-08
Chemical oxygen demand (COD)	5.341E-07
Total organic bounded carbon	4.595E-08
Heavy metals to sea water	1.319E-07
Arsenic (+V)	6.839E-10
Cadmium (+II)	3.838E-10
Chromium (unspecified)	1.036E-09

\	Cradle to Gate (RMA)
Cobalt	2.146E-10
Copper (+II)	3.503E-09
Iron	8.543E-09
Lead (+II)	1.007E-09
Manganese (+II)	8.565E-10
Mercury (+II)	1.582E-11
Molybdenum	9.104E-11
Nickel (+II)	1.105E-09
Silver	1.363E-10
Strontium	1.099E-07
Tin (+IV)	1.632E-10
Titanium	1.662E-11
Vanadium (+III)	1.680E-10
Zinc (+II)	4.059E-09
Inorganic emissions to sea water	8.038E-05
Aluminum (+III)	5.351E-10
Ammonia	1.590E-08
Barium	1.544E-08
Beryllium	9.727E-12
Boron	8.653E-09
Calcium (+II)	9.450E-07
Carbonate	9.600E-07
Chloride	7.667E-05
Magnesium	2.361E-07
Nitrate	1.260E-09
Sodium (+I)	9.177E-07
Sulphate	4.474E-07
Sulphide	1.664E-07
Sulphur	4.630E-09
Organic emissions to sea water	5.516E-08
Hydrocarbons to sea water	5.476E-08
Acenaphthene	1.131E-11
Acenaphthylene	4.340E-12
Acetic acid	2.612E-11
Anthracene	3.900E-12
Aromatic hydrocarbons (unspecified)	4.595E-10

\	Cradle to Gate (RMA)
Benzene	6.469E-09
Benzo{a}anthracene	2.473E-12
Benzofluoranthene	2.680E-12
Chrysene	1.384E-11
Cresol (methyl phenol)	1.199E-10
Ethyl benzene	1.036E-09
Fluoranthene	2.881E-12
Hexane (isomers)	1.309E-11
Oil (unspecified)	3.474E-08
Phenol (hydroxy benzene)	5.755E-09
Toluene (methyl benzene)	4.919E-09
Xylene (isomers; dimethyl benzene)	1.179E-09
Naphthalene	3.976E-10
Particles to sea water	3.657E-05
Solids (suspended)	3.657E-05
Emissions to agricultural soil	1.178E-05
Heavy metals to agricultural soil	1.178E-05
Cadmium (+II)	1.645E-07
Chromium (unspecified)	7.664E-06
Copper (+II)	5.210E-07
Lead (+II)	9.880E-08
Mercury (+II)	9.364E-10
Nickel (+II)	3.371E-07
Zinc (+II)	2.989E-06
Emissions to industrial soil	2.554E-05
Heavy metals to industrial soil	2.341E-05
Antimony	1.042E-20
Arsenic (+V)	1.259E-08
Cadmium (+II)	7.794E-12
Chromium (+III)	1.750E-14
Chromium (+VI)	3.777E-20
Chromium (unspecified)	2.108E-09
Cobalt	3.757E-11
Copper (+II)	2.138E-11
Iron	2.253E-05
Lead (+II)	9.000E-08

\	Cradle to Gate (RMA)
Manganese (+II)	4.437E-10
Mercury (+II)	2.328E-10
Nickel (+II)	6.184E-10
Selenium	1.495E-09
Strontium	6.996E-07
Thallium	1.088E-08
Vanadium (+III)	6.871E-08
Zinc (+II)	2.331E-10
Inorganic emissions to industrial soil	2.122E-06
Aluminum (+III)	2.361E-09
Ammonia	1.104E-06
Bromide	3.220E-10
Calcium (+II)	2.207E-09
Chloride	3.758E-07
Chlorine	8.812E-18
Fluoride	1.073E-08
Magnesium (+III)	3.085E-10
Phosphorus	1.138E-07
Potassium (+I)	2.698E-07
Sodium (+I)	1.924E-10
Sulphate	3.463E-08
Sulphide	2.078E-07
Organic emissions to industrial soil	1.229E-09
Oil (unspecified)	1.229E-09
Radioactive emissions to industrial soil	0.000E+00
Uranium	0.000E+00
Calcium Fluoride	1.719E-09
Radionuclide	0.000E+00

Embedded Unit Processes

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References

None.

Section III: Document Control Information

Date Created: September 12, 2011

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Revision History:

31MAY2012	Updated to revised model results.

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

NETL (2011). *NETL Life Cycle Inventory Data – Unit Process: Switchgrass, Production.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: May 2012 (version 02). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

Section IV: Disclaimer