NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Ethanol via Lignocellulosic Combustion of Switchgrass, Conversion

Reference Flow: 1 kg of Ethanol (E95)

Brief Description: This process includes all inputs for the energy conversion for 1 kg of ethanol, based on lignocellulosic combustion of switchgrass.

Section I: Meta Data

Geographical Coverage: US **Region:** Midwest

Year Data Best Represents: 2009

Process Type: Energy Conversion (EC)

Process Scope: Gate-to-Gate Process (GG)

Allocation Applied: Yes

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:

ETHANOL_PROD	*Ethanol production from refinery per 30-year study period*

Tracked Input Flows:

Switchgrass	*Switchgrass input into the ECF*

Tracked Output Flows:

Ethanol (E95) [Valuable substance]	*Ethanol fuel (E95) produced by the energy conversion facility and ready for transport*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_ECF_Ethanol_LignocellulosicCombustion_Switchgrass_2011.01.xls*, which provides additional details regarding relevant calculations, data quality, and references.

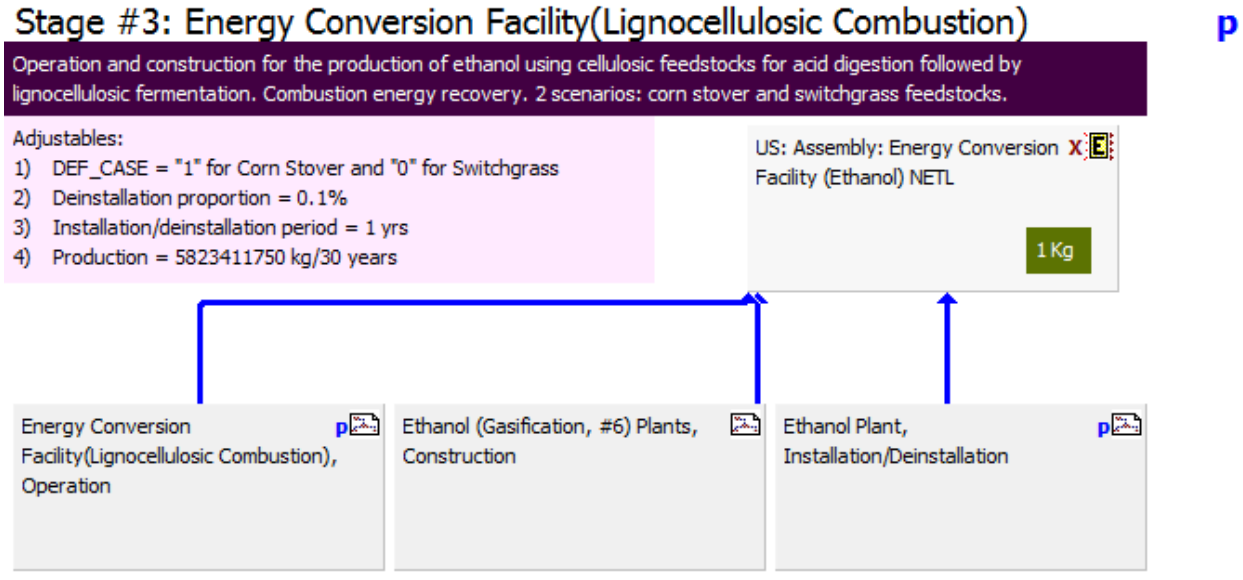
Goal and Scope

The scope of this unit process covers all aspects of the energy conversion facility (ECF) for the production of ethanol (E95) via lignocellulosic combustion of switchgrass, as shown in **Figure 1**. At the downstream boundary of this unit process, one kilogram finished ethanol (E95) is delivered to the upstream boundary of finished fuels transport (LC Stage #4).

Boundary and Description

LC Stage #3 (ECF) includes the conversion of switchgrass to fuel-grade ethanol (E95) via a lignocellulosic combustion. This process can use either corn stover or switchgrass as the cellulosic feedstock in the production of ethanol. Finished ethanol from the ECF process is delivered to the upstream boundary of LC Stage #4, finished fuels transport. The plan for the switchgrass/ethanol ECF (lignocellulosic combustion) is provided in **Figure 1**.

Figure 1: Plan for ECF of Switchgrass to Ethanol (E95) Finished Fuel



The profiles and processes included in the ECF are provided in **Table 1**. Those shown in bold face were developed by NETL.

Table 1: Profiles and Processes Included in ECF for Switchgrass

Stage #3: Energy Conversion Facility (Lignocellulosic Combustion)
- Energy Conversion Facility(Lignocellulosic Combustion), Operation
  - US: MROW Grid Power Mix, 2005 (eGRID2007)
    - EU-15: Power from biomass - Energy Quality EDIP
    - GLO: Power from nuclear power plant PE
    - GLO: Power from wind power PE
    - **US: MROW Power grid mix, 2005 (eGRID2007) NETL**
    - US: Power from hard coal PE
    - US: Power from heavy fuel oil PE
    - US: Power from hydropower PE
    - US: Power from lignite PE
    - US: Power from natural gas PE
  - DE: Limestone flour (CaCO3; dried) PE
  - RER: Sulphuric acid (96%) PE
  - **US: Biochemical Ethanol Plant with Boiler Cogen NETL <u-so>**
  - **US: Electricity, System Expansion NETL**
- Ethanol (Gasification, #6) Plants, Construction
  - US: MROW Grid Power Mix, 2005 (eGRID2007)
    - EU-15: Power from biomass - Energy Quality EDIP
    - GLO: Power from nuclear power plant PE
    - GLO: Power from wind power PE
    - **US: MROW Power grid mix, 2005 (eGRID2007) NETL**
    - US: Power from hard coal PE
    - US: Power from heavy fuel oil PE
    - US: Power from hydropower PE
    - US: Power from lignite PE
    - US: Power from natural gas PE
  - **US: Concrete, ready mixed, R-5-0 (100% Portland Cement) NETL <u-so>**
  - **US: Ethanol Plant, Thermochemical, Construction NETL <u-so>**
  - **WOR: Steel Plate, BF, Manufacture NETL <u-so>**
  - **WOR: Steel, Stainless, 316 2B, 80% Recycled NETL <u-so>**
- Ethanol Plant, Installation/Deinstallation
  - **US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>**
  - **US: Fischer-Tropsch Diesel (FTD) Energy Conversion Facility Commissioning/Decommissioning NETL <u-so>**
- **US: Assembly: Energy Conversion Facility (Ethanol) NETL**

Parameters and Balances

The parameters for the highest level modeling plan for ECF for switchgrass to ethanol production 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 ECF plan.

Table 2: Adjustable Parameters for ECF for Switchgrass Ethanol

Plan	Parameter	Value	Comment
LC Stage #3			
Stage #3: Energy Conversion Facility (Lignocellulosic Combustion)	ETHANOL_PROD	5.82E+09	[kg/Study Period] Ethanol production from refinery, per 30-year study period; see 'Calcs_FD' for ref

Table 3: Inputs and Output Balances for ECF for Ethanol Production via Lignocellulosic Combustion of Switchgrass (kg/kg produced)

Process or Category	Gate to Gate (ECF)
Inputs	
Flows	-9.960E+00
Resources	-9.960E+00
Energy resources	-1.886E-01
Non renewable energy resources	-1.886E-01
Crude oil (resource)	3.890E-02
Hard coal (resource)	-2.246E-01
Lignite (resource)	4.198E-04
Natural gas (resource)	-3.236E-03
Uranium (resource)	-2.694E-06
Renewable energy resources	-3.036E-06
Biomass	-7.087E-09
Renewable fuels	2.205E-10
Wood	-3.029E-06
Unspecified	0.000E+00
Land use	0.000E+00
Material resources	-9.772E+00
Non renewable elements	3.149E-06
Aluminum	-2.438E-09
Chromium	7.712E-13
Copper	6.030E-14
Iron	3.134E-06

Process or Category	Gate to Gate (ECF)
Lead	4.755E-13
Magnesium	9.108E-16
Mercury	2.268E-13
Nickel	2.855E-15
Phosphorus	9.102E-11
Sulphur	8.519E-10
Zinc	1.744E-08
Non renewable resources	-1.002E+00
Barium sulphate	1.779E-16
Basalt	6.136E-06
Bauxite	8.965E-06
Bentonite	1.074E-05
Calcium carbonate (CaCO3)	-1.587E-05
Calcium chloride	1.822E-14
Chalk (Calciumcarbonate)	8.453E-40
Chromium ore (39%)	2.429E-04
Clay	-9.465E-06
Colemanite ore	-4.095E-07
Copper - Gold - Silver - ore (1,0% Cu; 0,4 g/t Au; 66 g/t Ag)	-1.509E-06
Copper - Gold - Silver - ore (1,1% Cu; 0,01 g/t Au; 2,86 g/t Ag)	-9.190E-07
Copper - Gold - Silver - ore (1,16% Cu; 0,002 g/t Au; 1,06 g/t Ag)	-5.187E-07
Copper - Molybdenum - Gold - Silver - ore (1,13% Cu; 0,02% Mo; 0,01 g/t Au; 2,86 g/t Ag)	-1.264E-06
Copper ore (0.14%)	-7.651E-05
Copper ore (1.2%)	-1.564E-07
Copper ore (4%)	-1.455E-16
Copper ore (sulphidic, 1.1%)	-1.088E-06
Dolomite	1.580E-04
Feldspar (aluminum silicates)	6.419E-11
Ferro manganese	1.403E-13
Fluorspar (calcium fluoride; fluorite)	6.712E-08
Granite	1.739E-20
Gypsum (natural gypsum)	-1.075E-05
Heavy spar (BaSO4)	2.703E-05
Ilmenite (titanium ore)	7.250E-11
Inert rock	-1.104E+00
Iron ore (56,86%)	9.198E-04
Iron ore (65%)	-2.606E-08
Kaolin ore	-7.351E-07

Process or Category	Gate to Gate (ECF)
Lead - zinc ore (4.6%-0.6%)	2.401E-06
Limestone (calcium carbonate)	9.569E-02
Magnesit (Magnesium carbonate)	7.706E-08
Magnesium chloride leach (40%)	7.903E-06
Manganese ore	5.817E-05
Manganese ore (R.O.M.)	9.723E-08
Molybdenite (Mo 0,24%)	-7.715E-07
Molybdenum ore (0.1%)	8.397E-05
Natural Aggregate	-2.187E-03
Nickel ore (1,5%)	5.955E-05
Nickel ore (1.6%)	-7.447E-08
Olivine	1.463E-12
Peat	5.471E-05
Phosphate ore	1.953E-06
Phosphorus minerals	7.924E-09
Phosphorus ore (29% P2O5)	1.384E-08
Potassium chloride	3.038E-08
Precious metal ore (R.O.M)	-2.929E-08
Quartz sand (silica sand; silicon dioxide)	2.571E-06
Raw pumice	-7.142E-08
Rutile (titanium ore)	2.796E-11
sand	2.163E-10
Slate	3.193E-12
Sodium chloride (rock salt)	7.897E-05
Sodium nitrate	4.849E-20
Sodium sulphate	7.820E-10
Soil	7.620E-03
Sulphur (bonded)	-8.816E-12
Talc	-1.234E-08
Tin ore	1.543E-17
Titanium ore	-1.068E-06
Zinc - copper ore (4.07%-2.59%)	-4.457E-06
Zinc - lead - copper ore (12%-3%-2%)	-2.638E-06
Zinc - lead ore (4.21%-4.96%)	-4.968E-17
Zinc ore (4%)	-2.820E-06
Zinc ore (sulphidic, 4%)	-1.218E-15
Renewable resources	-8.770E+00
Water	-5.739E+00

Process or Category	Gate to Gate (ECF)
Water	8.027E-02
Water (feed water)	1.771E-04
Water (ground water)	-1.196E-01
Water (lake water)	2.193E-18
Water (sea water)	2.049E-03
Water (surface water)	-5.702E+00
Water (well water)	6.430E-07
Water (with river silt)	5.504E-12
Air	-3.031E+00
Carbon dioxide	-2.307E-04
Nitrogen	2.115E-08
Oxygen	0.000E+00
Unspecified	-6.997E-07
Unspecified minerals	-1.592E-07
Unspecified resources	-5.405E-07
Area of Production Land	0.000E+00
Output	
Flows	-5.298E+00
Resources	-4.804E+00
Energy resources	0.000E+00
Land use	0.000E+00
Material resources	-4.804E+00
Renewable resources	-4.804E+00
Water	-4.804E+00
Water (river water)	-4.804E+00
Water (wastewater)	4.045E-04
Nitrogen	0.000E+00
Oxygen	1.126E-04
Ecoinvent	-2.891E-11
Long-term emission	-2.891E-11
Fresh water	-2.891E-11
Dissolved organic carbon, DOC (Ecoinvent)	-2.891E-11
Production residues in life cycle	4.438E-01
Hazardous waste for disposal	3.470E-06
Chromium containing slag	2.293E-10
Dross (Fines)	2.340E-08

Process or Category	Gate to Gate (ECF)
Natrium oxide	3.979E-08
Red mud (dry)	3.457E-06
Soil and sand containing heavy metals	-5.488E-08
Toxic chemicals (unspecified)	4.194E-09
Hazardous waste for recovery	9.371E-05
Used oil	6.327E-09
Waste water processing residue	9.370E-05
Waste for disposal	4.437E-01
Incineration good	2.288E-09
Sludge from water works (6% dry matter-content)	1.282E-09
Waste (solid)	4.427E-01
Waste for disposal (unspecified)	2.228E-09
Waste from steel works	9.706E-04
Waste for recovery	4.567E-06
Aluminum scrap	2.393E-11
Chemicals (unspecified)	1.257E-09
Cooling water	4.311E-06
Cryolite	1.091E-08
Dross	7.857E-09
Filter dust	4.567E-11
Furnace clinker	3.340E-08
Gypsum	2.132E-08
Gypsum (contaminated)	7.701E-14
Gypsum (FDI)	6.301E-11
Plastic (unspecified)	2.497E-09
Production residues (unspecified)	1.742E-11
Rolling gravel	8.210E-09
Rolling tinder	6.393E-12
Slag	1.528E-07
Slag (containing precious metal)	2.143E-11
Slag (Iron plate production)	1.827E-10
Slag (Mn 6,5%)	1.658E-08
Wood	1.318E-12
Wooden pallet (EURO)	7.014E-18
Mixed Waste (Hazardous or Radioactive)	0.000E+00
Neutralized residues	2.302E-16
Emissions to air	-9.358E-01
Heavy metals to air	1.297E-07

Process or Category	Gate to Gate (ECF)
Antimony	-6.385E-09
Arsenic (+V)	-7.152E-08
Arsenic trioxide	1.032E-15
Cadmium (+II)	-3.665E-09
Chromium (+III)	-8.284E-12
Chromium (+VI)	1.884E-10
Chromium (unspecified)	3.241E-07
Cobalt	-1.005E-09
Copper (+II)	-5.028E-09
Heavy metals to air (unspecified)	-1.616E-10
Hydrogen arsenic (arsine)	8.576E-14
Iron	1.048E-08
Lanthanides	-1.538E-13
Lead (+II)	-2.046E-08
Manganese (+II)	-1.408E-08
Mercury (+II)	-6.318E-09
Molybdenum	4.230E-08
Nickel (+II)	1.040E-07
Palladium	5.043E-19
Rhodium	4.868E-19
Selenium	-1.855E-07
Silver	-5.670E-18
Tellurium	-1.105E-12
Thallium	-7.615E-12
Tin (+IV)	-7.117E-08
Titanium	-1.763E-11
Vanadium (+III)	9.645E-08
Zinc (+II)	-6.254E-08
Inorganic emissions to air	1.641E+00
Ammonia	-2.862E-06
Ammonium	-9.745E-12
Ammonium nitrate	-5.186E-14
Argon	2.760E-21
Barium	-9.676E-08
Beryllium	-7.842E-10
Boron compounds (unspecified)	-1.254E-06
Bromine	-5.473E-07
Carbon dioxide	-5.625E-01

Process or Category	Gate to Gate (ECF)
Carbon dioxide (biotic)	3.470E+00
Carbon disulphide	-1.131E-12
Carbon monoxide	-1.877E-04
Carbon monoxide (biotic)	2.256E-04
Chloride (unspecified)	2.143E-07
Chlorine	1.410E-10
Cyanide (unspecified)	4.257E-09
Fluoride	3.996E-08
Fluorides	6.949E-11
Fluorine	-1.424E-11
Helium	-5.919E-10
Hydrogen	3.402E-08
Hydrogen bromine (hydrobromic acid)	2.181E-11
Hydrogen chloride	-3.275E-06
Hydrogen cyanide (prussic acid)	-2.039E-11
Hydrogen fluoride	-4.249E-07
Hydrogen iodide	2.415E-14
Hydrogen phosphorous	-2.259E-14
Hydrogen sulphide	1.767E-07
Lead dioxide	-3.549E-11
Nitrogen (atmospheric nitrogen)	-1.497E-04
Nitrogen dioxide	2.270E-04
Nitrogen monoxide	8.701E-10
Nitrogen oxides	-1.124E-03
Nitrous oxide (laughing gas)	5.728E-05
Oxygen	-5.908E-05
Scandium	-4.159E-14
Steam	-1.264E+00
Strontium	-2.329E-12
Sulphur dioxide	-1.881E-03
Sulphur hexafluoride	-4.252E-12
Sulphuric acid	-2.326E-11
Tin oxide	-5.448E-15
Unspecified Particles	-1.303E-06
Zinc oxide	-1.090E-14
Zinc sulphate	2.603E-12
Organic emissions to air (group VOC)	-4.613E-04
Group NMVOC to air	2.647E-05

Process or Category	Gate to Gate (ECF)
Group PAH to air	1.635E-08
Anthracene	7.408E-13
Benzo{a}anthracene	3.729E-13
Benzo{a}pyrene	-3.536E-09
Benzo{ghi}perylene	3.327E-13
Benzofluoranthene	6.655E-13
Chrysene	9.161E-13
Dibenz(a)anthracene	2.071E-13
Indeno[1,2,3-cd]pyrene	2.474E-13
Naphthalene	7.787E-11
Phenanthrene	2.446E-11
Polycyclic aromatic hydrocarbons (PAH)	1.978E-08
Halogenated organic emissions to air	-5.120E-08
Dichloroethane (ethylene dichloride)	2.466E-16
Dichloromethane (methylene chloride)	9.872E-15
Dioxins (unspec.)	-3.635E-14
Halogenated hydrocarbons (unspecified)	1.179E-12
Halon (1301)	2.006E-19
Polychlorinated biphenyls (PCB unspecified)	2.200E-13
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	-3.340E-14
R 11 (trichlorofluoromethane)	-1.978E-08
R 114 (dichlorotetrafluoroethane)	-2.026E-08
R 116 (hexafluoroethane)	4.258E-11
R 12 (dichlorodifluoromethane)	-4.254E-09
R 13 (chlorotrifluoromethane)	-2.671E-09
R 22 (chlorodifluoromethane)	-4.649E-09
Tetrafluoromethane	2.320E-10
Vinyl chloride (VCM; chloroethene)	1.463E-10
Acetaldehyde (Ethanal)	-4.697E-09
Acetic acid	-3.675E-08
Acetone (dimethylcetone)	-4.868E-09
Acrolein	5.230E-12
Aldehyde (unspecified)	-2.027E-09
Alkane (unspecified)	-3.000E-06
Alkene (unspecified)	-2.975E-06
Aromatic hydrocarbons (unspecified)	-2.629E-09
Benzene	9.620E-08
Butadiene	-9.781E-12

Process or Category	Gate to Gate (ECF)
Butane	2.463E-06
Butane (n-butane)	-3.500E-07
Caprolactam	6.728E-13
Cumene (isopropylbenzene)	4.053E-19
Cyclohexane (hexahydro benzene)	-2.953E-11
Diethylamine	-2.477E-16
Ethane	5.776E-06
Ethanol	-2.607E-08
Ethene (ethylene)	-9.628E-11
Ethyl benzene	-2.974E-06
Fluoranthene	2.414E-12
Fluorene	7.664E-12
Formaldehyde (methanal)	-9.034E-07
Heptane (isomers)	9.690E-08
Hexamethylene diamine (HMDA)	-5.753E-13
Hexane (isomers)	1.409E-07
Mercaptan (unspecified)	2.224E-09
Methanethiol	-3.313E-08
Methanol	-1.321E-08
NMVOC (unspecified)	3.136E-05
Octane	5.330E-08
Pentane (n-pentane)	-1.218E-06
Phenol (hydroxy benzene)	-2.236E-13
Propane	1.212E-05
Propene (propylene)	-2.704E-07
Propionic acid (propane acid)	-4.031E-13
Styrene	-2.989E-14
Toluene (methyl benzene)	-1.351E-06
Trimethylbenzene	-5.287E-14
Xylene (dimethyl benzene)	-1.244E-05
Hydrocarbons (unspecified)	-1.237E-07
Methane	-4.916E-04
Methane (biotic)	5.565E-09
Organic chlorine compounds	1.442E-12
Unspecified Organic Compounds	-9.056E-13
VOC (unspecified)	3.944E-06
Other emissions to air	-2.576E+00
Aldehydes, unspecified	-4.528E-13

Process or Category	Gate to Gate (ECF)
Exhaust	-2.582E+00
Particulate Matter, unspecified	5.247E-07
Sand (Silica) (SiO2)	-8.632E-09
Used air	5.520E-03
Particles to air	-4.817E-05
Dust (PM10)	-2.274E-06
Dust (PM2.5)	-3.337E-05
Dust (Portland cement kiln)	3.451E-06
Dust (unspecified)	-1.598E-05
Metals (unspecified)	-2.763E-11
Unspecified Organic Chlorine Compounds	-5.975E-12
Wood (dust)	-2.003E-12
Radioactive emissions to air	-2.316E-08
Uranium (total)	-2.316E-08
Unspecified Heavy Metals	-4.666E-16
Emissions to fresh water	-3.481E-03
Analytical measures to fresh water	-2.305E-04
Adsorbable organic halogen compounds (AOX)	2.721E-08
Biological oxygen demand (BOD)	1.470E-07
Chemical oxygen demand (COD)	-2.294E-04
Nitrogenous Matter (unspecified, as N)	6.315E-07
Solids (dissolved)	-3.379E-06
Total dissolved organic bounded carbon	2.007E-10
Total organic bounded carbon	1.455E-06
Heavy metals to fresh water	6.678E-05
Aluminium	2.053E-05
Antimony	1.811E-07
Arsenic (+V)	5.619E-07
Cadmium (+II)	4.437E-08
Chromium (+III)	-6.239E-09
Chromium (+VI)	3.231E-08
Chromium (unspecified)	1.038E-06
Cobalt	1.203E-11
Copper (+II)	8.281E-07
Heavy metals to water (unspecified)	-4.400E-10
Iron	5.177E-07
Lead (+II)	1.912E-06
Manganese (+II)	-4.058E-07

Process or Category	Gate to Gate (ECF)
Mercury (+II)	8.593E-09
Molybdenum	-4.563E-08
Nickel (+II)	1.550E-05
Selenium	-9.586E-09
Silver	1.768E-07
Strontium	-9.885E-07
Thallium	3.293E-14
Tin (+IV)	9.885E-10
Titanium	-5.968E-09
Unspecified Substance	-4.036E-12
Vanadium (+III)	-1.599E-08
Zinc (+II)	2.692E-05
Inorganic emissions to fresh water	-3.222E-03
Acid (calculated as H+)	2.238E-07
Aluminum (+III)	-1.992E-06
Ammonia	3.317E-07
Ammonium (total N)	2.213E-04
Ammonium / ammonia	-1.966E-06
Barium	2.918E-08
Beryllium	-6.936E-11
Boron	-1.392E-06
Bromate	1.310E-14
Bromine	5.833E-12
Calcium (+II)	-2.110E-04
Carbonate	2.074E-06
Chlorate	1.254E-11
Chloride	-1.926E-03
Chlorine (dissolved)	-2.477E-06
Copper ion (+II/+III)	7.585E-10
Cyanide	1.647E-06
Fluoride	-6.341E-04
Fluorine	-7.389E-10
Hydrogen chloride	-1.208E-11
Hydrogen fluoride (hydrofluoric acid)	6.302E-12
Hydrogen Ions (H+)	-9.011E-10
Hydroxide	7.037E-09
Inorganic salts and acids (unspecified)	7.144E-16
Iron ion (+II/+III)	3.466E-07

Process or Category	Gate to Gate (ECF)
Magnesium (+III)	-4.252E-05
Magnesium chloride	1.356E-13
Metal ions (unspecific)	5.941E-10
Neutral salts	2.427E-11
Nickel ion (+III)	2.191E-08
Nitrate	-1.349E-05
Nitrate (as total N)	-1.447E-11
Nitrogen	2.446E-08
Nitrogen organic bounded	1.394E-06
Phosphate	9.442E-08
Phosphorus	1.954E-05
Potassium	1.570E-08
Silicate particles	-1.241E-12
Sodium (+I)	-4.115E-05
Sodium chloride (rock salt)	-3.018E-11
Sodium hypochlorite	4.127E-11
Sulphate	-5.932E-04
Sulphide	4.465E-07
Sulphite	-4.225E-07
Sulphur	8.999E-10
Sulphuric acid	-1.558E-09
Unspecified Iron Oxides	-1.034E-11
Unspecified Oil	-3.662E-11
Unspecified Organic Chlorine compounds	-8.298E-14
Unspecified Salt	-3.320E-10
Unspecified Solids (Suspended)	-1.289E-09
Organic emissions to fresh water	-1.961E-07
Halogenated organic emissions to fresh water	-1.875E-11
1,2-Dibromoethane	-6.936E-15
Chlorinated hydrocarbons (unspecified)	4.984E-18
Chloromethane (methyl chloride)	-1.870E-11
Dichloroethane (ethylene dichloride)	6.614E-19
Dichloropropane	-4.618E-16
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	3.120E-20
Vinyl chloride (VCM; chloroethene)	-4.521E-14
Hydrocarbons to fresh water	-2.634E-07
Acenaphthene	6.169E-12
Acenaphthylene	2.594E-12

Process or Category	Gate to Gate (ECF)
Acetic acid	1.258E-08
Acrylonitrile	-3.377E-11
Anthracene	1.012E-11
Aromatic hydrocarbons (unspecified)	4.864E-09
Benzene	1.263E-08
Benzo{a}anthracene	7.976E-13
Benzofluoranthene	2.951E-13
Chrysene	3.316E-12
Cresol (methyl phenol)	2.331E-11
Ethyl benzene	6.672E-10
Fluoranthene	9.663E-13
Hexane (isomers)	2.541E-12
Hydrocarbons (unspecified)	2.126E-07
Methanol	-5.908E-07
Oil (unspecified)	6.148E-08
Phenol (hydroxy benzene)	2.988E-08
Polycyclic aromatic hydrocarbons (PAH, unspec.)	-1.704E-08
Toluene (methyl benzene)	7.644E-09
Xylene (isomers; dimethyl benzene)	2.112E-09
Carbon, organically bound	8.844E-08
Naphthalene	3.994E-10
N-unspecified (N)	-2.866E-11
Organic chlorine compounds (unspecified)	1.939E-13
Organic compounds (dissolved)	9.444E-11
Organic compounds (unspecified)	2.650E-11
Unspecified wastewater	-2.167E-08
Other emissions to fresh water	0.000E+00
Particles to fresh water	-9.477E-05
Metals (unspecified)	-1.425E-10
Silicon dioxide (silica)	1.161E-06
Soil loss by erosion into water	3.116E-07
Solids (suspended)	-9.634E-05
Suspended solids, unspecified	8.940E-08
Unspecified Oxides	-8.592E-12
Radioactive emissions to fresh water	0.000E+00
Bromide	0.000E+00
Radionuclide	0.000E+00
Sulfite	0.000E+00

Process or Category	Gate to Gate (ECF)
Unspecified Solids (Dissolved)	-2.484E-09
Uranium (total)	0.000E+00
Emissions to sea water	1.450E-03
Analytical measures to sea water	1.979E-06
Adsorbable organic halogen compounds (AOX)	4.874E-14
Biological oxygen demand (BOD)	5.376E-08
Chemical oxygen demand (COD)	1.872E-06
Total organic bounded carbon	5.376E-08
Heavy metals to sea water	4.403E-07
Arsenic (+V)	6.627E-09
Cadmium (+II)	1.103E-09
Chromium (unspecified)	1.076E-08
Cobalt	6.437E-09
Copper (+II)	1.254E-08
Iron	8.774E-08
Lead (+II)	2.925E-09
Manganese (+II)	9.127E-09
Mercury (+II)	6.435E-11
Molybdenum	6.734E-11
Nickel (+II)	6.912E-09
Silver	1.998E-10
Strontium	1.628E-07
Tin (+IV)	2.393E-10
Titanium	2.438E-11
Vanadium (+III)	4.444E-09
Zinc (+II)	1.283E-07
Inorganic emissions to sea water	1.404E-03
Aluminum (+III)	7.847E-10
Ammonia	2.332E-08
Barium	2.763E-07
Beryllium	3.641E-10
Boron	1.269E-08
Calcium (+II)	1.386E-06
Carbonate	1.738E-05
Chloride	1.373E-03
Magnesium	3.439E-07
Nitrate	2.253E-08
Sodium (+I)	1.074E-06

Process or Category	Gate to Gate (ECF)
Sulphate	7.325E-06
Sulphide	3.164E-06
Sulphur	6.790E-09
Organic emissions to sea water	7.931E-07
Hydrocarbons to sea water	7.842E-07
Acenaphthene	2.662E-10
Acenaphthylene	1.015E-10
Acetic acid	8.186E-10
Anthracene	7.342E-11
Aromatic hydrocarbons (unspecified)	5.377E-10
Benzene	6.014E-08
Benzo{a}anthracene	5.944E-11
Benzofluoranthene	6.573E-11
Chrysene	3.352E-10
Cresol (methyl phenol)	1.759E-10
Ethyl benzene	6.612E-09
Fluoranthene	6.928E-11
Hexane (isomers)	1.920E-11
Oil (unspecified)	5.266E-07
Phenol (hydroxy benzene)	1.182E-07
Toluene (methyl benzene)	3.421E-08
Xylene (isomers; dimethyl benzene)	3.601E-08
Naphthalene	8.866E-09
Particles to sea water	4.279E-05
Solids (suspended)	4.279E-05
Emissions to agricultural soil	5.157E-12
Heavy metals to agricultural soil	5.157E-12
Cadmium (+II)	3.770E-12
Copper (+II)	1.978E-13
Lead (+II)	2.967E-13
Mercury (+II)	1.978E-15
Nickel (+II)	9.892E-14
Zinc (+II)	7.913E-13
Emissions to industrial soil	3.811E-06
Heavy metals to industrial soil	9.716E-07
Antimony	7.038E-19
Arsenic (+V)	1.097E-12
Cadmium (+II)	9.557E-12

Process or Category	Gate to Gate (ECF)
Chromium (+III)	5.823E-13
Chromium (+VI)	2.026E-18
Chromium (unspecified)	2.879E-09
Cobalt	5.318E-11
Copper (+II)	3.097E-11
Iron	4.307E-09
Lead (+II)	1.644E-12
Manganese (+II)	4.775E-10
Mercury (+II)	6.622E-14
Nickel (+II)	3.668E-10
Selenium	5.772E-18
Strontium	9.631E-07
Zinc (+II)	3.083E-10
Inorganic emissions to industrial soil	2.836E-06
Aluminum (+III)	3.116E-09
Ammonia	1.526E-06
Bromide	4.558E-10
Calcium (+II)	-6.413E-08
Chloride	5.280E-07
Chlorine	4.728E-16
Fluoride	1.519E-08
Magnesium (+III)	-8.856E-09
Phosphorus	1.566E-07
Potassium (+I)	3.669E-07
Sodium (+I)	-5.610E-09
Sulphate	4.549E-08
Sulphide	2.729E-07
Organic emissions to industrial soil	3.536E-09
Oil (unspecified)	3.536E-09
Radioactive emissions to industrial soil	0.000E+00
Calcium Fluoride	0.000E+00
Radionuclide	0.000E+00

Embedded Unit Processes

NETL (2010). *NETL Life Cycle Inventory Data – Unit Process: Biochemical Ethanol Plant with Boiler Cogen.* U.S. Department of Energy, National Energy Technology Laboratory. Last Updated: February 2010 (version 01). www.netl.doe.gov/energy-analyses (http://www.netl.doe.gov/energy-analyses)

References

None.

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