



NETL Life Cycle Inventory Data

Process Documentation File

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_RMA_Biomass_SRWC_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 short rotation woody crop (SRWC) has been cultivated and produced and ends at the boundary of life cycle (LC) Stage #2.

Boundary and Description

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

The RMA of SRWC 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 SRWC 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).

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

Stage #1: SRWC Biomass Production

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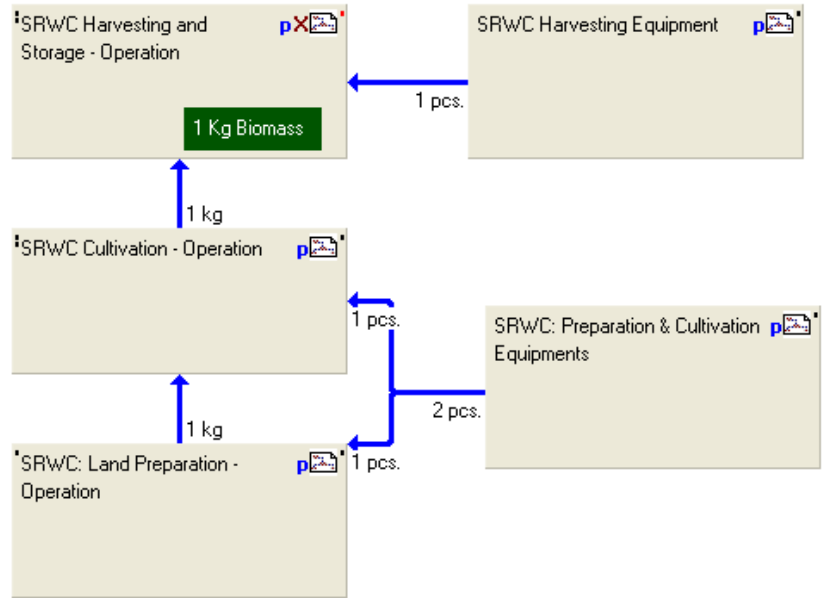
SRWC BIOMASS PRODUCTION EMISSIONS FROM THREE STAGES: LAND PREPARATION, CULTIVATION AND HARVESTING INCLUDING OPERATION AND CONSTRUCTION ACTIVITIES

Adj: Land preparation & cultivation

- 1) Tractor life time = 15 yrs
- 2) Tiller life time = 15 yrs
- 3) Tree Planter life = 15 yrs
- 4) Land pre. diesel acre year = 7.053 [L diesel/acre]
- 5) BTL yield = 3,628,739 kg/day
- 6) Capacity factor = 85%
- 7) Cultivation diesel acre year = 3.456 [L diesel/acre]

Adj: Harvesting

- 8) Annual days = 300 days/yr
- 9) Carvesting capacity = 3668 kg/hr
- 10) Working hours = 5 hrs/day
- 11) Chipper life time = 15 yrs
- 12) Trailer life time = 15 yrs
- 13) Biomass yield year = 2,540 [kg/acre-year]
- 14) Harvesting diesel acre year = 77.325 [L diesel/acre]



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

- Tiller
(DS/DF_Stage1_C_Tiller_5015_lbs_TractorPropelled_2009.01.doc)
- Tractor
(DS/DF_Stage1_C_Diesel_Tractor_165_HP_2009.01.doc)
- Tree Planter
(DS/DF_Stage1_C_Treeplanter_4500_lbs_TractorPropelled_2009.01.doc)
- Tree Harvester
(DS/DF_Stage1_C_Tree_Harvester_Chipper_440_HP_2010.01.doc)
- Pushoff Trailer
(DS/DF_Stage1_C_Pushoff_Trailer_60m3_Tractor_Propelled.01.doc)

Each piece of equipment is scaled to the production of one kilogram of SRWC 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 SRWC

Stage #1: SRWC Biomass Production

SRWC 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: SRWC Cultivation, Operation NETL <u-so>

SRWC Harvesting and Storage - Operation

US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>

US: SRWC Harvesting & Storage, Operation NETL <u-so>

SRWC Harvesting Equipment

Harvester Chipper (SRWC), Construction

US: Tree Harvester Chipper, 440 Horsepower, Construction NETL <u-so>

WOR: Steel Plate, BF, Manufacture NETL <u-so>

Trailer (SRWC), Construction

US: Pushoff Trailer, 60m³, Tractor Propelled, Construction NETL <u-so>

WOR: Steel Plate, BF, Manufacture NETL <u-so>

US: SRWC Harvesting Assembly, Construction NETL <u-so>

SRWC: Land Preparation - Operation

US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>

US: SRWC Land Preparation, Operation NETL <u-so>

SRWC: Preparation & Cultivation Equipments

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>
 Tree Planter (SRWC), Construction
 US: Treeplanter, 4500 lbs, Tractor-Propelled, Construction
 NETL <u-so>
 WOR: Steel Plate, BF, Manufacture NETL <u-so>
 US: SRWC Cultivation Assembly, Construction NETL <u-so>

Parameters and Balances

The parameters for the highest level modeling plans for RMA of SRWC 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 SRWC

Plan	Parameter	Value	Comment
<i>LC Stage #1</i>			
Stage #1: SRWC - Biomass	Biomass_yield_y	6214	[kg/acre-year] Adjustable parameter. Biomass yield is determined by type of biomass

Table 3: Inputs and Output Balances for RMA of SRWC (kg/kg delivered)

Process or Category	Cradle to Gate (RMA)
Inputs	
Flows	4.329E+02
Resources	4.329E+02
Energy resources	4.104E-02
Non renewable energy resources	4.104E-02
Crude oil (resource)	1.389E-02
Crude oil	2.296E-03
Crude oil Algeria	3.515E-04
Crude oil Angola	3.963E-04
Crude oil Argentina	6.096E-07
Crude oil Australia	5.022E-06
Crude oil Austria	1.678E-07
Crude oil Bolivia	2.195E-12
Crude oil Brazil	6.348E-06
Crude oil Brunei	7.412E-12
Crude oil Bulgaria	1.463E-11
Crude oil Cameroon	2.168E-06
Crude oil Canada	1.786E-03

Process or Category	Cradle to Gate (RMA)
Crude oil Central Africa	0.000E+00
Crude oil Central America	0.000E+00
Crude oil Chile	9.372E-11
Crude oil China	2.131E-06
Crude oil CIS	3.538E-04
Crude oil Colombia	1.560E-06
Crude oil Czech Republic	1.799E-08
Crude oil Denmark	2.160E-05
Crude oil Ecuador	2.567E-04
Crude oil Egypt	9.912E-07
Crude oil France	3.512E-07
Crude oil Gabon	1.169E-06
Crude oil Germany	2.849E-05
Crude oil Greece	3.310E-08
Crude oil Hungary	9.378E-09
Crude oil India	5.176E-12
Crude oil Indonesia	2.406E-06
Crude oil Iran	1.096E-05
Crude oil Iraq	3.994E-04
Crude oil Ireland	9.364E-13
Crude oil Italy	2.548E-06
Crude oil Japan	2.730E-13
Crude oil Kuwait	2.515E-04
Crude oil Libya	8.118E-05
Crude oil Malaysia	3.817E-12
Crude oil Mexico	9.446E-04
Crude oil Middle East	0.000E+00
Crude oil Netherlands	5.750E-06
Crude oil New Zealand	3.110E-07
Crude oil Nigeria	8.185E-04
Crude oil North Africa	0.000E+00
Crude oil Norway	2.242E-04
Crude oil Oman	9.294E-07
Crude oil Poland	1.033E-06
Crude oil Qatar	1.777E-06
Crude oil Romania	6.701E-08

Process or Category	Cradle to Gate (RMA)
Crude oil Saudi Arabia	9.044E-04
Crude oil Slovakia	6.070E-10
Crude oil South Africa	2.222E-12
Crude oil Spain	5.551E-08
Crude oil Syria	8.231E-11
Crude oil Trinidad and Tobago	4.055E-07
Crude oil Tunisia	2.727E-06
Crude oil Turkey	7.504E-16
Crude oil United Arab Emirates	3.701E-06
Crude oil United Kingdom	1.356E-04
Crude oil USA	3.726E-03
Crude oil Venezuela	8.650E-04
Hard coal (resource)	4.940E-03
Hard coal	1.046E-03
Hard Coal (Illinois No 6)	4.077E-04
Hard coal Australia	5.219E-05
Hard coal Belgium	1.049E-08
Hard coal Bosnia and Herzegovina	4.429E-09
Hard coal Brazil	1.017E-08
Hard coal Canada	2.803E-05
Hard coal Chile	9.772E-09
Hard coal China	7.119E-06
Hard coal CIS	3.143E-05
Hard coal Colombia	4.522E-05
Hard coal Czech Republic	1.571E-05
Hard coal France	3.174E-07
Hard coal Germany	3.266E-04
Hard coal India	3.719E-10
Hard coal Indonesia	6.382E-06
Hard coal Italy	2.321E-10
Hard coal Japan	1.396E-13
Hard coal Malaysia	1.341E-13
Hard coal Mexico	1.081E-07
Hard coal New Zealand	8.082E-09
Hard coal Poland	1.033E-04
Hard coal Portugal	2.400E-11

Process or Category	Cradle to Gate (RMA)
Hard coal South Africa	1.045E-04
Hard coal Spain	1.069E-07
Hard coal Turkey	3.270E-12
Hard coal United Kingdom	2.350E-06
Hard coal USA	2.758E-03
Hard coal Venezuela	2.390E-06
Hard coal Vietnam	1.874E-06
Hard Coal, Pure, Fuel	9.543E-09
Hard Coal, Raw, Fuel	7.472E-08
Powder River Basin Subbituminous Coal	0.000E+00
Lignite (resource)	2.303E-03
Lignite	4.239E-07
Lignite Australia	1.394E-06
Lignite Austria	1.617E-08
Lignite Bosnia and Herzegovina	1.023E-08
Lignite Bulgaria	3.824E-09
Lignite Canada	2.251E-06
Lignite CIS	1.087E-06
Lignite Czech Republic	3.008E-05
Lignite France	7.218E-08
Lignite Germany	1.923E-07
Lignite Germany (Central Germany)	2.570E-04
Lignite Germany (Lausitz)	7.319E-04
Lignite Germany (Rheinisch)	1.266E-03
Lignite Greece	1.239E-07
Lignite Hungary	9.133E-09
Lignite India	7.439E-11
Lignite Macedonia	4.615E-09
Lignite Poland	3.449E-06
Lignite Romania	5.436E-10
Lignite Serbia and Montenegro	2.202E-08
Lignite Slovakia	2.616E-09
Lignite Slovenia	1.797E-08
Lignite Spain	2.244E-07
Lignite Turkey	9.302E-14
Lignite USA	8.907E-06

Process or Category	Cradle to Gate (RMA)
Natural gas (resource)	1.990E-02
Natural gas	3.769E-07
Natural gas Algeria	2.987E-05
Natural gas Angola	4.855E-05
Natural gas Argentina	1.034E-07
Natural gas Australia	4.666E-07
Natural gas Austria	1.894E-08
Natural gas Bolivia	4.411E-09
Natural gas Brazil	4.134E-07
Natural gas Brunei	6.448E-08
Natural gas Bulgaria	1.572E-12
Natural gas Cameroon	5.401E-07
Natural gas Canada	2.237E-04
Natural gas Chile	2.229E-08
Natural gas China	1.188E-07
Natural gas CIS	2.935E-03
Natural gas Colombia	1.650E-07
Natural gas Czech Republic	9.124E-09
Natural gas Denmark	1.733E-04
Natural gas Ecuador	1.566E-05
Natural gas Egypt	7.924E-08
Natural gas France	7.226E-08
Natural gas Gabon	1.722E-07
Natural gas Germany	1.828E-03
Natural gas Greece	2.117E-09
Natural gas Hungary	9.147E-10
Natural gas India	2.851E-11
Natural gas Indonesia	1.545E-07
Natural gas Iran	9.161E-07
Natural gas Iraq	1.634E-05
Natural gas Ireland	2.100E-09
Natural gas Italy	1.974E-07
Natural gas Japan	9.425E-10
Natural gas Kuwait	9.285E-06
Natural gas Libyan	2.159E-06
Natural gas Malaysia	6.560E-08

Process or Category	Cradle to Gate (RMA)
Natural gas Mexico	5.279E-05
Natural gas Netherlands	1.671E-03
Natural gas New Zealand	2.067E-08
Natural gas Nigeria	1.452E-04
Natural gas Norway	1.922E-03
Natural gas Oman	1.203E-07
Natural gas Poland	7.782E-08
Natural gas Qatar	1.006E-06
Natural gas Romania	4.074E-09
Natural gas Saudi Arabia	3.270E-05
Natural gas Slovakia	4.787E-11
Natural gas South Africa	5.956E-10
Natural gas Spain	6.687E-09
Natural gas Syria	8.844E-12
Natural gas Trinidad and Tobago	3.994E-06
Natural gas Tunisia	3.462E-07
Natural gas Turkey	7.589E-17
Natural gas United Arab Emirates	1.552E-07
Natural gas United Kingdom	1.799E-04
Natural gas USA	9.650E-04
Natural gas Venezuela	3.748E-05
Natural Gas, Fuel	9.275E-03
Natural gas, Raw Material	3.200E-04
Pit gas	2.855E-09
Pit Methane	1.078E-05
Uranium (resource)	6.614E-08
Nuclear energy	0.000E+00
Uranium natural	6.614E-08
Renewable energy resources	9.785E-08
Biomass	3.903E-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

Process or Category	Cradle to Gate (RMA)
Renewable fuels	1.106E-10
Wood	9.735E-08
Unspecified	0.000E+00
Energy unspecified (APME)	0.000E+00
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	4.328E+02
Non renewable elements	5.903E-07
Aluminum	3.019E-11
Chromium	1.477E-14
Copper	2.471E-14
Iron	5.870E-07
Lead	7.488E-15
Magnesium	1.663E-17
Mercury	4.805E-15
Nickel	6.278E-17
Phosphorus	1.662E-12
Sulphur	1.038E-11
Zinc	3.255E-09
Non renewable resources	1.426E-01
Barium sulphate	3.517E-17
Basalt	5.970E-07

Process or Category	Cradle to Gate (RMA)
Bauxite	4.347E-07
Bentonite	7.282E-05
Calcium carbonate (CaCO ₃)	6.221E-03
Calcium chloride	3.601E-15
Chalk (Calcium carbonate)	8.046E-41
Chromium ore (39%)	3.759E-08
Clay	7.434E-06
Colemanite ore	7.035E-09
Copper - Gold - Silver - ore (1,0% Cu; 0,4 g/t Au; 66 g/t Ag)	1.216E-07
Copper - Gold - Silver - ore (1,1% Cu; 0,01 g/t Au; 2,86 g/t Ag)	7.407E-08
Copper - Gold - Silver - ore (1,16% Cu; 0,002 g/t Au; 1,06 g/t Ag)	4.181E-08
Copper - Molybdenum - Gold - Silver - ore (1,13% Cu; 0,02% Mo; 0,01 g/t Au; 2,86 g/t Ag)	3.353E-08
Copper ore (0.14%)	1.378E-06
Copper ore (1.2%)	1.261E-08
Copper ore (4%)	2.935E-17
Copper ore (sulphidic, 1.1%)	1.347E-08
Dolomite	3.128E-05
Feldspar (aluminum silicates)	1.172E-12
Ferro manganese	2.602E-15
Fluorspar (calcium fluoride; fluorite)	2.585E-09
Granite	3.506E-22
Gravel	4.276E-07
Gypsum (natural gypsum)	2.803E-06
Heavy spar (BaSO ₄)	1.761E-04
Ilmenite (titanium ore)	2.004E-12
Inert rock	3.462E-02
Iron ore (56,86%)	2.717E-03
Iron ore (65%)	9.231E-09
Kaolin ore	1.261E-08
Lead - zinc ore (4.6%-0.6%)	1.426E-05
Limestone (calcium carbonate)	8.648E-04
Magnesit (Magnesium carbonate)	5.581E-11
Magnesium chloride leach (40%)	8.363E-06
Manganese ore	7.293E-09
Manganese ore (R.O.M.)	5.626E-07
Molybdenite (Mo 0,24%)	2.048E-08

Process or Category	Cradle to Gate (RMA)
Molybdenum ore (0.1%)	1.398E-10
Natural Aggregate	5.141E-05
Nickel ore (1,5%)	1.721E-10
Nickel ore (1.6%)	1.987E-06
Olivine	2.712E-14
Peat	1.264E-07
Phosphate ore	1.209E-03
Phosphorus minerals	1.312E-05
Phosphorus ore (29% P2O5)	9.138E-16
Potassium chloride	9.649E-02
Precious metal ore (R.O.M)	1.170E-09
Quartz sand (silica sand; silicon dioxide)	1.051E-05
Raw pumice	1.225E-09
Rutile (titanium ore)	8.868E-16
sand	3.976E-12
Slate	4.998E-14
Sodium chloride (rock salt)	5.502E-05
Sodium nitrate	4.473E-21
Sodium sulphate	5.228E-10
Soil	1.684E-05
Sulphur (bonded)	1.631E-12
Talc	2.330E-10
Tin ore	3.050E-18
Titanium ore	2.008E-07
Zinc - copper ore (4.07%-2.59%)	2.487E-06
Zinc - lead - copper ore (12%-3%-2%)	1.054E-06
Zinc - lead ore (4.21%-4.96%)	1.002E-17
Zinc ore (4%)	-2.003E-05
Zinc ore (sulphidic, 4%)	1.296E-16
Renewable resources	4.327E+02
Water	4.325E+02
Water	1.624E-02
Water (feed water)	0.000E+00
Water (ground water)	4.395E+01
Water (lake water)	9.886E-07
Water (municipal)	8.809E-07

Process or Category	Cradle to Gate (RMA)
Water (rain water)	3.445E+02
Water (river water)	0.000E+00
Water (sea water)	1.219E-04
Water (surface water)	4.403E+01
Water (well water)	1.193E-08
Water (well-produced water)	3.442E-04
Water (with river silt)	4.470E-15
Water,turbine use, unspecified natural origin	0.000E+00
Air	2.140E-01
Carbon dioxide	1.783E-05
Nitrogen	3.079E-10
Oxygen	0.000E+00
Unspecified	8.664E-09
Unspecified minerals	1.971E-09
Unspecified resources	6.693E-09
Area of Production Land	0.000E+00
Output	
Flows	-3.898E-01
Resources	1.881E-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	1.881E-01
Renewable resources	1.881E-01
Water	1.881E-01
Water	0.000E+00

Process or Category	Cradle to Gate (RMA)
Water (feed water)	1.987E-06
Water (rain water)	0.000E+00
Water (river water)	1.858E-01
Water (sea water)	0.000E+00
Water (wastewater)	3.539E-04
Water (wastewater)	1.940E-03
Nitrogen	0.000E+00
Oxygen	7.062E-06
Ecoinvent	9.162E-07
Long-term emission	9.162E-07
Fresh water	9.162E-07
Chloride	9.162E-07
Dissolved organic carbon, DOC (Ecoinvent)	3.580E-13
Total organic carbon, TOC (Ecoinvent)	0.000E+00
Emissions to air	-5.905E-01
Heavy metals to air	1.262E-07
Antimony	3.674E-11
Arsenic (+V)	2.733E-10
Arsenic trioxide	9.775E-15
Cadmium (+II)	3.752E-10
Chromium (+III)	2.179E-12
Chromium (+VI)	3.136E-16
Chromium (unspecified)	5.246E-09
Cobalt	8.817E-11
Copper (+II)	2.064E-10
Heavy metals to air (unspecified)	2.852E-12
Hydrogen arsenic (arsine)	8.113E-13
Iron	4.102E-10
Lanthanides	1.298E-14
Lead (+II)	1.531E-08
Manganese (+II)	5.611E-10
Mercury (+II)	1.091E-09
Molybdenum	3.067E-11
Nickel (+II)	7.519E-10
Palladium	9.967E-20
Rhodium	9.622E-20

Process or Category	Cradle to Gate (RMA)
Selenium	7.872E-10
Silver	3.124E-19
Tellurium	2.905E-13
Thallium	2.164E-12
Tin (+IV)	2.512E-10
Titanium	8.426E-13
Vanadium (+III)	5.607E-09
Zinc (+II)	9.514E-08
Inorganic emissions to air	-7.921E-01
Ammonia	7.583E-05
Ammonium	1.737E-13
Ammonium nitrate	9.582E-15
Argon	5.954E-13
Barium	1.120E-07
Beryllium	5.391E-12
Boron compounds (unspecified)	1.292E-08
Bromine	3.289E-09
Carbon dioxide	1.137E-01
Carbon dioxide (biotic)	6.255E-09
Carbon dioxide (biotic)	-9.599E-01
Carbon disulphide	7.427E-14
Carbon monoxide	2.348E-04
Carbon monoxide (biotic)	1.014E-13
Chloride (unspecified)	4.112E-09
Chlorine	7.276E-11
Cyanide (unspecified)	1.034E-10
Fluoride	3.684E-09
Fluorides	7.367E-11
Fluorine	4.427E-13
Helium	8.116E-11
Hydrogen	4.840E-08
Hydrogen bromine (hydrobromic acid)	2.437E-11
Hydrogen chloride	1.750E-06
Hydrogen cyanide (prussic acid)	2.190E-12
Hydrogen fluoride	1.297E-08
Hydrogen iodide	2.465E-14

Process or Category	Cradle to Gate (RMA)
Hydrogen phosphorous	3.573E-15
Hydrogen sulphide	3.057E-07
Lead dioxide	4.405E-13
Nitrogen (atmospheric nitrogen)	2.880E-06
Nitrogen (N-compounds)	1.165E-13
Nitrogen dioxide	1.724E-05
Nitrogen monoxide	4.472E-13
Nitrogen oxides	2.092E-04
Nitrous oxide (laughing gas)	4.510E-04
Oxygen	5.955E-06
Scandium	6.135E-15
Steam	5.297E-02
Strontium	2.442E-13
Sulphur dioxide	1.430E-04
Sulphur hexafluoride	7.502E-10
sulphur oxide	8.639E-06
Sulphuric acid	5.414E-11
Tin oxide	1.611E-16
Unspecified Particles	1.613E-08
Zinc oxide	3.222E-16
Zinc sulphate	2.044E-11
Organic emissions to air (group VOC)	4.500E-02
Group NMVOC to air	4.485E-02
Group PAH to air	1.148E-08
Anthracene	2.551E-12
Benzo{a}anthracene	1.283E-12
Benzo{a}pyrene	4.534E-11
Benzo{ghi}perylene	1.145E-12
Benzofluoranthene	2.290E-12
Chrysene	3.153E-12
Dibenz(a)anthracene	7.134E-13
Indeno[1,2,3-cd]pyrene	8.519E-13
Naphthalene	2.679E-10
Phenanthrene	8.415E-11
Polycyclic aromatic hydrocarbons (PAH)	1.107E-08
Halogenated organic emissions to air	1.369E-09

Process or Category	Cradle to Gate (RMA)
Dichloroethane (ethylene dichloride)	1.224E-14
Dichloromethane (methylene chloride)	2.604E-16
Dioxins (unspec.)	-2.771E-14
Halogenated hydrocarbons (unspecified)	2.528E-14
Halon (1301)	0.000E+00
Polychlorinated biphenyls (PCB unspecified)	1.783E-12
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	4.814E-16
R 11 (trichlorofluoromethane)	4.827E-10
R 114 (dichlorotetrafluoroethane)	4.944E-10
R 116 (hexafluoroethane)	9.376E-13
R 12 (dichlorodifluoromethane)	1.038E-10
R 13 (chlorotrifluoromethane)	6.517E-11
R 22 (chlorodifluoromethane)	1.134E-10
Tetrafluoromethane	1.223E-11
Vinyl chloride (VCM; chloroethene)	9.427E-11
Acetaldehyde (Ethanal)	1.528E-09
Acetic acid	5.511E-09
Acetone (dimethylcetone)	1.368E-09
Acrolein	1.800E-11
Aldehyde (unspecified)	9.737E-11
Alkane (unspecified)	1.553E-08
Alkene (unspecified)	1.403E-08
Aromatic hydrocarbons (unspecified)	1.581E-10
Benzene	1.606E-08
Butadiene	1.677E-13
Butane	1.597E-06
Butane (n-butane)	3.138E-08
Caprolactam	2.124E-17
Cumene (isopropylbenzene)	7.803E-21
Cyclohexane (hexahydro benzene)	1.637E-12
Diethylamine	4.265E-18
Ethane	4.969E-06
Ethanol	1.107E-09
Ethene (ethylene)	3.194E-10
Ethyl benzene	1.413E-08
Fluoranthene	8.308E-12

Process or Category	Cradle to Gate (RMA)
Fluorene	2.636E-11
Formaldehyde (methanal)	4.483E-02
Heptane (isomers)	3.266E-08
Hexamethylene diamine (HMDA)	9.867E-15
Hexane (isomers)	4.858E-08
Mercaptan (unspecified)	1.247E-09
Methanethiol	4.102E-10
Methanol	7.920E-10
NMVOG (unspecified)	1.322E-05
Octane	1.797E-08
Pentane (n-pentane)	6.671E-07
Phenol (hydroxy benzene)	1.924E-14
Propane	6.193E-06
Propene (propylene)	1.268E-09
Propionic acid (propane acid)	1.940E-13
Styrene	1.818E-15
Toluene (methyl benzene)	7.215E-09
Trimethylbenzene	1.569E-15
Xylene (dimethyl benzene)	5.898E-08
Hydrocarbons (unspecified)	1.545E-09
Methane	1.350E-04
Methane (biotic)	1.168E-11
Organic chlorine compounds	3.420E-14
Unspecified Organic Compounds	1.121E-14
VOC (unspecified)	1.171E-05
Other emissions to air	1.560E-01
Aldehydes, unspecified	5.606E-15
Exhaust	5.184E-02
non used primary energy from wind power	0.000E+00
Particulate Matter, unspecified	5.365E-07
Sand (Silica) (SiO ₂)	1.069E-10
Unused primary energy from solar energy	0.000E+00
Used air	1.041E-01
Waste heat	0.000E+00
Particles to air	6.703E-04
Dust (PM10)	1.355E-07

Process or Category	Cradle to Gate (RMA)
Dust (PM2,5 - PM10)	5.468E-07
Dust (PM2.5)	3.985E-07
Dust (Portland cement kiln)	7.243E-09
Dust (unspecified)	6.692E-04
Metals (unspecified)	3.715E-13
Unspecified Organic Chlorine Compounds	7.398E-14
Wood (dust)	5.945E-14
Radioactive emissions to air	5.619E-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)	5.619E-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	5.777E-18
Emissions to fresh water	1.225E-02

Process or Category	Cradle to Gate (RMA)
Analytical measures to fresh water	3.281E-05
Adsorbable organic halogen compounds (AOX)	1.053E-08
Biological oxygen demand (BOD)	3.140E-07
Chemical oxygen demand (COD)	4.000E-06
Nitrogenous Matter (unspecified, as N)	3.611E-07
Solids (dissolved)	2.569E-05
Total Biochemical Oxygen Demand	0.000E+00
Total dissolved organic bounded carbon	2.415E-08
Total Dissolved Solids	2.260E-06
Total organic bounded carbon	1.493E-07
Total Suspended Solids	0.000E+00
Heavy metals to fresh water	2.878E-05
Aluminium	5.056E-10
Antimony	4.588E-08
Arsenic (+V)	1.692E-07
Cadmium (+II)	3.088E-08
Chromium (+III)	1.456E-10
Chromium (+VI)	5.643E-14
Chromium (unspecified)	3.370E-07
Cobalt	2.047E-12
Copper (+II)	3.034E-07
Heavy metals to water (unspecified)	1.884E-10
Iron	1.512E-05
Lead (+II)	5.680E-07
Manganese (+II)	1.448E-08
Mercury (+II)	1.479E-07
Molybdenum	1.444E-09
Nickel (+II)	4.246E-06
Selenium	3.167E-10
Silver	4.475E-08
Strontium	1.883E-08
Thallium	3.446E-13
Tin (+IV)	6.857E-13
Titanium	1.507E-10
Unspecified Substance	4.997E-14
Uranium	7.439E-07

Process or Category	Cradle to Gate (RMA)
Vanadium (+III)	4.716E-10
Zinc (+II)	6.991E-06
Inorganic emissions to fresh water	1.207E-02
Acid (calculated as H+)	5.546E-10
Acidity	0.000E+00
Aluminum (+III)	5.220E-06
Aluminum ion (+III)	5.555E-16
Ammonia	5.627E-05
Ammonia, as N	6.354E-14
Ammonium (total N)	5.471E-09
Ammonium / ammonia	2.213E-05
Barium	1.035E-07
Beryllium	1.702E-12
Boron	1.549E-08
Bromate	3.435E-16
Bromine	3.210E-12
Calcium (+II)	4.596E-03
Carbonate	6.888E-03
Chlorate	2.851E-13
Chloride	1.069E-04
Chlorine (dissolved)	7.454E-08
Copper ion (+II/+III)	6.309E-15
Cyanide	4.165E-07
Fluoride	2.625E-04
Fluorine	1.206E-10
Hydrogen chloride	2.269E-12
Hydrogen fluoride (hydrofluoric acid)	3.871E-12
Hydrogen Ions (H+)	1.116E-11
Hydroxide	2.298E-10
Inorganic salts and acids (unspecified)	6.889E-18
Iron ion (+II/+III)	7.023E-13
Magnesium (+III)	5.009E-07
Magnesium chloride	2.711E-14
Metal ions (unspecific)	3.313E-13
Neutral salts	1.241E-11
Nickel ion (+III)	3.647E-14

Process or Category	Cradle to Gate (RMA)
Nitrate	2.452E-07
Nitrate (as total N)	1.792E-13
Nitrogen	8.171E-06
Nitrogen (as total N)	1.769E-09
Nitrogen organic bounded	2.252E-08
Phosphate	3.551E-08
Phosphorus	7.388E-05
Potassium	1.541E-09
Silicate particles	1.084E-10
Sodium (+I)	1.980E-05
Sodium chloride (rock salt)	1.864E-06
Sodium hypochlorite	2.893E-11
Sulfates	1.483E-07
Sulphate	2.857E-05
Sulphide	1.120E-07
Sulphite	4.631E-09
Sulphur	1.810E-11
Sulphur dioxide	0.000E+00
Sulphuric acid	2.925E-10
Unspecified Iron Oxides	1.280E-13
Unspecified Oil	4.534E-13
Unspecified Organic Chlorine compounds	1.027E-15
Unspecified Salt	4.111E-12
Unspecified Solids (Suspended)	1.596E-11
Organic emissions to fresh water	2.127E-05
Halogenated organic emissions to fresh water	4.633E-12
1,2-Dibromoethane	3.844E-16
Chlorinated hydrocarbons (unspecified)	6.241E-14
Chloromethane (methyl chloride)	4.566E-12
Dichloroethane (ethylene dichloride)	5.127E-16
Dichloropropane	7.920E-18
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	1.669E-18
Vinyl chloride (VCM; chloroethene)	3.623E-15
Hydrocarbons to fresh water	2.105E-05
Acenaphthene	1.630E-12
Acenaphthylene	6.919E-13

Process or Category	Cradle to Gate (RMA)
Acetic acid	1.831E-09
Acrylonitrile	5.792E-13
Anthracene	2.903E-12
Aromatic hydrocarbons (unspecified)	1.257E-09
Benzene	4.043E-09
Benzo{a}anthracene	1.950E-13
Benzofluoranthene	4.449E-14
Chrysene	7.547E-13
Cresol (methyl phenol)	4.688E-13
Ethyl benzene	1.993E-10
Fluoranthene	2.373E-13
Hexane (isomers)	5.130E-14
Hydrocarbons (unspecified)	3.150E-09
Methanol	2.013E-05
Oil (unspecified)	8.940E-07
Phenol (hydroxy benzene)	3.673E-09
Polycyclic aromatic hydrocarbons (PAH, unspec.)	5.299E-10
Toluene (methyl benzene)	2.326E-09
Xylene (isomers; dimethyl benzene)	1.048E-09
Carbon, organically bound	2.219E-07
Naphthalene	1.138E-10
N-unspecified (N)	3.548E-13
Organic chlorine compounds (unspecified)	8.677E-15
Organic compounds (dissolved)	3.838E-13
Organic compounds (unspecified)	5.236E-13
Unspecified wastewater	2.683E-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	9.710E-05
Metals (unspecified)	2.347E-12
Silicon dioxide (silica)	1.933E-12
Soil loss by erosion into water	7.318E-11

Process or Category	Cradle to Gate (RMA)
Solids (suspended)	9.646E-05
Suspended solids, unspecified	6.350E-07
Unspecified Oxides	1.064E-13
Radioactive emissions to fresh water	0.000E+00
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)	3.076E-11
Uranium (total)	6.912E-14
Emissions to sea water	2.483E-04
Analytical measures to sea water	1.421E-06
Adsorbable organic halogen compounds (AOX)	9.620E-14
Biological oxygen demand (BOD)	1.061E-07
Chemical oxygen demand (COD)	1.209E-06
Total organic bounded carbon	1.061E-07

Process or Category	Cradle to Gate (RMA)
Heavy metals to sea water	3.220E-07
Arsenic (+V)	1.616E-09
Cadmium (+II)	8.453E-10
Chromium (unspecified)	2.476E-09
Cobalt	3.132E-10
Copper (+II)	8.168E-09
Iron	1.871E-08
Lead (+II)	2.394E-09
Manganese (+II)	1.863E-09
Mercury (+II)	3.558E-11
Molybdenum	1.621E-10
Nickel (+II)	2.513E-09
Silver	3.427E-10
Strontium	2.763E-07
Tin (+IV)	4.105E-10
Titanium	4.181E-11
Vanadium (+III)	2.671E-10
Zinc (+II)	5.575E-09
Inorganic emissions to sea water	1.620E-04
Aluminum (+III)	1.346E-09
Ammonia	4.000E-08
Barium	3.057E-08
Beryllium	1.152E-11
Boron	2.177E-08
Calcium (+II)	2.377E-06
Carbonate	1.916E-06
Chloride	1.537E-04
Magnesium	5.923E-07
Nitrate	2.493E-09
Sodium (+I)	2.119E-06
Sulphate	8.369E-07
Sulphide	3.432E-07
Sulphur	1.165E-08
Organic emissions to sea water	1.042E-07
Hydrocarbons to sea water	1.035E-07
Acenaphthene	1.740E-11

Process or Category	Cradle to Gate (RMA)
Acenaphthylene	6.713E-12
Acetic acid	3.124E-11
Anthracene	7.213E-12
Aromatic hydrocarbons (unspecified)	1.061E-09
Benzene	1.194E-08
Benzo{a}anthracene	3.722E-12
Benzofluoranthene	3.944E-12
Chrysene	2.065E-11
Cresol (methyl phenol)	3.017E-10
Ethyl benzene	1.009E-09
Fluoranthene	4.331E-12
Hexane (isomers)	3.294E-11
Oil (unspecified)	6.892E-08
Phenol (hydroxy benzene)	9.408E-09
Toluene (methyl benzene)	8.681E-09
Xylene (isomers; dimethyl benzene)	2.072E-09
Naphthalene	6.634E-10
Particles to sea water	8.445E-05
Solids (suspended)	8.445E-05
Emissions to agricultural soil	1.378E-05
Heavy metals to agricultural soil	1.378E-05
Cadmium (+II)	2.017E-07
Chromium (unspecified)	9.614E-06
Copper (+II)	5.443E-07
Lead (+II)	1.017E-07
Mercury (+II)	1.784E-09
Nickel (+II)	3.253E-07
Zinc (+II)	2.996E-06
Emissions to industrial soil	2.571E-05
Heavy metals to industrial soil	2.402E-05
Antimony	1.077E-20
Arsenic (+V)	1.300E-08
Cadmium (+II)	6.263E-12
Chromium (+III)	2.160E-14
Chromium (+VI)	3.901E-20
Chromium (unspecified)	1.659E-09

Process or Category	Cradle to Gate (RMA)
Cobalt	2.955E-11
Copper (+II)	1.670E-11
Iron	2.327E-05
Lead (+II)	9.297E-08
Manganese (+II)	3.495E-10
Mercury (+II)	2.405E-10
Nickel (+II)	4.856E-10
Selenium	1.545E-09
Strontium	5.609E-07
Thallium	1.124E-08
Vanadium (+III)	7.097E-08
Zinc (+II)	1.824E-10
Inorganic emissions to industrial soil	1.684E-06
Aluminum (+III)	1.848E-09
Ammonia	8.820E-07
Bromide	2.533E-10
Calcium (+II)	1.909E-09
Chloride	2.956E-07
Chlorine	9.103E-18
Fluoride	8.443E-09
Magnesium (+III)	2.667E-10
Phosphorus	9.122E-08
Potassium (+I)	2.105E-07
Sodium (+I)	1.665E-10
Sulphate	2.741E-08
Sulphide	1.645E-07
Organic emissions to industrial soil	1.017E-09
Oil (unspecified)	1.017E-09
Radioactive emissions to industrial soil	0.000E+00
Uranium	0.000E+00
Calcium Fluoride	1.776E-09
Radionuclide	0.000E+00

Embedded Unit Processes

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None.

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