NETL Life Cycle Inventory Data
Process Documentation File

Process Name: Natural Gas, Average Marcellus Shale, Extraction

Reference Flow: 1 kg of Natural Gas

Brief Description: This process includes all inputs for the raw material acquisition 1 kg of natural gas via average Marcellus shale extraction

Section I: Meta Data

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

Year Data Best Represents: 2009

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:

Product_rate	*The production rate of natural gas via the specified extraction method*

Tracked Input Flows:

Natural Gas from Marcellus shale	*The quantity of unprocessed natural gas from specified extraction method*

Tracked Output Flows:

Natural Gas from Marcellus shale	*The quantity of processed natural gas from specified extraction method*

Section II: Process Description

Associated Documentation

This unit process is composed of this document and the data sheet (DS) *DS_RMA_NaturalGas_MarcellusShale_Average_2012.01.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 raw material acquisition (RMA) and as seen in **Figure 1**. At the RMA downstream boundary, one kilogram of natural gas is delivered to the life cycle (LC) Stage #2 boundary for raw material transportation (RMT).

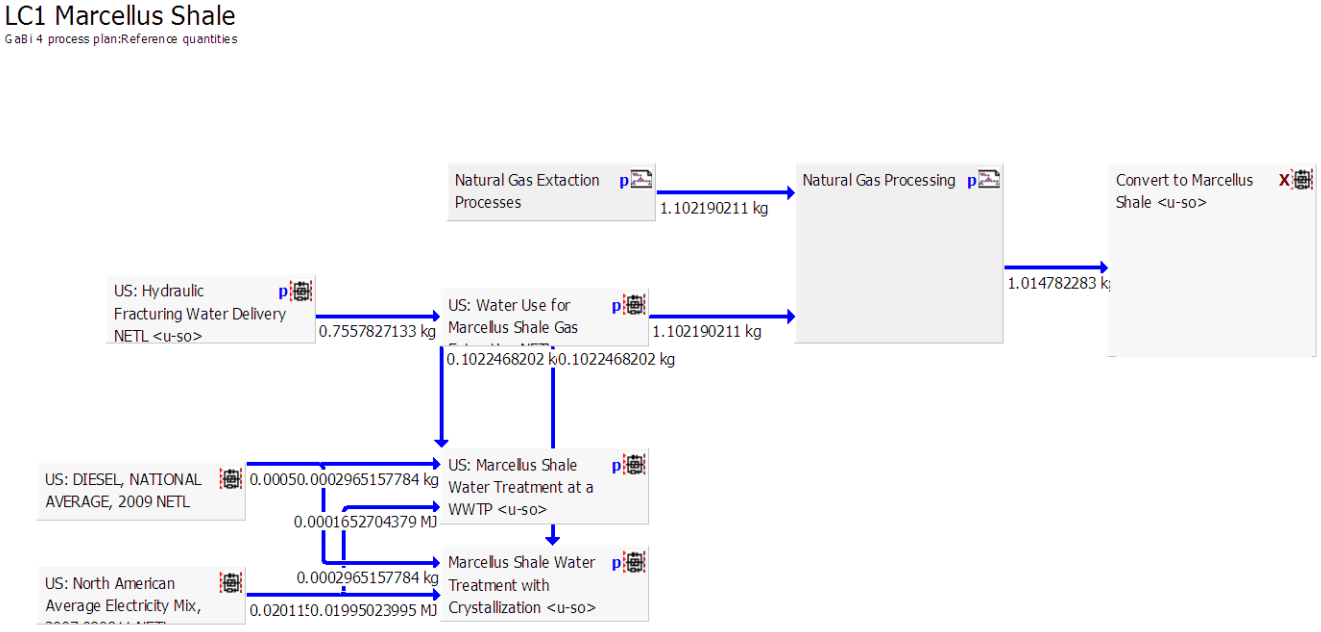
Boundary and Description

LC Stage #1, RMA of this unit process includes the acquisition of natural gas by average Marcellus shale extraction in 2009. The natural gas is processed in preparation for RMT in LC Stage #2.

Construction of the wells and pipelines are included. The upstream profiles for concrete and steel are rolled up into this process.

An example plan is provided in **Figure 1**. Overall plans for extraction and processes were created.

Figure 1: Plan for RMA of Average Marcellus Shale Natural Gas



The construction processes for both machinery and facilities were created with the only viable one being:

- Natural Gas Well Construction and Installation
  (DS/DF_Stage1_C_Natural_Gas_Well_Generic_2011.01.doc)

Each piece of equipment or facility is scaled to the production of one kilogram of natural gas. 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 Average Marcellus Shale Natural Gas

LC1 Marcellus Shale Extraction

Natural Gas Extraction Processes

Natural Gas Extraction Assembly <u-so>
Natural Gas Extraction, Pneumatic Venting <u-so>
US: Concrete, ready mixed, R-5-0 (100% Portland Cement) NETL <u-so>
US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>
US: Natural Gas Extraction, Other Venting Fugitives NETL <u-so>
US: Natural Gas Extraction, Other Venting Point Sources NETL <u-so>
US: Natural Gas Well Completion NETL <u-so>
US: Natural Gas Well Construction and Installation NETL <u-so>
US: NG Well Liquid Unloading NETL <u-so>
US: North American Average Electricity Mix, 2007 080811 NETL
US: Unconventional NG Well Workovers NETL <u-so>
V&F: Liquid Unloading
V&F: Other Venting Ext
V&F: Well Completion
V&F: Workovers
WOR: Steel Pipe, Welded, BF, Manufacture NETL <u-so>

Natural Gas Processing

Natio: Natural gas sweetening <u-so>
Natural Gas Processing, Pneumatic Venting <u-so>
US: Assembly of Natural Gas Compression NETL <u-so>
US: Diethanolamine (DEA) PE
US: Natural gas dehydration NETL <u-so>
US: Natural Gas Processing, Other Venting Fugitives NETL <u-so>
US: Natural Gas Processing, Other Venting Point Sources NETL <u-so>
US: North American Average Electricity Mix, 2007 080811 NETL
US: Wellhead Electrically-Powered Centrifugal Compressor NETL <u-so>
US: Wellhead Gas-Powered Centrifugal Compressor NETL <u-so>
US: Wellhead Reciprocating Compressor NETL <u-so>
V&F: Dehydration
V&F: Electrical Centrifugal Compression

V&F: Gas Centrifugal Compression
V&F: Other Venting, Point Source
V&F: Sweetening
Convert to Marcellus Shale <u-so>
US: DIESEL, NATIONAL AVERAGE, 2009 NETL <u-so>
US: Marcellus Shale Water Treatment with Crystallization NETL <u-so>
US: Hydraulic Fracturing Water Delivery NETL <u-so>
US: Marcellus Shale Water Treatment at a WWTP NETL <u-so>
US: Water Use for Marcellus Shale Natural Gas Extraction NETL <u-so>
US: North American Average Electricity Mix, 2007 080811 NETL

Parameters and Balances

The parameters for the highest level modeling plans for RMA of average Marcellus shale natural gas 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 Average Marcellus Shale Natural Gas

Plan	Parameter	Value	Comment
LC Stage #1			
RMA: Average Marcellus Shale Natural Gas	Product_rate	5653	[kg/day] Adjustable Parameter; production rate

Table 3: Inputs and Output Balances for RMA of Average Marcellus Shale Natural Gas (kg/kg delivered)

Process or Category	Cradle to Gate (RMA)
Inputs	
Flows	2.089E+00
Resources	2.089E+00
Energy resources	1.124E+00
Non renewable energy resources	1.124E+00
Crude oil (resource)	5.627E-04
Crude oil	1.601E-04
Crude oil Algeria	8.559E-06
Crude oil Angola	1.615E-05
Crude oil Argentina	4.814E-07
Crude oil Australia	3.050E-07

Process or Category	Cradle to Gate (RMA)
Crude oil Austria	4.810E-09
Crude oil Bolivia	6.359E-13
Crude oil Brazil	4.030E-07
Crude oil Brunei	4.638E-13
Crude oil Bulgaria	6.460E-13
Crude oil Cameroon	9.344E-08
Crude oil Canada	2.792E-05
Crude oil Central Africa	0.000E+00
Crude oil Central America	0.000E+00
Crude oil Chile	3.816E-12
Crude oil China	1.224E-07
Crude oil CIS	1.268E-06
Crude oil Colombia	1.574E-06
Crude oil Czech Republic	5.156E-10
Crude oil Denmark	1.671E-07
Crude oil Ecuador	6.817E-06
Crude oil Egypt	1.828E-08
Crude oil France	6.361E-09
Crude oil Gabon	1.122E-06
Crude oil Germany	2.865E-08
Crude oil Greece	8.981E-10
Crude oil Hungary	4.889E-10
Crude oil India	2.932E-12
Crude oil Indonesia	3.152E-07
Crude oil Iran	1.310E-07
Crude oil Iraq	1.764E-05
Crude oil Ireland	4.029E-14
Crude oil Italy	2.862E-08
Crude oil Kuwait	7.402E-06
Crude oil Libya	2.155E-07
Crude oil Malaysia	2.327E-13
Crude oil Mexico	4.679E-05
Crude oil Middle East	0.000E+00
Crude oil Netherlands	1.873E-08
Crude oil New Zealand	8.355E-10
Crude oil Nigeria	3.076E-05

Process or Category	Cradle to Gate (RMA)
Crude oil North Africa	0.000E+00
Crude oil Norway	2.951E-06
Crude oil Oman	1.045E-07
Crude oil Poland	1.472E-09
Crude oil Qatar	5.706E-08
Crude oil Romania	1.951E-09
Crude oil Saudi Arabia	4.345E-05
Crude oil Slovakia	3.021E-12
Crude oil South Africa	4.786E-14
Crude oil Spain	1.450E-09
Crude oil Syria	3.142E-12
Crude oil Trinidad and Tobago	4.242E-07
Crude oil Tunisia	8.556E-09
Crude oil Turkey	6.182E-16
Crude oil United Arab Emirates	5.818E-08
Crude oil United Kingdom	3.284E-06
Crude oil USA	1.427E-04
Crude oil Venezuela	4.125E-05
Hard coal (resource)	2.325E-03
Hard coal	3.363E-09
Hard Coal (Illinois No 6)	1.288E-03
Hard coal Australia	9.965E-08
Hard coal Belgium	6.378E-11
Hard coal Bosnia and Herzegovina	8.884E-09
Hard coal Brazil	8.735E-10
Hard coal Canada	3.795E-07
Hard coal Chile	4.003E-10
Hard coal China	1.397E-08
Hard coal CIS	4.725E-08
Hard coal Colombia	2.827E-07
Hard coal Czech Republic	9.813E-09
Hard coal France	1.649E-09
Hard coal Germany	1.964E-07
Hard coal India	2.171E-10
Hard coal Indonesia	5.511E-08
Hard coal Italy	5.154E-11

Process or Category	Cradle to Gate (RMA)
Hard coal Japan	1.167E-14
Hard coal Malaysia	8.414E-15
Hard coal Mexico	1.270E-08
Hard coal New Zealand	3.257E-10
Hard coal Poland	5.950E-08
Hard coal Portugal	4.426E-13
Hard coal South Africa	9.869E-08
Hard coal Spain	8.072E-09
Hard coal Turkey	2.663E-12
Hard coal United Kingdom	2.264E-08
Hard coal USA	1.035E-03
Hard coal Venezuela	9.530E-08
Hard coal Vietnam	8.855E-10
Hard Coal, Pure, Fuel	1.208E-08
Hard Coal, Raw, Fuel	9.457E-08
Lignite (resource)	3.804E-06
Lignite	1.219E-09
Lignite Australia	1.823E-08
Lignite Austria	5.513E-10
Lignite Bosnia and Herzegovina	2.052E-08
Lignite Bulgaria	1.974E-09
Lignite Canada	1.367E-07
Lignite CIS	2.271E-09
Lignite Czech Republic	8.899E-09
Lignite France	5.193E-10
Lignite Germany	3.283E-11
Lignite Germany (Central Germany)	4.910E-07
Lignite Germany (Lausitz)	1.525E-07
Lignite Germany (Rheinisch)	2.760E-07
Lignite Greece	7.685E-08
Lignite Hungary	1.091E-09
Lignite India	4.343E-11
Lignite Macedonia	1.257E-09
Lignite Poland	6.640E-09
Lignite Romania	1.941E-11
Lignite Serbia and Montenegro	7.404E-10

Process or Category	Cradle to Gate (RMA)
Lignite Slovakia	3.458E-09
Lignite Slovenia	2.328E-08
Lignite Spain	1.698E-08
Lignite Turkey	7.664E-14
Lignite USA	2.563E-06
Natural gas (resource)	1.121E+00
Natural gas	7.922E-09
Natural gas Algeria	7.414E-07
Natural gas Angola	1.980E-06
Natural gas Argentina	3.139E-08
Natural gas Australia	2.099E-08
Natural gas Austria	1.119E-09
Natural gas Bolivia	1.278E-09
Natural gas Brazil	3.414E-08
Natural gas Brunei	4.023E-09
Natural gas Bulgaria	3.565E-13
Natural gas Cameroon	2.318E-08
Natural gas Canada	1.063E-05
Natural gas Chile	9.049E-10
Natural gas China	9.013E-09
Natural gas CIS	2.438E-07
Natural gas Colombia	1.061E-07
Natural gas Czech Republic	8.968E-11
Natural gas Denmark	2.350E-08
Natural gas Ecuador	4.274E-07
Natural gas Egypt	1.816E-09
Natural gas France	2.709E-09
Natural gas Gabon	1.626E-07
Natural gas Germany	1.033E-07
Natural gas Greece	9.460E-11
Natural gas Hungary	9.506E-10
Natural gas India	1.664E-11
Natural gas Indonesia	1.831E-08
Natural gas Iran	1.479E-08
Natural gas Iraq	7.757E-07
Natural gas Ireland	9.138E-11

Process or Category	Cradle to Gate (RMA)
Natural gas Italy	7.635E-09
Natural gas Japan	3.494E-15
Natural gas Kuwait	2.961E-07
Natural gas Libyan	6.397E-09
Natural gas Malaysia	3.980E-09
Natural gas Mexico	2.785E-06
Natural gas Netherlands	1.587E-07
Natural gas New Zealand	5.477E-11
Natural gas Nigeria	5.479E-06
Natural gas Norway	1.698E-07
Natural gas Oman	1.162E-08
Natural gas Poland	6.708E-10
Natural gas Qatar	6.409E-08
Natural gas Romania	1.236E-10
Natural gas Saudi Arabia	1.652E-06
Natural gas Slovakia	9.504E-11
Natural gas South Africa	6.943E-12
Natural gas Spain	3.025E-10
Natural gas Syria	3.376E-13
Natural gas Trinidad and Tobago	3.087E-07
Natural gas Tunisia	1.098E-09
Natural gas Turkey	6.252E-17
Natural gas United Arab Emirates	3.791E-09
Natural gas United Kingdom	2.018E-07
Natural gas USA	1.860E-02
Natural gas Venezuela	1.930E-06
Natural Gas, Fuel	3.771E-08
Natural gas, Raw Material	1.103E+00
Pit gas	5.007E-13
Pit Methane	1.000E-07
Uranium (resource)	5.012E-10
Nuclear energy	0.000E+00
Uranium natural	5.012E-10
Renewable energy resources	8.403E-09
Biomass	8.395E-10
Energy, gross calorific value, in biomass, primary forest	0.000E+00

Process or Category	Cradle to Gate (RMA)
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	1.938E-14
Wood	7.563E-09
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	9.648E-01
Non renewable elements	1.671E-03
Aluminum	3.821E-11
Chromium	4.493E-14
Copper	4.269E-14
Iron	1.662E-03
Lead	2.579E-14
Magnesium	5.171E-17
Mercury	1.399E-14
Nickel	1.797E-16
Phosphorus	5.168E-12

Process or Category	Cradle to Gate (RMA)
Sulphur	3.850E-11
Zinc	9.251E-06
Non renewable resources	5.532E-04
Barium sulphate	3.943E-18
Basalt	4.786E-08
Bauxite	7.651E-07
Bentonite	1.843E-06
Calcium carbonate (CaCO3)	2.487E-07
Calcium chloride	4.037E-16
Chalk (Calciumcarbonate)	1.573E-40
Chromium ore (39%)	9.605E-09
Clay	1.874E-07
Colemanite ore	1.457E-09
Copper - Gold - Silver - ore (1,0% Cu; 0,4 g/t Au; 66 g/t Ag)	1.256E-07
Copper - Gold - Silver - ore (1,1% Cu; 0,01 g/t Au; 2,86 g/t Ag)	7.651E-08
Copper - Gold - Silver - ore (1,16% Cu; 0,002 g/t Au; 1,06 g/t Ag)	4.318E-08
Copper - Molybdenum - Gold - Silver - ore (1,13% Cu; 0,02% Mo; 0,01 g/t Au; 2,86 g/t Ag)	1.950E-08
Copper ore (0.14%)	2.734E-07
Copper ore (1.2%)	1.302E-08
Copper ore (4%)	1.775E-18
Copper ore (sulphidic, 1.1%)	1.705E-08
Dolomite	8.960E-05
Feldspar (aluminum silicates)	3.644E-12
Ferro manganese	8.166E-15
Fluorspar (calcium fluoride; fluorite)	5.737E-09
Granite	1.050E-21
Gravel	1.353E-06
Gypsum (natural gypsum)	1.105E-07
Heavy spar (BaSO4)	4.453E-06
Ilmenite (titanium ore)	2.534E-12
Inert rock	2.488E-04
Iron ore (56,86%)	1.740E-06
Iron ore (65%)	3.784E-10
Kaolin ore	2.614E-09
Lead - zinc ore (4.6%-0.6%)	3.805E-07
Limestone (calcium carbonate)	1.910E-04

Process or Category	Cradle to Gate (RMA)
Magnesit (Magnesium carbonate)	2.564E-12
Magnesium chloride leach (40%)	5.060E-08
Manganese ore	1.877E-09
Manganese ore (R.O.M.)	2.108E-08
Molybdenite (Mo 0,24%)	1.191E-08
Molybdenum ore (0.1%)	1.763E-10
Natural Aggregate	9.052E-06
Nickel ore (1,5%)	2.986E-10
Nickel ore (1.6%)	6.601E-08
Olivine	8.510E-14
Peat	3.178E-09
Phosphate ore	2.234E-12
Phosphorus minerals	2.906E-10
Phosphorus ore (29% P2O5)	2.677E-12
Potassium chloride	6.633E-11
Precious metal ore (R.O.M)	4.839E-10
Quartz sand (silica sand; silicon dioxide)	2.424E-07
Raw pumice	2.532E-10
Rutile (titanium ore)	9.497E-13
sand	1.237E-11
Slate	1.716E-13
Sodium chloride (rock salt)	6.774E-07
Sodium nitrate	8.667E-21
Sodium sulphate	1.638E-12
Soil	1.732E-06
Sulphur (bonded)	3.054E-14
Talc	4.449E-11
Tin ore	3.420E-19
Titanium ore	8.813E-09
Zinc - copper ore (4.07%-2.59%)	1.046E-07
Zinc - lead - copper ore (12%-3%-2%)	5.825E-08
Zinc - lead ore (4.21%-4.96%)	6.060E-19
Zinc ore (4%)	-1.513E-09
Zinc ore (sulphidic, 4%)	6.832E-18
Renewable resources	9.626E-01
Water	9.615E-01

Process or Category	Cradle to Gate (RMA)
Water	2.158E-03
Water (feed water)	0.000E+00
Water (ground water)	6.514E-02
Water (lake water)	7.444E-01
Water (municipal)	1.102E-06
Water (sea water)	3.547E-06
Water (surface water)	1.492E-01
Water (wastewater)	0.000E+00
Water (well water)	3.683E-08
Water (well-produced water)	5.471E-04
Water (with river silt)	4.314E-17
Water,turbine use, unspecified natural origin	0.000E+00
Air	1.058E-03
Carbon dioxide	4.827E-07
Nitrogen	1.103E-09
Oxygen	0.000E+00
Unspecified	1.097E-08
Unspecified minerals	2.495E-09
Unspecified resources	8.471E-09
Output	
Flows	3.225E-01
Resources	1.469E-01
Energy resources	0.000E+00
Non renewable energy resources	0.000E+00
Natural gas (resource)	0.000E+00
Natural gas USA	0.000E+00
Natural gas, Raw Material	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	1.469E-01

Process or Category	Cradle to Gate (RMA)
Renewable resources	1.469E-01
Water	1.469E-01
Water (feed water)	2.288E-06
Water (river water)	1.439E-01
Water (wastewater)	5.607E-04
Water (wastewater)	2.428E-03
Nitrogen	0.000E+00
Oxygen	3.888E-08
Ecoinvent	8.799E-06
Long-term emission	8.799E-06
Fresh water	8.799E-06
Chloride	2.899E-06
Dissolved organic carbon, DOC (Ecoinvent)	4.531E-13
Total organic carbon, TOC (Ecoinvent)	5.900E-06
Production residues in life cycle	9.872E-07
Hazardous waste for disposal	2.170E-07
Chromium containing slag	1.753E-11
Dross (Fines)	1.435E-09
Natrium oxide	2.440E-09
Red mud (dry)	2.120E-07
Soil and sand containing heavy metals	8.600E-10
Toxic chemicals (unspecified)	2.367E-10
Hazardous waste for recovery	7.908E-08
Used oil	3.859E-10
Waste water processing residue	7.869E-08
Waste for disposal	5.267E-07
Incineration good	1.317E-10
Sludge from water works (6% dry matter-content)	2.381E-09
Waste (solid)	2.453E-07
Waste for disposal (unspecified)	1.718E-10
Waste from steel works	2.787E-07
Waste for recovery	1.505E-07
Aluminum scrap	1.892E-15
Boiler ash (unspecified)	0.000E+00
Chemicals (unspecified)	6.914E-11
Cooling water	1.348E-07

Process or Category	Cradle to Gate (RMA)
Cryolite	6.691E-10
Dross	2.827E-10
Filter dust	2.782E-12
Fly ash (unspecified)	0.000E+00
Furnace clinker	6.955E-13
Gypsum	0.000E+00
Gypsum (contaminated)	1.109E-16
Gypsum (FDI)	2.238E-12
Plastic (unspecified)	1.360E-10
Production residues (unspecified)	1.263E-12
Rolling gravel	1.840E-10
Rolling tinder	3.895E-13
Slag	5.562E-09
Slag (containing precious metal)	2.573E-13
Slag (Iron plate production)	5.829E-09
Slag (Mn 6,5%)	3.027E-09
Waste paper	4.075E-13
Wood	4.549E-13
Wooden pallet (EURO)	3.941E-19
Mixed Waste (Hazardous or Radioactive)	1.391E-08
Neutralized residues	4.082E-13
Emissions to air	1.674E-01
Heavy metals to air	7.368E-08
Antimony	7.804E-13
Arsenic (+V)	2.061E-11
Arsenic trioxide	2.486E-16
Cadmium (+II)	3.195E-10
Chromium (+III)	8.571E-14
Chromium (+VI)	3.957E-16
Chromium (unspecified)	1.887E-09
Cobalt	2.601E-12
Copper (+II)	6.442E-12
Heavy metals to air (unspecified)	5.755E-13
Hydrogen arsenic (arsine)	2.064E-14
Iron	5.520E-12
Lanthanides	2.418E-16

Process or Category	Cradle to Gate (RMA)
Lead (+II)	1.220E-08
Manganese (+II)	7.093E-12
Mercury (+II)	4.053E-10
Molybdenum	4.933E-13
Nickel (+II)	6.276E-11
Palladium	1.118E-20
Rhodium	1.079E-20
Selenium	2.176E-11
Silver	3.271E-19
Tellurium	1.142E-14
Thallium	1.500E-13
Tin (+IV)	7.914E-12
Titanium	1.543E-14
Vanadium (+III)	5.384E-10
Zinc (+II)	5.820E-08
Inorganic emissions to air	1.479E-01
Ammonia	6.553E-09
Ammonium	4.502E-14
Ammonium nitrate	1.786E-16
Argon	7.451E-13
Barium	2.819E-09
Beryllium	4.511E-13
Boron compounds (unspecified)	1.621E-10
Bromine	6.596E-11
Carbon dioxide	1.431E-01
Carbon dioxide (biotic)	2.068E-07
Carbon dioxide (biotic)	5.267E-11
Carbon disulphide	9.918E-15
Carbon monoxide	3.438E-04
Carbon monoxide (biotic)	3.210E-13
Chloride (unspecified)	3.730E-11
Chlorine	2.289E-12
Cyanide (unspecified)	3.116E-12
Fluoride	1.230E-10
Fluorides	1.999E-12
Fluorine	4.180E-14

Process or Category	Cradle to Gate (RMA)
Helium	2.200E-12
Hydrogen	3.758E-10
Hydrogen bromine (hydrobromic acid)	7.727E-14
Hydrogen chloride	2.552E-07
Hydrogen cyanide (prussic acid)	6.861E-14
Hydrogen fluoride	3.358E-10
Hydrogen iodide	3.132E-17
Hydrogen phosphorous	4.374E-15
Hydrogen sulphide	1.323E-07
Lead dioxide	5.561E-13
Nitrogen (atmospheric nitrogen)	8.828E-05
Nitrogen (N-compounds)	1.457E-13
Nitrogen dioxide	1.254E-07
Nitrogen monoxide	1.683E-12
Nitrogen oxides	3.931E-03
Nitrous oxide (laughing gas)	1.105E-05
Oxygen	2.846E-07
Scandium	1.162E-16
Steam	4.015E-04
Strontium	4.574E-15
Sulphur dioxide	2.995E-05
Sulphur hexafluoride	9.330E-10
sulphur oxide	2.109E-11
Sulphuric acid	1.432E-12
Tin oxide	8.525E-17
Unspecified Particles	2.042E-08
Zinc oxide	1.705E-16
Zinc sulphate	5.193E-13
Organic emissions to air (group VOC)	1.869E-02
Group NMVOC to air	3.158E-03
Group PAH to air	1.044E-10
Anthracene	6.376E-14
Benzo{a}anthracene	3.209E-14
Benzo{a}pyrene	5.495E-11
Benzo{ghi}perylene	2.862E-14
Benzofluoranthene	5.725E-14

Process or Category	Cradle to Gate (RMA)
Chrysene	7.882E-14
Dibenz(a)anthracene	1.783E-14
Indeno[1,2,3-cd]pyrene	2.130E-14
Naphthalene	6.698E-12
Phenanthrene	2.104E-12
Polycyclic aromatic hydrocarbons (PAH)	4.035E-11
Halogenated organic emissions to air	3.730E-11
Dichloroethane (ethylene dichloride)	2.019E-14
Dichloromethane (methylene chloride)	6.904E-16
Dioxins (unspec.)	-1.491E-14
Halogenated hydrocarbons (unspecified)	7.313E-14
Halon (1301)	0.000E+00
Polychlorinated biphenyls (PCB unspecified)	4.528E-14
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	2.818E-17
R 11 (trichlorofluoromethane)	3.650E-12
R 114 (dichlorotetrafluoroethane)	3.737E-12
R 116 (hexafluoroethane)	2.611E-12
R 12 (dichlorodifluoromethane)	7.846E-13
R 13 (chlorotrifluoromethane)	4.927E-13
R 22 (chlorodifluoromethane)	8.576E-13
Tetrafluoromethane	2.419E-11
Vinyl chloride (VCM; chloroethene)	8.465E-13
Acetaldehyde (Ethanal)	1.806E-10
Acetic acid	6.951E-10
Acetone (dimethylcetone)	1.795E-10
Acrolein	4.500E-13
Aldehyde (unspecified)	1.500E-12
Alkane (unspecified)	1.015E-09
Alkene (unspecified)	3.613E-10
Aromatic hydrocarbons (unspecified)	6.925E-11
Benzene	1.444E-10
Butadiene	3.468E-14
Butane	3.414E-08
Butane (n-butane)	8.761E-11
Caprolactam	2.285E-14
Cumene (isopropylbenzene)	2.469E-20

Process or Category	Cradle to Gate (RMA)
Cyclohexane (hexahydro benzene)	2.232E-14
Diethylamine	8.786E-19
Ethane	9.291E-08
Ethanol	3.462E-10
Ethene (ethylene)	4.722E-12
Ethyl benzene	3.285E-10
Fluoranthene	2.077E-13
Fluorene	6.591E-13
Formaldehyde (methanal)	6.618E-10
Heptane (isomers)	1.140E-09
Hexamethylene diamine (HMDA)	2.040E-15
Hexane (isomers)	1.709E-09
Mercaptan (unspecified)	9.723E-12
Methanethiol	5.191E-10
Methanol	3.440E-10
NMVOC (unspecified)	3.158E-03
Octane	6.272E-10
Pentane (n-pentane)	1.192E-08
Phenol (hydroxy benzene)	5.612E-15
Propane	1.668E-07
Propene (propylene)	2.973E-11
Propionic acid (propane acid)	1.033E-14
Styrene	1.266E-16
Toluene (methyl benzene)	1.666E-10
Trimethylbenzene	8.305E-16
Xylene (dimethyl benzene)	1.380E-09
Hydrocarbons (unspecified)	1.973E-09
Methane	1.553E-02
Methane (biotic)	2.297E-08
Organic chlorine compounds	8.773E-14
Unspecified Organic Compounds	1.419E-14
VOC (unspecified)	7.035E-07
Other emissions to air	8.180E-04
Aldehydes, unspecified	7.095E-15
Exhaust	7.959E-04
non used primary energy from wind power	0.000E+00

Process or Category	Cradle to Gate (RMA)
Particulate Matter, unspecified	1.381E-08
Sand (Silica) (SiO2)	1.353E-10
Unused primary energy from solar energy	0.000E+00
Used air	2.212E-05
Waste heat	0.000E+00
Particles to air	3.157E-05
Dust (PM10)	1.098E-05
Dust (PM2,5 - PM10)	3.724E-13
Dust (PM2.5)	1.707E-08
Dust (Portland cement kiln)	1.424E-05
Dust (unspecified)	6.338E-06
Metals (unspecified)	4.984E-13
Unspecified Organic Chlorine Compounds	9.363E-14
Wood (dust)	3.147E-14
Radioactive emissions to air	4.476E-12
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)	4.476E-12
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

Process or Category	Cradle to Gate (RMA)
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	7.312E-18
Emissions to fresh water	8.190E-03
Analytical measures to fresh water	8.083E-03
Adsorbable organic halogen compounds (AOX)	1.468E-10
Biological oxygen demand (BOD)	6.755E-08
Chemical oxygen demand (COD)	1.199E-06
Nitrogenous Matter (unspecified, as N)	5.138E-08
Solids (dissolved)	1.638E-05
Total Biochemical Oxygen Demand	1.247E-05
Total dissolved organic bounded carbon	1.015E-05
Total Dissolved Solids	8.030E-03
Total organic bounded carbon	3.988E-09
Total Suspended Solids	1.247E-05
Heavy metals to fresh water	4.699E-06
Aluminium	5.428E-07
Antimony	4.808E-09
Arsenic (+V)	2.215E-08
Cadmium (+II)	1.636E-09
Chromium (+III)	9.250E-12
Chromium (+VI)	5.612E-13
Chromium (unspecified)	3.168E-08
Cobalt	4.618E-13
Copper (+II)	3.040E-08
Heavy metals to water (unspecified)	2.253E-10
Iron	1.542E-06
Lead (+II)	5.347E-08
Manganese (+II)	1.019E-08
Mercury (+II)	2.622E-10
Molybdenum	1.268E-11
Nickel (+II)	7.237E-07
Selenium	2.397E-11

Process or Category	Cradle to Gate (RMA)
Silver	4.696E-09
Strontium	1.373E-09
Thallium	8.783E-15
Tin (+IV)	1.632E-12
Titanium	1.484E-12
Unspecified Substance	6.325E-14
Uranium	9.310E-07
Vanadium (+III)	5.453E-12
Zinc (+II)	7.990E-07
Inorganic emissions to fresh water	4.216E-05
Acid (calculated as H+)	2.255E-10
Acidity	0.000E+00
Aluminum (+III)	2.491E-09
Ammonia	8.462E-06
Ammonia, as N	1.706E-13
Ammonium (total N)	5.874E-06
Ammonium / ammonia	7.261E-07
Barium	1.524E-07
Beryllium	1.289E-14
Boron	5.766E-10
Bromate	9.160E-16
Bromine	3.123E-14
Calcium (+II)	1.906E-07
Carbonate	1.093E-06
Chlorate	8.066E-13
Chloride	3.146E-06
Chlorine (dissolved)	1.669E-08
Copper ion (+II/+III)	7.979E-15
Cyanide	4.368E-08
Fluoride	9.551E-08
Fluorine	4.877E-12
Hydrogen chloride	1.014E-13
Hydrogen fluoride (hydrofluoric acid)	3.375E-14
Hydrogen Ions (H+)	1.412E-11
Hydroxide	4.634E-10
Inorganic salts and acids (unspecified)	1.051E-21

Process or Category	Cradle to Gate (RMA)
Iron ion (+II/+III)	1.032E-12
Magnesium (+III)	2.390E-08
Magnesium chloride	3.040E-15
Metal ions (unspecific)	2.055E-11
Neutral salts	3.751E-15
Nickel ion (+III)	4.602E-14
Nitrate	6.962E-09
Nitrate (as total N)	2.268E-13
Nitrogen	2.242E-08
Nitrogen (as total N)	9.461E-06
Nitrogen organic bounded	3.918E-10
Phosphate	3.770E-11
Phosphorus	6.451E-07
Potassium	1.720E-11
Silicate particles	1.749E-10
Sodium (+I)	6.457E-07
Sodium chloride (rock salt)	3.022E-06
Sodium hypochlorite	6.591E-14
Sulfates	2.267E-07
Sulphate	8.196E-06
Sulphide	3.418E-09
Sulphite	6.351E-11
Sulphur	4.624E-11
Sulphur dioxide	9.933E-08
Sulphuric acid	1.307E-11
Unspecified Iron Oxides	1.620E-13
Unspecified Oil	5.738E-13
Unspecified Organic Chlorine compounds	1.300E-15
Unspecified Salt	5.203E-12
Unspecified Solids (Suspended)	2.020E-11
Organic emissions to fresh water	1.611E-06
Halogenated organic emissions to fresh water	1.642E-13
1,2-Dibromoethane	5.242E-18
Chlorinated hydrocarbons (unspecified)	7.810E-14
Chloromethane (methyl chloride)	8.059E-14
Dichloroethane (ethylene dichloride)	8.451E-16

Process or Category	Cradle to Gate (RMA)
Dichloropropane	1.637E-18
Polychlorinated dibenzo-p-dioxins (2,3,7,8 - TCDD)	2.752E-18
Vinyl chloride (VCM; chloroethene)	4.689E-15
Hydrocarbons to fresh water	1.605E-06
Acenaphthene	5.804E-14
Acenaphthylene	2.411E-14
Acetic acid	2.037E-12
Acrylonitrile	1.197E-13
Anthracene	8.088E-14
Aromatic hydrocarbons (unspecified)	3.868E-11
Benzene	1.150E-10
Benzo{a}anthracene	8.535E-15
Benzofluoranthene	4.844E-15
Chrysene	3.893E-14
Cresol (methyl phenol)	1.198E-12
Ethyl benzene	5.665E-12
Fluoranthene	9.814E-15
Hexane (isomers)	1.308E-13
Hydrocarbons (unspecified)	5.111E-07
Methanol	1.813E-09
Oil (unspecified)	1.092E-06
Phenol (hydroxy benzene)	1.027E-10
Polycyclic aromatic hydrocarbons (PAH, unspec.)	2.675E-10
Toluene (methyl benzene)	7.441E-11
Xylene (isomers; dimethyl benzene)	2.480E-11
Carbon, organically bound	5.596E-09
Naphthalene	3.680E-12
N-unspecified (N)	4.490E-13
Organic chlorine compounds (unspecified)	1.246E-14
Organic compounds (dissolved)	3.691E-12
Organic compounds (unspecified)	1.570E-12
Unspecified wastewater	3.396E-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

Process or Category	Cradle to Gate (RMA)
Waste heat	0.000E+00
Waste water	0.000E+00
Particles to fresh water	5.636E-06
Metals (unspecified)	2.768E-12
Silicon dioxide (silica)	2.439E-12
Soil loss by erosion into water	6.048E-13
Solids (suspended)	5.636E-06
Suspended solids, unspecified	5.238E-11
Unspecified Oxides	1.346E-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	5.112E-05
Radionuclide	0.000E+00
Sulfite	1.932E-06
Unspecified Solids (Dissolved)	3.893E-11
Uranium (total)	8.649E-14

Process or Category	Cradle to Gate (RMA)
Emissions to sea water	6.077E-06
Analytical measures to sea water	2.814E-08
Adsorbable organic halogen compounds (AOX)	1.817E-15
Biological oxygen demand (BOD)	2.004E-09
Chemical oxygen demand (COD)	2.413E-08
Total organic bounded carbon	2.004E-09
Heavy metals to sea water	6.038E-09
Arsenic (+V)	6.417E-11
Cadmium (+II)	3.269E-11
Chromium (unspecified)	1.008E-10
Cobalt	5.416E-12
Copper (+II)	2.021E-10
Iron	3.337E-10
Lead (+II)	5.422E-11
Manganese (+II)	3.322E-11
Mercury (+II)	7.418E-13
Molybdenum	6.040E-11
Nickel (+II)	6.542E-11
Silver	6.163E-12
Strontium	4.969E-09
Tin (+IV)	7.382E-12
Titanium	7.519E-13
Vanadium (+III)	4.654E-12
Zinc (+II)	9.690E-11
Inorganic emissions to sea water	4.445E-06
Aluminum (+III)	2.421E-11
Ammonia	7.193E-10
Barium	8.484E-10
Beryllium	1.947E-13
Boron	3.914E-10
Calcium (+II)	4.275E-08
Carbonate	5.337E-08
Chloride	4.264E-06
Magnesium	1.067E-08
Nitrate	6.918E-11
Sodium (+I)	4.002E-08

Process or Category	Cradle to Gate (RMA)
Sulphate	2.253E-08
Sulphide	9.717E-09
Sulphur	2.094E-10
Organic emissions to sea water	2.686E-09
Hydrocarbons to sea water	2.672E-09
Acenaphthene	3.169E-13
Acenaphthylene	1.247E-13
Acetic acid	1.031E-13
Anthracene	2.134E-13
Aromatic hydrocarbons (unspecified)	2.004E-11
Benzene	3.089E-10
Benzo{a}anthracene	6.218E-14
Benzofluoranthene	5.983E-14
Chrysene	3.329E-13
Cresol (methyl phenol)	5.425E-12
Ethyl benzene	1.535E-11
Fluoranthene	7.226E-14
Hexane (isomers)	5.923E-13
Oil (unspecified)	1.780E-09
Phenol (hydroxy benzene)	2.713E-10
Toluene (methyl benzene)	2.062E-10
Xylene (isomers; dimethyl benzene)	6.234E-11
Naphthalene	1.439E-11
Particles to sea water	1.595E-06
Solids (suspended)	1.595E-06
Emissions to industrial soil	2.938E-05
Heavy metals to industrial soil	2.936E-05
Antimony	3.407E-20
Arsenic (+V)	1.627E-08
Cadmium (+II)	7.285E-14
Chromium (+III)	2.503E-14
Chromium (+VI)	1.235E-19
Chromium (unspecified)	1.412E-11
Cobalt	2.240E-13
Copper (+II)	1.491E-13
Iron	2.912E-05

Process or Category	Cradle to Gate (RMA)
Lead (+II)	1.163E-07
Manganese (+II)	4.872E-12
Mercury (+II)	3.010E-10
Nickel (+II)	1.120E-11
Selenium	1.933E-09
Strontium	4.664E-09
Thallium	1.407E-08
Vanadium (+III)	8.882E-08
Zinc (+II)	1.833E-12
Inorganic emissions to industrial soil	1.525E-08
Aluminum (+III)	1.732E-11
Ammonia	7.243E-09
Bromide	1.919E-12
Calcium (+II)	1.008E-09
Chloride	2.297E-09
Chlorine	2.881E-17
Fluoride	6.398E-11
Magnesium (+III)	1.392E-10
Phosphorus	7.591E-10
Potassium (+I)	1.815E-09
Sodium (+I)	8.813E-11
Sulphate	2.601E-10
Sulphide	1.561E-09
Organic emissions to industrial soil	2.527E-11
Oil (unspecified)	2.527E-11
Radioactive emissions to industrial soil	0.000E+00
Uranium	0.000E+00
Calcium Fluoride	2.222E-09
Radionuclide	0.000E+00

Embedded Unit Processes

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Point of Contact: Timothy Skone (NETL), Timothy.Skone@NETL.DOE.GOV

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