

APPENDIX B
FOOTPRINT CONVERSION FACTORS

Default Conversion and Emission Factors

Parameters Used, Extracted, Emitted, or Generated																								
		Energy Used	Electricity Used	All Water Used	Potable Water Used	Groundwater Extracted	CO2e Emitted	NO x Emitted	SO x Emitted	PM Emitted	Solid Waste Generated	Haz. Waste Generated	Air Toxics Emitted	Mercury Released	Lead Released	Dioxins Released								
		Mbtu	MWh	gal x 1000	gal x 1000	gal x 1000	lbs	lbs	lbs	lbs	tons	tons	lbs	lbs	lbs	lbs								
ON-SITE																								
Energy																								
Diesel (on-site use)	gal	139					22.5	0.17	0.0054	0.0034			0.0000052	0	0	0								
Gasoline (on-site use)	gal	124					19.6	0.11	0.0045	0.00054			0.000039	0	0	0								
Natural gas (on-site use)	ccf	103					12.2	0.01	0.0000063	0.00076			0.0000084	0.000000026	0.00000005	0								
Electricity (on-site use)	MWh	3413	1																					
Photovoltaic (on-site system)	MWh	37922.22222	1																					
Other Energy 2	TBD																							
Other Energy 3	TBD																							
Water																								
Groundwater Extracted On-site	gal x 1000			1		1																		
Potable Water Used On-site	gal x 1000			1	1																			
Other On-Site Water 1	gal x 1000			1																				
Other On-Site Water 2	gal x 1000			1																				
Other On-Site Water 3	gal x 1000			1																				
Waste Generation																								
On-Site Solid Waste Generation	ton										1													
On-Site Solid Waste Disposal	ton																							
On-Site Hazardous Waste Generation	ton											1												
On-Site Hazardous Waste Disposal	ton																							
Other																								
On-site process emissions (HAPs)	lbs												1											
On-site process emissions (GHGs)	lbs CO2e						1																	
On-site GHG storage	lbs CO2e						-1																	
On-site NOx reduction	lbs							-1																
On-site SOx reduction	lbs								-1															
On-site PM reduction	lbs									-1														
Other 4	TBD																							
Other 5	TBD																							
ELECTRICITY GENERATION																								
Electricity production	MWh	7800	0.06	2	X		1540	X	3.9	X	10	X	0.94	X	0.0009	0	0.4	X	0.000023	X	0.00017	X	2.40E-10	X
TRANSPORTATION																								
Diesel (off-site use)	gal	139					22.5	0.17	0.0054	0.0034			0.0000052	0	0	0								
Gasoline (off-site use)	gal	124					19.6	0.11	0.0045	0.00054			0.000039	0	0	0								
Natural gas (off-site use)	ccf	103					12.2	0.01	0.0000063	0.00076			0.0000084	0.000000026	0.00000005	0								
Potable Water Transported	gal x 1000	7.4	0.000645995	0.00129199			0.994832041	0.00251938	0.006459948	0.000607235	5.81395E-07	0	0.000258398	1.48579E-08	1.09819E-07	1.55039E-13								
Electricity transmission	MWh	410	0.12	0.24	X		184.8	X	0.468	X	1.2	X	0.1128	X	0.000108	0	0.048	X	0.00000276	X	0.0000204	X	2.88E-11	X
Other Transportation 1	TBD																							
Other Transportation 2	TBD																							
Other Transportation 3	TBD																							
OFF-SITE OTHER																								
Materials																								
Asphalt	tons																							
Bentonite	tons	55	0.0027	0.13			6.7	0.033	0.03	0.004	0	0	0.00000041	6.4E-11	1.2E-09	1.5E-16								
Borrow (clean soil)	tons	15.75	0.000059	0.000077			2.52	0.01764	0.00184	0.000374	0.000000036	0	0.00001252	4.8E-09	0.00000015	3E-15								
Cement	dry-ton	4100	0.13	0.41			1800	3.6	2.1	0.0063	0	0	0.058	0.000057	0.00013	8.50E-11								
Cheese Whey	lbs	1.87	0	0			1.1	0.0083	0.0099	0.000166	0	0	0	0	0	0								
Concrete	tons	3020	0.096	0.33	X		1322	2.6	1.5	0.0057	0.000000028	0	0.043	0.000042	0.0000095	6.2E-11								
Diesel Produced	gal	18.5	0.00059	0.00077			2.7	0.0064	0.013	0.00034	0.00000036	0	0.00012	0.000000048	0.00000015	3E-14								
Emulsified vegetable oil	lbs	3.6	0.000055	0.000024			3.51	0.0265	0.031	0.0017	0	0	0	0	0	0								
GAC: regenerated	lbs	9.6	0.00044	0.0064			2	0.025	0.015	0	0	0	0	0	0	0								
GAC: virgin coal-based	lbs	10.8	0.000045				4.5	0.12	0.074															
GAC: virgin coconut-based	lbs																							
Gasoline Produced	gal	21	0.00059	0.00079			4.4	0.008	0.019	0.00052	0.00000042	0	0.00016	0.000000085	0.0000022	3.1E-14								
Gravel/sand/clay	ton	55	0.0027	0.13			6.7	0.033	0.03	0.004	0	0	0.00000041	6.4E-11	1.2E-09	1.5E-16								
HDPE	lb	31	0.00025	0.0023			1.9	0.0032	0.0041	0.00064	0.00000043	0.000001	0.0000034	2.6E-09	2.4E-09	9.8E-10								

Default Conversion and Emission Factors

		Parameters Used, Extracted, Emitted, or Generated														
		Energy	Electricity	All Water	Potable Water	Groundwater	CO2e	NO x	SO x	PM	Solid Waste	Haz. Waste	Air Toxics	Mercury	Lead	Dioxins
		Used	Used	Used	Used	Extracted	Emitted	Emitted	Emitted	Emitted	Generated	Generated	Emitted	Released	Released	Released
		Mbtu	MWh	gal x 1000	gal x 1000	gal x 1000	lbs	lbs	lbs	lbs	tons	tons	lbs	lbs	lbs	
Hydrochloric acid (30%, SG = 1.18)	lbs															
Hydrogen peroxide (50%, SG=1.19)	lbs	4.95	0.000597	0.019			1.35	0.0087	0.0066	0.0025	0.000013	0.00000048	0.00023			
Hydroseed	lbs	0.049	1.46044E-07	0.00012			0.0046	0.000027	0.000053	0.00000028	0	0	0.00000081	2E-11	1.29E-10	0
Lime	lbs															
Molasses	lbs	1.31	0.000005	0.000091			0.4	0.003	0.0026	0.00006	0	0	0	0	0	0
Natural Gas Produced	ccf	5.2	0.00025	0.000077			2.2	0.0037	0.0046	0.000072	0	0	0.0000061	2.1E-08	0.0000009	5.1E-14
Nitrogen fertilizer	lbs	16.2	0.000023				1.5	0.00078	0.0174	0.000067			0.00026	6.1E-09	0.00000038	
Other Material #1 - PV System	W	33.6	0.000262994				4.47	0.015	0.032	0.00063		0.0000029	0.0000029		0.0000029	
Other Material #2 - Mulch	cy															
Other Material #3 - acetic acid	lb	5.2	0.00002				0.67	0.00064	0.02	0.000058			0.00029	1.7E-09	0.00000001	3E-15
Other Material #4 - guar gum	lb	0.91	0.000047	0.0001			1	0.073	0.0068	0.00012			0.000014	1.1E-09	0.00000011	6.00E-14
Other Material #5	TBD															
Phosphorus fertilizer	lbs	3.39	0.000073				0.35	0.0017	0.017	0.00011			0.000052	2.1E-09	0.000000048	
Polymer	lbs															
Potable Water Produced	gal x 1000	9.2	0.00044	0.021			5	0.0097	0.0059	0.016	8.34E-07	0	0.000015	8.2E-09	0.000000067	1E-13
Potassium permanganate	lbs	29.22	0.0016	0.003			4.5	0.021	0.016	0.0017	0.0000013		0.0006	0.000000038	0.00000038	3.5E-13
PVC	lbs	22	0.00056	0.0069			2.6	0.0048	0.0076	0.0012	0.0000022	0.0000016	0.00047	0.00000034	0.00000013	6.9E-09
Sequestering agent	lbs															
Sodium hydroxide (dry bulk)	lbs	6.6	0.00032	0.00115			1.37	0.003	0.0048	0.00054	0.000019	4.70E-07	0.000062	2.20E-07	2.50E-08	2.40E-14
Stainless Steel	lb	11.6	0.00056	0.0023			3.4	0.0075	0.012	0.0044	0.00062	0	0.000144	0	0.00000052	2.2E-12
Steel	lb	4.4	0.00021	0.00064			1.1	0.0014	0.0017	0.00056	0.00025	0	0.000067	0.0000001	0.0000025	6.5E-12
Tree: root ball	trees	3.7	0.0000019	0.004			0.6	0.003	0.00061	0.000029	0.00000001		0.000006	2.2E-09	0.00000006	
Tree: whip	trees			0												
Off-Site Services																
Off-site waste water treatment	gal x 1000	15	0.00073	0.00292			4.4	0.016	0.015	0.0017	0.0024	0	0.00058	3.70E-08	3.70E-07	3.45E-13
Off-site Solid Waste Disposal	ton	160	0.0077	0.15			25	0.14	0.075	0.4	0.000008	0	0.0014	9.70E-07	0.0000076	1.20E-11
Off-site Hazardous Waste Disposal	ton	176	0.0085	0.165			27.5	0.154	0.0825	0.44	0.0000088	0	0.00154	0.000001067	0.00000836	1.32E-11
Off-site Laboratory Analysis	\$	6.49	0.00035	0.00066			1	0.0048	0.0036	0.0004	0	0	0.00013	8.4E-09	0.000000085	7.9E-14
Other 1	TBD															
Other 2	TBD															
Other 3	TBD															
Other 4	TBD															
Other 5	TBD															
Other																
Other 1	TBD															
Other 2	TBD															
Other 3	TBD															
Other 4	TBD															
Other 5	TBD															

Notes: An "X" next to a conversion rate indicates that a "actual" value has been assigned and is overriding the "default" value.

Actual Conversion and Emission Factors

		Parameters Used, Extracted, Emitted, or Generated														
		Energy Used	Electricity Used	All Water Used	Potable Water Used	Groundwater Extracted	CO2e Emitted	NO x Emitted	SO x Emitted	PM Emitted	Solid Waste Generated	Haz. Waste Generated	Air Toxics Emitted	Mercury Released	Lead Released	Dioxins Released
		Mbtu	MWh	gal x 1000	gal x 1000	gal x 1000	lbs	lbs	lbs	lbs	tons	tons	lbs	lbs	lbs	lbs
ON-SITE																
Energy																
Diesel (on-site use)	gal															
Gasoline (on-site use)	gal															
Natural gas (on-site use)	ccf															
Electricity (on-site use)	MWh															
Other Energy 1	TBD															
Other Energy 2	TBD															
Other Energy 3	TBD															
Water																
Groundwater Extracted On-site	gal x 1000															
Potable Water Used On-site	gal x 1000															
Other On-Site Water 1	gal x 1000															
Other On-Site Water 2	gal x 1000															
Other On-Site Water 3	gal x 1000															
Waste Generation																
On-Site Solid Waste Generation	ton															
On-Site Solid Waste Disposal	ton															
On-Site Hazardous Waste Generation	ton															
On-Site Hazardous Waste Disposal	ton															
Other																
On-site process emissions (HAPs)	lbs															
On-site process emissions (GHGs)	lbs CO2e															
On-site GHG storage	lbs CO2e															
On-site NOx reduction	TBD															
On-site SOx reduction	TBD															
On-site PM reduction	TBD															
Other 4	TBD															
Other 5	TBD															
ELECTRICITY GENERATION																
Electricity production	MWh			2.5			810	1.53	6	0.322			0.1762	0.000008	0.00005	3E-11
TRANSPORTATION																
Diesel (off-site use)	gal															
Gasoline (off-site use)	gal															
Natural gas (off-site use)	ccf															
Potable Water Transported	gal x 1000															
Electricity transmission	MWh			0.3			97.2	0.1836	0.72	0.03864			0.021144	0.00000096	0.000006	
Other Transportation 1	TBD															
Other Transportation 2	TBD															
Other Transportation 3	TBD															

Actual Conversion and Emission Factors

	Parameters Used, Extracted, Emitted, or Generated															
	Energy	Electricity	All Water	Potable Water	Groundwater	CO2e	NO x	SO x	PM	Solid Waste	Haz. Waste	Air Toxics	Mercury	Lead	Dioxins	
	Used Mbtu	Used MWh	Used gal x 1000	Used gal x 1000	Extracted gal x 1000	Emitted lbs	Emitted lbs	Emitted lbs	Emitted lbs	Generated tons	Generated tons	Emitted lbs	Released lbs	Released lbs	Released lbs	
OFF-SITE OTHER																
Materials																
Asphalt	tons															
Bentonite	tons															
Borrow (clean soil)	tons															
Cement	dry-ton															
Cheese Whey	lbs															
Concrete	tons															
Diesel Produced	gal															
Emulsified vegetable oil	lbs															
GAC: regenerated	lbs															
GAC: virgin coal-based	lbs															
GAC: virgin coconut-based	lbs															
Gasoline Produced	gal															
Gravel/sand/clay	ton															
HDPE	lb															
Hydrochloric acid (30%, SG = 1.18)	lbs															
Hydrogen peroxide (50%, SG=1.19)	lbs															
Hydroseed	lbs															
Lime	lbs															
Molasses	lbs															
Natural Gas Produced	ccf															
Nitrogen fertilizer	lbs															
Other Material #1 - PV System	gal															
Other Material #2 - Mulch	TBD															
Other Material #3 - acetic acid	TBD															
Other Material #4 - guar gum	TBD															
Other Material #5	TBD															
Phosphorus fertilizer	lbs															
Polymer	lbs															
Potable Water Produced	gal x 1000															
Potassium permanganate	lbs															
PVC	lbs															
Sequestering agent	lbs															
Sodium hydroxide (dry bulk)	lbs															
Stainless Steel	lb															
Steel	lb															
Tree: root ball	trees															
Tree: whip	trees															
Off-Site Services																
Off-site waste water treatment	gal x 1000															
Off-site Solid Waste Disposal	ton															
Off-site Hazardous Waste Disposal	ton															
Off-site Laboratory Analysis	\$															
Other 1	TBD															
Other 2	TBD															
Other 3	TBD															
Other 4	TBD															
Other 5	TBD															
Other																
Other 1	TBD															
Other 2	TBD															
Other 3	TBD															
Other 4	TBD															
Other 5	TBD															

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Diesel (on-site use)	Energy Used	139	Mbtu/gal	The reference provides the higher heating value of diesel as 5.825 MMBTU per barrel and defines a barrel as 42 gallons. This converts to approximately 139 Mbtu/gallon.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/gal		
	All Water Used		gal x 1000/gal		
	Potable Water Used		gal x 1000/gal		
	Groundwater Extracted		gal x 1000/gal		
	CO2e Emitted	22.5	lbs/gal	The reference provides CO2e emitted as 10.15 kg of CO2 per gallon. This converts to 22.3 pounds per gallon. Additionally, N2O and CH4 emissions are provided as g/gal. Values are converted to lbs/gal using a global warming potential (GWP) of 1 for carbon dioxide, 21 for methane, and 310 for nitrous oxide.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	NO x Emitted	0.17	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (nitrogen oxides) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	SO x Emitted	0.0054	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (sulfur oxides) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	PM Emitted	0.0034	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (Particulates, > 2.5 um, and < 10um) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	Solid Waste Generated		tons/gal	not applicable -- no waste generated when diesel is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Haz. Waste Generated		tons/gal	not applicable -- no waste generated when diesel is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Air Toxics Emitted	0.0000052	lbs/gal	Not available in NREL LCI transport files. Summed hazardous air pollutants emitted from combusting diesel in industrial equipment. NREL LCI provides results in kg per L combusted. Converted this to pounds per gallon by multiplying by 3.785 and multiplying by .22	NREL LCI File: SS_diesel combusted in industrial equipment.xls
	Mercury Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of mercury.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml
	Lead Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of lead	
Dioxins Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of dioxins.		

"NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

EUROPA ECLD refers to the European Reference Life Cycle Database (ELCD core database), version II compiled under contract on behalf of the European Commission - DG Joint Research Centre - Institute for Environment and Sustainability with technical and scientific support by JRC-IES from early 2008 to early 2009. (<http://lca.jrc.ec.europa.eu/lcaifohub/datasetArea.vm>)

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Gasoline (on-site use)	Energy Used	124	Mbtu/gal	The reference provides the higher heating value of gasoline as 5.218 MMBTU per barrel and defines a barrel as 42 gallons. This converts to approximately 124 Mbtu/gallon.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/gal	not applicable -- no electricity used when gasoline is combusted on-site or in transportation	
	All Water Used		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	Potable Water Used		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	Groundwater Extracted		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	CO2e Emitted	19.6	lbs/gal	The reference provides CO2e emitted as 8.81 kg of CO2 per gallon. This converts to 19.4 pounds per gallon. Additionally, N2O and CH4 emissions are provided as g/gal. Values are converted to lbs/gal using a global warming potential (GWP) of 1 for carbon dioxide, 21 for methane, and 310 for nitrous oxide.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	NO x Emitted	0.11	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (nitrogen oxides) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	SO x Emitted	0.0045	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (sulfur oxides) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	PM Emitted	0.00054	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (Particulates, > 2.5 um, and < 10um) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	Solid Waste Generated		tons/gal	not applicable -- no waste generated when gasoline is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Haz. Waste Generated		tons/gal	not applicable -- no waste generated when gasoline is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Air Toxics Emitted	0.000039	lbs/gal	Not available in NREL LCI transport files. Summed hazardous air pollutants emitted from combusting gasoline in industrial equipment. NREL LCI provides results in kg per L combusted. Converted this to pounds per gallon by multiplying by 3.785 and multiplying by .2.2	NREL LCI File: SS_gasoline combusted in industrial equipment.xls
	Mercury Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of mercury.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml
	Lead Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of lead	
Dioxins Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of dioxins.		

"NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Natural gas (on-site use)	Energy Used	103	Mbtu/ccf	The reference provides the higher heating value of natural gas as 1,027 BTU per scf. This converts to approximately 103 Mbtu/ccf.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/ccf	not applicable -- no electricity used when nat gas is combusted on-site or in transportation	
	All Water Used		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	Potable Water Used		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	Groundwater Extracted		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	CO2e Emitted	12.2	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits. Outputs for carbon dioxide and fossil methane were used to calculate CO2e. Nitrous oxide was not included as an output. Methane was assigned a global warming potential equal to 21 times that of CO2.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	NO x Emitted	0.01	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	SO x Emitted	0.0000063	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	PM Emitted	0.00076	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Solid Waste Generated		tons/ccf	not applicable -- no solid waste generated when natural gas is combusted on-site or in transportation	
	Haz. Waste Generated		tons/ccf	not applicable -- no haz waste generated when natural gas is combusted on-site or in transportation	
	Air Toxics Emitted	0.0000084	lbs/ccf	NREL - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere converted from kg/m3 to lb/ccf. Note that the value for combustion in equipment is significantly lower than the value reported here for use in an industrial boiler.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Mercury Released	0.00000026	lbs/ccf	NREL - Mercury released converted from kg/m3 to lb/ccf. Note that according to NREL there is no mercury released for natural gas combusted in industrial equipment.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Lead Released	0.00000005	lbs/ccf	NREL - Lead released converted from kg/m3 to lb/ccf. Note that according to NREL there is no lead released for natural gas combusted in industrial equipment.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Dioxins Released	0	lbs/ccf	NREL does not indicate the formation of dioxins during natural gas combustion	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls

"NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity (on-site use)	Energy Used	3413	Mbtu/MWh	Actual conversion factor	
	Electricity Used	1	MWh/MWh	One to one conversion.	
	All Water Used		gal x 1000/MWh		
	Potable Water Used		gal x 1000/MWh		
	Groundwater Extracted		gal x 1000/MWh		
	CO2e Emitted		lbs/MWh		
	NO x Emitted		lbs/MWh		
	SO x Emitted		lbs/MWh		
	PM Emitted		lbs/MWh		
	Solid Waste Generated		tons/MWh		
	Haz. Waste Generated		tons/MWh		
	Air Toxics Emitted		lbs/MWh		
	Mercury Released		lbs/MWh		
	Lead Released		lbs/MWh		
	Dioxins Released		lbs/MWh		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Photovoltaic (on-site system)	Energy Used	37922.22222	Mbtu/MWh	Incoming radiation required to produce 1 MWh of electricity. Based on solar radiation and generated electricity from PVWATTS plus average of 12 watts per square foot of typical multicrystalline solar modules. Assumes AC electricity is generated.	
	Electricity Used	1	MWh/MWh	One to one conversion.	
	All Water Used		gal x 1000/MWh		
	Potable Water Used		gal x 1000/MWh		
	Groundwater Extracted		gal x 1000/MWh		
	CO2e Emitted		lbs/MWh		
	NO x Emitted		lbs/MWh		
	SO x Emitted		lbs/MWh		
	PM Emitted		lbs/MWh		
	Solid Waste Generated		tons/MWh		
	Haz. Waste Generated		tons/MWh		
	Air Toxics Emitted		lbs/MWh		
	Mercury Released		lbs/MWh		
	Lead Released		lbs/MWh		
Dioxins Released		lbs/MWh			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Energy 2	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO ₂ e Emitted		lbs/TBD		
	NO _x Emitted		lbs/TBD		
	SO _x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Energy 3	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Groundwater Extracted On-site	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Potable Water Used		gal x 1000/gal x 1000		
	Groundwater Extracted	1	gal x 1000/gal x 1000	One to one conversion.	
	CO2e Emitted		lbs/gal x 1000		
	NO x Emitted		lbs/gal x 1000		
	SO x Emitted		lbs/gal x 1000		
	PM Emitted		lbs/gal x 1000		
	Solid Waste Generated		tons/gal x 1000		
	Haz. Waste Generated		tons/gal x 1000		
	Air Toxic Emitted		lbs/gal x 1000		
	Mercury Released		lbs/gal x 1000		
	Lead Released		lbs/gal x 1000		
Dioxins Released		lbs/gal x 1000			

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Potable Water Used On-site	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Potable Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Groundwater Extracted		gal x 1000/gal x 1000		
	CO2e Emitted		lbs/gal x 1000		
	NO x Emitted		lbs/gal x 1000		
	SO x Emitted		lbs/gal x 1000		
	PM Emitted		lbs/gal x 1000		
	Solid Waste Generated		tons/gal x 1000		
	Haz. Waste Generated		tons/gal x 1000		
	Air Toxics Emitted		lbs/gal x 1000		
	Mercury Released		lbs/gal x 1000		
	Lead Released		lbs/gal x 1000		
Dioxins Released		lbs/gal x 1000			

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other On-Site Water 1	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Potable Water Used		gal x 1000/gal x 1000		
	Groundwater Extracted		gal x 1000/gal x 1000		
	CO2e Emitted		lbs/gal x 1000		
	NO x Emitted		lbs/gal x 1000		
	SO x Emitted		lbs/gal x 1000		
	PM Emitted		lbs/gal x 1000		
	Solid Waste Generated		tons/gal x 1000		
	Haz. Waste Generated		tons/gal x 1000		
	Air Toxics Emitted		lbs/gal x 1000		
	Mercury Released		lbs/gal x 1000		
	Lead Released		lbs/gal x 1000		
	Dioxins Released		lbs/gal x 1000		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other On-Site Water 2	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Potable Water Used		gal x 1000/gal x 1000		
	Groundwater Extracted		gal x 1000/gal x 1000		
	CO2e Emitted		lbs/gal x 1000		
	NO x Emitted		lbs/gal x 1000		
	SO x Emitted		lbs/gal x 1000		
	PM Emitted		lbs/gal x 1000		
	Solid Waste Generated		tons/gal x 1000		
	Haz. Waste Generated		tons/gal x 1000		
	Air Toxics Emitted		lbs/gal x 1000		
	Mercury Released		lbs/gal x 1000		
	Lead Released		lbs/gal x 1000		
	Dioxins Released		lbs/gal x 1000		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other On-Site Water 3	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used	1	gal x 1000/gal x 1000	One to one conversion.	
	Potable Water Used		gal x 1000/gal x 1000		
	Groundwater Extracted		gal x 1000/gal x 1000		
	CO2e Emitted		lbs/gal x 1000		
	NO x Emitted		lbs/gal x 1000		
	SO x Emitted		lbs/gal x 1000		
	PM Emitted		lbs/gal x 1000		
	Solid Waste Generated		tons/gal x 1000		
	Haz. Waste Generated		tons/gal x 1000		
	Air Toxics Emitted		lbs/gal x 1000		
	Mercury Released		lbs/gal x 1000		
	Lead Released		lbs/gal x 1000		
Dioxins Released		lbs/gal x 1000			

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-Site Solid Waste Generation	Energy Used		Mbtu/ton		
	Electricity Used		MWh/ton		
	All Water Used		gal x 1000/ton		
	Potable Water Used		gal x 1000/ton		
	Groundwater Extracted		gal x 1000/ton		
	CO2e Emitted		lbs/ton		
	NO x Emitted		lbs/ton		
	SO x Emitted		lbs/ton		
	PM Emitted		lbs/ton		
	Solid Waste Generated	1	tons/ton	One to one conversion.	
	Haz. Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
	Dioxins Released		lbs/ton		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-Site Solid Waste Disposal	Energy Used		Mbtu/ton		
	Electricity Used		MWh/ton		
	All Water Used		gal x 1000/ton		
	Potable Water Used		gal x 1000/ton		
	Groundwater Extracted		gal x 1000/ton		
	CO2e Emitted		lbs/ton		
	NO x Emitted		lbs/ton		
	SO x Emitted		lbs/ton		
	PM Emitted		lbs/ton		
	Solid Waste Generated		tons/ton		
	Haz. Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
	Dioxins Released		lbs/ton		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-Site Hazardous Waste Generation	Energy Used		Mbtu/ton		
	Electricity Used		MWh/ton		
	All Water Used		gal x 1000/ton		
	Potable Water Used		gal x 1000/ton		
	Groundwater Extracted		gal x 1000/ton		
	CO2e Emitted		lbs/ton		
	NO x Emitted		lbs/ton		
	SO x Emitted		lbs/ton		
	PM Emitted		lbs/ton		
	Solid Waste Generated		tons/ton		
	Haz. Waste Generated	1	tons/ton	One to one conversion.	
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
	Dioxins Released		lbs/ton		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-Site Hazardous Waste Disposal	Energy Used		Mbtu/ton		
	Electricity Used		MWh/ton		
	All Water Used		gal x 1000/ton		
	Potable Water Used		gal x 1000/ton		
	Groundwater Extracted		gal x 1000/ton		
	CO ₂ e Emitted		lbs/ton		
	NO _x Emitted		lbs/ton		
	SO _x Emitted		lbs/ton		
	PM Emitted		lbs/ton		
	Solid Waste Generated		tons/ton		
	Haz. Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
	Dioxins Released		lbs/ton		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site process emissions (HAPs)	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted	1	lbs/lbs	One to one conversion.	
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site process emissions (GHGs)	Energy Used		Mbtu/lbs CO2e		
	Electricity Used		MWh/lbs CO2e		
	All Water Used		gal x 1000/lbs CO2e		
	Potable Water Used		gal x 1000/lbs CO2e		
	Groundwater Extracted		gal x 1000/lbs CO2e		
	CO2e Emitted	1	lbs/lbs CO2e	One to one conversion.	
	NO x Emitted		lbs/lbs CO2e		
	SO x Emitted		lbs/lbs CO2e		
	PM Emitted		lbs/lbs CO2e		
	Solid Waste Generated		tons/lbs CO2e		
	Haz. Waste Generated		tons/lbs CO2e		
	Air Toxics Emitted		lbs/lbs CO2e		
	Mercury Released		lbs/lbs CO2e		
	Lead Released		lbs/lbs CO2e		
	Dioxins Released		lbs/lbs CO2e		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site GHG storage	Energy Used		Mbtu/lbs CO2e		
	Electricity Used		MWh/lbs CO2e		
	All Water Used		gal x 1000/lbs CO2e		
	Potable Water Used		gal x 1000/lbs CO2e		
	Groundwater Extracted		gal x 1000/lbs CO2e		
	CO2e Emitted	-1	lbs/lbs CO2e	One to one conversion.	
	NO x Emitted		lbs/lbs CO2e		
	SO x Emitted		lbs/lbs CO2e		
	PM Emitted		lbs/lbs CO2e		
	Solid Waste Generated		tons/lbs CO2e		
	Haz. Waste Generated		tons/lbs CO2e		
	Air Toxics Emitted		lbs/lbs CO2e		
	Mercury Released		lbs/lbs CO2e		
	Lead Released		lbs/lbs CO2e		
	Dioxins Released		lbs/lbs CO2e		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site NOx reduction	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted	-1	lbs/lbs	One to one conversion.	
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site SOx reduction	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted	-1	lbs/lbs	One to one conversion.	
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
On-site PM reduction	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted	-1	lbs/lbs	One to one conversion.	
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 4	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 5	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity production	Energy Used	7800	Mbtu/MWh	Calculated using information from the cited reference. See attached support file titled "Electricity and Energy Used for the Production, Transmission, and On-Site Use of Electricity" for calculations.	U.S. Dept. of Energy GridWorks: Overview of the Electric Grid http://sites.energetics.com/gridworks/grid.html
	Electricity Used	0.06	MWh/MWh	Calculated using information from the cited reference. See attached support file titled "Electricity and Energy Used for the Production, Transmission, and On-Site Use of Electricity" for calculations.	Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905
	All Water Used	2	gal x 1000/MWh	Default water usage is for U.S. average directly from Consumptive Water Use for U.S. Power Production. Actual water usage based on the specific fuel blend (see attached support file titled "Power Sources and Global Emissions Factors for Electricity Provided by PG&E" for calculations). Actual water usage includes estimate from Gleick for obtaining and processing fuel resources and consumptive use for thermoelectric and hydroelectric in California from Consumptive Water Use for U.S. Power Production. Default water usage does not include water use for obtaining and processing fuel for electricity generation.	Gleick PH. Water and energy. Annu. Rev. Energy Environ. Vol 19, 1994. p 267-99. Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905
	Potable Water Used		gal x 1000/MWh	potable water not delineated separately from "all water use"	
	Groundwater Extracted		gal x 1000/MWh	groundwater not delineated separately from "all water use"	
	CO2e Emitted	1540	lbs/MWh	Default for CO2e, NOx, and SOx obtained from EGRID 2007 v1.1 for average United States values. All results for actual values are multiplied by 1.12 to account for additional electricity generated to offset transmission losses (1.12 = 1 MWh + 0.12 MWh for transmission losses, see above). Default values DO NOT include resource extraction and transportation.	EGRID 2007 v1.1 U.S. EPA
	NO x Emitted	3.9	lbs/MWh		
	SO x Emitted	10	lbs/MWh		
	PM Emitted	0.94	lbs/MWh		
	Solid Waste Generated	0.0009	tons/MWh	EUROPA ELCD - Sum of all listed wastes (demolition debris) except for radioactive wastes, slag, and mining wastes, which would likely not be disposed of in a landfill.	EUROPA file location: Process data set: Electricity Mix; AC; consumption mix, at consumer; < 1kV (en) http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/001b3cb7-b868-4061-8a91-3e6d7bcc90c6_02.00.000.html
	Haz. Waste Generated	0	tons/MWh	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product. No hazardous waste is listed in EUROPA for diesel production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.4	lbs/MWh	For all parameters, used output values from NREL for electricity production from natural gas, bituminous coal, and nuclear. For natural gas and bituminous coal, accounted only for direct combustion for energy production and did not account for resource extraction as it is anticipated to be negligible. For nuclear, accounted for major components of processing uranium (electricity, coal in industrial boiler, natural gas in industrial boiler, and diesel in industrial boiler). For electricity in uranium processing, assumed a 50/50 blend of bituminous coal and natural gas (excluded resource extraction). For default values, applied output to an electricity generation blend of 54% bitum. coal, 17% natural gas, 21% nuclear, and 8% hydro, which approximates the NREL blend for US electricity generation. NREL output is for electricity at the power plant. All results are multiplied by 1.12 to account for additional electricity generated to offset transmission losses (1.12 = 1 MWh + 0.12 MWh for transmission losses, see above).	Primary NREL LCI Files: - SS_Electricity, natural gas, at power plant.xls - SS_Electricity, nuclear, at power plant.xls - SS_Electricity, bituminous coal, at power plant.xls Secondary NREL LCI files: - SS_Fuel grade uranium, at regional storage.xls - SS_Bituminous coal, combusted in industrial boiler.xls - SS_Natural gas, combusted in industrial boiler.xls - SS_Diesel, combusted in industrial boiler.xls
	Mercury Released	0.000023	lbs/MWh		
	Lead Released	0.00017	lbs/MWh		
Dioxins Released	2.4E-10	lbs/MWh			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Diesel (off-site use)	Energy Used	139	Mbtu/gal	The reference provides the higher heating value of diesel as 5.825 MMBTU per barrel and defines a barrel as 42 gallons. This converts to approximately 139 Mbtu/gallon.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/gal		
	All Water Used		gal x 1000/gal		
	Potable Water Used		gal x 1000/gal		
	Groundwater Extracted		gal x 1000/gal		
	CO2e Emitted	22.5	lbs/gal	The reference provides CO2e emitted as 10.15 kg of CO2 per gallon. This converts to 22.3 pounds per gallon. Additionally, N2O and CH4 emissions are provided as g/gal. Values are converted to lbs/gal using a global warming potential (GWP) of 1 for carbon dioxide, 21 for methane, and 310 for nitrous oxide.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	NO x Emitted	0.17	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (nitrogen oxides) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	SO x Emitted	0.0054	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (sulfur oxides) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	PM Emitted	0.0034	lbs/gal	NREL LCI reported the amount of diesel in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (Particulates, > 2.5 um, and < 10um) generated from transporting 1 tkm was divided by the amount of diesel required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, diesel powered.xls
	Solid Waste Generated		tons/gal	not applicable -- no waste generated when diesel is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Haz. Waste Generated		tons/gal	not applicable -- no waste generated when diesel is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Air Toxics Emitted	0.0000052	lbs/gal	Not available in NREL LCI transport files. Summed hazardous air pollutants emitted from combusting diesel in industrial equipment. NREL LCI provides results in kg per L combusted. Converted this to pounds per gallon by multiplying by 3.785 and multiplying by .22	NREL LCI File: SS_diesel combusted in industrial equipment.xls
	Mercury Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of mercury.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml
	Lead Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of lead	
Dioxins Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of dioxins.		

EUROPA ECLD refers to the European Reference Life Cycle Database (ELCD core database), version II compiled under contract on behalf of the European Commission - DG Joint Research Centre - Institute for Environment and Sustainability with technical and scientific support by JRC-IES from early 2008 to early 2009.
(<http://lca.jrc.ec.europa.eu/lcaifohub/datasetArea.vm>)

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Gasoline (off-site use)	Energy Used	124	Mbtu/gal	The reference provides the higher heating value of gasoline as 5.218 MMBTU per barrel and defines a barrel as 42 gallons. This converts to approximately 124 Mbtu/gallon.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/gal	not applicable -- no electricity used when gasoline is combusted on-site or in transportation	
	All Water Used		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	Potable Water Used		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	Groundwater Extracted		gal x 1000/gal	not applicable -- no water used when gasoline is combusted on-site or in transportation	
	CO2e Emitted	19.6	lbs/gal	The reference provides CO2e emitted as 8.81 kg of CO2 per gallon. This converts to 19.4 pounds per gallon. Additionally, N2O and CH4 emissions are provided as g/gal. Values are converted to lbs/gal using a global warming potential (GWP) of 1 for carbon dioxide, 21 for methane, and 310 for nitrous oxide.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	NO x Emitted	0.11	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (nitrogen oxides) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	SO x Emitted	0.0045	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (sulfur oxides) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	PM Emitted	0.00054	lbs/gal	NREL LCI reported the amount of gasoline in liters required to transport one ton-kilometer (tkm) and provided outputs to nature in kg. The output (Particulates, > 2.5 um, and < 10um) generated from transporting 1 tkm was divided by the amount of gasoline required to transport 1 tkm, and the units of the result were converted from kg/L to lbs/gallon.	NREL LCI File: SS_Transport, single unit truck, gasoline powered.xls
	Solid Waste Generated		tons/gal	not applicable -- no waste generated when gasoline is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Haz. Waste Generated		tons/gal	not applicable -- no waste generated when gasoline is combusted on-site or in transportation (solid waste and waste oil from maintenance would be tracked separately)	
	Air Toxics Emitted	0.000039	lbs/gal	Not available in NREL LCI transport files. Summed hazardous air pollutants emitted from combusting gasoline in industrial equipment. NREL LCI provides results in kg per L combusted. Converted this to pounds per gallon by multiplying by 3.785 and multiplying by .2.2	NREL LCI File: SS_gasoline combusted in industrial equipment.xls
	Mercury Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of mercury.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): http://ca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml
	Lead Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of lead	
Dioxins Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of dioxins.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Natural gas (off-site use)	Energy Used	103	Mbtu/ccf	The reference provides the higher heating value of natural gas as 1,027 BTU per scf. This converts to approximately 103 Mbtu/ccf.	Climate Leader GHG Inventory EPA-430--K-08-004, May 2008
	Electricity Used		MWh/ccf	not applicable -- no electricity used when nat gas is combusted on-site or in transportation	
	All Water Used		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	Potable Water Used		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	Groundwater Extracted		gal x 1000/ccf	not applicable -- no water used when nat gas is combusted on-site or in transportation	
	CO2e Emitted	12.2	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits. Outputs for carbon dioxide and fossil methane were used to calculate CO2e. Nitrous oxide was not included as an output. Methane was assigned a global warming potential equal to 21 times that of CO2.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	NO x Emitted	0.01	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	SO x Emitted	0.0000063	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	PM Emitted	0.00076	lbs/ccf	NREL LCI reported output in kg and input in m3. The units were converted from kg/m3 to lbs per 100 cubic feet (ccf) and rounded to two significant digits.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Solid Waste Generated		tons/ccf	not applicable -- no solid waste generated when natural gas is combusted on-site or in transportation	
	Haz. Waste Generated		tons/ccf	not applicable -- no haz waste generated when natural gas is combusted on-site or in transportation	
	Air Toxics Emitted	0.0000084	lbs/ccf	NREL - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere converted from kg/m3 to lb/ccf. Note that the value for combustion in equipment is significantly lower than the value reported here for use in an industrial boiler.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Mercury Released	0.00000026	lbs/ccf	NREL - Mercury released converted from kg/m3 to lb/ccf. Note that according to NREL there is no mercury released for natural gas combusted in industrial equipment.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Lead Released	0.00000005	lbs/ccf	NREL - Lead released converted from kg/m3 to lb/ccf. Note that according to NREL there is no lead released for natural gas combusted in industrial equipment.	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls
	Dioxins Released	0	lbs/ccf	NREL does not indicate the formation of dioxins during natural gas combustion	NREL LCI File: SS_Natural gas, combusted in industrial boiler.xls

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Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Potable Water Transported	Energy Used	7.4	Mbtu/gal x 1000	Calculated based on electricity used. Accounts for 10% energy loss through electricity transmission losses and a thermal efficiency of 33%.	
	Electricity Used	0.000645995	MWh/gal x 1000	Electricity usage calculated assuming water is distributed from the source at 50 psi by a 75% efficient pump with a 75% efficient motor. Some head loss will be realized during pipe flow such that the site will receive water at a lower pressure, but the 50 psi represents the energy that is needed at the treatment plant to distribute the water through the distribution network. All other environmental parameters are calculated from this calculated electricity usage using site-specific conversion factors for electricity.	
	All Water Used	0.00129199	gal x 1000/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Potable Water Used		gal x 1000/gal x 1000	not applicable -- no potable water used when potable water is being transported (assumes no leakage water distribution system).	
	Groundwater Extracted		gal x 1000/gal x 1000	not applicable -- no on-site ground water used when potable water is being transported.	
	CO2e Emitted	0.994832041	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	NO x Emitted	0.00251938	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	SO x Emitted	0.006459948	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	PM Emitted	0.000607235	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Solid Waste Generated	5.81395E-07	tons/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Haz. Waste Generated	0	tons/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Air Toxics Emitted	0.000258398	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Mercury Released	1.48579E-08	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Lead Released	1.09819E-07	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Dioxins Released	1.55039E-13	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity transmission	Energy Used	410	Mbtu/MWh	Calculated using information from the cited reference. See attached support file titled "Electricity and Energy Used for the Production, Transmission, and On-Site Use of Electricity" for calculations.	<p align="center">U.S. Dept. of Energy GridWorks: Overview of the Electric Grid http://sites.energetics.com/gridworks/grid.html Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905</p> <p>Note relevant to all the entries for "electricity transmitted": "electricity transmitted" refers to the flow of electricity through the lines, which would have 0 emissions and resource use. Another aspect of electrical transmissions would be installation and maintenance of electrical transmission lines. This would result in emissions and resource use, but they would be very small when allocated per kWh transmitted. It would also be similar in concept to installation and maintenance of roadways for truck transportation, which we also do not account for in this analysis.</p>
	Electricity Used	0.12	MWh/MWh	Calculated using information from the cited reference. See attached support file titled "Electricity and Energy Used for the Production, Transmission, and On-Site Use of Electricity" for calculations.	
	All Water Used	0.24	gal x 1000/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Potable Water Used		gal x 1000/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Groundwater Extracted		gal x 1000/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	CO2e Emitted	184.8	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	NO x Emitted	0.468	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	SO x Emitted	1.2	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	PM Emitted	0.1128	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Solid Waste Generated	0.000108	tons/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Haz. Waste Generated	0	tons/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Air Toxics Emitted	0.048	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Mercury Released	0.0000276	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Lead Released	0.0000204	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Dioxins Released	2.88E-11	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Transportation 1	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO ₂ e Emitted		lbs/TBD		
	NO _x Emitted		lbs/TBD		
	SO _x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Transportation 2	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Transportation 3	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Asphalt	Energy Used		Mbtu/tons		
	Electricity Used		MWh/tons		
	All Water Used		gal x 1000/tons		
	Potable Water Used		gal x 1000/tons		
	Groundwater Extracted		gal x 1000/tons		
	CO2e Emitted		lbs/tons		
	NO x Emitted		lbs/tons		
	SO x Emitted		lbs/tons		
	PM Emitted		lbs/tons		
	Solid Waste Generated		tons/tons		
	Haz. Waste Generated		tons/tons		
	Air Toxics Emitted		lbs/tons		
	Mercury Released		lbs/tons		
	Lead Released		lbs/tons		
	Dioxins Released		lbs/tons		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Bentonite	Energy Used	55	Mbtu/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Electricity Used	0.0027	MWh/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	All Water Used	0.13	gal x 1000/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Potable Water Used		gal x 1000/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Groundwater Extracted		gal x 1000/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	CO2e Emitted	6.7	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	NO x Emitted	0.033	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	SO x Emitted	0.03	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	PM Emitted	0.004	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Solid Waste Generated	0	tons/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Haz. Waste Generated	0	tons/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Air Toxics Emitted	0.00000041	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Mercury Released	6.4E-11	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
	Lead Released	1.2E-09	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".	
Dioxins Released	1.5E-16	lbs/tons	Absent other information, gravel and sand used as a surrogate material. See notes for "gravel and sand".		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Borrow (clean soil)	Energy Used	15.75	Mbtu/tons	All parameters based on the use of 0.1 gallons of diesel per ton of soil provided, which is representative of excavating bulk soil with a hydraulic excavator and hauling bulk soil a short distance in a dump truck.	
	Electricity Used	0.000059	MWh/tons		
	All Water Used	0.000077	gal x 1000/tons		
	Potable Water Used		gal x 1000/tons		
	Groundwater Extracted		gal x 1000/tons		
	CO2e Emitted	2.52	lbs/tons		
	NO x Emitted	0.01764	lbs/tons		
	SO x Emitted	0.00184	lbs/tons		
	PM Emitted	0.000374	lbs/tons		
	Solid Waste Generated	0.000000036	tons/tons		
	Haz. Waste Generated	0	tons/tons		
	Air Toxics Emitted	0.00001252	lbs/tons		
	Mercury Released	4.8E-09	lbs/tons		
	Lead Released	0.00000015	lbs/tons		
	Dioxins Released	3E-15	lbs/tons		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Cement	Energy Used	4100	Mbtu/dry-ton	EUROPA ELCD - All forms of energy summed and converted to Mbtus per short ton of product.	<p align="center">Primary NREL LCI Files: -SS_portland cement, at plant.xls</p> <p align="center">EUROPA file location: Portland Cement: http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/600573dd-dfa5-44e5-b458-8727e793ffd7_02.00.000.html</p>
	Electricity Used	0.13	MWh/dry-ton	Not provided by EUROPA ELCD. NREL LCI includes electricity usage for portland cement. Electricity from portland cement, at plant (but none of the subcomponent files as they are assumed to be negligible) is included in this estimate.	
	All Water Used	0.41	gal x 1000/dry-ton	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per short ton of product.	
	Potable Water Used		gal x 1000/dry-ton	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/dry-ton	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	1800	lbs/dry-ton	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per short ton of product.	
	NO x Emitted	3.6	lbs/dry-ton	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per short ton of product.	
	SO x Emitted	2.1	lbs/dry-ton	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per short ton of product.	
	PM Emitted	0.0063	lbs/dry-ton	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per short ton of product.	
	Solid Waste Generated	0	tons/dry-ton	EUROPA ELCD - There is no indication of generated solid waste that would be disposed of at a landfill. Typical wastes indicated include radioactive wastes, mining wastes, and slag (expected to be used in some form elsewhere in industry).	
	Haz. Waste Generated	0	tons/dry-ton	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product. No hazardous waste is listed in EUROPA for gravel/sand, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.058	lbs/dry-ton	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported in pounds per short ton of product.	
	Mercury Released	0.000057	lbs/dry-ton	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported in pounds per short ton of product.	
	Lead Released	0.00013	lbs/dry-ton	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported in pounds per short ton of product.	
Dioxins Released	8.5E-11	lbs/dry-ton	EUROPA ELCD - Sum of all dioxins released to air or water. Reported in pounds per short ton of product.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Cheese Whey	Energy Used	1.87	Mbtu/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	<p>- Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk</p> <p>Andersen M and Jensen JD (2003). Marginale producenter af udvalgte basislevnedsmidler (in Danish) Udkast d. 5. februar 2003</p>
	Electricity Used	0	MWh/lbs	None indicated.	
	All Water Used	0	gal x 1000/lbs	None indicated.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	1.1	lbs/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	
	NO x Emitted	0.0083	lbs/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	
	SO x Emitted	0.0099	lbs/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	
	PM Emitted	0.000166	lbs/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	
	Solid Waste Generated	0	tons/lbs	Not available	
	Haz. Waste Generated	0	tons/lbs	Not available	
	Air Toxics Emitted	0	lbs/lbs	Not available	
	Mercury Released	0	lbs/lbs	Not available	
	Lead Released	0	lbs/lbs	Not available	
	Dioxins Released	0	lbs/lbs	Not available	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Concrete	Energy Used	3020	Mbtu/tons	Energy and all parameters calculated using values for potable water, sand/gravel, and cement grout assuming a 0.45:1:4 ratio by weight (typical). A quantity of 0.02 gals x 1000 is also added to "all water" to account for the 8.25% of the concrete mass that is water.	
	Electricity Used	0.096	MWh/tons		
	All Water Used	0.33	gal x 1000/tons		
	Potable Water Used		gal x 1000/tons		
	Groundwater Extracted		gal x 1000/tons		
	CO2e Emitted	1322	lbs/tons		
	NO x Emitted	2.6	lbs/tons		
	SO x Emitted	1.5	lbs/tons		
	PM Emitted	0.0057	lbs/tons		
	Solid Waste Generated	0.000000028	tons/tons		
	Haz. Waste Generated	0	tons/tons		
	Air Toxics Emitted	0.043	lbs/tons		
	Mercury Released	0.000042	lbs/tons		
	Lead Released	0.000095	lbs/tons		
Dioxins Released	6.2E-11	lbs/tons			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Diesel Produced	Energy Used	18.5	Mbtu/gal	EUROPA ELCD - All forms of energy summed and converted to Mbtus per gallon of product.	<p align="center"> Primary NREL LCI File: -SS_crude oil, in refinery.xls Secondary NREL LCI File: -SS_crude oil, at production.xls EUROPA file location: Diesel at refinery: http://ca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/244524ed-7b85-4548-b345-f58dc5cf9dac_02.00.000.html </p>
	Electricity Used	0.00059	MWh/gal	Not provided by EUROPA ELCD. NREL LCI includes electricity usage for crude oil, in refinery with an allocation to diesel. Electricity from crude oil, in refinery (allocated to diesel) and crude oil, at production are included.	
	All Water Used	0.00077	gal x 1000/gal	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per gallon of product	
	Potable Water Used		gal x 1000/gal	Not applicable -- no local potable water used during diesel production.	
	Groundwater Extracted		gal x 1000/gal	Not applicable -- no local or on-site ground water extracted during diesel production.	
	CO2e Emitted	2.7	lbs/gal	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per gallon of product.	
	NO x Emitted	0.0064	lbs/gal	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per gallon of product.	
	SO x Emitted	0.013	lbs/gal	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per gallon of product.	
	PM Emitted	0.00034	lbs/gal	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per gallon of product.	
	Solid Waste Generated	0.00000036	tons/gal	EUROPA ELCD - Sum of all listed wastes (demolition debris) except for radioactive wastes, slag, and mining wastes, which would likely not be disposed of in a landfill.	
	Haz. Waste Generated	0	tons/gal	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product. No hazardous waste is listed in EUROPA for diesel production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.00012	lbs/gal	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per gallon of product.	
	Mercury Released	0.000000048	lbs/gal	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported as pounds per gallon of product.	
	Lead Released	0.0000015	lbs/gal	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported as pounds per gallon of product.	
Dioxins Released	3E-14	lbs/gal	EUROPA ELCD - Sum of all dioxins released to air or water. Reported as pounds per gallon of product.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Emulsified vegetable oil	Energy Used	3.6	Mbtu/lbs	See attached support file titled "Derivation of Vegetable Oil Values from LCA Food"	<p>Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk</p> <p>Landbrugets rådgivningscenter (2000). Tal fra Fodermiddeltabellen, Raport nr. 91. In Danish.</p> <p>Weidema BP (1999). System expansions to handle co-products of renewable materials. Presentation Summaries of the 7th LCA Case Studies Symposium SETAC-Europe, 1999. Pp. 45-48. pdf.</p> <p>Weidema B (2003). Market information in life cycle assessments. Technical report, Danish Environmental Protection Agency (Environmental Project no. 863).</p>
	Electricity Used	0.000055	MWh/lbs	See attached support file titled "Derivation of Vegetable Oil Values from LCA Food"	
	All Water Used	0.000024	gal x 1000/lbs	See attached support file titled "Derivation of Vegetable Oil Values from LCA Food"	
	Potable Water Used		gal x 1000/lbs	Not used. -- no local potable water used during soybean oil production.	
	Groundwater Extracted		gal x 1000/lbs	Not used. -- no local or on-site ground water extracted during soybean oil production.	
	CO2e Emitted	3.51	lbs/lbs	See attached support file titled "Derivation of Vegetable Oil Values from LCA Food"	
	NO x Emitted	0.0265	lbs/lbs		
	SO x Emitted	0.031	lbs/lbs		
	PM Emitted	0.0017	lbs/lbs		
	Solid Waste Generated	0	tons/lbs	Not available	
	Haz. Waste Generated	0	tons/lbs	Not available	
	Air Toxics Emitted	0	lbs/lbs	Not available	
	Mercury Released	0	lbs/lbs	Not available	
	Lead Released	0	lbs/lbs	Not available	
Dioxins Released	0	lbs/lbs	Not available		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
GAC: regenerated	Energy Used	9.6	Mbtu/lbs	Calculated using information from the cited reference. See support file for calculations.	Use of Adsorbents for the Removal of Pollutants from Wastewaters, by Gordon McKay, published by CRC Press, 1995, ISBN 0849369207
	Electricity Used	0.00044	MWh/lbs	Calculated using information from the cited reference. See support file for calculations.	
	All Water Used	0.0064	gal x 1000/lbs	Calculated using information from the cited reference. See support file for calculations.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	2	lbs/lbs	Calculated using information from the cited reference. See support file for calculations.	
	NO x Emitted	0.025	lbs/lbs		
	SO x Emitted	0.015	lbs/lbs		
	PM Emitted	0	lbs/lbs	Not calculated	
	Solid Waste Generated	0	tons/lbs	Information not available. To be added when additional information becomes available.	
	Haz. Waste Generated	0	tons/lbs	Information not available. To be added when additional information becomes available.	
	Air Toxics Emitted	0	lbs/lbs	Information not available. To be added when additional information becomes available.	
	Mercury Released	0	lbs/lbs	Information not available. To be added when additional information becomes available.	
	Lead Released	0	lbs/lbs	Information not available. To be added when additional information becomes available.	
Dioxins Released	0	lbs/lbs	Information not available. To be added when additional information becomes available.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
GAC: virgin coal-based	Energy Used	10.8	Mbtu/lbs	Calculated using information from the cited reference. See support file for calculations.	Use of Adsorbents for the Removal of Pollutants from Wastewaters, by Gordon McKay, published by CRC Press, 1995, ISBN 0849369207
	Electricity Used	0.000045	MWh/lbs	Calculated using information from the cited reference. See support file for calculations.	
	All Water Used		gal x 1000/lbs	Calculated using information from the cited reference. See support file for calculations.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	4.5	lbs/lbs	Calculated using information from the cited reference. See support file for calculations.	
	NO x Emitted	0.12	lbs/lbs		
	SO x Emitted	0.074	lbs/lbs		
	PM Emitted		lbs/lbs	Not calculated	
	Solid Waste Generated		tons/lbs	Information not available. To be added when additional information becomes available.	
	Haz. Waste Generated		tons/lbs	Information not available. To be added when additional information becomes available.	
	Air Toxics Emitted		lbs/lbs	Information not available. To be added when additional information becomes available.	
	Mercury Released		lbs/lbs	Information not available. To be added when additional information becomes available.	
	Lead Released		lbs/lbs	Information not available. To be added when additional information becomes available.	
Dioxins Released		lbs/lbs	Information not available. To be added when additional information becomes available.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
GAC: virgin coconut-based	Energy Used		Mbtu/lbs	Calculated using information from the cited reference. See support file for calculations.	Use of Adsorbents for the Removal of Pollutants from Wastewaters, by Gordon McKay, published by CRC Press, 1995, ISBN 0849369207
	Electricity Used		MWh/lbs	Calculated using information from the cited reference. See support file for calculations.	
	All Water Used		gal x 1000/lbs	Calculated using information from the cited reference. See support file for calculations.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted		lbs/lbs	Calculated using information from the cited reference. See support file for calculations.	
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs	Not calculated	
	Solid Waste Generated		tons/lbs	Information not available. To be added when additional information becomes available.	
	Haz. Waste Generated		tons/lbs	Information not available. To be added when additional information becomes available.	
	Air Toxics Emitted		lbs/lbs	Information not available. To be added when additional information becomes available.	
	Mercury Released		lbs/lbs	Information not available. To be added when additional information becomes available.	
	Lead Released		lbs/lbs	Information not available. To be added when additional information becomes available.	
Dioxins Released		lbs/lbs	Information not available. To be added when additional information becomes available.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Gasoline Produced	Energy Used	21	Mbtu/gal	EUROPA ELCD - All forms of energy summed and converted to Mbtus per gallon of product.	<p align="center"> Primary NREL LCI File: -SS_crude oil, in refinery.xls Secondary NREL LCI File: -SS_crude oil, at production.xls EUROPA file location: Gasoline at refinery: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/5f62ed77-85d0-4c99-8d2c-be56951d8fb3_02.00.000.html </p>
	Electricity Used	0.00059	MWh/gal	Not provided by EUROPA ELCD. NREL LCI includes electricity usage for crude oil, in refinery with an allocation to diesel. Electricity from crude oil, in refinery (allocated to diesel) and crude oil, at production are included.	
	All Water Used	0.00079	gal x 1000/gal	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per gallon of product	
	Potable Water Used		gal x 1000/gal	Not applicable -- no local potable water used during gasoline production.	
	Groundwater Extracted		gal x 1000/gal	Not applicable -- no local or on-site ground water extracted during gasoline production.	
	CO2e Emitted	4.4	lbs/gal	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per gallon of product.	
	NO x Emitted	0.008	lbs/gal	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per gallon of product.	
	SO x Emitted	0.019	lbs/gal	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per gallon of product.	
	PM Emitted	0.00052	lbs/gal	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per gallon of product.	
	Solid Waste Generated	0.00000042	tons/gal	EUROPA ELCD - Sum of all listed wastes (demolition debris) except for radioactive wastes, slag, and mining wastes, which would likely not be disposed of in a landfill.	
	Haz. Waste Generated	0	tons/gal	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product. No hazardous waste is listed in EUROPA for diesel production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.00016	lbs/gal	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per gallon of product.	
	Mercury Released	0.000000085	lbs/gal	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported as pounds per gallon of product.	
	Lead Released	0.0000022	lbs/gal	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported as pounds per gallon of product.	
	Dioxins Released	3.1E-14	lbs/gal	EUROPA ELCD - Sum of all dioxins released to air or water. Reported as pounds per gallon of product.	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Gravel/sand/clay	Energy Used	55	Mbtu/ton	EUROPA ELCD - All forms of energy summed and converted to Mbtus per short ton of product.	EUROPA file Location: Gravel 2/32: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/898618b2-3306-11dd-bd11-0800200c9a66_02.00.000.html
	Electricity Used	0.0027	MWh/ton	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.13	gal x 1000/ton	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per short ton of product.	
	Potable Water Used		gal x 1000/ton	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/ton	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	6.7	lbs/ton	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per short ton of product.	
	NO x Emitted	0.033	lbs/ton	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per short ton of product.	
	SO x Emitted	0.03	lbs/ton	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per short ton of product.	
	PM Emitted	0.004	lbs/ton	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per short ton of product.	
	Solid Waste Generated	0	tons/ton	EUROPA ELCD - There is no indication of generated solid waste that would be disposed of at a landfill. Typical wastes indicated include radioactive wastes, mining wastes, and slag (expected to be used in some form elsewhere in industry).	
	Haz. Waste Generated	0	tons/ton	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product. No hazardous waste is listed in EUROPA for gravel/sand, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.00000041	lbs/ton	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported in pounds per short ton of product.	
	Mercury Released	6.4E-11	lbs/ton	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported in pounds per short ton of product.	
	Lead Released	1.2E-09	lbs/ton	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported in pounds per short ton of product.	
Dioxins Released	1.5E-16	lbs/ton	EUROPA ELCD - Sum of all dioxins released to air or water. Reported in pounds per short ton of product.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
HDPE	Energy Used	31	Mbtu/lb	EUROPA ELCD - All forms of energy summed and converted to Mbtus per pound of product.	EUROPA file location: Polyethylene high density granulate (PE-HD) ; production mix, at plant: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/0704c700-2fb0-43c5-8803-bed8a6f1b968_02.00.000.html
	Electricity Used	0.00025	MWh/lb	Not provided by EUROPA ELCD. NREL LCI includes electricity usage for HDPE manufacturing. Electricity from polyvinyl chloride resin, at plant file and the following major subcomponent files is included in this estimate: Ethylene dichloride-vinyl chloride monomer, at plant; Ethylene, at plant; Chlorine, PVC producer average, at plant; Oxygen, liquid, at plant.	
	All Water Used	0.0023	gal x 1000/lb	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per pound.	
	Potable Water Used		gal x 1000/lb	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lb	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	1.9	lbs/lb	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per pound of product.	
	NO x Emitted	0.0032	lbs/lb	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.0041	lbs/lb	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.00064	lbs/lb	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated	0.00000043	tons/lb	EUROPA ELCD - Sum of all wastes except for mine wastes and toxic chemical wastes.	
	Haz. Waste Generated	0.000001	tons/lb	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product.	
	Air Toxics Emitted	0.0000034	lbs/lb	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	2.6E-09	lbs/lb	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	2.4E-09	lbs/lb	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	9.8E-10	lbs/lb	EUROPA ELCD - Sum of all dioxins released to air or water.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Hydrochloric acid (30%, SG = 1.18)	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
Dioxins Released		lbs/lbs			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Hydrogen peroxide (50%, SG=1.19)	Energy Used	4.95	Mbtu/lbs	The value for energy is obtained from the provided reference, converted from MJ to Mbtus and multiplied by 50% to convert from a pure product to the 50% product indicated here.	<p align="center"> Ecoprofile of Hydrogen Peroxide CEFIC Peroxygens Sector Group European Chemical Industry Council http://www.cefic.be/sector/peroxy/ecohydro/tc.htm </p>
	Electricity Used	0.000597	MWh/lbs	The value for energy is obtained from the provided reference, converted from MJ to MWh and multiplied by 50% to convert from a pure product to the 50% product indicated here.	
	All Water Used	0.019	gal x 1000/lbs	The value for all water is obtained from the provided reference, converted from mg/kg to 1000 gallons per lb multiplied by 50% plus an additional lb of water per lb of product to account for the 50% solution used here. Process water and cooling water are used. Sea water is not used.	
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted	1.35	lbs/lbs	The value for CO2e emissions is obtained from the provided reference, converted from mg/kg to lbs/lb and multiplied by 50% to convert from a pure product to the 50% product indicated here. CO2 is given a global warming potential of 1 CO2e, methane is given a global warming potential of 21 CO2e, and nitrous oxide is given a global warming potential of 310 CO2e.	
	NO x Emitted	0.0087	lbs/lbs	The value for NOx emissions is obtained from the provided reference, converted from mg/kg to lbs/lb and multiplied by 50% to convert from a pure product to the 50% product indicated here.	
	SO x Emitted	0.0066	lbs/lbs	The value for SOx emissions is obtained from the provided reference, converted from mg/kg to lbs/lb and multiplied by 50% to convert from a pure product to the 50% product indicated here.	
	PM Emitted	0.0025	lbs/lbs	The value for PM emissions is obtained from the "dust" category in the provided reference, converted from mg/kg to lbs/lb and multiplied by 50% to convert from a pure product to the 50% product indicated here.	
	Solid Waste Generated	0.000013	tons/lbs	Solid waste values are obtained from the provided reference, converted from mg/kg to tons/lb and multiplied by 50% to convert from the pure product in the ecoprofile to the 50% solution used here. Mixed industrial, slags/ash, inert chemical, metals, and plastics are considered. Mineral (i.e., mining wastes), regulated waste, and incinerated waste are not considered.	
	Haz. Waste Generated	0.00000048	tons/lbs	Hazardous waste values are obtained from the provided reference, converted from mg/kg to tons/lb and multiplied by 50% to convert from the pure product in the ecoprofile to the 50% solution used here. Only regulated chemical waste is included.	
	Air Toxics Emitted	0.00023	lbs/lbs	The value for air toxics emissions is obtained from the provided reference, converted from mg/kg to lbs/lb and multiplied by 50% to convert from a pure product to the 50% product indicated here. All metals, H2S, HCl, chlorine, HF, metals, fluorine, organo-Cl, and aromatic HCs are considered air toxics.	
	Mercury Released		lbs/lbs	Not available	
	Lead Released		lbs/lbs	Not available	
	Dioxins Released		lbs/lbs	Not available	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Hydroseed	Energy Used	0.049	Mbtu/lbs	Assume content by weight as follows: - 90% water - 10% mulch - 0.3% nitrogen fertilizer - 0.5% seed Assume mulch is readily available wood waste product that is being recycled and has a negligible footprint. Assume water is obtained by pumping against a head of 50 psi with a 75% efficient pump and 75% efficient motor Assume seeds have a negligible footprint.	
	Electricity Used	1.46044E-07	MWh/lbs		
	All Water Used	0.00012	gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted	0.0046	lbs/lbs		
	NO x Emitted	0.0000027	lbs/lbs		
	SO x Emitted	0.000053	lbs/lbs		
	PM Emitted	0.00000028	lbs/lbs		
	Solid Waste Generated	0	tons/lbs		
	Haz. Waste Generated	0	tons/lbs		
	Air Toxics Emitted	0.00000081	lbs/lbs		
	Mercury Released	2E-11	lbs/lbs		
	Lead Released	1.29E-10	lbs/lbs		
Dioxins Released	0	lbs/lbs			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Lime	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Molasses	Energy Used	1.31	Mbtu/lbs	See attached support file titled "Derivation of Molasses Values from LCA Food"	<p align="center">Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk</p> <p align="center">Sugar Production based on Danisco Sugar Author: Per H. Nielsen July 2003</p>
	Electricity Used	0.000005	MWh/lbs	See attached support file titled "Derivation of Molasses Values from LCA Food"	
	All Water Used	0.000091	gal x 1000/lbs	See attached support file titled "Derivation of Molasses Values from LCA Food"	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	0.4	lbs/lbs	See attached support file titled "Derivation of Molasses Values from LCA Food"	
	NO x Emitted	0.003	lbs/lbs		
	SO x Emitted	0.0026	lbs/lbs		
	PM Emitted	0.00006	lbs/lbs		
	Solid Waste Generated	0	tons/lbs	Not available	
	Haz. Waste Generated	0	tons/lbs	Not available	
	Air Toxics Emitted	0	lbs/lbs	Not available	
	Mercury Released	0	lbs/lbs	Not available	
	Lead Released	0	lbs/lbs	Not available	
	Dioxins Released	0	lbs/lbs	Not available	

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Natural Gas Produced	Energy Used	5.2	Mbtu/ccf	EUROPA ELCD - All forms of energy summed and converted to Mbtus per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot (approximately 20 liters per mole of methane).	EUROPA file location: Natural Gas at consumer: http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/3d602e55-aaa2-44e3-adb9-40f49eb1a915_02.00.000.html
	Electricity Used	0.00025	MWh/ccf	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.000077	gal x 1000/ccf	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	Potable Water Used		gal x 1000/ccf	Not applicable -- no local potable water used during natural gas production.	
	Groundwater Extracted		gal x 1000/ccf	Not applicable -- no local or on-site ground water extracted during natural gas production.	
	CO2e Emitted	2.2	lbs/ccf	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	NO x Emitted	0.0037	lbs/ccf	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	SO x Emitted	0.0046	lbs/ccf	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	PM Emitted	0.000072	lbs/ccf	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	Solid Waste Generated	0	tons/ccf	EUROPA ELCD - There is no indication of generated solid waste that would be disposed of at a landfill. Typical wastes indicated include radioactive wastes, mining wastes, and slag (expected to be used in some form elsewhere in industry).	
	Haz. Waste Generated	0	tons/ccf	EUROPA ELCD - No hazardous waste is listed in EUROPA for natural gas production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.0000061	lbs/ccf	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	Mercury Released	0.000000021	lbs/ccf	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported as pounds per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
	Lead Released	0.0000009	lbs/ccf	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported as pounds per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.	
Dioxins Released	5.1E-14	lbs/ccf	EUROPA ELCD - Sum of all dioxins released to air or water. Reported as pounds per hundred cubic feet (ccf) of product, assuming 0.05 pounds per cubic foot.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Nitrogen fertilizer	Energy Used	16.6	Mbtu/lbs	NREL - Consistent with www.eia.gov calculators, coal assumed to have an energy content of 10,000 btu per pound, and natural gas is assumed to have an energy content of 1,000 btus. Electricity at the grid is assumed to be generated with 33% thermal efficiency and 10% loss from transmission.	<p align="center">Primary NREL LCI File: -SS_Nitrogen fertilizer, production mix, at plant.xls</p> <p align="center">All supporting files</p>
	Electricity Used	0.000023	MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted	1.5	lbs/lbs	NREL - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide.	
	NO x Emitted	0.00078	lbs/lbs	NREL - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.0174	lbs/lbs	NREL - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.000067	lbs/lbs	NREL - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted	0.00026	lbs/lbs	NREL - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	6.1E-09	lbs/lbs	NREL - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.000000038	lbs/lbs	NREL - Sum of all lead and lead compounds released to air or water.	
Dioxins Released		lbs/lbs			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Material #1 - PV System	Energy Used	33.6	Mbtu/W	Energy per rated W of multi-crystalline modules on page 50 (34 MJ/W = 32 Mbtu/W) plus the percentage of the energy for balance of system components, installation, and inverter associated with the multi-crystalline modules. Transportation is excluded because it is accounted for separately in this remediation footprint analysis. $10,560W / (10,560W + 17,952W + 4650W) = 32\%$ from page 21 for percentage associated with the multi-crystalline modules and 48,000 MJ for balance of system components, installation, and inverter from page 49 of reference. Electricity used is based on 85% of the total energy for module manufacturing due to electricity use (i.e., 85% of 32 Mbtu/W), page 12. Assume 33% thermal efficiency and 10% transmission loss for electricity.	Life-Cycle Assessment of the 33 kW Photovoltaic System on the Dana Building at the University of Michigan Thin Film Laminates, Multi-Crystalline Modules, and Balance of System Components Sergio Pacca, Deepak Sivaraman and Gregory A. Keoleian Center for Sustainable Systems, University of Michigan Report No. CSS05-09, June 1, 2006
	Electricity Used	0.000262994	MWh/W		
	All Water Used		gal x 1000/W	Not calculated	
	Potable Water Used		gal x 1000/W	Not calculated	
	Groundwater Extracted		gal x 1000/W	Not calculated	
	CO2e Emitted	4.47	lbs/W	Emissions of CO2e, NOx, SOx, PM, and hazardous pollutants per rated kW of module for the multi-crystalline modules on page 51 of reference plus the percentage of pollutant emissions for balance of system components, installation, and inverter associated with the multi-crystalline modules. Transportation is excluded because it is accounted for separately in this remediation footprint analysis. $10,560W / (10,560 + 17,952 + 4650) = 32\%$ from page 21 of reference document for percentage of system associated with multi-crystalline modules and the emissions on page 51 of reference for balance of system components (excluding transportation). Using NOx as an example on page 51: - Multi-crystalline panels (KC120) = 67.60 kg x 2.2 lbs/kg / 10,560 W = 0.014 lbs/W - BOS = 2.38 kg x 2.2 lbs/kg x 32% associated with multicrystalline modules / 10,560 W = 0.00016 lbs/W - Installation = 2.33 kg x 2.2 lbs/kg x 32% associated with multicrystalline modules / 10,560W = 0.0016 lbs/W - Inverter = 3.45 kg x 2.2 lbs/kg x 32% associated with multicrystalline modules / 10,560W = 0.00023 lbs/W Total = 0.015 lbs/W	
	NO x Emitted	0.015	lbs/W		
	SO x Emitted	0.032	lbs/W		
	PM Emitted	0.00063	lbs/W	NOTE: Based on the text of the reference document and a comparison of the energy and emission values, it appears that the "installation" and "transport" categories in the table on page 51 are reversed. The values used here take this into account.	
	Solid Waste Generated		tons/W	Not calculated	
	Haz. Waste Generated	0.0000029	tons/W	Not calculated	
	Air Toxics Emitted	0.0000029	lbs/W	Air toxic emissions are limited to lead emissions because no additional information is available from this study. Other hazardous air pollutants are likely emitted, including some of the emitted hydrocarbons that are quantified in the study.	
	Mercury Released		lbs/W	Not calculated	
	Lead Released	0.0000029	lbs/W	Not calculated	
Dioxins Released		lbs/W	Not calculated		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Material #2 - Mulch	Energy Used		Mbtu/cy		
	Electricity Used		MWh/cy		
	All Water Used		gal x 1000/cy		
	Potable Water Used		gal x 1000/cy		
	Groundwater Extracted		gal x 1000/cy		
	CO2e Emitted		lbs/cy		
	NO x Emitted		lbs/cy		
	SO x Emitted		lbs/cy		
	PM Emitted		lbs/cy		
	Solid Waste Generated		tons/cy		
	Haz. Waste Generated		tons/cy		
	Air Toxics Emitted		lbs/cy		
	Mercury Released		lbs/cy		
	Lead Released		lbs/cy		
	Dioxins Released		lbs/cy		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Material #3 - acetic acid	Energy Used	5.2	Mbtu/lb	NREL - Consistent with www.eia.gov calculators, coal assumed to have an energy content of 10,000 btu per pound, and natural gas is assumed to have an energy content of 1,000 btus. Electricity at the grid is assumed to be generated with 33% thermal efficiency and 10% loss from transmission.	<p align="center">Primary NREL LCI File: -SS_acetic acid, at plant.xls</p> <p align="center">All supporting files</p>
	Electricity Used	0.00002	MWh/lb		
	All Water Used		gal x 1000/lb		
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted	0.67	lbs/lb	NREL - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide.	
	NO x Emitted	0.00064	lbs/lb	NREL - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.02	lbs/lb	NREL - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.000058	lbs/lb	NREL - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated		tons/lb		
	Haz. Waste Generated		tons/lb		
	Air Toxics Emitted	0.00029	lbs/lb	NREL - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	1.7E-09	lbs/lb	NREL - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.00000001	lbs/lb	NREL - Sum of all lead and lead compounds released to air or water.	
	Dioxins Released	3E-15	lbs/lb		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Material #4 - guar gum	Energy Used	0.91	Mbtu/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	<p align="center">wheat flour www.lcafood.dk Landbrugets radgivningscenter (2000) Tal fra Fodermiddeltabellen, Raport nr. 91. In Danish</p>
	Electricity Used	0.000047	MWh/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	All Water Used	0.0001	gal x 1000/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted	1	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	NO x Emitted	0.073	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	SO x Emitted	0.0068	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	PM Emitted	0.00012	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Solid Waste Generated		tons/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Haz. Waste Generated		tons/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Air Toxics Emitted	0.000014	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Mercury Released	1.1E-09	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
	Lead Released	0.00000011	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.	
Dioxins Released	6E-14	lbs/lb	Guar gum is produced by milling and sifting of plant matter. Publicly available life-cycle inventory data for guar gum could not be identified. Life-cycle inventory data was identified for wheat flour, which is also produced by milling plant matter, in the provided reference and is used here. Values were extracted directly from the provided database using the Demo Version of Simapro 7.1.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other Material #5	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Phosphorus fertilizer	Energy Used	3.39	Mbtu/lbs	NREL - Consistent with www.eia.gov calculators natural gas is assumed to have an energy content of 1,000 btus. Electricity at the grid is assumed to be generated with 33% thermal efficiency and 10% loss from transmission.	
	Electricity Used	0.000073	MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted	0.35	lbs/lbs	NREL - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide.	
	NO x Emitted	0.0017	lbs/lbs	NREL - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.017	lbs/lbs	NREL - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.00011	lbs/lbs	NREL - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted	0.000052	lbs/lbs	NREL - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	2.1E-09	lbs/lbs	NREL - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.000000048	lbs/lbs	NREL - Sum of all lead and lead compounds released to air or water.	
Dioxins Released		lbs/lbs			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Polymer	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Potable Water Produced	Energy Used	9.2	Mbtu/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. All forms of energy summed and converted to Mbtus per thousand gallons of product.	<p align="center">EUROPA file location: Drinking water from surface water and drinking water from groundwater: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/db009014-338f-11dd-bd11-0800200c9a66_02.00.000.html http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/db009013-338f-11dd-bd11-0800200c9a66_02.00.000.html</p>
	Electricity Used	0.00044	MWh/gal x 1000	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33% and divided by 3,413 Mbtu/MWh to convert to MWh).	
	All Water Used	0.021	gal x 1000/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per thousand gallons of product. The EUROPA file provides all of the water required to produce on gallon of water leaving the treatment plant. In this analysis, the 1 gallon that is used is tracked separately ("potable water used"). Therefore, for this analysis, the water required to produce one gallon of water is the EUROPA value (1.21 gallons per gallon) minus the 1 gallon that is used.	
	Potable Water Used		gal x 1000/gal x 1000	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/gal x 1000	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	5	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per thousand gallons of product.	
	NO x Emitted	0.0097	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per thousand gallons of product.	
	SO x Emitted	0.0059	lbs/gal x 1000	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per gallon of product.	
	PM Emitted	0.016	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per thousand gallons of product.	
	Solid Waste Generated	0.00000834	tons/gal x 1000	EUROPA ELCD - Sum of all listed wastes (demolition debris) except for radioactive wastes, slag, and mining wastes, which would likely not be disposed of in a landfill.	
	Haz. Waste Generated	0	tons/gal x 1000	EUROPA ELCD - No hazardous waste is listed in EUROPA for water production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.000015	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per thousand gallons of product.	
	Mercury Released	8.2E-09	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of all mercury and mercury compounds released to air or water. Reported as pounds per thousand gallons of product.	
	Lead Released	0.00000067	lbs/gal x 1000	EUROPA ELCD -Average of values from drinking water derived from surface water and from groundwater. Sum of all lead and lead compounds released to air or water. Reported as pounds per thousand gallons of product.	
Dioxins Released	1E-13	lbs/gal x 1000	EUROPA ELCD - Average of values from drinking water derived from surface water and drinking water derived from groundwater. Sum of all dioxins released to air or water. Reported as pounds per thousand gallons of product.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Potassium permanganate	Energy Used	29.22	Mbtu/lbs	Based on the cited reference, approximately 1.36 lb of CO2 is emitted per dollar of output in the manufacturing sector. In the absence of other information, it is assumed that the permanganate manufacturer also has an emission profile of approximately 1.36 lb of CO2 emitted per dollar of output. Conversion factor estimates assume that 50% of each pound CO2 results from electricity use (U.S. average fuel blend) and 50% results from diesel use. Using an approximate, typical cost of \$3 per pound of product, a pound of product can then be converted into electricity and diesel usage. The conversion factors for the other parameters result from this electricity and diesel usage. The resulting carbon footprint is consistent the values presented by the permanganate manufacturer CARUS in marketing presentations.	U.S. CARBON DIOXIDE EMISSIONS AND INTENSITIES OVER TIME: A DETAILED ACCOUNTING OF INDUSTRIES, GOVERNMENT AND HOUSEHOLDS, APRIL 2010
	Electricity Used	0.0016	MWh/lbs		
	All Water Used	0.003	gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted	4.5	lbs/lbs		
	NO x Emitted	0.021	lbs/lbs		
	SO x Emitted	0.016	lbs/lbs		
	PM Emitted	0.0017	lbs/lbs		
	Solid Waste Generated	0.0000013	tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted	0.0006	lbs/lbs		
	Mercury Released	0.000000038	lbs/lbs		
	Lead Released	0.000000038	lbs/lbs		
Dioxins Released	3.5E-13	lbs/lbs			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
PVC	Energy Used	22	Mbtu/lbs	EUROPA ELCD - All forms of energy summed and converted to Mbtus per pound of product.	Primary NREL file for electricity: polyvinyl chloride resin, at plant file Secondary NREL files for electricity: Ethylene dichloride-vinyl chloride monomer, at plant; Ethylene, at plant; Chlorine, PVC producer average, at plant; Oxygen, liquid, at plant. EUROPA file <u>location</u> : Suspension Polymerisation PVC: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/129b8f8d-7667-41bc-91f4-421bfcd8c3_02.00.000.html
	Electricity Used	0.00056	MWh/lbs	Not provided by EUROPA ELCD. NREL LCI includes electricity usage for PVC manufacturing. Electricity from polyvinyl chloride resin, at plant file and the following major subcomponent files is included in this estimate: Ethylene dichloride-vinyl chloride monomer, at plant; Ethylene, at plant; Chlorine, PVC producer average, at plant; Oxygen, liquid, at plant.	
	All Water Used	0.0069	gal x 1000/lbs	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to gallons per pound.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	2.6	lbs/lbs	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per pound of product.	
	NO x Emitted	0.0048	lbs/lbs	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.0076	lbs/lbs	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.0012	lbs/lbs	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated	0.0000022	tons/lbs	EUROPA ELCD - Sum of all wastes except for mine wastes and toxic chemical wastes.	
	Haz. Waste Generated	0.0000016	tons/lbs	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product.	
	Air Toxics Emitted	0.00047	lbs/lbs	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	0.00000034	lbs/lbs	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.00000013	lbs/lbs	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	6.9E-09	lbs/lbs	EUROPA ELCD - Sum of all dioxins released to air or water.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Sequestering agent	Energy Used		Mbtu/lbs		
	Electricity Used		MWh/lbs		
	All Water Used		gal x 1000/lbs		
	Potable Water Used		gal x 1000/lbs		
	Groundwater Extracted		gal x 1000/lbs		
	CO2e Emitted		lbs/lbs		
	NO x Emitted		lbs/lbs		
	SO x Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Haz. Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
	Dioxins Released		lbs/lbs		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Sodium hydroxide (dry bulk)	Energy Used	6.6	Mbtu/lbs	EUROPA ELCD - All forms of energy summed and converted to Mbtus per pound of product.	EUROPA file location: Sodium Hydroxide, at plant 100%
	Electricity Used	0.00032	MWh/lbs	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.00115	gal x 1000/lbs	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per pound.	
	Potable Water Used		gal x 1000/lbs	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lbs	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	1.37	lbs/lbs	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per pound of product.	
	NO x Emitted	0.003	lbs/lbs	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.0048	lbs/lbs	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of <u>SO_x</u> per pound of product.	
	PM Emitted	0.00054	lbs/lbs	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated	0.000019	tons/lbs	EUROPA ELCD - All waste for steel production is listed as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Haz. Waste Generated	0.00000047	tons/lbs	EUROPA ELCD - All waste for steel production is listed as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Air Toxics Emitted	0.000062	lbs/lbs	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	0.00000022	lbs/lbs	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.000000025	lbs/lbs	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	2.4E-14	lbs/lbs	EUROPA ELCD - Sum of all dioxins released to air or water.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Stainless Steel	Energy Used	11.6	Mbtu/lb	EUROPA ELCD - All forms of energy summed and converted to Mbtus per pound of product.	EUROPA file location: Stainless Steel: http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html
	Electricity Used	0.00056	MWh/lb	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.0023	gal x 1000/lb	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per pound.	
	Potable Water Used		gal x 1000/lb	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lb	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	3.4	lbs/lb	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per pound of product.	
	NO x Emitted	0.0075	lbs/lb	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.012	lbs/lb	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.0044	lbs/lb	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated	0.00062	tons/lb	EUROPA ELCD - All waste for steel production is listed as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Haz. Waste Generated	0	tons/lb	EUROPA ELCD - All waste for steel production is listed as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Air Toxics Emitted	0.000144	lbs/lb	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	0	lbs/lb	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.00000052	lbs/lb	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	2.2E-12	lbs/lb	EUROPA ELCD - Sum of all dioxins released to air or water.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Steel	Energy Used	4.4	Mbtu/lb	EUROPA ELCD - All forms of energy summed and converted to Mbtus per pound of product.	<p>Conversion numbers were based upon an average of the following three files, EUROPA file locations: Steel hot rolled section:http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/f9d4581e-14de-417e-8f9f-6c74e6f14051_02.00.000.html Steel hot rolled coil: http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html Steel rebar: http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/268a11fb-baf2-4b9e-8867-38bea0e76ef6_02.00.000.html</p>
	Electricity Used	0.00021	MWh/lb	Not provided by EUROPA ELCD or NREL. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.00064	gal x 1000/lb	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per pound.	
	Potable Water Used		gal x 1000/lb	Not applicable -- no local potable water used.	
	Groundwater Extracted		gal x 1000/lb	Not applicable -- no local or on-site ground water extracted.	
	CO2e Emitted	1.1	lbs/lb	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per pound of product.	
	NO x Emitted	0.0014	lbs/lb	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per pound of product.	
	SO x Emitted	0.0017	lbs/lb	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.00056	lbs/lb	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per pound of product.	
	Solid Waste Generated	0.00025	tons/lb	EUROPA ELCD - All waste for steel production is listed as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Haz. Waste Generated	0	tons/lb	EUROPA ELCD - EUROPA indicates all waste for steel production as "unspecified". Until additional information is available, all "unspecified" waste has been included in the "solid waste generated" category, and no value is provided for hazardous waste.	
	Air Toxics Emitted	0.000067	lbs/lb	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	0.0000001	lbs/lb	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.0000025	lbs/lb	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	6.5E-12	lbs/lb	EUROPA ELCD - Sum of all dioxins released to air or water.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Tree: root ball	Energy Used	3.7	Mbtu/trees	Energy based on electricity required to pump water to water trees and gasoline for commute. For electricity assume 4 gallons of water (Keeling Nursery) at a total head of 50 psi., 75% pump efficiency, 0.746 kW per horsepower, energy for electricity and electricity production. For gasoline, assume 0.025 gallons of gasoline based on a tree requiring 0.2 man hours over lifetime at nursery (Keeling Nursery), a 8-hour day, and a gallon of gasoline to commute to and from the nursery.	
	Electricity Used	0.0000019	MWh/trees		
	All Water Used	0.004	gal x 1000/trees	4 gallons of water over life-time in nursery based on verbal discussions with Keeling Nursery	
	Potable Water Used		gal x 1000/trees		
	Groundwater Extracted		gal x 1000/trees		
	CO2e Emitted	0.6	lbs/trees	All paramete values based on the energy consumption outlined above.	
	NO x Emitted	0.003	lbs/trees		
	SO x Emitted	0.00061	lbs/trees		
	PM Emitted	0.000029	lbs/trees		
	Solid Waste Generated	0.00000001	tons/trees		
	Haz. Waste Generated		tons/trees		
	Air Toxics Emitted	0.000006	lbs/trees	All paramete values based on the energy consumption outlined above.	
	Mercury Released	2.2E-09	lbs/trees		
	Lead Released	0.00000006	lbs/trees		
Dioxins Released		lbs/trees			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Tree: whip	Energy Used		Mbtu/trees		
	Electricity Used		MWh/trees		
	All Water Used	0	gal x 1000/trees		
	Potable Water Used		gal x 1000/trees		
	Groundwater Extracted		gal x 1000/trees		
	CO2e Emitted		lbs/trees		
	NO x Emitted		lbs/trees		
	SO x Emitted		lbs/trees		
	PM Emitted		lbs/trees		
	Solid Waste Generated		tons/trees		
	Haz. Waste Generated		tons/trees		
	Air Toxics Emitted		lbs/trees		
	Mercury Released		lbs/trees		
	Lead Released		lbs/trees		
Dioxins Released		lbs/trees			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Off-site waste water treatment	Energy Used	15	Mbtu/gal x 1000	Consistent with life-cycle total energy requirements for the Ann Arbor waste water treatment plant and the average of all three waste water treatment plants in the study. See Table 5-2 of the referenced report.	<p align="center">Life-Cycle Energy and Emissions for Municipal Water and Wastewater Services: Case-Studies of Treatment Plants in US Malavika Tripathi, Center for Sustainable Systems, University of Michigan Report No. CSS07-06, April 17, 2007</p>
	Electricity Used	0.00073	MWh/gal x 1000	Consistent with total energy for electricity for the Ann Arbor waste water treatment plant and the average of all three waste water treatment plants in the study. See Figure 5-3 of the referenced report. Total energy converted to electricity usage assuming a 33% thermal efficiency.	
	All Water Used	0.00292	gal x 1000/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.	
	Potable Water Used		gal x 1000/gal x 1000		
	Groundwater Extracted		gal x 1000/gal x 1000		
	CO2e Emitted	4.4	lbs/gal x 1000	Consistent with life-cycle total energy requirements for the Ann Arbor waste water treatment plant and the average of all three waste water treatment plants in the study. See Table 5-2 of the referenced report.	
	NO x Emitted	0.016	lbs/gal x 1000	Calculated from acidification potential from NOx (Table 3-5 of the reference document) by dividing by an impact factor of 40.04 (Table 1-2 of the referenced document).	
	SO x Emitted	0.015	lbs/gal x 1000	Calculated from acidification potential from SOx (Table 3-5 of the reference document) by dividing by an impact factor of 50.79 (Table 1-2 of the referenced document).	
	PM Emitted	0.0017	lbs/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.	
	Solid Waste Generated	0.0024	tons/gal x 1000	Calculated from approximate average of 15,000 metric tons of sludge taken to landfill (see Table 3-1 of referenced report), converted to short tons, and assuming sludge generation from 19 million gallons of wastewater per day (see page 53 of referenced report).	
	Haz. Waste Generated	0	tons/gal x 1000		
	Air Toxics Emitted	0.00058	lbs/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.	
	Mercury Released	0.00000037	lbs/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.	
	Lead Released	0.00000037	lbs/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.	
Dioxins Released	3.45E-13	lbs/gal x 1000	Assume that 50% of the CO2e results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. The conversion factor results from this electricity and diesel usage.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Off-site Solid Waste Disposal	Energy Used	160	Mbtu/ton	EUROPA ELCD - All forms of energy summed and converted to Mbtus per short ton disposed of.	<p align="center">EUPOA ECLD file location: Inert waste disposal: http://ca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/64197304-3307-11dd-bd11-0800200c9a66_02.00.000.html</p> <p align="center">Inert waste used so that methane and carbon dioxide from decomposing waste is not included.</p>
	Electricity Used	0.0077	MWh/ton	Not provided by EUROPA ELCD. Arbitrarily taken as 50% of all energy consumed assuming a 33% thermal efficiency. (i.e., MWh 50% of Mbtus of energy multiplied by 33%)	
	All Water Used	0.15	gal x 1000/ton	EUROPA ELCD - Sum of "water", "surface water", "groundwater", and "river water". Negative values (indicating return of water to the hydrosphere) were not included. Sea water was also not included. Result converted to thousands of gallons per short ton disposed of.	
	Potable Water Used		gal x 1000/ton	Not applicable -- no local potable water used during waste disposal.	
	Groundwater Extracted		gal x 1000/ton	Not applicable -- no local or on-site ground water extracted during waste disposal.	
	CO2e Emitted	25	lbs/ton	EUROPA ELCD - Sum of total global warming potential for carbon dioxide, methane, and nitrous oxide released to atmosphere. A global warming potential of 21 is used for methane and a global warming potential of 310 is used for nitrous oxide. Results converted to pounds of carbon dioxide equivalents per short ton disposed of.	
	NO x Emitted	0.14	lbs/ton	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per short ton disposed of.	
	SO x Emitted	0.075	lbs/ton	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per short ton disposed of.	
	PM Emitted	0.4	lbs/ton	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per short ton disposed of.	
	Solid Waste Generated	0.000008	tons/ton	EUROPA ELCD - Sum of all listed wastes (demolition debris) except for radioactive wastes, slag, and mining wastes, which would likely not be disposed of in a landfill.	
	Haz. Waste Generated	0	tons/ton	EUROPA ELCD - No hazardous waste is listed in EUROPA for water production, suggesting that little or no hazardous waste is produced as a result of these activities.	
	Air Toxics Emitted	0.0014	lbs/ton	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per short ton disposed of.	
	Mercury Released	0.0000097	lbs/ton	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported as pounds per short ton disposed of.	
	Lead Released	0.0000076	lbs/ton	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported as pounds per short ton disposed of.	
Dioxins Released	1.2E-11	lbs/ton	EUROPA ELCD - Sum of all dioxins released to air or water. Reported as pounds per short ton disposed of.		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Off-site Hazardous Waste Disposal	Energy Used	176	Mbtu/ton	For energy and all other parameters, values are calculated by assuming a 10% premium on values for solid waste disposal.	
	Electricity Used	0.0085	MWh/ton		
	All Water Used	0.165	gal x 1000/ton		
	Potable Water Used		gal x 1000/ton		
	Groundwater Extracted		gal x 1000/ton		
	CO2e Emitted	27.5	lbs/ton		
	NO x Emitted	0.154	lbs/ton		
	SO x Emitted	0.0825	lbs/ton		
	PM Emitted	0.44	lbs/ton		
	Solid Waste Generated	0.0000088	tons/ton		
	Haz. Waste Generated	0	tons/ton		
	Air Toxics Emitted	0.00154	lbs/ton		
	Mercury Released	0.000001067	lbs/ton		
	Lead Released	0.00000836	lbs/ton		
Dioxins Released	1.32E-11	lbs/ton			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Off-site Laboratory Analysis	Energy Used	6.49	Mbtu/\$	Based on the cited reference, approximately 1 lb of CO ₂ is emitted per dollar of GDP. In the absence of other information, it is assumed that the laboratory also has an emission profile of approximately 1 lb of CO ₂ emitted per dollar of sample cost. Conversion factor estimates assume that 50% of this 1 lb of CO ₂ per dollar of sample cost results from electricity use (U.S. average fuel blend) and 50% is due to diesel use. A dollar of sample cost can then be converted into electricity and diesel usage. The conversion factors result from this electricity and diesel usage. Additionally, one gallon of potable water is added per \$100 of analytical cost to account for water usage associated with lab activities.	U.S. CARBON DIOXIDE EMISSIONS AND INTENSITIES OVER TIME: A DETAILED ACCOUNTING OF INDUSTRIES, GOVERNMENT AND HOUSEHOLDS, APRIL 2010
	Electricity Used	0.00035	MWh/\$		
	All Water Used	0.00066	gal x 1000/\$		
	Potable Water Used		gal x 1000/\$		
	Groundwater Extracted		gal x 1000/\$		
	CO ₂ e Emitted	1	lbs/\$		
	NO _x Emitted	0.0048	lbs/\$		
	SO _x Emitted	0.0036	lbs/\$		
	PM Emitted	0.0004	lbs/\$		
	Solid Waste Generated	0	tons/\$		
	Haz. Waste Generated	0	tons/\$		
	Air Toxics Emitted	0.00013	lbs/\$		
	Mercury Released	8.4E-09	lbs/\$		
	Lead Released	0.000000085	lbs/\$		
Dioxins Released	7.9E-14	lbs/\$			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 1	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 2	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 3	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 4	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 5	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 1	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 2	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 3	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 4	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
	Dioxins Released		lbs/TBD		

Default Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other 5	Energy Used		Mbtu/TBD		
	Electricity Used		MWh/TBD		
	All Water Used		gal x 1000/TBD		
	Potable Water Used		gal x 1000/TBD		
	Groundwater Extracted		gal x 1000/TBD		
	CO2e Emitted		lbs/TBD		
	NO x Emitted		lbs/TBD		
	SO x Emitted		lbs/TBD		
	PM Emitted		lbs/TBD		
	Solid Waste Generated		tons/TBD		
	Haz. Waste Generated		tons/TBD		
	Air Toxics Emitted		lbs/TBD		
	Mercury Released		lbs/TBD		
	Lead Released		lbs/TBD		
Dioxins Released		lbs/TBD			

Actual Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity production	Energy Used		Mbtu/MWh		
	Electricity Used		MWh/MWh		
	All Water Used	2.5	gal x 1000/MWh	Actual water usage based on the specific fuel blend (see attached support file titled "Power Sources and Global Emissions Factors for Electricity Provided by eGRID for Tucson Electric Power" for calculations).	Gleick PH. Water and energy. Annu. Rev. Energy Environ. Vol 19, 1994. p 267-99. Consumptive Water Use for U.S. Power Production
	Potable Water Used		gal x 1000/MWh		
	Groundwater Extracted		gal x 1000/MWh		
	CO2e Emitted	810	lbs/MWh	Actual values for emissions for electricity production calculated based upon the fuel blend for the local electricity provider (Pacific Gas & Electric). Emissions of CO2e, NOx, SOx, and PM for all fuel blends calculated using NREL LCI and includes resource extraction, transportation, and power generation. Actual values DO include resource extraction and transportation.	Primary NREL LCI Files: - SS_Electricity, natural gas, at power plant.xls - SS_Electricity, nuclear, at power plant.xls - SS_Electricity, bituminous coal, at power plant.xls Secondary NREL LCI files: - SS_Natural gas, processed, at plant.xls - SS_Fuel grade uranium, at regional storage.xls All Supporting NREL LCI files to the above files except for SS_Electricity, at grid, US.xls. CO2, NOx, SOx, and PM emissions provided by EGRID were used in place of this file to avoid circular references. No value used for "dummy" inputs.
	NO x Emitted	1.53	lbs/MWh		
	SO x Emitted	6	lbs/MWh		
	PM Emitted	0.322	lbs/MWh		
	Solid Waste Generated		tons/MWh		
	Haz. Waste Generated		tons/MWh		
	Air Toxics Emitted	0.1762	lbs/MWh	For all parameters, used output values from NREL for electricity production from natural gas, bituminous coal, and nuclear. For natural gas and bituminous coal, accounted only for direct combustion for energy production and did not account for resource extraction as it is anticipated to be negligible. For nuclear, accounted for major components of processing uranium (electricity, coal in industrial boiler, natural gas in industrial boiler, and diesel in industrial boiler). For electricity in uranium processing, assumed a 50/50 blend of bituminous coal and natural gas (excluded resource extraction). For actual values, applied output 2% bitum. coal, 47% natural gas, 20% nuclear, and 20% hydro, which approximates the PG&E blend. Assumed no emissions/releases associated with hydro power. NREL output is for electricity at the power plant. All results are multiplied by 1.12 to account for additional electricity generated to offset transmission losses (1.12 = 1 MWh + 0.12 MWh for transmission losses, see above).	Primary NREL LCI Files: - SS_Electricity, natural gas, at power plant.xls - SS_Electricity, nuclear, at power plant.xls - SS_Electricity, bituminous coal, at power plant.xls Secondary NREL LCI files: - SS_Fuel grade uranium, at regional storage.xls - SS_Bituminous coal, combusted in industrial boiler.xls - SS_Natural gas, combusted in industrial boiler.xls - SS_Diesel, combusted in industrial boiler.xls
	Mercury Released	0.000008	lbs/MWh		
	Lead Released	0.00005	lbs/MWh		
Dioxins Released	3E-11	lbs/MWh			

Actual Environmental Footprint Conversion Factor References

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity transmission	Energy Used		Mbtu/MWh		<p align="center">U.S. Dept. of Energy GridWorks: Overview of the Electric Grid http://sites.energetics.com/gridworks/grid.html Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905</p> <p>Note relevant to all the entries for "electricity transmitted": "electricity transmitted" refers to the flow of electricity through the lines, which would have 0 emissions and resource use. Another aspect of electrical transmissions would be installation and maintenance of electrical transmission lines. This would result in emissions and resource use, but they would be very small when allocated per kWh transmitted. It would also be similar in concept to installation and maintenance of roadways for truck transportation, which we also do not account for in this analysis.</p>
	Electricity Used		MWh/MWh		
	All Water Used	0.3	gal x 1000/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Potable Water Used		gal x 1000/MWh		
	Groundwater Extracted		gal x 1000/MWh		
	CO2e Emitted	97.2	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	NO x Emitted	0.1836	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	SO x Emitted	0.72	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	PM Emitted	0.03864	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Solid Waste Generated		tons/MWh		
	Haz. Waste Generated		tons/MWh		
	Air Toxics Emitted	0.021144	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Mercury Released	0.0000096	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Lead Released	0.000006	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Dioxins Released		lbs/MWh		

**Power Sources and Global Emissions Factors for Electricity Provided by
Western Area Power Administration**

Type	% Used*	Water (gal/kWh)		CO2e (lbs/kWh)		NOx (lbs/kWh)		SOx (lbs/kWh)		PM (lbs/kWh)		HAPs (lbs/kWh)		Lead (lbs/kWh)		Mercury (lbs/kWh)		Dioxins (lbs/kWh)	
		Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted
Biomass	1.4%	168	2.3268	0	0	0.0015	0.000020775	0.00060	0.00000831	0.000084	1.1634E-06	0	0	0	0	0	0	0	0
Coal	17.4%	0.52	0.090324	2.4	0.41688	0.0067	0.00116379	0.015	0.0026055	0.0017	0.00029529	0.0007	0.00012159	0.00000024	4.1688E-08	0.000000042	7.2954E-09	3.8E-13	3.43231E-14
Geothermal	2.6%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hydro	40.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Natural Gas	28.1%	0.37	0.103892	1.4	0.393106	0.0012	0.000336948	0.012	0.00336948	0.000088	2.47095E-05	0.000193	5.41925E-05	1.31E-08	3.67835E-09	2.9E-09	8.14291E-10	0	0
Nuclear	8.7%	0.3	0.025995	0.024	0.00208	0.000056	0.0000049	0.000131	1.13512E-05	0.0000126	1.09179E-06	0.0000053	4.59245E-07	5.2E-09	4.5058E-10	4.6E-10	3.9859E-11	2.9E-15	7.53855E-17
Oil	0.0%	3.1	0	1.9	0	0.0036	0.0000000	0.0041	0	0.00029	0	0.0000902	0	0.00000129	0	1.01E-08	0	1.04E-12	0
Solar	0.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wind	1.8%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Other	0.0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total based on kWh at plant	100%		2.5		0.81		0.00153		0.006		0.000322		0.0001762		0.00000005		0.000000008		3E-14
Total based on kWh at point of use (0.12 kWh/kWh lost in transmission)			2.8		0.91		0.00171		0.0067		0.000361		0.000197		0.00000006		0.000000009		3E-14

* Based on the following:

22% power provided by WAPA from a Bureau of Reclamation hydroelectric facilities (email communication from WAPA, 2/2/11)

55% power from the California Total System Power Mix, based on 70% of the non-hydro WAPA power coming from the California pool (email communication from WAPA, 2/2/11), California Total System Mix obtained from California Energy Commission, 2008 Net System Power Report, July 2009.

23% power from the Northwest Power Mix, based on 30% of the non-hydro WAPA power coming from the Northwest pool (email communication from WAPA, 2/2/11), Northwest pool mix obtained from eGRID (NWPP subregion), www.epa.gov/egrid 2010 Version 1.0 for 2007 data

Notes:

- Water consumption for thermoelectric power plants in California - 0.05 gallons per kWh*
- Water consumption for hydroelectric power assumed to be 0 gallons per kWh (i.e., considers evaporation from reservoir as non-additive)
- Water consumption for coal resource extraction and fuel processing - 0.16 cubic meters per GJ of extracted energy, and 33% thermal energy conversion to electricity**
- Water consumption for uranium resource extraction and fuel processing - 0.086 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity**
- Water consumption for natural gas resource extraction and fuel processing - 0.11 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity**
- Water consumption for oil resource extraction and fuel processing - 1.06 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity**
- Water consumption for biomass based on 55 cubic meters per GJ of extracted energy and 33% thermal energy conversion to electricity***
- CO2e, Nox, SOx, and PM emissions from NREL LCI for each fuel type ****

* Consumptive Water Use for U.S. Power Production, December 2003 • NREL/TP-550-33905

** Gleick PH. Water and energy. Annu. Rev. Energy Environ. Vol 19, 1994. p 267-99.

*** The Water Footprint of Energy Consumption : an Assessment of Water Requirements of Primary Energy Carriers, Winnie Gerbens-Leenes, Arjen Hoekstra, Theo an der Meer, ISESCO Science and Technology Vision, Volume 4 - Number 5, May 2008

**** "NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

Electricity and Energy Used for the Production, Transmission, and On-Site Use of Electricity

For the purpose of this study, the sum of the "energy used" for "electricity production", "electricity transmission", and "on-site electricity use" equals the total amount of energy used to generate the 1 MWh used by the consumer. According to the U.S. Dept. of Energy (GridWorks: Overview of the Electric Grid <http://sites.energetics.com/gridworks/grid.html>) approximately power plants have a thermal efficiency of approximately 33% and the transmission of electricity results in a loss of approximately 10% of the electricity produced. In addition, the National Renewable Energy Laboratory (Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905) states that thermoelectric plants use approximately 5% of the gross electricity produced for on-site demand (i.e., parasitic loads).

This study assumes that the 33% thermal efficiency includes the 5% parasitic load and that this efficiency applies to all major electricity generation technologies. It is noted that actual efficiencies may differ by method of generation and by power plant.

For use of 1 MWh of electricity on-site, the following calculations illustrate the electricity and energy used.

$$G = P + T + U$$

$$G = 5\% G + 10\% G + 1$$

$$G(1 - 15\%) = 1$$

$$G = 1.18$$

where

G = electricity generated (MWh)
 P = parasitic load (MWh):5% of G
 T = transmission loss (MWh):10% of G
 U = energy used onsite (MWh)

$$P = 5\% \times 1.18 = 0.06 \text{ MWh}$$

$$T = 10\% \times 1.18 = 0.12 \text{ MWh}$$

$$E_I = E_p + E_T + E_U$$

$$E_U + E_T = \eta \times E_I$$

$$E_U = 1 \text{ MWh} \times \frac{3,413 \text{ btu}}{\text{MWh}} = 3,413 \text{ btu}$$

$$E_T = 0.12 \text{ MWh} \times \frac{3,413 \text{ btu}}{\text{MWh}} = 410 \text{ btu}$$

$$E_I = \frac{(3,413 + 410)}{33\%} = 11,584 \text{ btu}$$

$$E_p = 11,584 - 3,413 - 410 = 7,761 \text{ btu}$$

where

E_I = energy input (btu)
 E_p = energy lost electricity production
 (thermal loss and parasitic load) (btu)
 E_T = energy lost electricity transmission (btu)
 E_U = energy used onsite in the form of
 electricity (btu)
 η = thermal efficiency (33%)

Virgin and Regenerated GAC Footprints

Information from Literature

Use of Adsorbents for the Removal of Pollutants from Wastewaters, by Gordon McKay, published by CRC Press, 1995, ISBN 0849369207

Table 8.1

Granular Carbon Regeneration Process Energy Requirements (15,000 kg/day Regeneration Rate)			
System	Fuel, kJ/kg	Electricity, kWh/kg	Steam, kg/kg
Electric infrared furnace	0	0.36	0
Multiple-hearth furnace	18,600	0.10	1.0
Rotary Kiln	23,300	0.07	1.0
Fluid bed furnace	11,700	0.11	0.8

1.2		Specific gravity of coal (www.engineeringtoolbox.com)
0.5		Specific gravity of GAC (Westates/Siemens)
0.7		Fraction of coal that is carbon (http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html)
0.015		Fraction of coal that is sulfur (http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html)
0.015		Fraction of coal that is nitrogen (assumed to be similar to that of sulfur)
0.27	lb CO ₂ e/lb	Carbon footprint of extracting and delivering 1 lb of coal to a plant (EUROPA ELCD - Hard Coal)
0.0007	lb SO ₂ /lb	Sulfur dioxide (SO _x) footprint of extracting and delivering 1 lb of coal (EUROPA ELCD - Hard Coal)
0.001	lb NO ₂ /lb	Nitrogen dioxide (NO _x) footprint of extracting and delivering 1 lb of coal (EUROPA ELCD - Hard Coal)
600	btu/lb	Energy requirement of extracting and delivering 1 lb of coal to plant (EUROPA ELCD)
0.38	gal/lb	Water requirement of extracting and delivering 1 lb of coal to plant (EUROPA ELCD)
14	lb CO ₂ e	Carbon footprint of natural gas, including natural gas production (per therm) (NREL, industrial boiler)
0.0046	lb SO ₂	SO _x footprint of natural gas combustion per therm (NREL), including natural gas production (EUROPA ELCD)
0.0138	lb NO ₂	NO _x footprint of natural gas combustion per therm (NREL), including natural gas production (EUROPA ELCD)
1.34	lb CO ₂ e	Carbon footprint of electricity (per kWh) (EGRID, US Average)
0.0053	lb SO ₂	SO _x footprint of electricity (per kWh) (EGRID, US Average)
0.00088	lb NO ₂	NO _x footprint of electricity (per kWh) (EGRID, US Average)

Assumptions:

- Use fuel and electricity requirements for multiple hearth furnace to estimate energy required for regeneration
- Assume energy and water requirements for regeneration is the same as they are for initial activation

Calculations for Virgin Coal:

Carbon Footprint

2.4		Pounds of coal required to produce one pound of GAC
1.68		Pounds of that coal that is carbon
1		Pounds of carbon in one pound of GAC
0.68		Pounds of carbon from coal emitted to atmosphere
2.5	lb CO ₂ e	Pounds of carbon dioxide emitted for burning off coal (measured as pounds of CO ₂)
0.65	lb CO ₂ e	Pounds of CO ₂ e emitted during coal extraction
8,920	btus	Fuel required to activate one pound of GAC (2.2 pounds per kg and 1.055 kJ/btu)
1.2	lb CO ₂ e	Pounds of CO ₂ e emitted for combustion of natural gas during activation (100,000 btus per therm)
0.045	kWh	Electricity required to activate one pound of GAC
0.061	lb CO ₂ e	Pounds of CO ₂ e emitted for electricity generation
4.5	lb CO ₂ e	Total CO ₂ e emitted for carbon activation

Energy Footprint

2.4		Pounds of coal required to produce one pound of GAC
1440	btus	Energy required during coal extraction
8,920	btus	Fuel required to activate one pound of GAC (2.2 pounds per kg and 1.055 kJ/btu)
0.045	kWh	Electricity required to activate one pound of GAC
470	btus	Energy required to generate that electricity (3,413 btus/kWh and 33% thermal efficiency)
10,800	btus	Total energy required for virgin carbon activation

SOx Footprint

2.4		Pounds of coal required to produce one pound of GAC
0.036		Pounds of that coal that is sulfur
0		Pounds of sulfur in one pound of GAC
0.036		Pounds of sulfur from coal emitted to atmosphere
0.072	lb SO2	Pounds of sulfur dioxide emitted for burning off coal (measured as pounds of SO2)
0.00168	lb SO2	Pounds of SO2 emitted during coal extraction
8,920	btus	Fuel required to activate one pound of GAC (2.2 pounds per kg and 1.055 kJ/btu)
0.00041	lb SO2	Pounds of SO2 emitted for combustion of natural gas during activation (100,000 btus per therm)
0.045	kWh	Electricity required to activate one pound of GAC
0.00024	lb SO2	Pounds of SO2 emitted for electricity generation
0.074	lb SO2	Total SO2 emitted for carbon activation

NOx Footprint

2.4		Pounds of coal required to produce one pound of GAC
0.036		Pounds of that coal that is nitrogen
0		Pounds of nitrogen in one pound of GAC
0.036		Pounds of nitrogen from coal emitted to atmosphere
0.12	lb NO2	Pounds of nitrogen dioxide emitted for burning off coal (measured as pounds of NO2)
0.0024	lb NO2	Pounds of NO2 emitted during coal extraction
8,920	btus	Fuel required to activate one pound of GAC (2.2 pounds per kg and 1.055 kJ/btu)
0.00123	lb NO2	Pounds of NO2 emitted for combustion of natural gas during activation (100,000 btus per therm)
0.045	kWh	Electricity required to activate one pound of GAC
0.00004	lb NO2	Pounds of NO2 emitted for electricity generation
0.12	lb NO2	Total NO2 emitted for carbon activation

Calculations for Regenerated Coal

Footprint per Regeneration Cycle (including 10% virgin GAC to make-up for loss)

Energy	CO2e	NOx	SOx
9500	1.6	0.014	0.008

Footprints over 10 Regeneration Cycles

Cycle	Energy	CO2e	NOx	SOx
1	10,800	4.50	0.12	0.074
2	10,200	3.1	0.069	0.041
3	9,900	2.6	0.051	0.03
4	9,800	2.3	0.041	0.025
5	9,800	2.2	0.036	0.021
6	9,700	2.1	0.032	0.019
7	9,700	2	0.03	0.017
8	9,700	2	0.028	0.016
9	9,600	1.9	0.026	0.015
10	9,600	1.9	0.025	0.015

Calculations for Water Footprint

Use Siemens Water Technologies (formerly Westates Carbon) in Parker, AZ as a basis

4,000 tons/yr hazardous spent carbon treated at Siemens

Each year, Siemens receives about 4,000 tons of spent carbon from 30 - 35 states across the United States. About half of this is considered hazardous waste by EPA.

source: <http://www.epa.gov/region09/waste/siemens/>

EPA Web Page on Siemens Carbon Regeneration Facility (last updated Dec 2007), see third paragraph on first page

conversion: 2,000 lb/ton

8,000,000 lbs/yr spent carbon treated

138,000 gallons/day wastewater discharged by Siemens to POTW

source: Fact Sheet for NPDES Permit for Colorado River Sewage System Joint Venture (EPA June 2001) -- hard copy in EPA files

page 1, General Information: Westates Carbon discharges about 138,000 gallons per day of process waste water used in the air pollution control unit, equipment/facility washdown, and slurry spent carbon.

conversion: 365 days/yr

50,370,000 gal/yr wastewater discharged

as an estimate, assume this is equal to the amount of fresh water withdrawn for processing spent carbon

this assumption will lead to an underestimate of the water withdrawn because water is "lost" as steam in the stack gases (note also that some of the steam exiting in the stack gases is due to products of combustion, rather than volatilization of water introduced into the system as liquid)

50,370,000 gal/yr fresh water withdrawn

6.3 gallons H₂O / lb carbon regenerated

Water Footprint for Coal Extraction

2.4		Pounds of coal required to produce one pound of GAC
0.91	gallons	Gallons of water consumed during extraction of the coal

7.2 Total gallons of water for generating one pound of virgin GAC

6.3 Gallons of water per pound of regenerated GAC (includes makeup GAC if the original GAC is produced at the same plant)

Footprints over 10 Regeneration Cycles

Cycle	Water
1	7.2
2	6.8
3	6.6
4	6.5
5	6.5
6	6.5
7	6.4
8	6.4
9	6.4
10	6.4

Derivation of Molasses Values from LCA Food

The LCA Food database (process and product files) indicates the following allocation of products from sugar production by weight

- Sugar - 1 ton
- Molasses - 0.24 tons
- Feed pills - 0.33
- Grass, cut off etc. - 0.53 tons

This is a total of 2.1 tons, of which molasses is 0.24 tons or 11.4%. For the purposes of this study the allocation of input and output data is based on weight (molasses is 11.4% of the products/byproducts by weight). This essentially equally distributes the inputs/outputs by weight evenly across the various products and byproducts (e.g., the footprint of 1 lb of sugar would be the same as a footprint of one lb of molasses). Because molasses is a byproduct of sugar production, a more appropriate footprint for molasses might be to assign to molasses the footprint of the materials that it displaces in other applications, but insufficient information is known about the footprints of the various materials that molasses displaces to assign an appropriate footprint values. However, LCA Food also accounts for some assumed offset to the footprint by assuming production byproducts displace some animal feed. Overall, this described approach for determining the molasses footprint, results in a lower footprint than what is reported for sugar because the footprint is distributed amongst various products/byproducts by weight and constructive use of some byproducts is assumed.

All relevant inputs and outputs are multiplied by 11.4% to allocate the input/output to molasses and multiplied by 4.17 (i.e., 1/0.24) to obtain one unit of molasses (rather than 0.24 units). Combined, this is a factor of 0.475.

General Conversion Factors Used in Calculations

3.29	kg/gal	density of diesel (NREL - Crude Oil)
139	Mbtu/gal	heat content of diesel (Climate Leaders)
0.027224	L/tkm	diesel usage per ton-kilometer of transport (NREL)
3.785	L/gal	standard conversion
3.413	Mbtu/kWh	standard conversion
10%		energy loss due to electricity transmission (Gridworks)
33%		thermal efficiency of power plant (Gridworks)
947.8	Mbtu/GJ	standard conversion
263.95	gal/m ³	standard conversion
2.2	lb/kg	standard conversion
2200	lb/ton	standard conversion of pounds to metric tons
0.00755556	lb/lb	ratio of Nox emission to CO2e emission for combustion of diesel in truck (NREL)
0.00015111	lb/lb	ratio of PM emission to CO2e emission for combustion of diesel in truck (NREL)

Energy Footprint

0.0112	kg diesel	diesel for farm machinery for crop harvesting for one metric ton of sugar
0.00340426	gal diesel	diesel for farm machinery for crop harvesting for one metric ton of sugar
0.47319149	Mbtu diesel	energy from diesel for farm machinery for crop harvesting for one metric ton of sugar
0.511	tkm	transportation of crops to factory for one metric ton of sugar
0.01391146	L	diesel for transportation (NREL) associated with production of one metric ton of sugar
0.00367542	gal	diesel for transportation (NREL) associated with production of one metric ton of sugar
0.511	Mbtu	energy from diesel for transportation for production of one metric ton of sugar
23	kWh	electricity for producing one metric ton of sugar
78.499	Mbtu	energy contained in electricity for producing one metric ton of sugar
86.3	Mbtu	energy in electricity from power plant (prior to transmission) for producing one metric ton of sugar
261.7	Mbtu	energy needed to produce electricity (including transmission losses) for one metric ton of sugar
6.1	GJ	energy for heat for industrial processing of one metric ton of sugar
5,782	Mbtu	energy for heat for industrial processing of one metric ton of sugar
6,044.2	Mbtu/ton	total energy for producing 1 metric ton of sugar
2,871.01	Mbtu/ton	total energy for producing 1 metric ton of molasses (apply allocation conversion factor of 0.475)
1.31	Mbtu/lb	total energy for producing 1 lb of molasses (apply allocation conversion factor of 0.475)

Electricity Footprint

23	kWh/ton	electricity per metric ton of sugar
10.9	KWh/ton	electricity for producing 1 metric ton of molasses (apply allocation conversion factor of 0.475)
0.0050	KWh/lb	electricity for producing 1 pound of molasses (divide by 2200)

Water Footprint

1.6	m ³	water for industrial processing of one metric ton of sugar (i.e., no water for irrigation)
422.3	gal	water for industrial processing of one metric ton of sugar (i.e., no water for irrigation)
0.422	1000 gals.	water for industrial processing of one metric ton of sugar (i.e., no water for irrigation)
0.200603	1000 gals.	water for producing one metric ton of molasses (does not include any water for irrigation) (apply 0.475 factor)
0.000091	1000 gals./lb	water for producing one pound of molasses (does not include any water for irrigation) (divide by 2200)

Carbon Footprint

840.0	g/kg	carbon dioxide equivalents emitted per production of one kg of sugar
0.84	lb/lb	carbon dioxide equivalents emitted per production of one pound of sugar
0.40	lb/lb	carbon dioxide equivalents emitted per production of one pound of molasses (apply factor of 0.475)

NOx Footprint

840.0	g/kg	carbon dioxide equivalents emitted per production of one kg of sugar
6.3467	g/kg	approximated NOx equivalents emitted per production of one kg of sugar based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions
0.0063	lb/lb	approximated NOx equivalents emitted per production of one pound of sugar based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions
0.0030	lb/lb	approximated NOx equivalents emitted per production of one pound of molasses based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions (apply factor of 0.475)

SOx Footprint

5.5	g/kg	SOx equivalents emitted per production of one kg of sugar
0.0055	lb/lb	SOx equivalents emitted per production of one pound of sugar
0.0026	lb/lb	SOx equivalents emitted per production of one pound of molasses (apply factor of 0.475)

PM Footprint

840.0	g/kg	carbon dioxide equivalents emitted per production of one kg of sugar
0.1269	g/kg	approximated PM equivalents emitted per production of one kg of sugar based on scaling the carbon equivalent by the ratio of PM:CO2e emissions
0.000127	lb/lb	approximated PM equivalents emitted per production of one pound of sugar based on scaling the carbon equivalent by the ratio of PM:CO2e emissions
0.000060	lb/lb	approximated PM equivalents emitted per production of one pound of molasses based on scaling the carbon equivalent by the ratio of PM:CO2e emissions (apply factor of 0.475)

Insufficient information to estimate other footprints.

References

- Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk, Sugar Production based on Danisco Sugar, Author: Per H. Nielsen July 2003
- NREL - Transport - transport, combination truck, diesel powered
- NREL - Crude oil - crude oil, at refinery

"NREL" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

Derivation of Cheese Whey Values from LCA Food

The LCA Food database (product and process files) indicates the following allocation of products from cheese production by weight under natural market conditions

- Cheese - 1 ton
- Whey - 8.5 tons (94% of which is water, only approximately 0.5 tons is solids)
- Cream - 0.68 tons

This is a total of 10.18 tons, of which whey is approximately 83.5%. For the purposes of this study, the allocation of input and output data is based on weight (whey is 83.5% of the products/byproducts by weight). Because 8.5 times more whey is made for each pound of cheese, less cheese needs to be made to make one pound of whey. This essentially equally distributes the inputs/outputs by weight evenly across the various products and byproducts (e.g., the footprint of 1 lb of cheese would be the same as a footprint of one lb of whey). Because whey is a byproduct of cheese production, a more appropriate footprint for whey might be to assign to whey the footprint of the materials that it displaces in other applications, but insufficient information is known about the footprints of the various materials that whey displaces to assign an appropriate footprint values. However, LCA Food also accounts for some assumed offset to the footprint by assuming production byproducts displace some animal feed. Overall, this described approach for determining the whey footprint, results in a lower footprint than what is reported for cheese because the footprint is distributed amongst various products/byproducts by weight and constructive use of some byproducts is assumed.

All relevant inputs and outputs are multiplied by 83.5% to allocate the inputs/outputs to whey and multiplied by 0.118 (i.e., 1/8.5) to obtain one unit of whey (rather than 8.5 units). Combined, this is a factor of 0.098.

General Conversion Factors Used in Calculations

3.29	kg/gal	density of diesel (NREL - Crude Oil)
139	Mbtu/gal	heat content of diesel (Climate Leaders)
0.027224	L/tkm	diesel usage per ton-kilometer of transport (NREL)
3.785	L/gal	standard conversion
3.413	Mbtu/kWh	standard conversion
10%		energy loss due to electricity transmission (Gridworks)
33%		thermal efficiency of power plant (Gridworks)
947.8	Mbtu/GJ	standard conversion
263.95	gal/m ³	standard conversion
2.2	lb/kg	standard conversion
2200	lb/ton	standard conversion of pounds to metric tons
0.00755556	lb/lb	ratio of Nox emission to CO2e emission for combustion of diesel in truck (NREL)
0.00015111	lb/lb	ratio of PM emission to CO2e emission for combustion of diesel in truck (NREL)

Energy Footprint

0.157	kg diesel	diesel for farm machinery for crop harvesting associated with one kg of cheese production
0.04772036	gal diesel	diesel for farm machinery for crop harvesting for one kg of cheese
6.6331307	Mbtu diesel	energy from diesel for farm machinery for crop harvesting for one kg of cheese
0	tkm	assume crops are co-located with cows and dairy such that transportation between feed and dairy is 0.
0	L	diesel for transportation (NREL) associated with production of one kg of cheese
0	gal	diesel for transportation (NREL) associated with production of one kg of cheese
0.000	Mbtu	energy from diesel for transportation for production of one kg of cheese
0	kWh	no electricity usage indicated for cheese production without quotas
0.000	Mbtu	no electricity usage indicated for cheese production without quotas
0.0	Mbtu	no electricity usage indicated for cheese production without quotas
0.0	Mbtu	no electricity usage indicated for cheese production without quotas
0.013	GJ	energy for heat for industrial processing of one kg of cheese
12.4	Mbtu	energy for heat for producing one kg of cheese
19.0	Mbtu/kg	total energy for producing 1 kg of cheese
1.87	Mbtu/lb	total energy for producing 1 lb of cheese whey solids (apply allocation conversion factor of 0.098)

Electricity Footprint

N/A	kWh	no electricity usage indicated for cheese production without quotas
N/A	kWh	no electricity usage indicated for cheese production without quotas
N/A	kWh	no electricity usage indicated for cheese production without quotas

Water Footprint

N/A	m ³	information not available for cheese processing without quotas
N/A	gal	information not available for cheese processing without quotas
N/A	1000 gals.	information not available for cheese processing without quotas
N/A	1000 gals.	information not available for cheese processing without quotas
N/A	1000 gals.	information not available for cheese processing without quotas

Carbon Footprint

11,200.0	g/kg	carbon dioxide equivalents emitted per production of one kg of cheese (ex dairy)
11.20	lb/lb	carbon dioxide equivalents emitted per production of one pound of cheese
1.10	lb/lb	carbon dioxide equivalents emitted per pound of cheese whey solids (apply factor of 0.098)

NOx Footprint

11,200.0	g/kg	carbon dioxide equivalents emitted per production of one kg of cheese
84.6222	g/kg	approximated NOx equivalents emitted per production of one kg of cheese based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions
0.0846	lb/lb	approximated NOx equivalents emitted per production of one pound of cheese based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions
0.0083	lb/lb	approximated NOx equivalents emitted per production of one pound of cheese whey solids based on scaling the carbon equivalent by the ratio of Nox:CO2e (apply factor of 0.098) emissions

SOx Footprint

101.0	g/kg	SOx equivalents emitted per production of one kg of cheese
0.1010	lb/lb	SOx equivalents emitted per production of one pound of cheese
0.0099	lb/lb	SOx equivalents emitted per production of one pound of cheese whey solids (apply factor of 0.098)

PM Footprint

11,200.0	g/kg	carbon dioxide equivalents emitted per production of one kg of cheese
1.6924	g/kg	approximated PM equivalents emitted per production of one kg of cheese based on scaling the carbon equivalent by the ratio of PM:CO2e emissions
0.001692	lb/lb	approximated PM equivalents emitted per production of one pound of cheese based on scaling the carbon equivalent by the ratio of PM:CO2e emissions
0.000166	lb/lb	approximated PM equivalents emitted per production of one pound of cheese whey solids based on scaling the carbon equivalent by the ratio of PM:CO2e emissions (apply factor of 0.098)

Insufficient information to estimate other footprints.

References

- Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk, Andersen M and Jensen JD (2003). Marginale producenter af udvalgte
- NREL - Transport - transport, combination truck, diesel powered
- NREL - Crude oil - crude oil, at refinery

"NREL" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.

Derivation of Vegetable Oil Values from LCA Food

The LCA Food database (vegetable oil product and rapeseed crushing process files) provides information for producing vegetable oil, with some of the byproducts used as animal feed. The LCA Food database assumes that some of the offset animal feed is shipped from overseas, which is not likely applicable for farming and vegetable oil production in the U.S.

General Conversion Factors Used in Calculations

3.29	kg/gal	density of diesel (NREL - Crude Oil)
139	Mbtu/gal	heat content of diesel (Climate Leaders)
0.027224	L/tkm	diesel usage per ton-kilometer of transport (NREL)
3.785	L/gal	standard conversion
3.413	Mbtu/kWh	standard conversion
10%		energy loss due to electricity transmission (Gridworks)
33%		thermal efficiency of power plant (Gridworks)
947.8	Mbtu/GJ	standard conversion
263.95	gal/m ³	standard conversion
2.2	lb/kg	standard conversion
2200	lb/ton	standard conversion of pounds to metric tons
0.00755556	lb/lb	ratio of Nox emission to CO2e emission for combustion of diesel in truck (NREL)
0.00015111	lb/lb	ratio of PM emission to CO2e emission for combustion of diesel in truck (NREL)

Energy Footprint

0.102	kg diesel	diesel for farm machinery for crop harvesting associated with one kg of vegetable oil
0.03100304	gal diesel	diesel for farm machinery for crop harvesting for one kg of vegetable oil
4.30942249	Mbtu diesel	energy from diesel for farm machinery for crop harvesting for one kg of vegetable oil
0.22	tkm	transportation of crops to factory for one kg of vegetable oil (assumes no overseas shipment of crops)
0.00598928	L	diesel for transportation (NREL) associated with production of one metric ton of cheese
0.00158237	gal	diesel for transportation (NREL) associated with production of one metric ton of cheese
0.220	Mbtu	energy from diesel for transportation for production of one metric ton of cheese
120	kWh/ton	electricity for crushing rapeseed for production of 1 metric ton of vegetable oil
0.12	kWh/kg	electricity for crushing rapeseed for production of 1 kg of vegetable oil
0.410	Mbtu	energy contained in electricity for producing one kg ton of processed oil
0.5	Mbtu	energy in electricity from power plant (prior to transmission) for producing one kg of processed oil
1.4	Mbtu	energy needed to produce electricity (including transmission losses) for one kg of processed oil
0.0021	GJ	energy for heat for industrial processing of one kg of vegetable oil
1.99	Mbtu	energy for heat for industrial processing of one kg of vegetable oil
7.9	Mbtu/kg	total energy for producing 1 kg of vegetable oil
3.6	Mbtu/lb	total energy for producing 1 lb of vegetable oil

Electricity Footprint

120	kWh/ton	electricity for crushing rapeseed for production of 1 metric ton of vegetable oil
0.12	kWh/kg	electricity for crushing rapeseed for production of 1 kg of vegetable oil
0.055	kWh/lb	electricity for producing 1 lb of vegetable oil
0.000055	MWh/lb	electricity for producing 1 lb of vegetable oil

Water Footprint

200.0	L	water required for processing 1 metric ton of oil (does not include water potentially used for crop irrigation)
52.8	gal	water required for processing 1 metric ton of oil
0.053	1000 gals.	water required for processing 1 metric ton of oil
0.000053	1000 gals.	water required for processing 1 kg of oil
0.000024	1000 gals./lb	water required for processing 1 lb of oil

Carbon Footprint

3,510.0	g/kg	carbon dioxide equivalents emitted per production of one kg of vegetable oil (ex factory)
3.51	lb/lb	carbon dioxide equivalents emitted per production of one pound of oil

NOx Footprint

3,510.0	g/kg	carbon dioxide equivalents emitted per production of one kg of vegetable oi;
26.5200	g/kg	approximated NOx equivalents emitted per production of one kg of vegetable oil based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions
0.0265	lb/lb	approximated NOx equivalents emitted per production of one pound of vegetable oil based on scaling the carbon equivalent by the ratio of Nox:CO2e emissions

SOx Footprint

31.0	g/kg	SOx equivalents emitted per production of one kg of vegetable oil
0.0310	lb/lb	SOx equivalents emitted per production of one pound of vegetable oil

PM Footprint

11,200.0	g/kg	carbon dioxide equivalents emitted per production of one kg of vegetable oil
1.6924	g/kg	approximated PM equivalents emitted per production of one kg of vegetable oil based on scaling the carbon equivalent by the ratio of PM:CO2e emissions
0.001692	lb/lb	approximated PM equivalents emitted per production of one pound of vegetable oil based on scaling the carbon equivalent by the ratio of PM:CO2e emissions

Insufficient information to estimate other footprints.

References

- Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. www.lcafood.dk
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- NREL - Transport - transport, combination truck, diesel powered
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"NREL" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database (www.nrel.gov/lci) maintained by the Alliance for Sustainable Energy, LLC.