

**APPENDIX B**  
**FOOTPRINT CONVERSION FACTORS**

**Default Conversion and Emission Factors**

		Parameters Used, Extracted, Emitted, or Generated On-Site														
		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	
<b>Energy</b>																
Diesel (on-site)	gal	139					22.5	0.17	0.0054	0.0034			0.0003	0	0	0
Gasoline (on-site use)	gal	124					19.6	0.11	0.0045	0.00054			0.0003	0	0	0
Natural gas (on-site use)	ccf	103					12	0.0001	0.0000063	0.0000076			0.29	0	0	0
Diesel (off-site use)	gal	0														
Gasoline (off-site use)	gal	0														
Natural gas (off-site use)	ccf	0														
On-site electricity use	MWh	3413	1													
Electricity transmission	MWh															
Electricity production	MWh															
<b>Materials</b>																
PVC	lb															
HDPE	lb															
Steel	lb															
Stainless Steel	lb															
Gravel/sand	ton															
Cement Grout	dry-ton															
Concrete	tons															
Bentonite	ton															
Regenerated GAC	lbs															
Bioinjection (Molasses)	lbs															
Bioinjection (Cheese Whey)	lbs															
Bioinjection (Vegetable Oil)	lbs															
Diesel Produced	gal															
Gasoline Produced	gal															
Natural Gas Produced	ccf															
Groundwater Extracted On-site	gal x 1000			1		1										
Potable Water Produced	gal x 1000															
Potable Water Transported	gal x 1000															
Potable Water Used	gal x 1000			1	1											
Other On-Site Water Used	gal x 1000			1												
<b>Waste and Other Services</b>																
Off-site waste water treatment	gal x 1000															
Solid Waste Generation	ton									1						
Solid Waste Disposal	ton															
Hazardous Waste Generation	ton										1					
Hazardous Waste Disposal	ton															
Laboratory Analysis	\$															
<b>Other</b>																
On-site process emissions (HAPs)	lbs												1			
On-site process emissions (GHGs)	lbs CO2e						1									

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

**Default Conversion and Emission Factors**

		Parameters Used, Extracted, Emitted, or Generated Off-Site														
		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	lbs
<b>Energy</b>																
Diesel (on-site)	gal															
Gasoline (on-site use)	gal															
Natural gas (on-site use)	ccf															
Diesel (off-site use)	gal	139					22.5	0.17	0.0054	0.0034			0.0003	0	0	0
Gasoline (off-site use)	gal	124					19.6	0.11	0.0045	0.00054			0.0003	0	0	0
Natural gas (off-site use)	ccf	103					12	0.0001	0.0000063	0.0000076			0.29	0	0	0
On-site electricity use	MWh															
Electricity transmission	MWh	410	0.12	0.24	X		190.8	X 0.2328	X 0.636	X 0.00936	X 0.000108	X 0	X 0.048	X 0.000003	X 0.000018	X 2.76E-11
Electricity production	MWh	7800	0.06	X 2	X		1590	X 1.94	X 5.3	X 0.078	X 0.0009	X 0	X 0.4	X 0.000025	X 0.00015	X 2.30E-10
<b>Materials</b>																
PVC	lb	22	0.00056	0.0069			4.1	0.0048	0.0076	0.0012	0.0000022	0.0000016	0.00047	0.00000034	0.00000013	6.9E-09
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
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
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
Gravel/sand	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
Cement Grout	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
Concrete	tons	793	0.026	0.19			335	0.68	0.41	0.0044	2.80258E-08	0	0.011	0.00001	0.000024	1.6E-11
Bentonite	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
Regenerated GAC	lbs	9.6	0.00044	0.0064			2	0.025	0.015	0	0	0	0	0	0	0
Bioinjection (Molasses)	lbs	1.31	0.000005	0.000091			0.4	0.003	0.0026	0.00006	0	0	0	0	0	0
Bioinjection (Cheese Whey)	lbs	1.87	0	0			1.1	0.0083	0.0099	0.000166	0	0	0	0	0	0
Bioinjection (Vegetable Oil)	lbs	3.6	0.000055	0.000024			3.51	0.0265	0.031	0.0017	0	0	0	0	0	0
Diesel Produced	gal	18.5	0.00059	0.00077			2.7	0.0064	0.013	0.00034	0.00000036	0	0.00012	0.000000048	0.0000015	3E-14
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
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
Groundwater Extracted On-site	gal x 1000															
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
Potable Water Transported	gal x 1000	7.4	0.000645995	0.00129199	X		1.027131783	X 0.00125323	X 0.003423773	X 5.03876E-05	X 5.81395E-07	0	0.000258398	X 1.61499E-08	X 9.68992E-08	X 1.48579E-13
Potable Water Used	gal x 1000															
Other On-Site Water Used	gal x 1000															
<b>Waste and Other Services</b>																
Off-site waste water treatment	gal x 1000	370	X 0.018	X 0.084	X		300	X 0.61	X 0.29	X 0.008	X 0.000046	X 0	0.012	X 0.0000081	X 0.000064	X 1.00E-10
Solid Waste Generation	ton															
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
Hazardous Waste Generation	ton															
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
Laboratory Analysis	\$	8.8	0.0005	0.00056			1.3	0.0045	0.003	0.000114	0	0	0.000208	0	0	0
<b>Other</b>																
On-site process emissions (HAPs)	lbs															
On-site process emissions (GHGs)	lbs CO2e															

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

**Actual (Site-Specific) Conversion and Emission Factors**

	Parameters Used, Extracted, Emitted, or Generated On-Site															
	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	lbs	
<b>Energy</b>																
Diesel (on-site)	gal															
Gasoline (on-site use)	gal															
Natural gas (on-site use)	ccf															
Diesel (off-site use)	gal															
Gasoline (off-site use)	gal															
Natural gas (off-site use)	ccf															
On-site electricity use	MWh															
Electricity transmission	MWh															
Electricity production	MWh															
<b>Materials</b>																
PVC/Fiberglass	lb															
HDPE	lb															
Steel	lb															
Stainless Steel	lb															
Gravel/sand	ton															
Cement Grout	dry-ton															
Concrete	tons															
Bentonite	ton															
Regenerated GAC	lbs															
Bioinjection (Molasses)	lbs															
Bioinjection ( Cheese Whey)	lbs															
Bioinjection (Vegetable Oil)	lbs															
Diesel Produced	gal															
Gasoline Produced	gal															
Natural Gas Produced	ccf															
Groundwater extracted	gal x 1000															
Potable Water Produced	gal x 1000															
Potable Water Transported	gal x 1000															
Potable Water Used	gal x 1000															
Other Water Used	gal x 1000															
<b>Waste and Other Services</b>																
Off-site waste water treatment	gal x 1000															
Solid Waste Generation	ton															
Solid Waste Disposal	ton															
Hazardous Waste Generation	ton															
Hazardous Waste Disposal	ton															
Laboratory Analysis	\$															
<b>Other</b>																
On-site process emissions (HAPs)	lbs															
On-site process emissions (GHGs)	lbs CO2e															

Notes: A blank value in this table will result in the default value being used. A value in this table will override the default value.

Actual (Site-Specific) Conversion and Emission Factors

		Parameters Used, Extracted, Emitted, or Generated Off-Site														
		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	
<b>Energy</b>																
Diesel (on-site)	gal															
Gasoline (on-site use)	gal															
Natural gas (on-site use)	ccf															
Diesel (off-site use)	gal															
Gasoline (off-site use)	gal															
Natural gas (off-site use)	ccf															
On-site electricity use	MWh															
Electricity transmission	MWh			0			0	0	0	0	0	0	0	0	0	0
Electricity production	MWh		0.06	7.3			800	0.84	6.7	0.087	0.0009	0	0.017	0.0000026	0.000031	8.60E-12
<b>Materials</b>																
PVC/Fiberglass	lb															
HDPE	lb															
Steel	lb															
Stainless Steel	lb															
Gravel/sand	ton															
Cement Grout	dry-ton															
Concrete	tons															
Bentonite	ton															
Regenerated GAC	lbs															
Bioinjection (Molasses)	lbs															
Bioinjection ( Cheese Whey)	lbs															
Bioinjection (Vegetable Oil)	lbs															
Diesel Produced	gal															
Gasoline Produced	gal															
Natural Gas Produced	ccf															
Groundwater extracted	gal x 1000															
Potable Water Produced	gal x 1000															
Potable Water Transported	gal x 1000			0.004715762			0.516795866	0.000542636	0.004328165	5.62016E-05		0	2.67054E-06	3.88501E-08	2.94444E-14	
Potable Water Used	gal x 1000															
Other Water Used	gal x 1000															
<b>Waste and Other Services</b>																
Off-site waste water treatment	gal x 1000	3.7	0.00018	0.00084			3	0.0061	0.0029	0.00008	0.00000046		0.00012	0.000000081	0.00000064	1.00E-12
Solid Waste Generation	ton															
Solid Waste Disposal	ton															
Hazardous Waste Generation	ton															
Hazardous Waste Disposal	ton															
Laboratory Analysis	\$															
<b>Other</b>																
On-site process emissions (HAPs)	lbs															
On-site process emissions (GHGs)	lbs CO2e															

Notes: A blank value in this table will result in the default value being used. A value in this table will override the default value.

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Diesel on-site use and 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	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	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)	
	Hazardous 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	0.0003	lbs/gal	EUROPA ELCD - Sum of all HAPs (which is limited to benzene, toluene, and xylenes), emitted per unit of fuel combusted for lorry transport. Mass of HAPs to mass of diesel is converted to mass of HAPs to gallons of diesel assuming 7.5 pounds per gallon.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): <a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml</a>
	Mercury Released	0	lbs/gal	EUROPA ELCD - Reference does not indicate a release of mercury.	
	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](http://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 and off-site use	Energy Used	124	Mbtu/gal	The reference provides the higher heating value of diesel 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 natural gas is combusted on-site or in transportation	
	All Water Used		gal x 1000/gal	not applicable -- no water used when natural gas is combusted on-site or in transportation	
	Potable Water Used		gal x 1000/gal	not applicable -- no water used when natural gas is combusted on-site or in transportation	
	Groundwater Extracted		gal x 1000/gal	not applicable -- no water used when natural gas is combusted on-site or in transportation	
	CO2e Emitted	19.6	lbs/gal	The reference provides CO2e emitted as 19.4 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	0.11	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)	
	Hazardous 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	0.0003	lbs/gal	not available in referenced life-cycle inventory databases. Temporarily assume that it is equal to that of diesel although the HAP emissions for gasoline are likely higher.	EUROPA file location: Lorry transport; Euro 0, 1, 2, 3, 4 mix; 22 t total weight, 17,3 t max payload (excluding fuel supply): <a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/elcd/processes/b444f4d2-3393-11dd-bd11-0800200c9a66_02.00.000.xml</a>
	Mercury Released	0	lbs/gal	not available in referenced life-cycle inventory databases. Assume that it is similar to that of diesel	
	Lead Released	0	lbs/gal	not available in referenced life-cycle inventory databases. Assume that it is similar to that of diesel	
Dioxins Released	0	lbs/gal	not available in referenced life-cycle inventory databases. Assume that it is similar to that of diesel		

"NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database ([www.nrel.gov/lci](http://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 and 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	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	0.0001	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	0.0000076	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	
	Hazardous Waste Generated		tons/ccf	not applicable -- no haz waste generated when natural gas is combusted on-site or in transportation	
	Air Toxics Emitted	0.29	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	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	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](http://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 Used	Energy Used		Mbtu/MWh	Standard conversion of 3,413 btus per kWh or 3,413 Mbtus per MWh.	
	Electricity Used		MWh/MWh	One to one ratio of electricity use input to electricity use output	
	All Water Used		gal x 1000/MWh	not applicable -- no water used when electricity is used on-site or in transportation	
	Potable Water Used		gal x 1000/MWh	not applicable -- no water used when electricity is used on-site or in transportation	
	Groundwater Extracted		gal x 1000/MWh	not applicable -- no water used when electricity is used on-site or in transportation	
	CO2e Emitted		lbs/MWh	not applicable -- no CO2 emitted when electricity is used on-site or in transportation	
	NO x Emitted		lbs/MWh	not applicable -- no NO x emitted when electricity is used on-site or in transportation	
	SO x Emitted		lbs/MWh	not applicable -- no SO x emitted when electricity is used on-site or in transportation	
	PM Emitted		lbs/MWh	not applicable -- no PM emitted when electricity is used on-site or in transportation	
	Solid Waste Generated		tons/MWh	not applicable -- no solid waste generated when electricity is used on-site or in transportation	
	Hazardous Waste Generated		tons/MWh	not applicable -- no haz waste generated when electricity is used on-site or in transportation	
	Air Toxics Emitted		lbs/MWh	not applicable -- no air toxics emitted when electricity is used on-site or in transportation	
	Mercury Released		lbs/MWh	not applicable -- no Hg released when electricity is used on-site or in transportation	
	Lead Released		lbs/MWh	not applicable -- no Pb released when electricity is used on-site or in transportation	
Dioxins Released		lbs/MWh	not applicable -- no dioxins released when electricity is used on-site or in transportation		

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Electricity Transmitted	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 <a href="http://sites.energetics.com/gridworks/grid.html">http://sites.energetics.com/gridworks/grid.html</a>                       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	190.8	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	0.2328	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	0.636	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	PM Emitted	0.00936	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	
	Hazardous 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	0.000003	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
	Lead Released	0.000018	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using U.S. average fuel blend for electricity production	
Dioxins Released	2.76E-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
Electricity Produced	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 <a href="http://sites.energetics.com/gridworks/grid.html">http://sites.energetics.com/gridworks/grid.html</a>  Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905
	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.	
	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	1590	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	1.94	lbs/MWh		
	SO x Emitted	5.3	lbs/MWh		
	PM Emitted	0.078	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) <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/001b3cb7-b868-4061-8a91-3e6d7bcc90c6_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/001b3cb7-b868-4061-8a91-3e6d7bcc90c6_02.00.000.html</a>
	Hazardous 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	0.000025	lbs/MWh		
	Lead Released	0.00015	lbs/MWh		
Dioxins Released	2.3E-10	lbs/MWh			

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
PVC for resin only pipe extrusion not included	Energy Used	22	Mbtu/lb	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 location: Suspension Polymerisation PVC: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/129b8f8d-7667-41bc-91f4-421bfcd8c3_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/129b8f8d-7667-41bc-91f4-421bfcd8c3_02.00.000.html</a>
	Electricity Used	0.00056	MWh/lb	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/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 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	4.1	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	0.0048	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	0.0076	lbs/lb	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per pound of product.	
	PM Emitted	0.0012	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	0.0000022	tons/lb	EUROPA ELCD - Sum of all wastes except for mine wastes and toxic chemical wastes.	
	Hazardous Waste Generated	0.0000016	tons/lb	EUROPA ELCD - "Chemical waste, toxic" converted into tons per pound of product.	
	Air Toxics Emitted	0.00047	lbs/lb	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere.	
	Mercury Released	0.00000034	lbs/lb	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water.	
	Lead Released	0.00000013	lbs/lb	EUROPA ELCD - Sum of all lead and lead compounds released to air or water.	
Dioxins Released	6.9E-09	lbs/lb	EUROPA ELCD - Sum of all dioxins released to air or water.		

EUROPA ELCD 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/lcainfohub/datasetArea.vm>)

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
HDPE for resin only pipe extrusion not included	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: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/0704c700-2fb0-43c5-8803-bed8a6f1b968_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/0704c700-2fb0-43c5-8803-bed8a6f1b968_02.00.000.html</a>
	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.	
	Hazardous 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.		

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**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Steel excludes forming or casting into final product	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:<a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/f9d4581e-14de-417e-8f9f-6c74e6f14051_02.00.000.html">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/f9d4581e-14de-417e-8f9f-6c74e6f14051_02.00.000.html</a>                      Steel hot rolled coil:  <a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html</a>                      Steel rebar:  <a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/268a11fb-baf2-4b9e-8867-38bea0e76ef6_02.00.000.html">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/268a11fb-baf2-4b9e-8867-38bea0e76ef6_02.00.000.html</a></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.	
	Hazardous 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.		

*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
Stainless Steel excludes forming or casting into final product	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: <a href="http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html">http://lca.jrc.ec.europa.eu/lcaifohub/datasets/html/processes/119e8cc1-0859-45ca-8f63-93a8a518ffd2_02.00.000.html</a>
	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.	
	Hazardous 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.		

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(<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
Gravel/sand	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: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/898618b2-3306-11dd-bd11-0800200c9a66_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/898618b2-3306-11dd-bd11-0800200c9a66_02.00.000.html</a>
	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).	
	Hazardous 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.		

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/lcainfohub/datasetArea.vm>)



**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Cement Grout	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: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/600573dd-dfa5-44e5-b458-8727e793ffd7_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/600573dd-dfa5-44e5-b458-8727e793ffd7_02.00.000.html</a></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).	
	Hazardous 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.		

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**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Concrete	Energy Used	793	Mbtu/tons	Energy and all parameters calculated using values for potable water, sand/gravel, and cement grout assuming a 0.45:1:4 ration 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	0.026	MWh/tons		
	All Water Used	0.19	gal x 1000/tons		
	Potable Water Used		gal x 1000/tons		
	Groundwater Extracted		gal x 1000/tons		
	CO2e Emitted	335	lbs/tons		
	NO x Emitted	0.68	lbs/tons		
	SO x Emitted	0.41	lbs/tons		
	PM Emitted	0.0044	lbs/tons		
	Solid Waste Generated	2.80258E-08	tons/tons		
	Hazardous Waste Generated	0	tons/tons		
	Air Toxics Emitted	0.011	lbs/tons		
	Mercury Released	0.00001	lbs/tons		
	Lead Released	0.000024	lbs/tons		
Dioxins Released	1.6E-11	lbs/tons			

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Bentonite LCI data not available, Sand/gravel data used as a proxy	Energy Used	55	Mbtu/ton	EUROPA ELCD - All forms of energy summed and converted to Mbtus per short ton of product.	EUROPA file <u>Location</u> : Gravel 2/32: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/898618b2-3306-11dd-bd11-0800200c9a66_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/898618b2-3306-11dd-bd11-0800200c9a66_02.00.000.html</a>
	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).	
	Hazardous 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.		

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**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Regenerated GAC (including production of original virgin GAC)	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.	
	Hazardous 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
Bioinjection (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. <a href="http://www.lcafood.dk">www.lcafood.dk</a></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	
	Hazardous 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
Bioinjection (Cheese Whey Solids)	Energy Used	1.87	Mbtu/lbs	See attached support file titled "Derivation of Cheese Whey Values from LCA Food"	<p align="center">- Nielsen PH, Nielsen AM, Weidema BP, Dalgaard R and Halberg N (2003). LCA food data base. <a href="http://www.lcafood.dk">www.lcafood.dk</a></p> <p align="center">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	
	Hazardous 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
Bioinjection (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. <a href="http://www.lcafood.dk">www.lcafood.dk</a></p> <p>Landbrugets rådgivningscenter (2000). Tal fra Fodermiddeltabellen, Rapport 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	As calculated by NREL, replacing palm kernels with soybeans as stated below.	
	All Water Used	0.000024	gal x 1000/lbs	As calculated by NREL, replacing palm kernels with soybeans as stated below.	
	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	As calculated using NREL LCI with the following exceptions: - oil assumed to come from soybeans grown in the U.S. instead of palm kernels - assume NREL process for palm kernel oil is appropriate for soybean oil - no ocean freight transport assumed - soy beans are 20% oil and palm kernels are 50% oil such that 50/20 times more mass of soybeans is needed in the NREL calculations.	
	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	
	Hazardous 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		

"NREL LCI" refers to the U.S. Dept. of Energy, National Renewable Energy Laboratory (NREL), Life-Cycle Inventory Database ([www.nrel.gov/lci](http://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
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:  <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/244524ed-7b85-4548-b345-f58dc5cf9dac_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/244524ed-7b85-4548-b345-f58dc5cf9dac_02.00.000.html</a> </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.	
	Hazardous 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.		

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**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:  <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/5f62ed77-85d0-4c99-8d2c-be56951d8fb3_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/5f62ed77-85d0-4c99-8d2c-be56951d8fb3_02.00.000.html</a> </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.	
	Hazardous 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.		

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**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: <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/3d602e55-aaa2-44e3-adb9-40f49eb1a915_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/3d602e55-aaa2-44e3-adb9-40f49eb1a915_02.00.000.html</a>
	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).	
	Hazardous 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.		

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**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>EUROPA file location: Drinking water from surface water and drinking water from groundwater:  <a href="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/db009014-338f-11dd-bd11-0800200c9a66_02.00.000.html</a>  <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/db009013-338f-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</a></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	0.000000834	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.	
	Hazardous 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	0.000000067	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.		

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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	1.027131783	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	0.00125323	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	0.003423773	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	5.03876E-05	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.	
	Hazardous 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	1.61499E-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	9.68992E-08	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	1.48579E-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
Potable water used	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used		gal x 1000/gal x 1000	One to one ratio of input to output. Energy and other parameters determined as part of the extraction process and accounted for elsewhere in footprinting process.	
	Potable Water Used		gal x 1000/gal x 1000	One to one ratio of input to output. Energy and other parameters determined as part of the extraction process and accounted for elsewhere in footprinting process.	
	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		
	Hazardous 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			

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Other water used	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used		gal x 1000/gal x 1000	One to one ratio of input to output. Energy and other parameters determined as part of the extraction process and accounted for elsewhere in footprinting process.	
	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		
	Hazardous 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			

**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Off-site wastewater treatment	Energy Used	370	Mbtu/gal x 1000	EUROPA ELCD - All forms of energy summed and converted to Mbtus per 1000 gallons treated.	<p align="center">EUROPA ECLD file location:                      Waste water treatment; industrial waste water according to the Directive 91/271/EEC concerning urban waste water treatment; at waste water treatment plant; slightly organic contaminated</p> <p align="center"><a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/db00901e-338f-11dd-bd11-0800200c9a66_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/db00901e-338f-11dd-bd11-0800200c9a66_02.00.000.html</a></p>
	Electricity Used	0.018	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%)	
	All Water Used	0.084	gal x 1000/gal x 1000	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 1000 gallons treated.	
	Potable Water Used		gal x 1000/gal x 1000	Not applicable -- no local potable water used during waste water treatment.	
	Groundwater Extracted		gal x 1000/gal x 1000	Not applicable -- no local or on-site ground water extracted during waste water treatment.	
	CO2e Emitted	300	lbs/gal x 1000	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 1000 gallons treated.	
	NO x Emitted	0.61	lbs/gal x 1000	EUROPA ELCD - Sum of nitrogen oxides emitted to atmosphere. Results converted to pounds of NO x per 1000 gallons treated.	
	SO x Emitted	0.29	lbs/gal x 1000	EUROPA ELCD - Sum of sulfur oxides emitted to atmosphere. Results converted to pounds of SO x per 1000 gallons treated.	
	PM Emitted	0.008	lbs/gal x 1000	EUROPA ELCD - Sum of particulate matter (PM 10 and smaller) emitted to atmosphere. Results converted to pounds of PM per 1000 gallons treated.	
	Solid Waste Generated	0.000046	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.	
	Hazardous 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	0.012	lbs/gal x 1000	EUROPA ELCD - Sum of all hazardous air pollutants and groups of contaminants as defined by EPA (HAPs) emitted to atmosphere. Reported as pounds per 1000 gallons treated.	
	Mercury Released	0.0000081	lbs/gal x 1000	EUROPA ELCD - Sum of all mercury and mercury compounds released to air or water. Reported as pounds per 1000 gallons treated.	
	Lead Released	0.000064	lbs/gal x 1000	EUROPA ELCD - Sum of all lead and lead compounds released to air or water. Reported as pounds per 1000 gallons treated.	
Dioxins Released	1E-10	lbs/gal x 1000	EUROPA ELCD - Sum of all dioxins released to air or water. Reported as pounds per 1000 gallons treated.		

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**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Solid waste generated	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	One to one ratio of input to output. Energy and all other parameters for disposal are accounted for in "solid waste disposal".	
	Hazardous 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
Solid waste disposal does not include transport	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:  <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/64197304-3307-11dd-bd11-0800200c9a66_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/64197304-3307-11dd-bd11-0800200c9a66_02.00.000.html</a></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.	
	Hazardous 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	0.00000097	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.		

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**Default Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator	Value	Units	Assumptions	Information Source
Hazardous waste generated	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		
	Hazardous Waste Generated		tons/ton	One to one ratio of input to output. Energy and all other parameters for disposal are accounted for in "solid waste disposal".	
	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
Hazardous waste disposal does not include transport	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		
	Hazardous 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
Laboratory Analysis	Energy Used	8.8	Mbtu/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Footprint calculated using values for electricity production, diesel use, and diesel production). Assume an approximate electricity cost of \$0.10 per kWh and \$2.50 per gallon of diesel.	
	Electricity Used	0.0005	MWh/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Footprint calculated using values for electricity production, diesel use, and diesel production). Assume an approximate electricity cost of \$0.10 per kWh and \$2.50 per gallon of diesel.	
	All Water Used	0.00056	gal x 1000/\$	Assume 5 gallon per \$100 (i.e., approximately 1 gallon per sample) in addition to water use associated with energy.	
	Potable Water Used		gal x 1000/\$	Not applicable -- no local potable water used during sample analysis.	
	Groundwater Extracted		gal x 1000/\$	Not applicable -- no local or on-site ground water extracted during sample analysis.	
	CO2e Emitted	1.3	lbs/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Calculate footprint using values for electricity production, diesel use, and diesel production).	
	NO x Emitted	0.0045	lbs/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Calculate footprint using values for electricity production, diesel use, and diesel production).	
	SO x Emitted	0.003	lbs/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Calculate footprint using values for electricity production, diesel use, and diesel production).	
	PM Emitted	0.000114	lbs/\$	Assume 10% of each dollar is spent on energy (50% electricity and 50% diesel fuel) whether that energy be directly used or used in the manufacturing of bottlere, preservatives, or other disposable supplies. Calculate footprint using values for electricity production, diesel use, and diesel production).	
	Solid Waste Generated	0	tons/\$	Insufficient information available. Parameter to be updated when additional information is available.	
	Hazardous Waste Generated	0	tons/\$	Insufficient information available. Parameter to be updated when additional information is available.	
	Air Toxics Emitted	0.000208	lbs/\$	Insufficient information available. Parameter to be updated when additional information is available.	
	Mercury Released	0	lbs/\$	Insufficient information available. Parameter to be updated when additional information is available.	
	Lead Released	0	lbs/\$	Insufficient information available. Parameter to be updated when additional information is available.	
Dioxins Released	0	lbs/\$	Insufficient information available. Parameter to be updated when additional information is available.		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Diesel on-site use and off-site use	Energy Used		Mbtu/gal		
	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		lbs/gal		
	NO x Emitted		lbs/gal		
	SO x Emitted		lbs/gal		
	PM Emitted		lbs/gal		
	Solid Waste Generated		tons/gal		
	Hazardous Waste Generated		tons/gal		
	Air Toxics Emitted		lbs/gal		
	Mercury Released		lbs/gal		
	Lead Released		lbs/gal		
Dioxins Released		lbs/gal			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Gasoline on-site use and off-site use	Energy Used		Mbtu/gal		
	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		lbs/gal		
	NO x Emitted		lbs/gal		
	SO x Emitted		lbs/gal		
	PM Emitted		lbs/gal		
	Solid Waste Generated		tons/gal		
	Hazardous Waste Generated		tons/gal		
	Air Toxics Emitted		lbs/gal		
	Mercury Released		lbs/gal		
	Lead Released		lbs/gal		
Dioxins Released		lbs/gal			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Natural Gas on-site use and off-site use	Energy Used		Mbtu/ccf		
	Electricity Used		MWh/ccf		
	All Water Used		gal x 1000/ccf		
	Potable Water Used		gal x 1000/ccf		
	Groundwater Extracted		gal x 1000/ccf		
	CO2e Emitted		lbs/ccf		
	NO x Emitted		lbs/ccf		
	SO x Emitted		lbs/ccf		
	PM Emitted		lbs/ccf		
	Solid Waste Generated		tons/ccf		
	Hazardous Waste Generated		tons/ccf		
	Air Toxics Emitted		lbs/ccf		
	Mercury Released		lbs/ccf		
	Lead Released		lbs/ccf		
Dioxins Released		lbs/ccf			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator		Assumptions	Information Source
Electricity Used	Energy Used		Mbtu/MWh	
	Electricity Used		MWh/MWh	
	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	
	Hazardous Waste Generated		tons/MWh	
	Air Toxics Emitted		lbs/MWh	
	Mercury Released		lbs/MWh	
	Lead Released		lbs/MWh	
Dioxins Released		lbs/MWh		



**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Electricity Transmitted	Energy Used		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 <a href="http://sites.energetics.com/gridworks/grid.html">http://sites.energetics.com/gridworks/grid.html</a>                       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	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	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	potable water not delineated separately from "all water use" for off-site usage	
	Groundwater Extracted		gal x 1000/MWh	potable water not delineated separately from "all water use" for off-site usage	
	CO2e Emitted	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	NO x Emitted	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	SO x Emitted	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	PM Emitted	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Solid Waste Generated	0	tons/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Hazardous Waste Generated	0	tons/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Air Toxics Emitted	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Mercury Released	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
	Lead Released	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production	
Dioxins Released	0	lbs/MWh	Footprint associated with electricity that is generated but lost to transmission, using local fuel blend for electricity production		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Electricity (includes electricity produced but lost in transmission and distribution) Produced	Energy Used		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 <a href="http://sites.energetics.com/gridworks/grid.html">http://sites.energetics.com/gridworks/grid.html</a>  Consumptive Water Use for U.S. Power Production December 2003 • NREL/TP-550-33905
	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.	
	All Water Used	7.3	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 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.	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" for off-site usage	
	Groundwater Extracted		gal x 1000/MWh	potable water not delineated separately from "all water use" for off-site usage	
	CO2e Emitted	800	lbs/MWh	Actual values for emissions for electricity production calculated based upon the fuel blend for the local electricity provider (PG&E). According to the August 2009 Power Content Label, PG&E Power Mix includes 47% Natural Gas, 20% Nuclear, 20% Hydroelectric, 4% geothermal, 3% wind, 4% biomass/waste, <1% solar, and 2% Coal as the power sources. All environmental footprint conversion numbers were adjusted to the percentages listed on the PG&E Power Content Label. Negligible emissions assumed for hydroelectric, geothermal, wind, and solar energy. Emissions of CO2e, NOx, SOx, and PM for all fuel blends calculated using NREL LCI and includes resource extraction, transportation, and power generation. 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).  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	0.84	lbs/MWh		
	SO x Emitted	6.7	lbs/MWh		
	PM Emitted	0.087	lbs/MWh		
	Solid Waste Generated	0.0009	tons/MWh		EUROPA file location: Process data set: Electricity Mix; AC; consumption mix, at consumer; < 1kV (en) <a href="http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/001b3cb7-b868-4061-8a91-3e6d7bcc90c6_02.00.000.html">http://lca.jrc.ec.europa.eu/lcainfohub/datasets/html/processes/001b3cb7-b868-4061-8a91-3e6d7bcc90c6_02.00.000.html</a>
	Hazardous Waste Generated		tons/MWh		
	Air Toxics Emitted	0.017	lbs/MWh		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	0.0000026	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.	
	Lead Released	0.000031	lbs/MWh	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).	
Dioxins Released	8.6E-12	lbs/MWh			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
PVC for resin only pipe extrusion not included	Energy Used		Mbtu/lb		
	Electricity Used		MWh/lb		
	All Water Used		gal x 1000/lb		
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted		lbs/lb		
	NO x Emitted		lbs/lb		
	SO x Emitted		lbs/lb		
	PM Emitted		lbs/lb		
	Solid Waste Generated		tons/lb		
	Hazardous Waste Generated		tons/lb		
	Air Toxics Emitted		lbs/lb		
	Mercury Released		lbs/lb		
	Lead Released		lbs/lb		
Dioxins Released		lbs/lb			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
HDPE for resin only pipe extrusion not included	Energy Used		Mbtu/lb		
	Electricity Used		MWh/lb		
	All Water Used		gal x 1000/lb		
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted		lbs/lb		
	NO x Emitted		lbs/lb		
	SO x Emitted		lbs/lb		
	PM Emitted		lbs/lb		
	Solid Waste Generated		tons/lb		
	Hazardous Waste Generated		tons/lb		
	Air Toxics Emitted		lbs/lb		
	Mercury Released		lbs/lb		
	Lead Released		lbs/lb		
Dioxins Released		lbs/lb			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Steel excludes forming or casting of final product	Energy Used		Mbtu/lb		
	Electricity Used		MWh/lb		
	All Water Used		gal x 1000/lb		
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted		lbs/lb		
	NO x Emitted		lbs/lb		
	SO x Emitted		lbs/lb		
	PM Emitted		lbs/lb		
	Solid Waste Generated		tons/lb		
	Hazardous Waste Generated		tons/lb		
	Air Toxics Emitted		lbs/lb		
	Mercury Released		lbs/lb		
	Lead Released		lbs/lb		
Dioxins Released		lbs/lb			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Stainless Steel excludes forming or casting of final product	Energy Used		Mbtu/lb		
	Electricity Used		MWh/lb		
	All Water Used		gal x 1000/lb		
	Potable Water Used		gal x 1000/lb		
	Groundwater Extracted		gal x 1000/lb		
	CO2e Emitted		lbs/lb		
	NO x Emitted		lbs/lb		
	SO x Emitted		lbs/lb		
	PM Emitted		lbs/lb		
	Solid Waste Generated		tons/lb		
	Hazardous Waste Generated		tons/lb		
	Air Toxics Emitted		lbs/lb		
	Mercury Released		lbs/lb		
	Lead Released		lbs/lb		
Dioxins Released		lbs/lb			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Gravel/sand	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		
	Hazardous Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
Dioxins Released		lbs/ton			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Cement Grout	Energy Used		Mbtu/dry-ton		
	Electricity Used		MWh/dry-ton		
	All Water Used		gal x 1000/dry-ton		
	Potable Water Used		gal x 1000/dry-ton		
	Groundwater Extracted		gal x 1000/dry-ton		
	CO2e Emitted		lbs/dry-ton		
	NO x Emitted		lbs/dry-ton		
	SO x Emitted		lbs/dry-ton		
	PM Emitted		lbs/dry-ton		
	Solid Waste Generated		tons/dry-ton		
	Hazardous Waste Generated		tons/dry-ton		
	Air Toxics Emitted		lbs/dry-ton		
	Mercury Released		lbs/dry-ton		
	Lead Released		lbs/dry-ton		
Dioxins Released		lbs/dry-ton			



**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Concrete	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		
	Hazardous Waste Generated		tons/tons		
	Air Toxics Emitted		lbs/tons		
	Mercury Released		lbs/tons		
	Lead Released		lbs/tons		
Dioxins Released		lbs/tons			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Bentonite LCI data not available, Sand/gravel data used as a proxy	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		
	Hazardous Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
Dioxins Released		lbs/ton			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Regenerated GAC (including production of original virgin GAC)	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		
	Hazardous Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
Dioxins Released		lbs/lbs			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Bioinjection (Molasses)	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		
	Hazardous Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
Dioxins Released		lbs/lbs			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Bioinjection (Cheese Whey Solids)	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		
	CO <sub>2</sub> e Emitted		lbs/lbs		
	NO <sub>x</sub> Emitted		lbs/lbs		
	SO <sub>x</sub> Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Hazardous Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
Dioxins Released		lbs/lbs			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Bioinjection (Vegetable oil)	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		
	CO <sub>2</sub> e Emitted		lbs/lbs		
	NO <sub>x</sub> Emitted		lbs/lbs		
	SO <sub>x</sub> Emitted		lbs/lbs		
	PM Emitted		lbs/lbs		
	Solid Waste Generated		tons/lbs		
	Hazardous Waste Generated		tons/lbs		
	Air Toxics Emitted		lbs/lbs		
	Mercury Released		lbs/lbs		
	Lead Released		lbs/lbs		
Dioxins Released		lbs/lbs			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Diesel produced	Energy Used		Mbtu/gal		
	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		lbs/gal		
	NO x Emitted		lbs/gal		
	SO x Emitted		lbs/gal		
	PM Emitted		lbs/gal		
	Solid Waste Generated		tons/gal		
	Hazardous Waste Generated		tons/gal		
	Air Toxics Emitted		lbs/gal		
	Mercury Released		lbs/gal		
	Lead Released		lbs/gal		
Dioxins Released		lbs/gal			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Gasoline produced	Energy Used		Mbtu/gal		
	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		lbs/gal		
	NO x Emitted		lbs/gal		
	SO x Emitted		lbs/gal		
	PM Emitted		lbs/gal		
	Solid Waste Generated		tons/gal		
	Hazardous Waste Generated		tons/gal		
	Air Toxics Emitted		lbs/gal		
	Mercury Released		lbs/gal		
	Lead Released		lbs/gal		
Dioxins Released		lbs/gal			



**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Natural gas produced	Energy Used		Mbtu/ccf		
	Electricity Used		MWh/ccf		
	All Water Used		gal x 1000/ccf		
	Potable Water Used		gal x 1000/ccf		
	Groundwater Extracted		gal x 1000/ccf		
	CO2e Emitted		lbs/ccf		
	NO x Emitted		lbs/ccf		
	SO x Emitted		lbs/ccf		
	PM Emitted		lbs/ccf		
	Solid Waste Generated		tons/ccf		
	Hazardous Waste Generated		tons/ccf		
	Air Toxics Emitted		lbs/ccf		
	Mercury Released		lbs/ccf		
	Lead Released		lbs/ccf		
Dioxins Released		lbs/ccf			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Potable water produced	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used		gal x 1000/gal x 1000		
	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		
	Hazardous 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			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Potable water transported	Energy Used		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		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	0.004715762	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	0.516795866	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	0.000542636	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	0.004328165	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	5.62016E-05	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		tons/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.	
	Hazardous Waste Generated		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	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	2.67054E-06	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	3.88501E-08	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	2.94444E-14	lbs/gal x 1000	Calculated based on calculated "electricity used". Default value uses default electricity parameters and actual value uses actual electricity parameters.		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator		Assumptions	Information Source
Potable water used	Energy Used		Mbtu/gal x 1000	
	Electricity Used		MWh/gal x 1000	
	All Water Used		gal x 1000/gal x 1000	
	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	
	Hazardous 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		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Other water used	Energy Used		Mbtu/gal x 1000		
	Electricity Used		MWh/gal x 1000		
	All Water Used		gal x 1000/gal x 1000		
	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		
	Hazardous 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			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Off-site wastewater treatment	Energy Used	3.7	Mbtu/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Electricity Used	0.00018	MWh/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	All Water Used	0.00084	gal x 1000/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Potable Water Used		gal x 1000/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Groundwater Extracted		gal x 1000/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	CO2e Emitted	3	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	NO x Emitted	0.0061	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	SO x Emitted	0.0029	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	PM Emitted	0.00008	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Solid Waste Generated	0.00000046	tons/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Hazardous Waste Generated		tons/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Air Toxics Emitted	0.00012	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Mercury Released	0.000000081	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
	Lead Released	0.00000064	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.	
Dioxins Released	1E-12	lbs/gal x 1000	Actual values are 1% of default values to represent lower level of contamination relative to typical industrial waste water.		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator		Assumptions	Information Source
Solid waste generated	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	
	Hazardous Waste Generated		tons/ton	
	Air Toxics Emitted		lbs/ton	
	Mercury Released		lbs/ton	
	Lead Released		lbs/ton	
Dioxins Released		lbs/ton		

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Solid waste disposal does not include transport	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		
	Hazardous Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
Dioxins Released		lbs/ton			



**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Hazardous waste generated	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		
	Hazardous Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
Dioxins Released		lbs/ton			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Hazardous waste disposal does not include transport	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		
	Hazardous Waste Generated		tons/ton		
	Air Toxics Emitted		lbs/ton		
	Mercury Released		lbs/ton		
	Lead Released		lbs/ton		
Dioxins Released		lbs/ton			

**Actual (Site-Specific) Environmental Footprint Conversion Factor References**

Material/Fuel/Service	Green Indicator			Assumptions	Information Source
Laboratory Analysis	Energy Used		Mbtu/\$		
	Electricity Used		MWh/\$		
	All Water Used		gal x 1000/\$		
	Potable Water Used		gal x 1000/\$		
	Groundwater Extracted		gal x 1000/\$		
	CO2e Emitted		lbs/\$		
	NO x Emitted		lbs/\$		
	SO x Emitted		lbs/\$		
	PM Emitted		lbs/\$		
	Solid Waste Generated		tons/\$		
	Hazardous Waste Generated		tons/\$		
	Air Toxics Emitted		lbs/\$		
	Mercury Released		lbs/\$		
	Lead Released		lbs/\$		
Dioxins Released		lbs/\$			

**Power Sources and Global Emissions Factors for Electricity Provided by PG&E**

Type	Percentage Used*	Water (gal/kWh)		CO2e (lbs/kWh)		NOx (lbs/kWh)		SOx (lbs/kWh)		PM (lbs/kWh)	
		Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted	Full Load	Adjusted
Hydro	20%	21	4.2	0	0	0	0	0	0	0	0
Nuclear	20%	0.13	0.026	0.020	0.004	0.000029	0.0000058	0	0	0	0
Coal	2%	0.21	0.0042	2.3	0.046	0.0062	0.000124	0.015	0.0003	0.0017	0.000034
Natural Gas	47%	0.15	0.0705	1.4	0.658	0.0012	0.000564	0.012	0.00564	0.000086	0.00004042
Biomass	4%	55	2.2	0	0	0.0015	0.00006	0.00060	0.000024	0.000084	0.00000336
Geothermal	4%	0.05	0.002	0	0	0	0	0	0	0	0
Wind	3%	0	0	0	0	0	0	0	0	0	0
Solar	0%	0	0	0	0	0	0	0	0	0	0
Other	1%	0	0	0	0	0	0	0	0	0	0
<b>Total based on kWh at plant</b>	<b>100%</b>		<b>6.5</b>		<b>0.71</b>		<b>0.00075</b>		<b>0.006</b>		<b>0.000078</b>
<b>Total based on kWh at point of use (0.12 kWh/kWh lost in transmission)</b>			<b>7.3</b>		<b>0.8</b>		<b>0.00084</b>		<b>0.0067</b>		<b>0.000087</b>

\* Provided by PG&E

*Notes:*

- Water consumption for thermoelectric power plants in California - 0.05 gallons per kWh\*
- Water consumption for hydroelectric power in California - 21 gallons per kWh\*
- Water consumption for coal resource extraction and fuel processing - 0.16 gallons per kWh\*\*
- Water consumption for uranium resource extraction and fuel processing - 0.082 gallons per kWh\*\*
- Water consumption for natural gas resource extraction and fuel processing - 0.10 gallons per kWh\*\*
- Water consumption for biomass based on 55 gallons per kWh\*\*\*
- 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.

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)

$\eta$  = 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**

<b>Granular Carbon Regeneration Process Energy Requirements (15,000 kg/day Regeneration Rate)</b>			
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 ( <a href="http://www.engineeringtoolbox.com">www.engineeringtoolbox.com</a> )
0.5		Specific gravity of GAC (Westates/Siemens)
0.7		Fraction of coal that is carbon ( <a href="http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html">http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html</a> )
0.015		Fraction of coal that is sulfur ( <a href="http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html">http://www.eia.doe.gov/cneaf/coal/quarterly/co2_article/co2.html</a> )
0.015		Fraction of coal that is nitrogen (assumed to be similar to that of sulfur)
0.27	lb CO <sub>2</sub> e/lb	Carbon footprint of extracting and delivering 1 lb of coal to a plant (EUROPA ELCD - Hard Coal)
0.0007	lb SO <sub>2</sub> /lb	Sulfur dioxide (SO <sub>x</sub> ) footprint of extracting and delivering 1 lb of coal (EUROPA ELCD - Hard Coal)
0.001	lb NO <sub>2</sub> /lb	Nitrogen dioxide (NO <sub>x</sub> ) 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 <sub>2</sub> e	Carbon footprint of natural gas, including natural gas production (per therm) (NREL, industrial boiler)
0.0046	lb SO <sub>2</sub>	SO <sub>x</sub> footprint of natural gas combustion per therm (NREL), including natural gas production (EUROPA ELCD)
0.0138	lb NO <sub>2</sub>	NO <sub>x</sub> footprint of natural gas combustion per therm (NREL), including natural gas production (EUROPA ELCD)
1.34	lb CO <sub>2</sub> e	Carbon footprint of electricity (per kWh) (EGRID, US Average)
0.0053	lb SO <sub>2</sub>	SO <sub>x</sub> footprint of electricity (per kWh) (EGRID, US Average)
0.00088	lb NO <sub>2</sub>	NO <sub>x</sub> 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 <sub>2</sub> e	Pounds of carbon dioxide emitted for burning off coal (measured as pounds of CO <sub>2</sub> )
0.65	lb CO <sub>2</sub> e	Pounds of CO <sub>2</sub> 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 <sub>2</sub> e	Pounds of CO <sub>2</sub> 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 <sub>2</sub> e	Pounds of CO <sub>2</sub> e emitted for electricity generation
4.5	lb CO <sub>2</sub> e	Total CO <sub>2</sub> 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 H<sub>2</sub>O / 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 <sup>3</sup>	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 <sup>3</sup>	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](http://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](http://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 <sup>3</sup>	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 <sup>3</sup>	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](http://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](http://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 <sup>3</sup>	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](http://www.lcafood.dk)
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- 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](http://www.nrel.gov/lci)) maintained by the Alliance for Sustainable Energy, LLC.