

**Appendix A**  
**Sample Inventory Spreadsheet**

(This is a fictitious example of the life cycle inventory for a gasoline system and does not represent real data).

<b>PROCESS NAME:</b>			Fictitious Gasoline Life Cycle Inventory						
<b>PROCESS ID:</b>			Gasoline						
<b>REFERENCE FLOW:</b>			1000	Units:	gallons	of:	Gasoline		
<b>PROCESS DESCRIPTION:</b>	Summary of LCI to extract, produce, and distribute 1,000 gallons of gasoline used to fuel a typical passenger automobile in the US.								
<b>BASIS OF CALCULATIONS</b>									
			Summer	Winter	Average	Units	Reference		
	Oxygen Content		2.1	1.9	0.02	percent	EPA, OTAQ; MOBILE 6		
	Molecular Weight				88	g/mol	www.chemfinder.com		
	Oxygenate Content by Volume				11.05	percent by volume			
	Oxygenate Content by Weight				11.15	percent by weight			
	Fuel Economy Estimated for Average Car By Fuel Type				20.22	miles/gal	MOBILE 6		
	Petroleum Refining Process Efficiency (mass outputs/mass inputs)								
		Petroleum Refinery Process Efficiency (mass basis)			92	percent	EIA		
		GREET v1.6 Published Petroleum Refinery Efficiency			85	percent	Greet1.6		
		Process Efficiency Used in Calculations			85	percent			
<b>Process Inputs</b>									
	Material	Coal				9.88E+01	lb		
		Crude Oil				5.64E+02	gal		
		Natural Gas				3.23E+02	SCF		
		Uranium				6.69E-02	lb		
		Wood				3.99E+00	lb		
		Drilling Fluids				Unknown			
<b>Process Outputs</b>									
	Product	Gasoline				594	gal	Calculated	
	Co-Product	N/A							
<b>Air Emissions</b>									

			Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units	
		Volatile Organic Compounds (VOC)	1.86E-01	1.49E-01	2.98E-01	1.36E+01	1.42E+01	lb	
		Carbon Monoxide (CO)	4.69E-01	4.78E-01	2.32E+00	3.00E+02	3.03E+02	lb	
		Nitrogen Oxides (NOx)	1.51E+00	1.64E+00	8.33E+00	2.26E+01	3.41E+01	lb	
		PM10	6.16E-02	2.06E-01	2.45E-01	6.79E-01	1.19E+00	lb	
		Sulfur Oxides (SOx)	6.41E-01	2.17E+00	2.52E+00	1.44E+00	6.77E+00	lb	
		Methane	5.60E-01	1.26E+00	3.18E-01	1.70E+00	3.84E+00	lb	
		Nitrous Oxide (N2O)	3.91E-03	4.38E-03	2.85E-02		3.68E-02	lb	
		Carbon Dioxide (CO2)	2.20E+02	3.75E+02	1.56E+03	1.20E+04	1.41E+04	lb	
		VOC loss: evaporation				1.39E+01	1.39E+01	lb	
		VOC loss: spillage	2.70E-04	2.36E-03			2.62E-03	lb	
		1 1 1-Trichloroethane				2.19E-05	2.19E-05	lb	
		1 2 3-Trichloropropane				9.67E-06	9.67E-06	lb	
		1 2 4-Trichlorobenzene				5.8E-07	5.8E-07	lb	
		1 2 4-Trimethylbenzene	1.07E-04	1.02E-04		1.23E-01	1.23E-01	lb	
		1 2-Dibromoethane	1.24E-06	1.19E-06		1.61E-05	1.86E-05	lb	
		1 2-Dichloroethane	3.2E-06	3.06E-06		4.15E-05	4.78E-05	lb	
		1 3-Butadiene	2.9E-05	2.77E-05		8.39E-02	8.40E-02	lb	
		2 2 4-TM-Pentane				1.20E+00	1.20E+00	lb	
		2 2 5-TM-Hexane				1.39E-01	1.39E-01	lb	
		2 3 3-TM-Pentane				2.22E-01	2.22E-01	lb	
		2 3 4-TM-Pentane				2.21E-01	2.21E-01	lb	
		2 3-Dimethylbutane				1.39E-01	1.39E-01	lb	
		2 4-Dimethylphenol				1.01E-07	1.01E-07	lb	
		2-Methyl-2-butene				9.19E-02	9.19E-02	lb	
		2-Methylhexane				1.57E-01	1.57E-01	lb	
		2-Methylpentane				2.84E-01	2.84E-01	lb	
		3-Methylhexane				1.64E-01	1.64E-01	lb	
		3-Methylpentane				1.82E-01	1.82E-01	lb	
		Acenaphthene				9.23E-05	9.23E-05	lb	
		Acenaphthylene				5.20E-04	5.20E-04	lb	
		Acetonitrile				4.29E-06	4.29E-06	lb	
		Acetophenone				2.75E-06	2.75E-06	lb	
		Acreolin	4.29E-07	3.2E-06	1.57E+03	8.21E-03	8.21E-03	lb	
		Aluminum (fume or dust)				2.36E-08	2.36E-08	lb	

		Ammonia	1.32E-03	2.43E-03		2.68E+00	2.68E+00	lb		
		Anthracene	5.88E-07	5.62E-07		1.14E-04	1.16E-04	lb		
		Antimony	2.17E-07	1.62E-06		1.85E-06	3.69E-06	lb		
		Antimony Compounds	5.9E-07	5.64E-07		7.65E-06	8.80E-06	lb		
		Arsenic	9.85E-07	7.34E-06		7.60E-05	8.43E-05	lb		
		Asbestos (friable)					0.00E+00	lb		
		Barium				8.80E-08	8.80E-08	lb		
		Barium Compounds				1.05E-06	1.05E-06	lb		
		Benzene	1.60E-03	2.26E-03		6.38E-01	6.42E-01	lb		
		Benzo(a)anthracene				1.30E-05	1.30E-05	lb		
		Benzo(a)pyrene				1.30E-05	1.30E-05	lb		
		Benzo(b)fluoranthene				1.54E-05	1.54E-05	lb		
		Benzo(g,h,i)perylene				3.24E-05	3.24E-05	lb		
		Benzo(k)fluoranthene				1.54E-05	1.54E-05	lb		
		Beryllium	1.12E-07	8.35E-07			9.47E-07	lb		
		Biphenyl	2.31E-05	1.05E-05		3.73E-04	4.06E-04	lb		
		Butraldehyde				5.58E-06	5.58E-06	lb		
		Cadmium	2.14E-07	1.6E-06		2.79E-08	1.84E-06	lb		
		Carbon Disulfide	1.89E-06	1.81E-06		2.45E-05	2.83E-05	lb		
		Carbon Tetrachloride	2.43E-06	7.29E-06		2.16E-05	3.13E-05	lb		
		Carbonyl Sulfide	5.23E-05	5.01E-05		7.58E-05	1.78E-04	lb		
		Certain Glycol Ethers				3.11E-05	3.11E-05	lb		
		Chlorine	4.06E-05	3.97E-05		5.25E-04	6.05E-04	lb		
		Chlorine Dioxide				4.29E-09	4.29E-09	lb		
		Chlorobenzene					0.00E+00	lb		
		Chlorodifluoromethane	8.34E-06	7.99E-06		1.08E-04	1.25E-04	lb		
		Chloromethane				2.97E-06	2.97E-06	lb		
		Chromium	1.28E-06	9.52E-06		7.51E-08	1.09E-05	lb		
		Chromium Compounds	9.85E-08	9.42E-08		1.28E-06	1.47E-06	lb		
		Chromium III				7.85E-05	7.85E-05	lb		
		Chromium VI				5.23E-05	5.23E-05	lb		
		Chrysene				1.30E-05	1.30E-05	lb		
		Cobalt	7.22E-07	4.86E-06		3.22E-08	5.62E-06	lb		
		Cobalt Compounds	2.48E-09	2.38E-09		1.02E-06	1.03E-06	lb		
		Copper				3.01E-08	3.01E-08	lb		

		Copper Compounds	3.2E-07	3.07E-07		4.16E-06	4.78E-06	lb		
		Cresol (mixed Isomers)	3.87E-06	3.7E-06		5.02E-05	5.78E-05	lb		
		Cumene	1.42E-03	3.36E-03		5.10E-03	9.88E-03	lb		
		Cumene Hydroperoxide				1.09E-05	1.09E-05	lb		
		Cyanide Compounds				8.07E-05	8.07E-05	lb		
		Cyclohexane	2.54E-04	2.43E-04		3.30E-03	3.79E-03	lb		
		Dibenz(a,h)anthracene					0.00E+00	lb		
		Dicyclopentadiene				3.94E-06	3.94E-06	lb		
		Diethanolamine	2.94E-05	2.82E-05		3.82E-04	4.40E-04	lb		
		Dioxins	2.36E-12	1.76E-11			1.99E-11	lb		
		Ethylbenzene	7.00E-04	1.11E-03		3.44E-01	3.46E-01	lb		
		Ethylene	3.62E-04	3.46E-04		4.69E-03	5.40E-03	lb		
		Ethylene Glycol	1.89E-05	1.81E-05		2.45E-04	2.82E-04	lb		
		Ethylene Oxide				4.29E-06	4.29E-06	lb		
		Formaldehyde	2.93E-05	3.95E-05		2.32E-01	2.32E-01	lb		
		Fluoranthene				1.15E-04	1.15E-04	lb		
		Fluorene				1.91E-04	1.91E-04	lb		
		Hydrazine				1.63E-06	1.63E-06	lb		
		Hydrocarbons (non CH4)	2.49E-02	1.86E-01			2.11E-01	lb		
		Hydrochloric Acid	2.27E-03	1.63E-02		1.26E-03	1.98E-02	lb		
		Hydrogen Cyanide				4.21E-05	4.21E-05	lb		
		Hydrogen Fluoride	3.50E-04	2.28E-03		6.52E-04	3.28E-03	lb		
		Indeno(123cd)pyrene				9.71E-06	9.71E-06	lb		
		Isopentane		4.1E-07		4.55E-01	4.55E-01	lb		
		Isopropyl Alcohol				3.59E-06	3.59E-06	lb		
		Kerosene	1.09E-05	8.09E-05			9.18E-05	lb		
		Lead	1.73E-06	1.29E-05		1.29E-08	1.46E-05	lb		
		Lead Compounds	2.08E-07	1.99E-07		2.69E-06	3.10E-06	lb		
		m-Xylene	9.61E-04	1.66E-03		4.01E-03	6.63E-03	lb		
		Manganese	2.97E-06	2.21E-05		4.43E-05	6.94E-05	lb		
		Manganese Compounds				2.23E-06	2.23E-06	lb		
		Mercury	8.13E-07	6.06E-06		2.31E-05	3.00E-05	lb		
		Mercury Compounds				1.29E-07	1.29E-07	lb		
		Metals	4.5E-06	3.35E-05			3.80E-05	lb		
		Methanol	1.05E-03	1.00E-03		1.36E-02	1.57E-02	lb		

	Methyl Ethyl Ketone	4.91E-04	4.70E-04		6.37E-03	7.33E-03	lb		
	Methyl Isobutyl Ketone	3.37E-05	3.22E-05		4.37E-04	5.03E-04	lb		
	Methyl Tert-Butyl Ether	3.42E-04	3.27E-04		2.30E+00	2.30E+00	lb		
	Methylene Chloride	1.85E-06	1.38E-05		0.00E+00	1.56E-05	lb		
	Molybdenum Trioxide	4.50E-07	4.31E-07		5.84E-06	6.72E-06	lb		
	n-Butane				1.10E-01	1.10E-01	lb		
	n-Butyl Alcohol				2.45E-05	2.45E-05	lb		
	n-Pentane	7.21E-04	5.29E-04		1.91E-01	1.92E-01	lb		
	n-Hexane	7.21E-04	6.90E-04		4.13E-01	4.14E-01	lb		
	n-Heptane				1.90E-01	1.90E-01	lb		
	n-Octane				4.12E-03	4.12E-03	lb		
	n-nonane				3.19E-03	3.19E-03	lb		
	n-Decane				3.07E-03	3.07E-03	lb		
	n-Undecane				1.75E-03	1.75E-03	lb		
	n-Dodecane				2.31E-03	2.31E-03	lb		
	n-Tridecane				2.74E-03	2.74E-03	lb		
	n-Tetradecane				2.97E-03	2.97E-03	lb		
	n-Pentadecane				2.83E-03	2.83E-03	lb		
	n-Hexadecane				2.67E-03	2.67E-03	lb		
	n-Heptadecane				2.62E-03	2.62E-03	lb		
	n-Octadecane				1.60E-03	1.60E-03	lb		
	n-Nonadecane				1.95E-03	1.95E-03	lb		
	n-Icosane				1.79E-03	1.79E-03	lb		
	n-Henicosane				1.66E-03	1.66E-03	lb		
	n-Docosane				1.62E-03	1.62E-03	lb		
	n-Methyl-2-Pyrrolidone	3.8E-05	3.64E-05		4.93E-04	5.67E-04	lb		
	n-Nitrodimethylamine	9.06E-08	6.75E-07			7.66E-07	lb		
	Naphthalene	7.36E-05	5.09E-05		1.76E-02	1.77E-02	lb		
	Nickel	6.68E-06	4.83E-05		9.81E-05	1.53E-04	lb		
	Nickel Compounds	5.81E-06	5.56E-06		7.53E-05	8.67E-05	lb		
	Nitrate Compounds					0.00E+00	lb		
	o-Xylene	9.39E-04	1.64E-03		3.73E-03	6.31E-03	lb		
	Other Aldehydes	8.17E-05	6.08E-04			6.90E-04	lb		
	Other Organics	1.24E-04	9.27E-04			1.05E-03	lb		
	p-Xylene	9.94E-04	1.69E-03		1.61E-03	4.30E-03	lb		

		Particulates (total)	3.61E-02	2.69E-01		0.00E+00	3.05E-01	lb		
		Perchloroethylene	4.10E-07	3.05E-06		0.00E+00	3.46E-06	lb		
		Phenanthrene	3.00E-05	1.31E-05		4.81E-04	5.24E-04	lb		
		Phenols	2.52E-05	3.15E-05		3.12E-04	3.69E-04	lb		
		Polycyclic Aromatic Compounds	7.74E-06	7.41E-06		1.00E-04	1.16E-04	lb		
		Propionaldehyde				8.97E-03	8.97E-03	lb		
		Propylene	6.65E-04	6.36E-04		8.63E-03	9.93E-03	lb		
		Pyrene				1.57E-04	1.57E-04	lb		
		Quinoline				1.01E-05	1.01E-05	lb		
		Radionuclides (Ci)	8.90E-06	6.63E-05			7.52E-05	lb		
		Selenium	3.09E-06	2.30E-05			2.61E-05	lb		
		Selenium Compounds				1.07E-07	1.07E-07	lb		
		Styrene	1.23E-06	1.18E-06		4.10E-02	4.10E-02	lb		
		Sulfuric Acid	1.36E-03	1.30E-03		1.76E-02	2.03E-02	lb		
		Tert-Butyl Alcohol	9.20E-07	8.81E-07		1.19E-05	1.37E-05	lb		
		Tetrachloroethylene	1.03E-05	9.81E-06		1.33E-04	1.53E-04	lb		
		Toluene	3.36E-03	4.36E-03		2.00E+00	2.00E+00	lb		
		Toluene-2 6-Diisocyanate				4.14E-06	4.14E-06	lb		
		Trichloroethylene	1.08E-05	1.30E-05		1.35E-04	1.59E-04	lb		
		Vanadium				5.93E-06	5.93E-06	lb		
		Vinyl Acetate				1.51E-05	1.51E-05	lb		
		Xylene (mixed isomers)	5.52E-04	5.28E-04		1.31E+00	1.31E+00	lb		
		Zinc (fume or dust)	1.09E-06	1.05E-06		1.42E-05	1.63E-05	lb		
		Zinc Compounds	8.05E-06	7.71E-06		1.04E-04	1.20E-04	lb		
		Acetaldehyde	0.00E+00	0.00E+00		6.72E-02	6.72E-02	lb		
		Total	2.24E+02	3.85E+02	1.57E+03	1.24E+04	1.45E+04	lb		
		<b>Water Emissions</b>								
			Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units		
		1 1 1-Trichloroethane					0.00E+00	lb		
		1 2 3-Trichloropropane					0.00E+00	lb		
		1 2 4-Trichlorobenzene					0.00E+00	lb		
		1 2 4-Trimethylbenzene	3.99E-07	1.6E-06		2.17E-01	2.17E-01	lb		
		1 2-Dibromoethane	9.6E-10	9.41E-10		1.29E-08	1.48E-08	lb		
		1 2-Dichloroethane				2.15E-09	2.15E-09	lb		
		1 3-Butadiene	1.27E-07	1.25E-07		1.70E-06	1.96E-06	lb		

		2 2 4-TM-Pentane				7.97E-01	7.97E-01	lb		
		2 2 5-TM-Hexane				2.49E-01	2.49E-01	lb		
		2 3 3-TM-Pentane				3.96E-01	3.96E-01	lb		
		2 3 4-TM-Pentane				3.95E-01	3.95E-01	lb		
		2 3-Dimethylbutane				2.49E-01	2.49E-01	lb		
		2 4-Dimethylphenol				2.25E-07	2.25E-07	lb		
		2-Methyl-2-Butene				1.64E-01	1.64E-01	lb		
		2-Methylhexane				2.80E-01	2.80E-01	lb		
		2-Methylpentane				5.07E-01	5.07E-01	lb		
		3-Methylhexane				2.93E-01	2.93E-01	lb		
		3-Methylpentane				3.25E-01	3.25E-01	lb		
		Acetaldehyde				5.25E-07	5.25E-07	lb		
		Acetonitrile					0.00E+00	lb		
		Acetophenone					0.00E+00	lb		
		Acid	4.96E-10	3.7E-09			4.19E-09	lb		
		Aluminum (fume or dust)					0.00E+00	lb		
		Ammonia	1.02E-04	2.25E-04		1.11E-03	1.44E-03	lb		
		Anthracene				8.07E-07	8.07E-07	lb		
		Antimony				9.17E-07	9.17E-07	lb		
		Antimony Compounds	1.51E-07	1.48E-07		2.03E-06	2.33E-06	lb		
		Arsenic				8.37E-08	8.37E-08	lb		
		Barium				3.99E-06	3.99E-06	lb		
		Barium Compounds				1.37E-05	1.37E-05	lb		
		Benzene	4.25E-04	1.16E-03		8.58E-02	8.73E-02	lb		
		Beryllium				4.94E-08	4.94E-08	lb		
		Biphenyl	0.00E+00	1.15E-06		7.19E-07	1.87E-06	lb		
		Biological Oxygen Demand (BOD)	1.11E-03	8.31E-03			9.42E-03	lb		
		Boron	5.46E-06	4.07E-05			4.62E-05	lb		
		Cadmium	3.60E-04	2.83E-04		1.63E-03	2.27E-03	lb		
		Carbon Disulfide				8.59E-09	8.59E-09	lb		
		Certain Glycol Ethers				3.33E-06	3.33E-06	lb		
		Chlorine	2.56E-06	2.51E-06		3.43E-05	3.94E-05	lb		
		Chromates	5.46E-06	4.07E-05			4.62E-05	lb		
		Chromium				5.65E-07	5.65E-07	lb		
		Chromium Compounds	9.24E-07	9.05E-07		1.24E-05	1.42E-05	lb		

		Cobalt				4.81E-06	4.81E-06	lb		
		Cobalt Compounds				3.18E-06	3.18E-06	lb		
		Copper				1.07E-08	1.07E-08	lb		
		Copper Compounds	3.42E-07	3.35E-07		4.59E-06	5.27E-06	lb		
		Cresol (mixed isomers)	3.43E-07	3.36E-07		4.60E-06	5.28E-06	lb		
		Cumene	7.80E-04	4.13E-03		1.92E-03	6.83E-03	lb		
		Cyclohexane	3.15E-07	3.09E-07		4.23E-06	4.85E-06	lb		
		Diethanolamine	1.21E-01	9.00E-01		2.55E-05	1.02E+00	lb		
		Ethylbenzene	2.26E-04	7.83E-04		1.40E-01	1.41E-01	lb		
		Ethylene				1.42E-06	1.42E-06	lb		
		Ethylene Glycol	4.48E-05	3.24E-04		2.02E-05	3.89E-04	lb		
		Fluorine				5.71E-05	5.71E-05	lb		
		Hydrogen Fluoride				1.52E-07	1.52E-07	lb		
		Iron	6.62E-01	4.03E-01		3.08E+00	4.14E+00	lb		
		Isopentane				9.86E-01	9.86E-01	lb		
		Lead				1.42E-07	1.42E-07	lb		
		Lead Compounds	1.40E-07	1.37E-07		1.87E-06	2.15E-06	lb		
		m-Xylene				1.41E-03	1.41E-03	lb		
		Manganese	2.64E-02	1.61E-02		1.23E-01	1.65E-01	lb		
		Manganese Compounds				3.41E-06	3.41E-06	lb		
		Mercury	4.65E-05	9.99E-05		1.68E-04	3.14E-04	lb		
		Methanol	3.15E-04	1.95E-04		1.55E-03	2.06E-03	lb		
		Methyl Ethyl Ketone	1.32E-06	1.29E-06		1.77E-05	2.03E-05	lb		
		Methyl Isobutyl Ketone	4.96E-09	4.86E-09		6.65E-08	7.64E-08	lb		
		Methyl Tert-Butyl Ether	1.88E-05	2.57E-05		1.32E+00	1.32E+00	lb		
		Molybdenum Trioxide	5.99E-07	5.87E-07		8.03E-06	9.22E-06	lb		
		n-Butane				1.96E-01	1.96E-01	lb		
		n-Butyl Alcohol				2.58E-08	2.58E-08	lb		
		n-Pentane				3.75E-01	3.75E-01	lb		
		n-Hexane	3.38E-07	2.07E-06		3.14E-01	3.14E-01	lb		
		n-Heptane				1.74E-01	1.74E-01	lb		
		n-Methyl-2-Pyrrolidone				6.72E-05	6.72E-05	lb		
		n-Octane				1.65E-02	1.65E-02	lb		
		n-Nonane				1.28E-02	1.28E-02	lb		
		n-Decane				1.23E-02	1.23E-02	lb		

		n-undecane				7.00E-03	7.00E-03	lb		
		n-Dodecane				9.24E-03	9.24E-03	lb		
		n-Tridecane				1.10E-02	1.10E-02	lb		
		n-Tetradecane				1.19E-02	1.19E-02	lb		
		n-Pentadecane				1.13E-02	1.13E-02	lb		
		n-Hexadecane				1.07E-02	1.07E-02	lb		
		n-Heptadecane				1.05E-02	1.05E-02	lb		
		n-Octadecane				6.39E-03	6.39E-03	lb		
		n-Nonadecane				7.80E-03	7.80E-03	lb		
		n-Icosane				7.16E-03	7.16E-03	lb		
		n-Henicosane				6.63E-03	6.63E-03	lb		
		n-Docosane				6.46E-03	6.46E-03	lb		
		Naphthalene	1.47E-04	4.13E-04		6.59E-04	1.22E-03	lb		
		Nickel				4.06E-07	4.06E-07	lb		
		Nickel Compounds	5.53E-06	3.18E-05		1.95E-05	5.69E-05	lb		
		Nitrates	2.73E-03	2.68E-03		3.67E-02	4.21E-02	lb		
		o-Xylene				1.41E-03	1.41E-03	lb		
		Oil	5.58E-04	4.16E-03		0.00E+00	4.72E-03	lb		
		p-Cresol				7.83E-07	7.83E-07	lb		
		p-Xylene				1.41E-03	1.41E-03	lb		
		Phenanthrene				9.23E-08	9.23E-08	lb		
		Phenol	1.35E-04	1.00E-03		2.07E-05	1.16E-03	lb		
		Polycyclic Aromatic Compounds	4.98E-08	4.88E-08		6.68E-07	7.66E-07	lb		
		Propylene				1.43E-06	1.43E-06	lb		
		Selenium				6.12E-07	6.12E-07	lb		
		Selenium Compounds				4.94E-06	4.94E-06	lb		
		Sodium Nitrite				6.01E-05	6.01E-05	lb		
		Styrene				1.01E-07	1.01E-07	lb		
		Sulfates	2.68E-04	2.00E-03		0.00E+00	2.27E-03	lb		
		Sulfuric Acid	2.04E-02	1.52E-01		0.00E+00	1.73E-01	lb		
		Tert-Butyl Alcohol				1.76E-05	1.76E-05	lb		
		Tetrachloroethylene				1.07E-06	1.07E-06	lb		
		Toluene	9.15E-04	2.65E-03		6.30E-01	6.33E-01	lb		
		Vanadium				7.08E-08	7.08E-08	lb		
		Xylene (mixed Isomers)	3.84E-06	1.94E-05		6.22E-01	6.22E-01	lb		

		Zinc Compounds	1.32E-01	8.05E-02		6.15E-01	8.27E-01	lb		
		Volatile Organic Compounds (VOC)		5.05E-07		9.08E-02	9.09E-02	lb		
		Total	9.70E-01	1.58E+00		1.28E+01	1.54E+01	lb		
		<b>Solid Waste</b>								
			Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units		
		Sludge	2.52E+01	1.54E+01		1.17E+02	1.58E+02	lb		
		Solid Waste #1	5.50E+00	4.08E+01			4.63E+01	lb		
		Disposal Off-site, Subtitle D Landfill	7.73E-03	5.78E-03		1.70E-02	3.05E-02	lb		
		Disposal Off-site, Subtitle C Landfill	3.04E-03	2.27E-03		6.68E-03	1.20E-02	lb		
		Disposal On-site, Subtitle D Landfill	1.34E-03	1.00E-03		2.94E-03	5.28E-03	lb		
		Disposal On-site, Subtitle C landfill	3.41E-04	2.55E-04		7.50E-04	1.35E-03	lb		
		Total:	3.08E+01	5.61E+01		1.17E+02	2.04E+02	lb		
		<b>Raw Materials Extracted</b>								
		Fossil Fuel	Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units		
		Coal	1.08E+05	8.06E+05			9.14E+05	Btu		
		Crude Oil	1.19E+07	4.73E+06		5.67E+07	7.33E+07	Btu		
		Natural Gas	3.54E+04	2.64E+05			3.00E+05	Btu		
		Non-Fossil Fuel								
		Uranium	4.72E-05	6.69E-02			6.69E-02	lb		
		Wood	3.79E-01	3.61E+00			3.99E+00	lb		
		<b>Water Consumption</b>								
			Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units		
		Public Supply					0.00E+00	gal		
		River/Canal					0.00E+00	gal		
		Sea					0.00E+00	gal		
		Unspecified				2.27E+02	2.27E+02	gal		
		Well					0.00E+00	gal		
		Total:				2.27E+02	2.27E+02	gal		
		<b>Land Use</b>								
			Mat. P&D	Fuel P&D	Fuel Use	Process	Total	Units		
		Unknown						acres		

## Appendix B LCA and LCI Software Tools

Tool	Vendor	URL
BEES 3.0	NIST Building and Fire Research Laboratory	<a href="http://www.bfrl.nist.gov/oe/software/bees.html">http://www.bfrl.nist.gov/oe/software/bees.html</a>
Boustead Model 5.0	Boustead Consulting	<a href="http://www.boustead-consulting.co.uk/products.htm">http://www.boustead-consulting.co.uk/products.htm</a>
CMLCA 4.2	Centre of Environmental Science	<a href="http://www.leidenuniv.nl/cml/ssp/software/cmlca/index.html">http://www.leidenuniv.nl/cml/ssp/software/cmlca/index.html</a>
Dubo-Calc	Netherlands Ministry of Transport, Public Works and Water Management	<a href="http://www.rws.nl/rws/bwd/home/www/cgi-bin/index.cgi?site=1&amp;doc=1785">http://www.rws.nl/rws/bwd/home/www/cgi-bin/index.cgi?site=1&amp;doc=1785</a>
Ecoinvent 1.2	Swiss Centre for Life Cycle Inventories	<a href="http://www.ecoinvent.ch">http://www.ecoinvent.ch</a>
Eco-Quantum	IVAM	<a href="http://www.ivam.uva.nl/uk/producten/product7.htm">http://www.ivam.uva.nl/uk/producten/product7.htm</a>
EDIP PC-Tool	Danish LCA Center	<a href="http://www.lca-center.dk">http://www.lca-center.dk</a>
eiolca.net	Carnegie Mellon University	<a href="http://www.eiolca.net">http://www.eiolca.net</a>
Environmental Impact Indicator	ATHENA™ Sustainable Materials Institute	<a href="http://www.athenaSMI.ca">http://www.athenaSMI.ca</a>
EPS 2000 Design System	Assess Ecostrategy Scandinavia AB	<a href="http://www.assess.se/">http://www.assess.se/</a>
GaBi 4	PE Europe GmbH and IKP University of Stuttgart	<a href="http://www.gabi-software.com/software.html">http://www.gabi-software.com/software.html</a>
GEMIS	Öko-Institut	<a href="http://www.oeko.de/service/gemis/en/index.htm">http://www.oeko.de/service/gemis/en/index.htm</a>
GREET 1.7	DOE's Office of Transportation	<a href="http://www.transportation.anl.gov/software/GREET/index.html">http://www.transportation.anl.gov/software/GREET/index.html</a>
IDEMAT 2005	Delft University of Technology	<a href="http://www.io.tudelft.nl/research/dfs/idemat/index.htm">http://www.io.tudelft.nl/research/dfs/idemat/index.htm</a>
KCL-ECO 4.0	KCL	<a href="http://www1.kcl.fi/eco/softw.html">http://www1.kcl.fi/eco/softw.html</a>
LCAIT 4.1	CIT Ekologik	<a href="http://www.lcait.com/01_1.html">http://www.lcait.com/01_1.html</a>
LCAPIX v1.1	KM Limited	<a href="http://www.kmlmtd.com/pas/index.html">http://www.kmlmtd.com/pas/index.html</a>
MIET 3.0	Centre of Environmental Science	<a href="http://www.leidenuniv.nl/cml/ssp/software/miet/index.html">http://www.leidenuniv.nl/cml/ssp/software/miet/index.html</a>
REGIS	Sinum AG	<a href="http://www.sinum.com/htdocs/e_software_regis.shtml">http://www.sinum.com/htdocs/e_software_regis.shtml</a>
SimaPro 6.0	PRé Consultants	<a href="http://www.pre.nl/simapro.html">http://www.pre.nl/simapro.html</a>
SPINE@CPM	Chalmers	<a href="http://www.globalspine.com">http://www.globalspine.com</a>
SPOLD	The Society for Promotion of Life-Cycle Assessment	<a href="http://lca-net.com/spold/">http://lca-net.com/spold/</a>
TEAM™ 4.0	Ecobalance	<a href="http://www.ecobalance.com/uk_lcatool.php">http://www.ecobalance.com/uk_lcatool.php</a>
Umberto	ifu Hamburg GmbH	<a href="http://www.ifu.com/en/products/umberto">http://www.ifu.com/en/products/umberto</a>
US LCI Data	National Renewable Energy Lab	<a href="http://www.nrel.gov/lci">http://www.nrel.gov/lci</a>

**BEES 3.0.** Created by the National Institute for Standards and Technology (NIST) Building and Fire Research Laboratory, the BEES (Building for Environmental and Economic Sustainability) software can be used for balancing the environmental and economic performance of building products. Version 3.0 of the Windows™-based decision support software, aimed at designers, builders, and product

manufacturers, includes actual environmental and economic performance data for 200 building products. BEES 3.0 can be downloaded free of charge from the NIST website.

**Boustead Model 5.0.** Created by Boustead Consulting, the Boustead Model is an extensive database in which data such as fuels and energy use, raw materials requirements, and solid, liquid, and gaseous emissions are stored. It also includes software which enables the user to manipulate data in the database and to select a suitable data presentation method from a host of options.

**CMLCA 4.2.** Created by the Centre of Environmental Science (CML) at Leiden University, Chain Management by Life Cycle Assessment (CMLCA) is a software tool that is intended to support the technical steps of the LCA procedure. The program can be downloaded from the CML website.

**Dubo-Calc.** The Netherlands Ministry of Transport, Public Works, and Water Management has created a database containing LCI data of construction materials which are used in civil works. Data included are secondary data, derived from other databases, brought together in a set to use with their software for designers.

**Ecoinvent Database v1.2.** The ecoinvent data v1.2 comprises more than 2700 datasets with global/European/Swiss coverage. About 1000 elementary flows are reported for each dataset, including emissions to air, water, and soil, mineral and fossil resources, and land use. Several actual and widespread impact assessment methods, namely the cumulative energy demand, climate change, CML 2001, Eco-indicator 99, the ecological scarcity method 1997, EDIP 1997, EPS 2000, and Impact 2002+ are implemented. The ecoinvent data are available through EMIS, GaBi, Regis, SimaPro, and Umberto and are importable into CMLCA, KCL-eco, and TEAM.

**Eco-Quantum.** Eco-Quantum is a calculating tool on the basis of LCA which serves actors in the building sector with quantitative information on the environmental impact of buildings as a whole. The added value of Eco-Quantum in this context is the database with composition data of about 1000 building components. Eco-Quantum is available only in Dutch.

**EDIP PC-Tool.** Developed for the Danish EPA, the EDIP PC-Tool is a user friendly Windows application and database that supports the LCA process carried out according to the EDIP method. To carry out an LCA, detailed information on all the processes and materials included in the life cycle of the product is needed. Therefore, the tool has been equipped with a relational database, close in structure to the internationally recognized SPOLD format.

**eiolca.net.** Created by the Green Design Institute of Carnegie Mellon, this web site allows users to estimate the overall environmental impacts from producing a certain dollar amount of a commodity or service in the United States. The database first was made publicly available in 1999; since then two major and several minor updates have been conducted. The web-based model provides rough guidance on the relative impacts of different types of products, materials, services, or industries with respect to resource use and emissions. The latest version is based on the 1997 industry benchmark input-output accounts compiled by the Bureau of Economic Analysis of the U.S. Department of Commerce. It incorporates emissions and resource use factors estimated for all 491 sectors of the U.S. economy, using publicly available electricity and fuel consumption data compiled by the U.S. Census Bureau, the U.S. Departments of Energy and Transportation, and environmental databases created by the U.S. EPA.

**Environmental Impact Indicator.** Developed by the Athena Institute, the Estimator was prepared for architects, engineers, and researchers to get LCA answers about conceptual designs of new buildings or renovations to existing buildings. The Estimator assesses the environmental implications of industrial, institutional, office, or both multi-unit and single-family residential designs. The Estimator incorporates

the Institute's inventory databases that cover more than 90 structural and envelope materials. Released in 2002, it simulates over 1,000 different assembly combinations and is capable of modeling 95 percent of the building stock in North America. Athena has also developed databases for energy use and related air emissions for on-site construction of building assemblies; maintenance, repair and replacement effects through the operating life; and, demolition and disposal.

**EPS 2000 Design System.** Created by Assess Ecostrategy Scandinavia AB, EPS (Environmental Priority Strategies) is a life cycle impact assessment software for sustainable product development. A demo version can be ordered from the website.

**GaBi 4 Software System and Database.** GaBi is supported jointly by PE Europe GmbH and IKP University of Stuttgart. Different versions are available from educational to professional use of Life Cycle Analysis to evaluate life cycle environmental, cost, and social profiles of products, processes and technologies. GaBi offers databases with worldwide coverage as well as Ecoinvent data. A demo version is available for download.

**GEMIS (Global Emission Model for Integrated Systems).** The Öko-Institut's GEMIS is a life cycle analysis program and database for energy, material, and transport systems. The GEMIS database offers information on fossil fuels, renewables, processes for electricity and heat, raw materials, and transports. The GEMIS database can be downloaded for free from the website.

**GREET 1.7.** The U.S. Department of Energy's Office of Transportation Technologies fuel-cycle model called GREET (Greenhouse gases, Regulated Emissions, and Energy use in Transportation) allows researchers to evaluate various engine and fuel combinations on a consistent fuel-cycle basis.

**IDEMAT 2005.** Created by Delft University of Technology, IDEMAT is a tool for material selections in the design process. It provides a database with technical information about materials, processes and components and allows the user to compare information. A demo version can be downloaded from the DTU website.

**KCL-ECO 4.0.** KCL-ECO can be used to apply LCA to complicated systems with many modules and flows. It includes allocation, impact assessment (characterization, normalization, and weighting), and graphing features. A demo version can be downloaded from the KCL website.

**LCAIT 4.1.** Offered by CIT Ekologik since 1992, LCAit has been used for the environmental assessment of products and processes. It includes an impact assessment database, including characterization factors and weighting factors. A demo version can be downloaded from the CIT website.

**LCAPIX.** Offered by KM Limited, the LCAPIX v1.1 software combines LCA and Activity Based Costing (ABC) to help businesses assure environmental compliance while assuring sustained profitability. It allows for a quantitative measurement which can indicate the potential burden of any product. A licensing fee is required, but a demo version can be downloaded from the KM Ltd. website.

**MIET 3.0. – Missing Inventory Estimation Tool.** Created by the Centre of Environmental Science (CML), MIET is a Microsoft Excel spreadsheet that enables LCA practitioners to estimate LCI of missing flows that were truncated. MIET is based on the most up-to-date U.S. input-output table and environmental data. MIET covers about 1,200 different environmental interventions including air, water, industrial and agricultural soil emissions, and resource use by various industrial sectors. MIET can be downloaded for free from the CML website after filling out a short questionnaire.

**REGIS.** Developed by Sinum AG, REGIS is a software tool for creating corporate ecobalances and improving corporate environmental performance according to ISO14031. A demo version can be downloaded from the Sinum website.

**SimaPro 6.0.** Created by PRé Consultants, SimaPro is a professional LCA software tool that contains several impact assessment methods and several inventory databases, which can be edited and expanded without limitation. It can compare and analyze complex products with complex life cycles. A demo version can be downloaded from the web site link provided above.

**SPINE@CPM.** Maintained by IMI, Industrial Environmental Informatics at Chalmers University of Technology, LCI@CPM is a web portal for LCI information. The portal provides the possibility to: search for specific LCI-data in the database; purchase LCI-data sets; and convert SPINE data sets into ISO/TS 14048 automatically. The database contains more than 500 data sets. SPINE@CPM is the ISO/TS 14048 version of the Swedish national database. Some of the data sets in the database are reported as full flow-charts where each included process or transport is separately stored in the database. The data published in LCI@CPM are reviewed in order to ensure that the quality requirements according to ISO/TS 14048 have been fulfilled.

**SPOLD Data Exchange Software.** The Society for Promotion of Life Cycle Development, a now defunct group, lives on in memory through this software that can be used to create, edit, import, and export data in the SPOLD '99 format. It can be downloaded from the 2.-0 LCA consultants website.

**TEAM™ 4.0.** Offered by Pricewaterhouse Coopers Ecobilan Group (also known as Ecobalance), TEAM™ 3.0 is a professional tool for evaluating the life cycle environmental and cost profiles of products and technologies. It contains comprehensive database of over 600 modules with worldwide coverage. An online demo is available from the website.

**Umberto.** Created by the Institute for Environmental Informatics (ifeu) in Hamburg, Germany, Umberto serves to visualize material and energy flow systems. Data are taken from external information systems or are newly modeled and calculated.

**US LCI Data.** In May 2001, NREL and its partners created the U.S. Life-Cycle Inventory (LCI) Database to provide support to public, private, and non-profit sector efforts in developing product life cycle assessments and environmentally-oriented decision support systems and tools. The objective of the U.S. LCI Database Project is to provide LCI data for commonly used materials, products and processes following a single data development protocol consistent with international standards. Since the goal is to make the creation of LCIs easier, rather than to carry out full product LCIs, database modules provide data on many of the processes needed by others for conducting LCIs. However, the modules do not contain data characterizing the full life cycles of specific products. The data protocol is based on ISO 14048 and is compatible with the EcoSpold format. The LCI data are available in several formats: a streamlined spreadsheet, an EcoSpold format spreadsheet, an EcoSpold XML file, and a detailed spreadsheet with all the calculation details.

## Glossary

<b>Accidental Emission</b>	An unintended environmental release.
<b>Allocation</b>	Partitioning the input or output flows of a unit process to the product of interest.
<b>Attributional LCA</b>	An LCA that accounts for flows/impacts of pollutants, resources, and exchanges among processes within a chosen temporal window.
<b>Background Data</b>	The background data include energy and materials that are delivered to the foreground system as aggregated data sets in which individual plants and operations are not identified.
<b>Brines (oilfield)</b>	Wastewater produced along with crude oil and natural gas from oilfield operations.
<b>By-Products</b>	an incidental product deriving from a manufacturing process or chemical reaction, and not the primary product or service being produced. A by-product can be useful and marketable, or it can have negative ecological consequences.
<b>Characterization</b>	Characterization is the second step of an impact assessment and characterizes the magnitude of the potential impacts of each inventory flow to its corresponding environmental impact.
<b>Characterization Factor</b>	Factor derived from a characterization model which is applied to convert the assigned LCI results to the common unit of the category indicator.
<b>Classification</b>	Classification is the first step of an impact assessment and is the process of assigning inventory outputs into specific environmental impact categories.
<b>Composite Data</b>	Data from multiple facilities performing the same operation that have been combined or averaged in some manner.
<b>Consequential LCA</b>	An LCA that attempts to account for flows/impacts that are caused beyond the immediate system in response to a change to the system.
<b>Co-Product</b>	A product produced together with another product.
<b>Environmental Aspects</b>	Elements of a business' products, actions, or activities that may interact with the environment.
<b>Environmental Loadings</b>	Releases of pollutants to the environment, such as atmospheric and waterborne emissions and solid wastes.

<b>Equivalency Factor</b>	An indicator of the potential of each chemical to impact the given environmental impact category in comparison to the reference chemical used.
<b>Equivalent Usage Ratio</b>	A basis for comparing two or more products that fulfill the same function. For example, comparing two containers based on a set volume of beverage to be delivered to the customer.
<b>Facility-Specific Data</b>	Data from a particular operation within a given facility that are not combined in any way.
<b>Foreground Data</b>	Data from the foreground system that is the system of primary concern to the analyst.
<b>Fuel P&amp;D</b>	Activities involved in the processing and delivery of fuel used to run a process; also called Precombustion Energy.
<b>Functional Unit</b>	The unit of comparison that assures that the products being compared provide an equivalent level of function or service.
<b>Green Technology</b>	A technology that offers a more environmentally benign approach compared to an existing technology.
<b>Impact Assessment</b>	The assessment of the environmental consequences of energy and natural resource consumption and waste releases associated with an actual or proposed action.
<b>Impact Categories</b>	Classifications of human health and environmental effects caused by a product throughout its life cycle.
<b>Impact Indicators</b>	Impact indicators measure the potential for an impact to occur rather than directly quantifying the actual impact.
<b>Industrial System</b>	A collection of operations that together perform some defined function.
<b>Inventory Analysis</b>	The identification and quantification of energy, resource usage, and environmental emissions for a particular product, process, or activity.
<b>Interpretation</b>	The evaluation of the results of the inventory analysis and impact assessment to reduce environmental releases and resource use with a clear understanding of the uncertainty and the assumptions used to generate the results.
<b>Life Cycle Assessment</b>	A cradle-to-grave approach for assessing industrial systems that evaluates all stages of a product's life. It provides a comprehensive view of the environmental aspects of the product or process.
<b>Material P&amp;D</b>	Activities involved in the processing and delivery of materials to a process.

<b>Normalization</b>	Normalization is a technique for changing impact indicator values with differing units into a common, unitless format by dividing the value(s) by a selected reference quantity. This process increases the comparability of data among various impact categories.
<b>Precombustion Energy</b>	The extraction, transportation, and processing of fuels used for power generation, including adjusting for inefficiencies in power generation and transmission losses.
<b>Product Life Cycle</b>	The life cycle of a product system begins with the acquisition of raw materials and includes bulk material processing, engineered materials production, manufacture and assembly, use, retirement, and disposal of residuals produced in each stage.
<b>Routine emissions</b>	Those releases that normally occur from a process, as opposed to accidental releases that proceed from abnormal process conditions.
<b>Sensitivity Analysis</b>	A systematic evaluation process for describing the effect of variations of inputs to a system on the output.
<b>Specific data</b>	Data that are characteristic of a particular subsystem, or process.
<b>Stressors</b>	A set of conditions that may lead to an environmental impact. For example, an increase in greenhouse gases may lead to global warming.
<b>System Flow Diagram</b>	A depiction of the inputs and outputs of a system and how they are connected.
<b>Weighting</b>	The act of assigning subjective, value-based weighting factors to the different impact categories based on their perceived importance or relevance.