OSU~EmEA - 8:

Emergy of Materials, Energy, and Finished Products

UEVs of non-renewable fossil fuels
UEVs of minerals and metals
UEVs of slowly renewables
UEVs of some quaternary products

Non-Renewable Resources...

Nonrenewable resources are resources that cannot be replaced by natural means at a rate equal to the rate of their consumption.

Most fossil fuels, such as oil, natural gas and coal are considered nonrenewable resources

Non-Renewable Resources...

Fossil Fuel

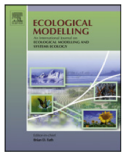
UEVs

Ecological Modelling 222 (2011) 879–887

Contents lists available at ScienceDirect

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel



Assessing geobiosphere work of generating global reserves of coal, crude oil, and natural gas

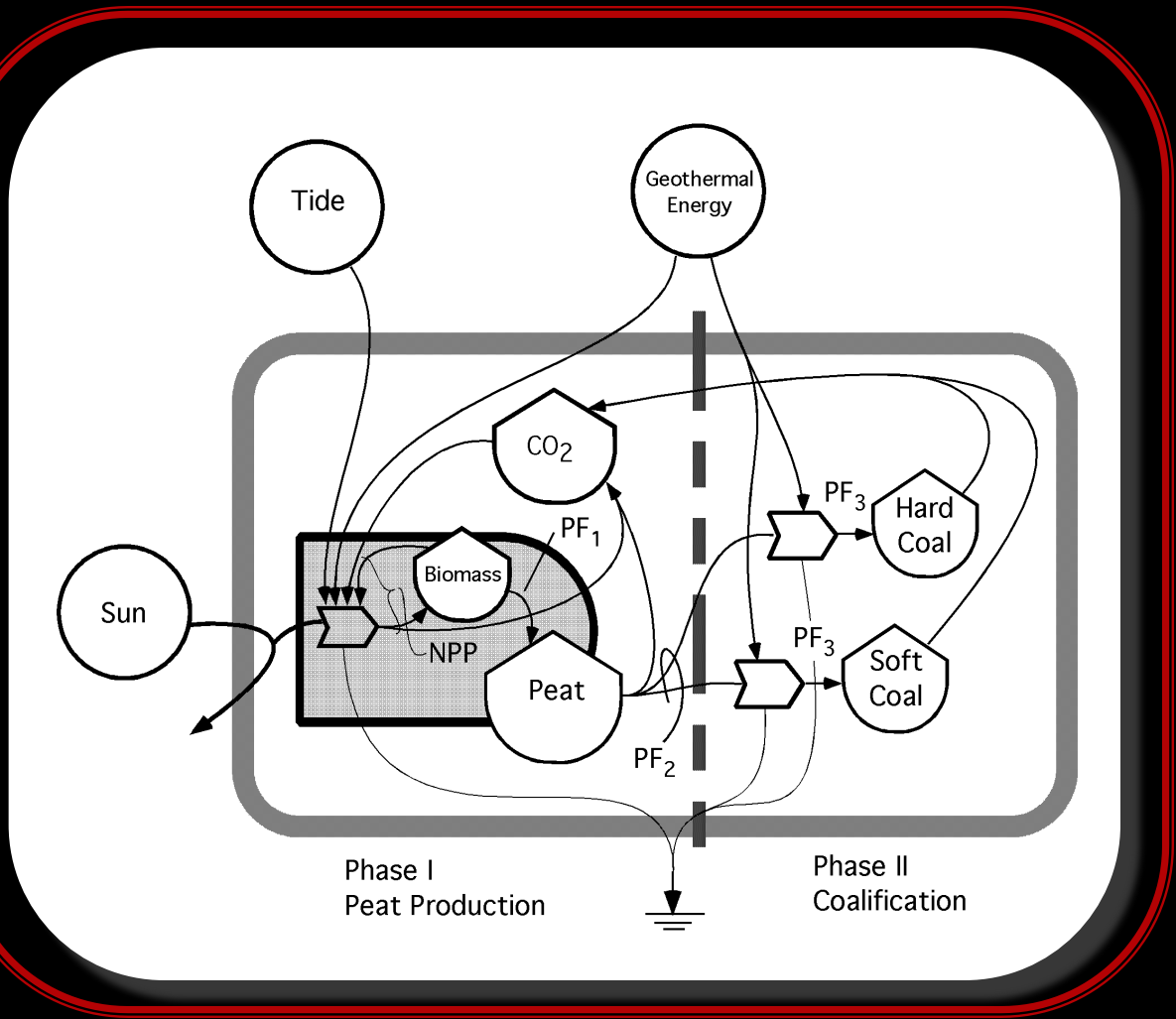
Mark T. Brown[a,*], Gaetano Protano[b], Sergio Ulgiati[b]

[a] Center for Environmental Policy, Department of Environmental Engineering Science, University of Florida, USA
[b] Department of Sciences for the Environment, Parthenope University of Naples, Italy

Non-Renewable Resources...

Coal

There are two distinct processes to coalification with different temperatures and times yielding either soft or hard coal. Higher temperatures and longer times yield hard coals, while lower temperatures and shorter times yield the soft coals



Non-Renewable Energy Sources...

UEVs for…COAL

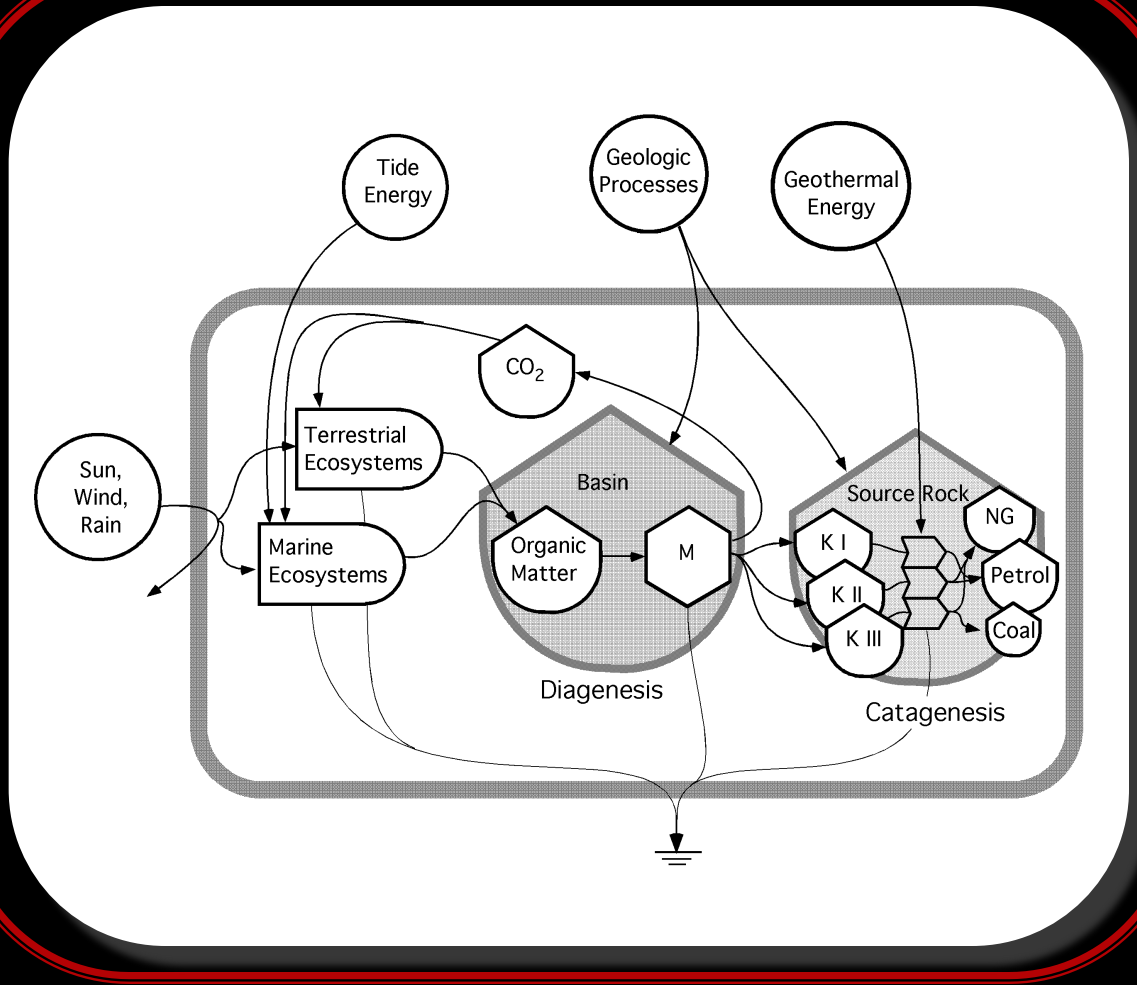
Table 2. Computation of Coal resource UEVs

Period	Mass fraction of crust		Geothermal exergy (J)		Geothermal Emergy		Ecosystem Emergy (E23 sej)		UEV^4 (sej/J)	
	Anthracite & Bituminous	Sub-bituminous & Lignite	Anthracite & Bituminous	Sub-bituminous & Lignite	Anthracite & Bituminous	Sub-bituminous & Lignite	Anthracite & Bituminous	Sub-bituminous & Lignite	Anthracite & Bituminous	Sub-bituminous & Lignite
Devonian	2.44E-11	1.41E-11	2.03E+17	6.03E+16	9.94E+20	2.95E+20	5.1	2.5	35836	29768
Carboniferous	5.92E-09	3.42E-09	4.93E+19	0.00E+00	2.41E+23	0.00E+00	1304.0	652.6	37927	31472
Permian	7.72E-09	4.46E-09	6.43E+19	1.91E+19	3.15E+23	9.37E+22	1337.2	669.2	29829	24774
Triassic	9.74E-11	5.63E-11	8.11E+17	2.41E+17	3.97E+21	1.18E+21	16.9	8.5	29854	24795
Jurassic	4.09E-09	2.37E-09	3.41E+19	1.01E+19	1.67E+23	4.96E+22	2398.4	1200.3	100782	83759
Cretaceous	3.24E-09	1.87E-09	2.70E+19	8.02E+18	1.32E+23	3.93E+22	217.8	109.0	11625	9640
Tertiary	3.29E-09	1.90E-09	2.74E+19	8.14E+18	1.34E+23	3.99E+22	233.3	116.8	12264	10172
								Weighted Average (sej/J)	38,921	32,324
								J/g	29458	19995
								seJ/g	1.15E+09	6.46E+08

Non-Renewable Energy Sources...

Oil & Natural Gas

Diagram of oil production showing the processes of diagenesis (burial and physical, chemical or biological alteration of organic matter at relatively low temperatures and pressures) which forms three types of kerogen (KI, KII, and KIII) and Catagenesis (cracking process in which organic kerogens are broken down into hydrocarbons).



Non-Renewable Energy Sources...

UEVs for…CRUDE Oil & NATURAL GAS

Table 2. Aggregated oil and natural gas UEVs

Geologic Age	sej/g C in hydrocarbon		sej/gC weighted average	
	Oil	NG	Oil	NG
Silurian	6.93E+09	6.93E+09	6.23E+08	6.23E+08
Upper Devonian-Turonian	1.48E+10	1.48E+10	1.18E+09	1.18E+09
Pennsylvanian-Lower Permian	7.00E+09	1.12E+10	5.60E+08	8.97E+08
Upper Jurassic	1.94E+09	1.94E+09	4.85E+08	4.85E+08
Middle Cretaceous	2.89E+09	5.75E+09	8.37E+08	1.67E+09
Oligocene-Miocene	6.52E+09	7.61E+09	8.15E+08	9.51E+08
		sum	4.92E+09	6.34E+09
		sej/g crude fuel[1.]	5.79E+09	7.46E+09
		sej/J crude fuel	1.32E+05	1.40E+05
		sej/m3	5.09E+15	5.36E+12

Non-Renewable Energy Sources...

UEVs for…CRUDE Oil & NATURAL GAS including mining and transport

Coal, crude oil, and natural gas UEVs including mining/drilling and transport				
Fuel Type			Unit Emergy Value [3.]	
	Mining/Drilling [1.]	Transport [2.]	Specific Emergy	Trasnformity
	(sej g^{-1})	(sej g^{-1})	(sej g^{-1})	(sej J^{-1})
Soft Coal	1.93E+08	2.20E+07	**8.61E+08**	**4.31E+04**
Hard Coal	1.93E+09	2.20E+07	**3.10E+09**	**1.05E+05**
Oil (crude)	3.16E+08	1.41E+08	**6.25E+09**	**1.42E+05**
Natural Gas	3.16E+08	1.05E+07	**7.79E+09**	**1.46E+05**

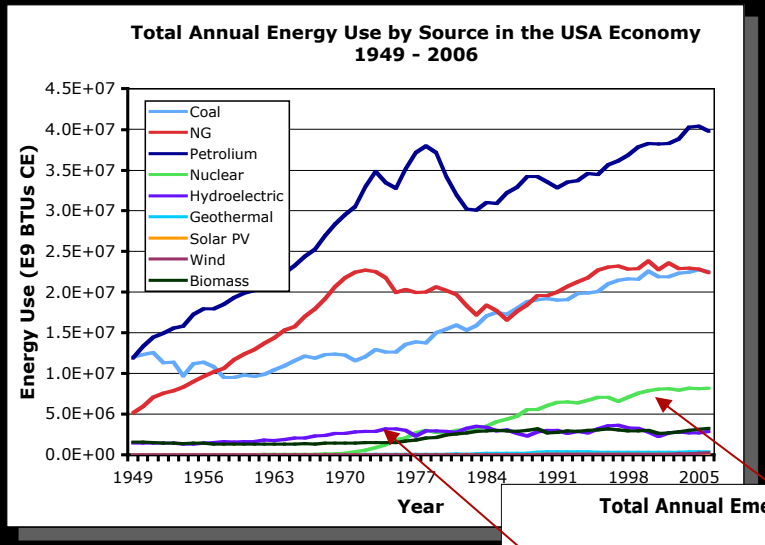
Non-Renewable Energy Sources...

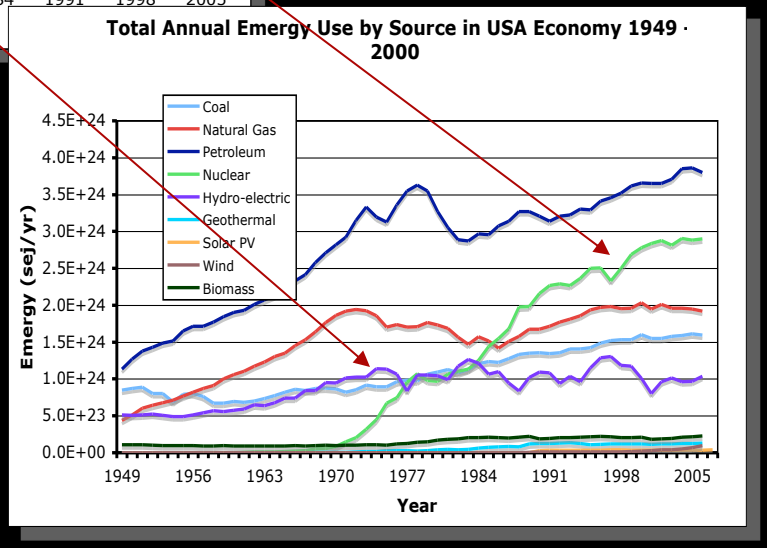
Petrolium derived fuels…

Unit emergy values for petroleum derived fuels without services

Fuel Type	Crude Oil Input [1.]	Refining Emergy [2.]	Transport [3.]	Unit Emergy Value [4.]	
				Specific Emergy of fuel	Transformity of fuel
	(sej g^{-1})	(sej g^{-1})	(sej g^{-1})	(sej g^{-1})	(sej J^{-1})
Gasoline	6.25E+09	1.25E+09	5.60E+07	**7.56E+09**	**1.74E+05**
Kerosene (Jet fue	6.25E+09	1.10E+09	5.60E+07	**7.41E+09**	**1.70E+05**
Diesel	6.25E+09	9.58E+08	5.60E+07	**7.26E+09**	**1.70E+05**
LPG	6.25E+09	5.36E+08	5.60E+07	**6.84E+09**	**1.47E+05**
Residual oil	6.25E+09	5.36E+08	5.60E+07	**6.84E+09**	**1.73E+05**

Non-Renewable Energy Sources...





Relative share of nuclear and hydroelectric is much higher when corrected for Quality

Mineral & Metal

UEVs

Final Technical Report to USEPA

Contract EP-11-C-000197:

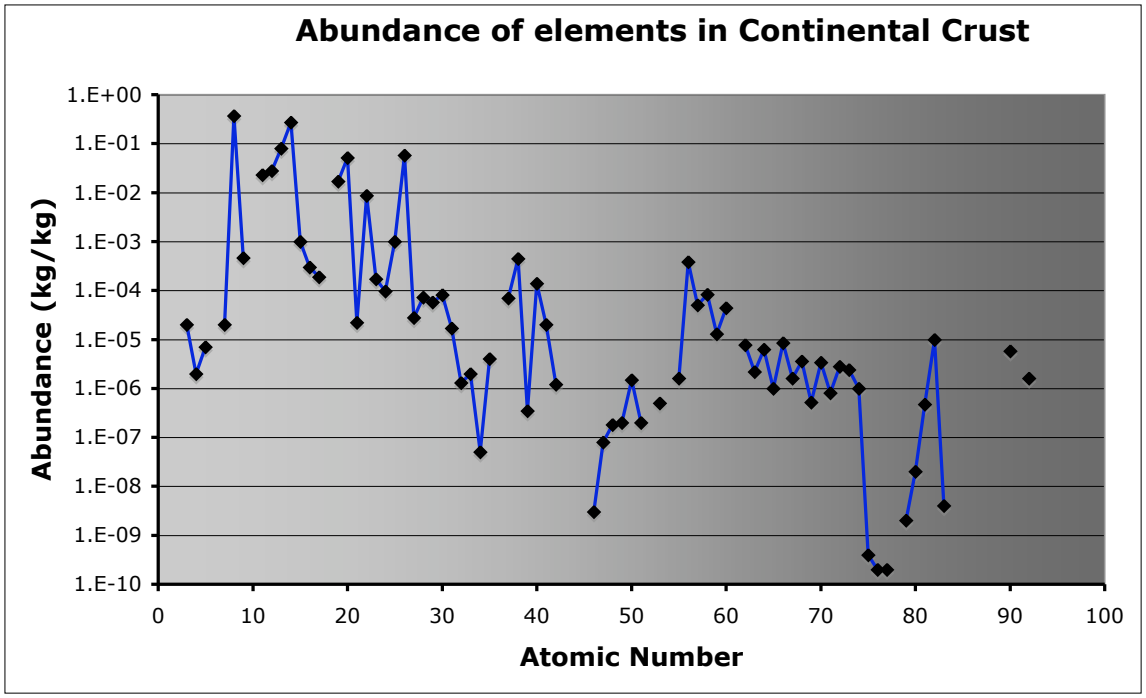
Emergy research support for supply chains

Christopher De Vilbiss and Mark T. Brown

Center for Environmental Policy
School of Sustainable Infrastructure and Environment
College of Engineering
University of Florida
Gainesville, FL 32611

Non-Renewable Minerals & Metals...

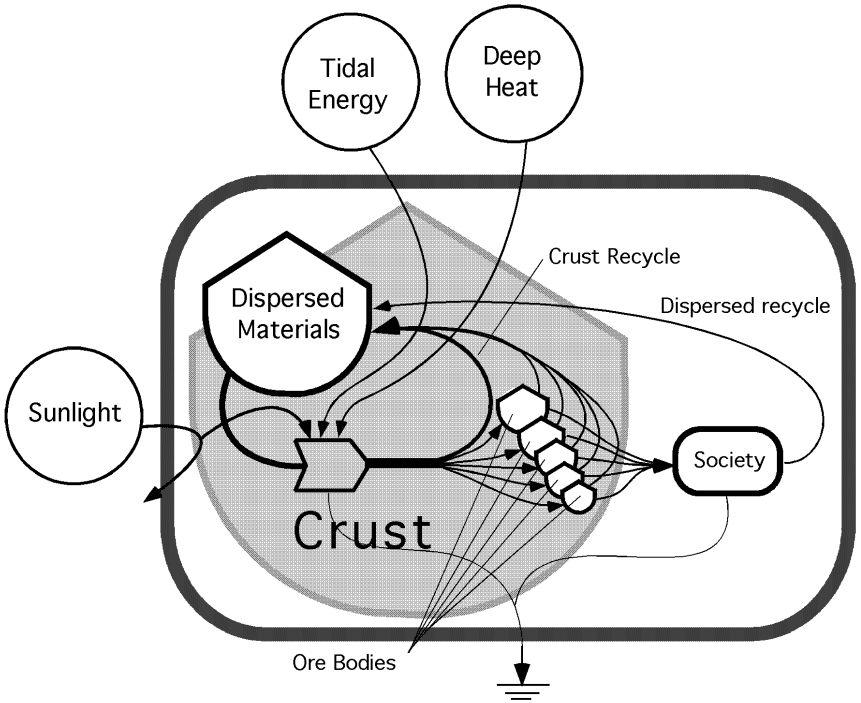
The emergy of minerals and metals is related to their concentration in the Earth's crust



Non-Renewable Minerals & Metals...

The distribution of ore body concentrations in the crust that arise from dispersed elements and the work of geologic processes driven by sunlight, tidal, and geothermal exergy.

Ore bodies of differing concentrations result form these process represented in the diagram by the different sizes of storages.



Minerals & Metals...

Are minerals and metals

non-renewable?

Minerals & Metals...

A mineral is a naturally occurring chemical compound, that has one specific chemical composition

A metal is an element or compound that is typically hard, opaque, shiny, and has good electrical and thermal conductivity.

An ore is a mineral that has a high concentration of a certain element, typically a metal.

Minerals & Metals...

Calculation of mineral & metal UEVs begins by computing the average crustal specific emergy...

To compute a UEV for crust, the annual global emergy (12.0 E24 sej yr^{-1}) is divided by the estimated flux of continental crust (8.68E12 kg y^{-1}):

UEV_{crust} = 12.0 E24 sej yr^{-1} / 8.68 E12 kg y^{-1}
= 1.38 E12 sej kg^{-1}

Minerals & Metals...

Calculation of mineral & metal UEVs next computes an average transformity at crustal abundance, as the ratio of average crustal specific emergy (Sp_{crust} =1.38 E12 sej kg^{-1}) and the mineral's Gibb's energy as follows:

$$Tr_i = Sp_{crust} / |\Delta Gi|$$

Where:

$$\Delta g_i = x_i(\Delta G_{f,I} + RT_0 \, ln \, x_i)$$

and,

x_i = the molar fraction (mole/mole) of mineral *i*

Next we compute a UEV based on concentration in an ore body, which requires concentration exergy be taken into account (mixing exergy). The mineral's mixing exergy is the difference in free energy between ore deposit concentration (c) and average crustal concentration (cr) as follows:.

$$Ex_i = \Delta G_{i,c} - \Delta G_{i,cr} = RT_0 \ln x_{i,c} / x_{i,cr}$$

where,

$x_{i,c}$ = is the molar fraction (mole/mole) of mineral *i* at concentration *c*.

$x_{i,cr}$ = average molar fraction of mineral *i* in the crust

Minerals & Metals...

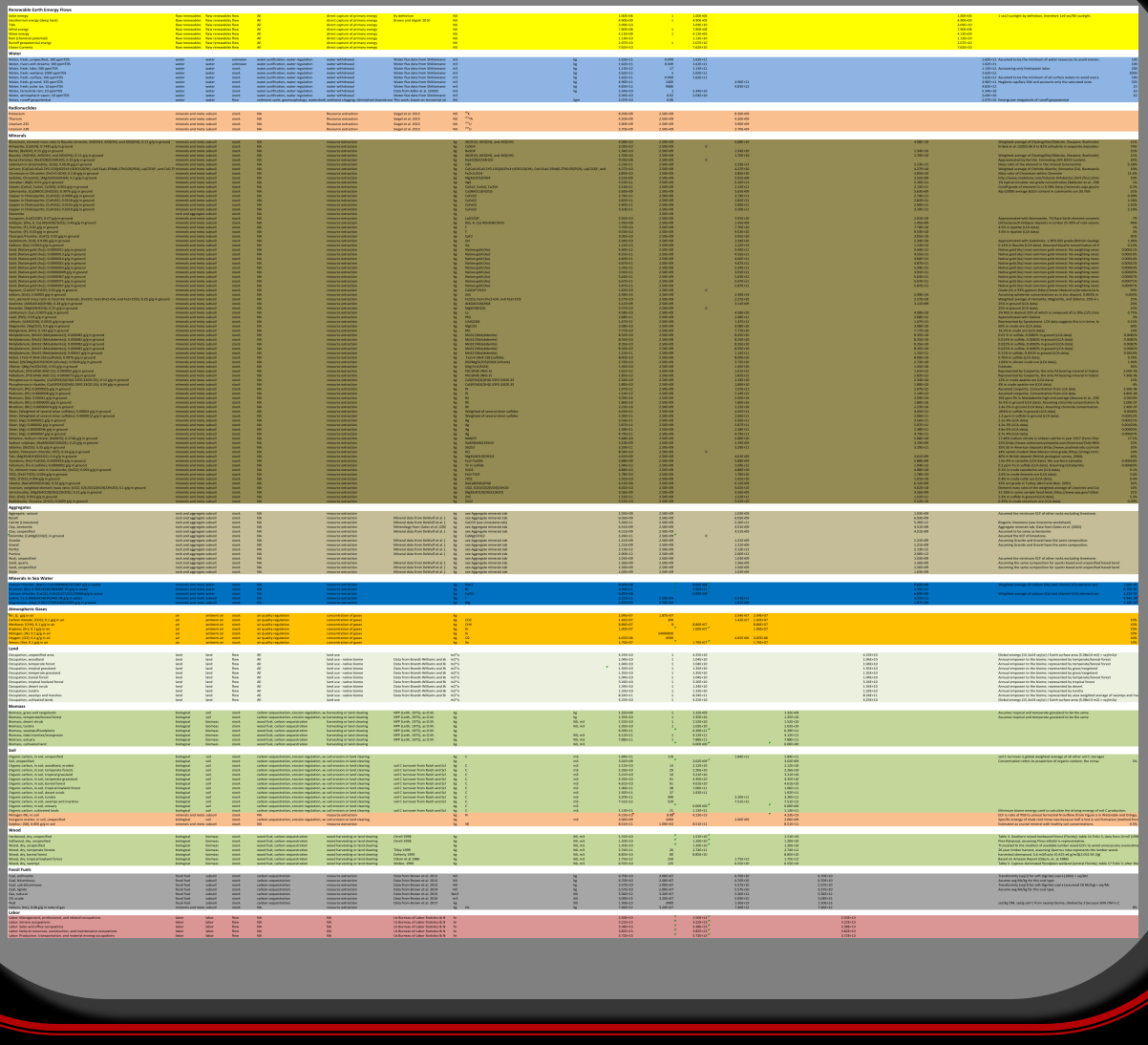
Finally, the product of mineral mixing exergy (Ex_i) and its crustal average transformity (Tr_i) is the mineral's specific emergy at mine concentration as follows:

$$Sp_{i,c} = Tr_i * Ex_i$$

Since there are as many ore body concentrations as there are ore bodies, we may have numerous UEVs depending on the mineral concentrations in the various ore bodies.

Minerals & Metals...

Unit Emergy Value data base - (UEVdb)



Minerals & Metals...

UEVs of some common minerals and metal ores including mining and transport				
Mineral	Mineral UEV [1.]	Mining & Beneficiation [2.]	Transportation [3.]	Total
	(1.0 E12 sej kg^{-1})	(1.0 E9 sej kg^{-1})	(1.0 E9 sej kg^{-1})	(1.0 E12 sej kg^{-1})
Limestone [4.]	5.93	4.4	18.0	6.0
Bauxite (~ 40% alumina)	11.2	12.5	61.6	11.3
Iron (as 25% FE)	2.97	68.5	61.6	3.1
Phosphate	10.9	425.2	61.6	11.4
Lead (concentrate, ~70% Pb)	5.65	699.5	61.6	6.4
Zinc (concentrate, ~45-55% Zn)	14	1061.2	61.6	15.1
Copper (concentrate, ~28% CU)	13.5	1330.0	61.6	14.9
Lithium (as carbonate Li_2CO_3; ~19% Li)	91.8	1991.5	61.6	93.9
Silver (as dore; ~53% Ag)	5.85	8020.0	61.6	13.9
Gold (as dore; ~47% Au)	5.65	8020.0	61.6	13.7
Titanium (concentrate, ~50% Ti)	5.05	16889.4	61.6	22.0
Magnesium, at plant	10.9	23100.0	61.6	34.1
Uranium (as yellow cake; 80% UO_2)	4.36	67547.9	61.6	72.0

Slowly-Renewable Resources

Slowly-renewable resources can be renewable if used at rates less than their regeneration rate. Examples:

Soil, Biomass, Wood, Water

Slowly-Renewable Resources...

Soils…

Soil is composed of an organic fraction and a mineral fraction.

The organic fraction is the product of plant primary production and is composed of organic carbon.

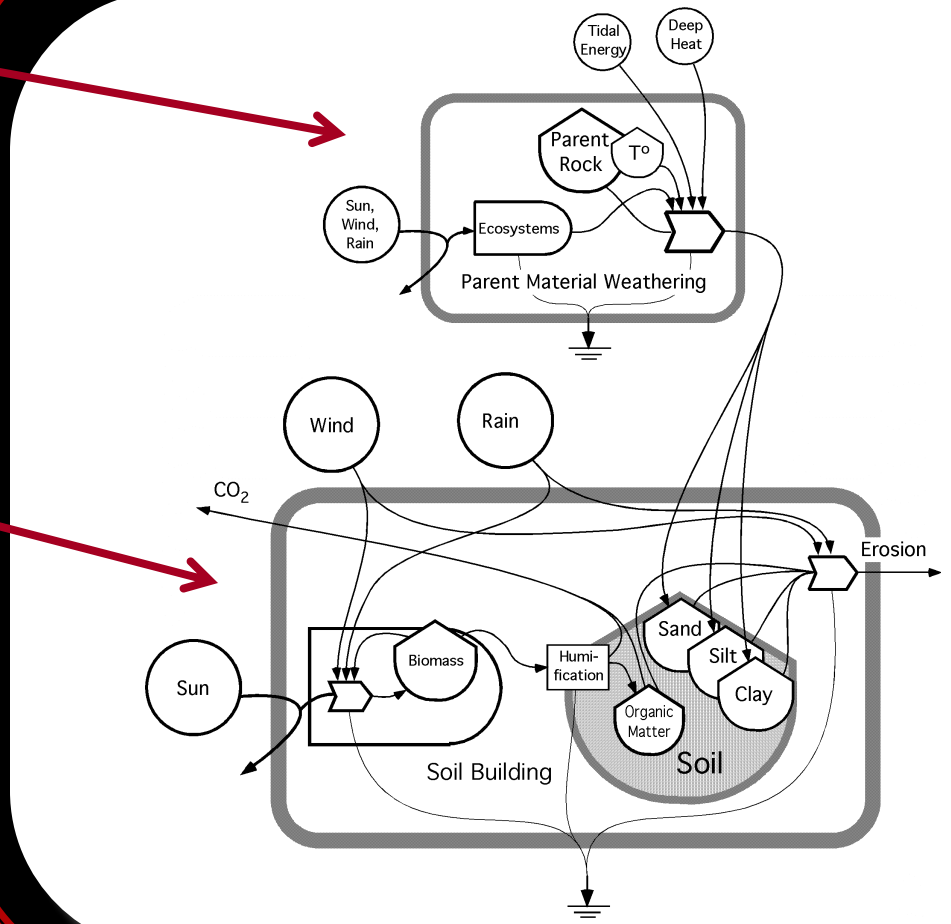
The mineral fraction is the product of weathering of parent rock materials and is composed of sand, silt, and clay.

As a result, soils have two distinct components that should be evaluated separately.

Slowly-Renewable Resources...

Mineral fraction

Organic fraction



Slowly-Renewable Resources...

Soil, organic fraction. UEVs are computed using the turnover time of the top 1.0 meter of soil (Raich and Schlesinger,1992; Table 3)

Table 3. Transformity and specific emergy of soil C in biomes

Biome	Soil C ($kg\ C\ m^{-2}$) [1]	Energy ($E+12\ J\ ha^{-1}$) [2]	Areal empower ($E+14\ sej\ ha^{-1}\ yr^{-1}$) [3]	Turnover (yr) [4]	Specific emergy ($E+9\ sej\ kg^{-1}$)	Transformity ($sej\ J^{-1}$)
Woodland[5]	6.9	2.9	1.04	14	21.19	506
Temperate forests[5]	13.4	5.6	1.04	29	22.6	540
Tropical grassland	4.2	1.8	1.35	10	32.1	766
Temperate grassland	18.9	7.9	1.35	61	43.5	1038
Boreal forest[5]	20.6	8.6	1.04	91	46.1	1102
Tropical forest[6]	11.7	4.9	2.02	38	65.5	1564
Desert[7]	2.58	1.1	1.34	37	192.0	4586
Tundra	20.4	8.5	1.33	490	319.8	7637
Swamps and marshes[8]	72.3	30.3	64.88	520	4666.3	111448
Cultivated lands[9]	7.9	3.3	3.07	21	81.5	1946

Slowly-Renewable Resources...

Soil, mineral fraction. UEVs are computed using weighted average of sand silt and clay for soil type.

An average loamy soil of 40% sand, 40% silt and 20% clay has the following UEVs for each constituent (from the UEVdb):

Sand = 1.56 E9 sej kg^{-1}
Silt = 1.45 E9 sej kg^{-1}
Clay = 4.51 E9 sej kg^{-1}

…yielding a weighted average UEV for loamy soil of 2.11 E9 sej kg^{-1}.

Slowly-Renewable Resources...

Biome Biomass… Biome Biomass

Table 2. Transformity and specific emergy of biome biomass

Biome[1]	Areal empower (E+14 sej ha^{-1} yr^{-1})[2]	NPP energy (E+11 J ha^{-1} yr^{-1})[3]	NPP mass (E+7 g ha^{-1} yr^{-1})[3]	Transformity (sej J^{-1})[4]	Specific emergy (E+03 sej kg^{-1})[5]
Tundra	1.3	2.45	1.30	544	10.2
Swamps/floodplains	79.4	3.52	2.00	22578	397.0
Tropical forest	2.0	4.28	2.48	473	8.2
Ocean shelf	8.9	0.68	0.36	13157	247.9
Grass/rangelands	1.3	17.08	10.20	79	1.3
Temperate/boreal forest	1.0	1.51	0.78	691	13.5
Desert	1.3	1.67	0.88	805	15.2
Ice/rock	1.9	0	0	0	-
Open ocean	12.2	0.27	0.13	45716	937.9
Lakes	17.2	0.94	0.50	18306	344.9
Tidal Marsh, mangroves	51.2	3.52	2.00	14546	255.8
Estuaries	141.8	3.39	1.80	41809	787.7
Coral reefs	425.4	3.77	2.00	112884	2126.9
Rivers	228.8	0.94	0.50	242890	4576.4
Terrestrial world ave[6]	3.1	6.4	3.7	859	15.54
World average[7]	11.16	2.06	1.19	31608	644.6

Slowly-Renewable Resources…

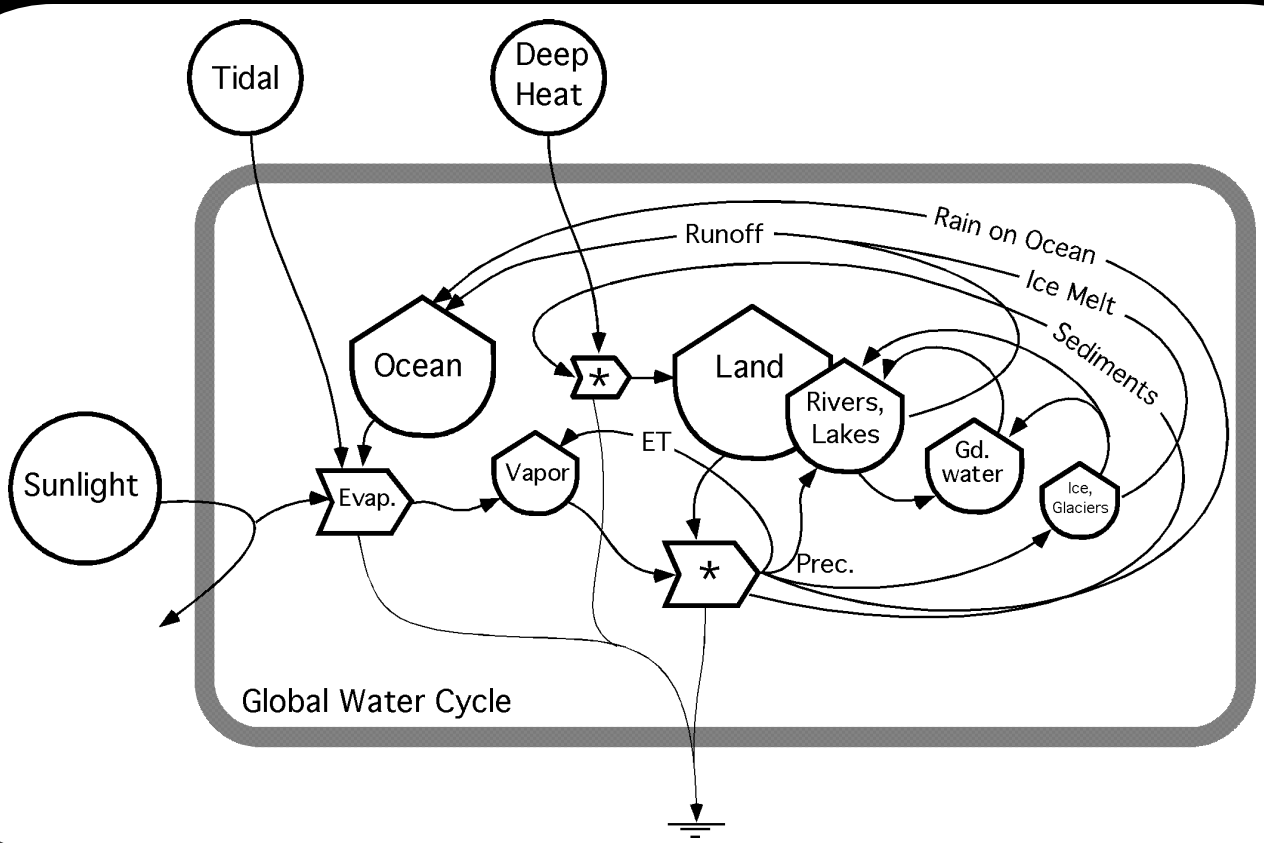
Wood…

Table 1. Summary of Wood Transformities and Specific Emergy

Types of wood	sej J^{-1}	sej kg^{-1}	sej m^{-3}
Boreal spruce and pine		5.49E+10	
Southern mixed hardwood	563	9.38E+09	5.72E+12
Pine flatwood	418	7.43E+09	4.01E+12
Cypress dominated floodplain		3.75E+10	
Subtropical Cypress wetland	2614	1.05E+11	
Temperate forest	11581	1.70E+11	
Southern mixed hardwood swamp		6.55E+11	
Tropical lowland forest		1.09E+12	

Slowly-Renewable Resources...

Global Water Storages…



Slowly-Renewable Resources...

Global Water Storages…

Specific emergy (*Sp)* of each global water storage (at its global average purity) is the ratio of driving emergy (*Em)* to the quotient of mass *m* of water and its turnover time *t*.

$$Sp_i = \frac{Em}{m_i / t_i}$$

Slowly-Renewable Resources...

Water storges…

Global average mixing exergy, specific emergy, and transformity of various freshwater storages

Type	Turnover (yrs)	TDS (mg l^{-1})	Exergy (J g^{-1})	Annual Flux: Mass (g y^{-1})	Annual Flux: Chem. Pot. (J y^{-1})	Driving Emergy (sej y^{-1})	Specific Emergy (sej g^{-1})	Transformity (1E3 sej J^{-1})
World Ocean	2500	35000		5.35E+20	0.00E+00	1.20E+25	2.24E+04	
Ground water (gravity and capillary)[a.]	1400	335	4.68	1.67E+19	7.82E+19	6.30E+24	3.77E+05	8.10E+04
Predominantly fresh ground water[b.]	1400	335	4.68	7.52E+18	3.52E+19	6.30E+24	8.38E+05	1.79E+05
Soil moisture	1	10	4.72	1.65E+19	7.79E+19	6.30E+24	3.82E+05	8.10E+04
Glaciers and permanent snow cover	9686	10	4.72	2.48E+18	1.17E+19	6.30E+24	2.54E+06	5.37E+05
Ground ice of permafrost zone	10000	10	4.72	3.00E+16	1.42E+17	6.30E+24	2.10E+08	4.45E+07
Lakes (Fresh)	17	200	4.70	5.35E+18	2.51E+19	6.30E+24	1.18E+06	2.51E+05
Swamp	0.50	2000	4.46	2.30E+19	1.03E+20	6.30E+24	2.74E+05	6.10E+04
River/stream	0.057	100	4.71	3.72E+19	1.75E+20	6.30E+24	1.69E+05	3.60E+04
Biological	0.003	9000	3.53	4.09E+20	1.44E+21	6.30E+24	1.54E+04	4.00E+03
Terrestrial Precipitation	1	10	4.72	1.13E+20	5.34E+20	6.30E+24	5.58E+04	1.20E+04
Ocean Precipitation	1	10	4.72	4.13E+20	1.95E+21	5.70E+24	2.91E+04	6.00E+03
Atmosphere	0.022	10	4.72	5.89E+20	2.78E+21	1.20E+25	2.04E+04	4.00E+03

Quaternary Products

UEVs

Unit Emergy Values (UEVs)...

EXAMPLE: Pulpwood Production, Florida

UEVs are computed by first evaluating all the inputs to the processes in emergy, summing them, and dividing by the energy or mass of the output.

Emergy evaluation o fpulpwood production southeastern USA (1 hectare) - 27 year rotation (flows are annual flows)

Note	Item	Units	Quantity	UEVs (sej unit^{-1})	Solar Emergy (E12 sej yr^{-1})
Primary Renewable Inputs					
1	Sunlight	J y^{-1}	7.81E+13	1	78.1
2	Earth Cycle (Geothermal)	J y^{-1}	8.66E+08	4900	4.2
				Sum of Tripartite	**82.4**
Secondary and Tertiary Renewable Sources					
3	Wind	J y^{-1}	2.37E+11	790	186.9
4	Rain Chemical Potential of Transpiration	J y^{-1}	3.78E+10	12000	453.7
5	Runoff: Geopotential	J y^{-1}	5.86E+07	22000	1.3
6	Runoff: Chem. Potential	J y^{-1}	4.79E+07	35800	1.7
				Largest of Secondary & Tertiary	**453.7**
Storages From Within					
7	Top soil loss	g y^{-1}	3.70E+05	2.11E+06	0.8
8	Top Soil C Loss	J y^{-1}	7.41E+03	6.55E+07	0.5
				Total Storages from Within	1.3
Purchased Inputs					
9	Seedlings	g y^{-1}	2.63E+03	1.14E+10	30.0
10	Fertilizer, Elemental N	g y^{-1}	5.56E+03	2.02E+10	112.3
11	Fertilizer, Elemental P	g y^{-1}	1.30E+03	1.84E+10	23.9
12	Herbicides	g y^{-1}	1.22E+02	1.88E+10	2.3
13	Fuel	J y^{-1}	9.64E+08	1.70E+05	163.8
14	Machinary, Equipment	g y^{-1}	5.93E+03	8.52E+09	50.5
15	Labor	hr y^{-1}	1.30E+00	3.22E+13	41.7
16	Services	$ y^{-1}	$50.00	1.93E+12	96.5
				Total Purchased	**521.0**
				Total Inputs	**976.0**
Outputs					
17	Pulpwood Chips (with services)	J y^{-1}	5.00E+10	**1.95E+04**	976.0
	Pulpwood Chips (with services)	g y^{-1}	3.33E+06	**2.93E+08**	976.0
18	Pulpwood Chips (w/out services & labor)	J y^{-1}	5.00E+10	**1.68E+04**	837.7
	Pulpwood Chips (w/out services & labor)	g y^{-1}	3.33E+06	**2.51E+08**	837.7

Unit Emergy Values (UEVs)...

EXAMPLE:
Oil fired - Electricity

Emergy evaluation of 500MW oil-fired power plant

Note	Item	Units	Quantity	UEV (sej unit^{-1})	Emergy (sej)
Inputs for Construction Phase					
1	*Material inputs (M)*				
1.1	Concrete (as limestone)	g	1.20E+11	1.57E+09	1.88E+20
1.2	Lubricants (as crude oil)	g	8.78E+07	5.79E+09	5.08E+17
1.3	Cu (as metal)	g	7.50E+08	2.12E+11	1.59E+20
1.4	Al (as metal)	g	3.00E+08	1.35E+11	4.04E+19
1.5	Steel (as iron metal)	g	3.38E+09	1.31E+10	4.43E+19
1.6	Plastics (as crude oil)	g	3.00E+08	5.79E+09	1.74E+18
2	*Fuel inputs (E1)*				
2.1	Diesel (as crude oil)	g	6.92E+09	5.79E+09	4.01E+19
2.2	Heavy fuel oil (as crude oil)	g	6.95E+09	5.79E+09	4.02E+19
3	*Electricity input (E1)*	*J*	*2.00E+13*		
3.1	Oil (as crude oil)	J	1.94E+12	1.73E+05	3.36E+17
3.2	Coal (at the mine)	J	3.33E+13	7.65E+04	2.55E+18
3.3	Natural gas (at well head)	J	5.39E+12	1.46E+05	7.89E+17
3.4	Uranium (as metal)	g	3.28E+04	6.76E+13	2.21E+18
3.5	Hydropower	J	8.50E+11	1.70E+04	1.44E+16
3.6	Wind power	J	9.72E+11	2.50E+03	2.43E+15
4	*Energy & Machinery (crude oil*	J	1.11E+15	1.73E+05	1.91E+20
5	*Construction Services (S1)*	$	7.00E+08	2.00E+12	1.40E+21
Inputs for Feedstock					
6	*Feedstock Services (S2)*	$	5.47E+09	2.00E+12	1.094E+22
7	*Energy & Machinery (crude oil*	J	4.85E+16	1.73E+05	8.40E+21
8	*Refining Services (S2)*	$	3.28E+08	2.00E+12	6.56E+20
Inputs for Operation Phase					
9	*Wind for pollutant dispersal (R)*	J	8.98E+18	5.20E+02	4.67E+21
10	*Water for cooling (R)*	J	1.20E+16	2.13E+04	2.56E+20
11	*Heavy fuel oil (as crude oil) (Fs)*	J	8.41E+17	1.73E+05	1.456E+23
12	*Operational Labor (L)*	$	1.31E+08	2.00E+12	2.62E+20
Output					
13	*Electricity generated* ***(Y)***	J	**3.07E+17**	**U =**	**1.728E+23**
UEVs					
14	UEV with labor & services **(U/Y)**	sej/J		**5.62E+05**	
15	UEV without labor & services **([U-**	sej/J		**5.21E+05**	

Unit Emergy Values (UEVs)...

EXAMPLE: Concrete

Concrete from EcoInvent

	Flow	Unit	Quantity	UEV (sej unit^{-1})	Emergy (E12 sej)
	Diesel, burned in building machine	MJ	22.7	1.70E+11	3.85
	Electricity, medium voltage, at grid	kWh	4.36	7.95E+11	3.47
	Gravel, round, at mine	kg	1890	1.73E+12	3269.70
	Heavy fuel oil, burned in industrial furnace 1MW,	MJ	3.09	1.73E+11	0.54
	Light fuel oil, burned in industrial furnace 1MW,	MJ	13.3	1.70E+11	2.26
	Lubricating oil, at plant	kg	0.0119	6.84E+12	0.08
	Natural gas, burned in industrial furnace>100kW	MJ	1.16	1.46E+11	0.17
	Portland cement, strength class Z 42.5, at plant	kg	300	8.50E+12	2550.00
	Steel, low-alloyed, at plant	kg	0.0238	1.31E+13	0.31
	Tap water, at user	kg	186	4.96E+08	0.09
	Transport, barge	t*km	49.2	1.20E+10	0.59
	Tansport, freight, rail	t*km	6.82	3.16E+11	2.16
	Transport, lorry 20-28t, fleet average	t*km	9.44	1.80E+11	1.70
	Transport, lorry 3.5-20t, fleet average	t*km	0.998	1.80E+11	0.18
	Concrete	**m3**	**1.0**	**5.84E+15**	5835.09
	Concrete (2400 kg/m3)	**kg**	**1.0**	**2.43E+12**	

Unit Emergy Values (UEVs)...

EXAMPLE:
28 ton Truck

Lorry production, 28 metric ton				
Flow	**Unit**	**Amount**	UEV	Emergy
Aluminium, cast alloy	kg	112.3	1.35E+14	1.52E+16
Aluminium, wrought alloy	kg	238.6	1.35E+14	3.22E+16
Cast iron	kg	1799.4	1.53E+13	2.75E+16
Copper	kg	49.0	2.00E+13	9.80E+14
Diesel	kg	166.9	7.26E+12	1.21E+15
Diesel, burned in building machine	MJ	20.1	7.26E+12	1.46E+14
Electricity, medium voltage	kWh	4738.4	1.88E+12	8.91E+15
Flat glass, uncoated	kg	73.4	1.00E+12	7.34E+13
Heat, district or industrial, natural gas	MJ	33149.5	1.46E+11	4.84E+15
Lead	kg	73.6	1.42E+13	1.05E+15
Lime, hydrated, packed	kg	0.3	1.10E+11	3.41E+10
Lubricating oil	kg	100.0	6.84E+12	6.84E+14
Pig iron	kg	2939.0	1.28E+13	3.76E+16
Polyethylene, high density, granulate	kg	374.9	9.66E+12	3.62E+15
Reinforcing steel	kg	3968.7	1.85E+13	7.34E+16
Section bar rolling, steel	kg	2939.0	1.52E+13	4.47E+16
Sheet rolling, steel	kg	681.8	1.52E+13	1.04E+16
Synthetic rubber	kg	611.8	1.00E+13	6.12E+15
Ttap water	kg	16393.7	2.20E+08	3.61E+12
Water, well, in ground	m3	69.5	2.23E+11	1.55E+13
Wire drawing, copper	kg	49.0	2.00E+13	9.80E+14
1 28t truck (weight = 10,200kg) price = $20,000	unit			2.70E+17
weight = 10,200 kg	kg		**2.64E+13**	
Price = $40,000	$		**6.74E+12**	

Questions?