EmEa - 11

Emergy and the Economy:

Emergy Money Ratio, “Value Added”, international trade, emergy advantage, Emergy Based Exchange Rate, emergy of labor,

Valuing…

Two distinct opposing views…

- Receiver system of value
- Donor system of value

Biophysical Values...

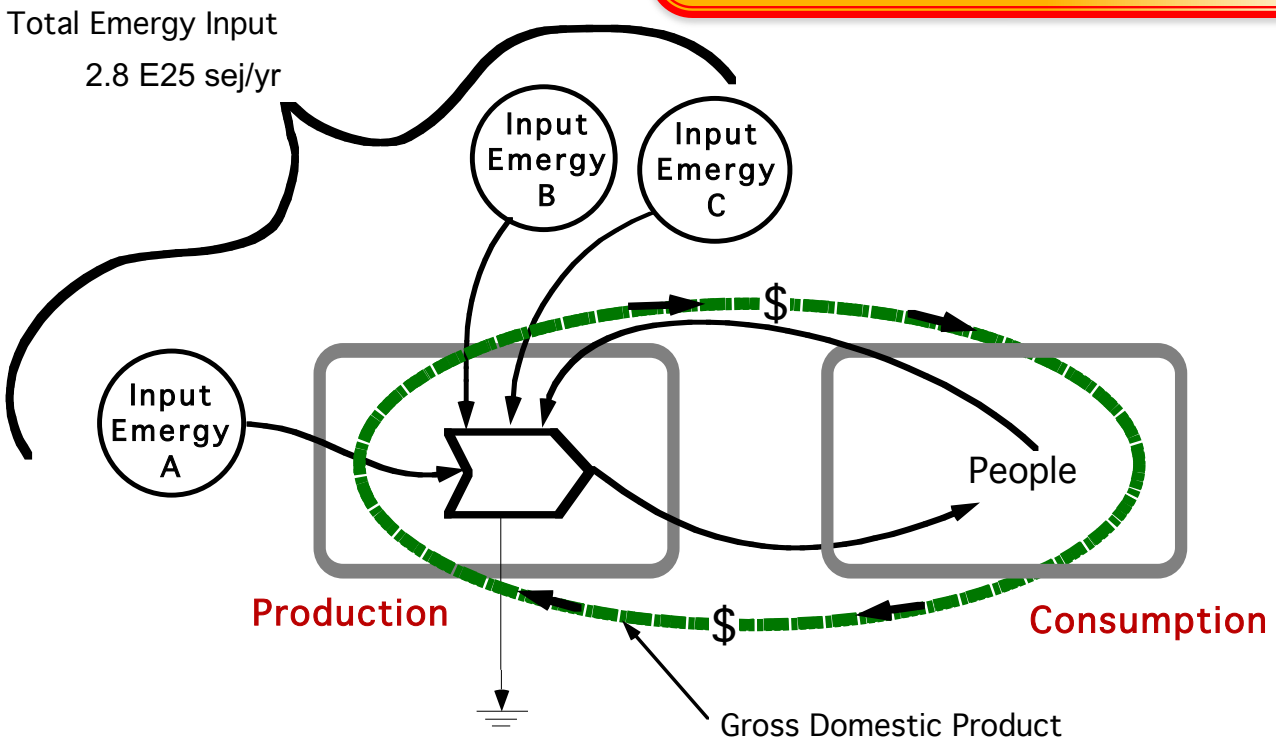
EmDollars…

the money equivalent of emergy.

- By using a standard conversion factor, we can express emergy in dollar equivalents…
- In the same way as we could express dollars in energy equivalents..ie liters of gas

Biophysical Values...

Emergy Money Ratio
USA Economy



Total Emergy Use / GDP = 2.8 E25 sej/yr / 1.4 E13 $/yr = 2.0 E12 sej/$

Emdollars of the US Economy

$$\frac{\text{Total Emergy Use}}{\text{Gross Domestic Product}} = 2.0 \text{ E12 sej/dollar}$$

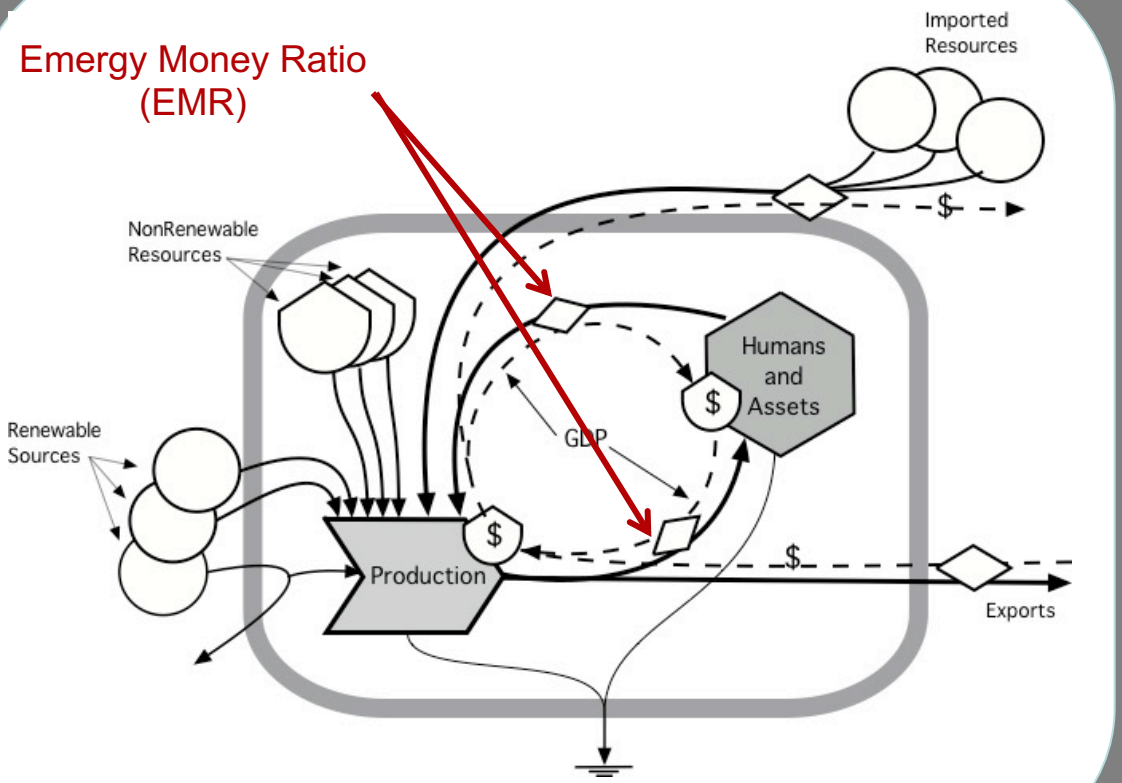
So...

Every dollar spent in US economy has "embodied" in it, 2.0 E 12 sej of emergy

Biophysical Economy...

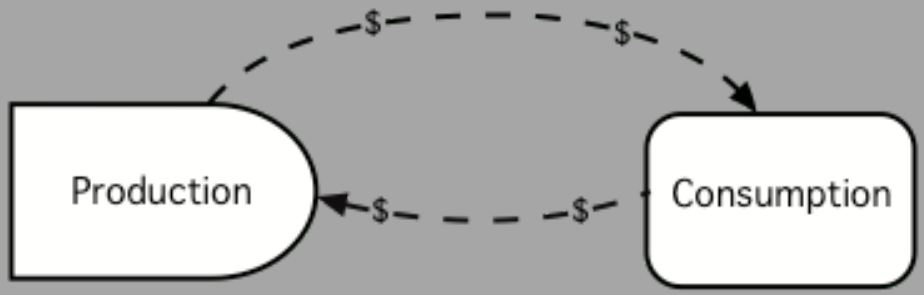
Relationship of money to emergy

Economic production is a function of renewable energy, non-renewable resources (minerals, and fuels) and human labor. In modern economies imported resources are also important contributions to production. The circulation of money (gross domestic product; GDP) is driven by the resource and labor flows.



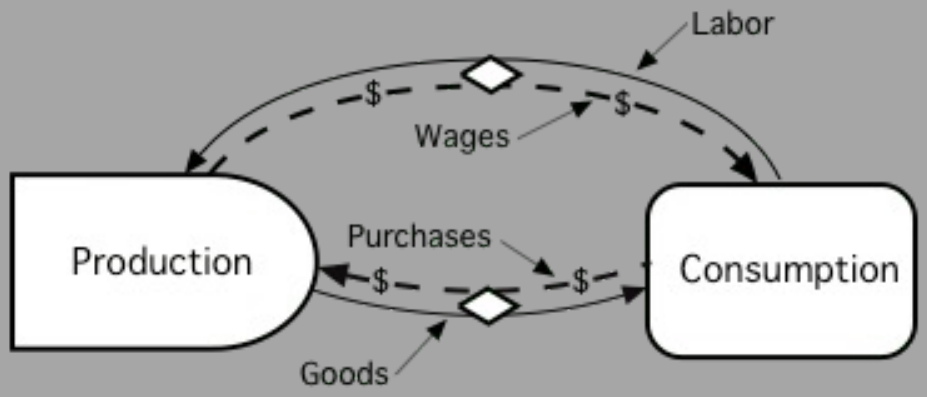
Macro Economic System...

The “standard” economic model



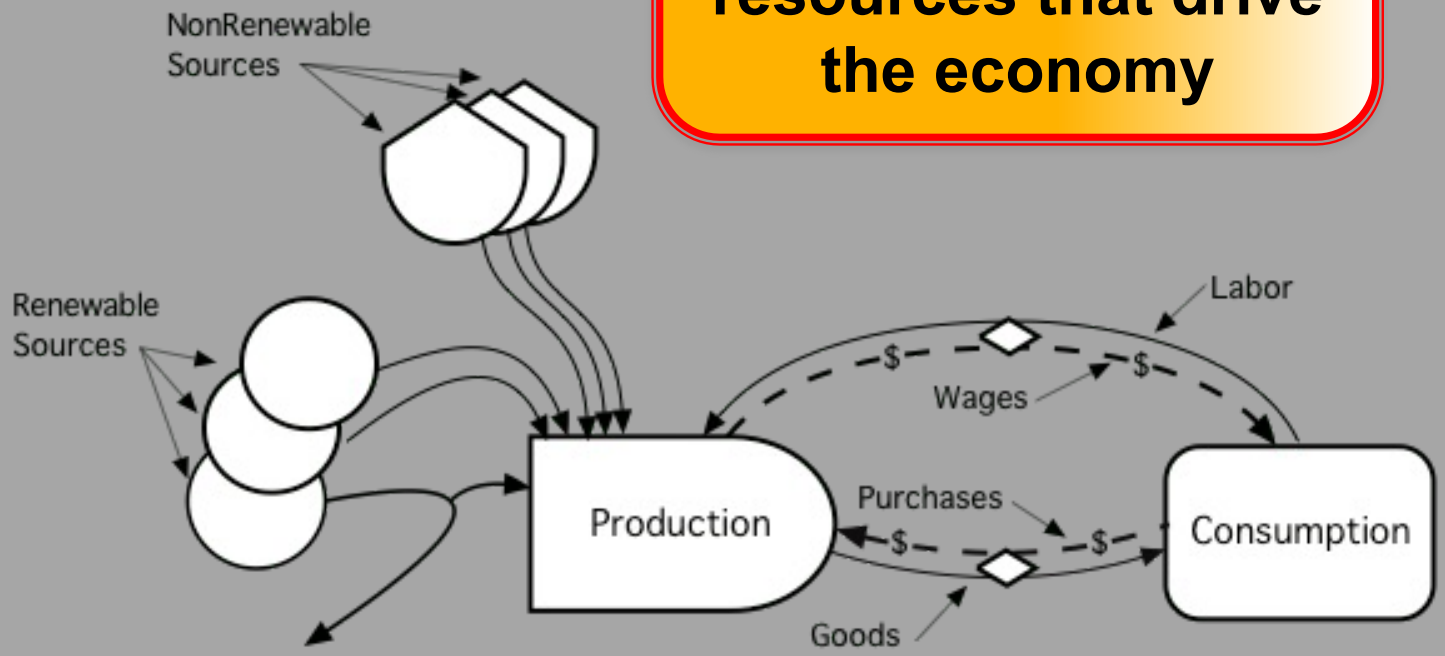
Macro Economic System...

The textbooks leave out the counter flows of goods and labor



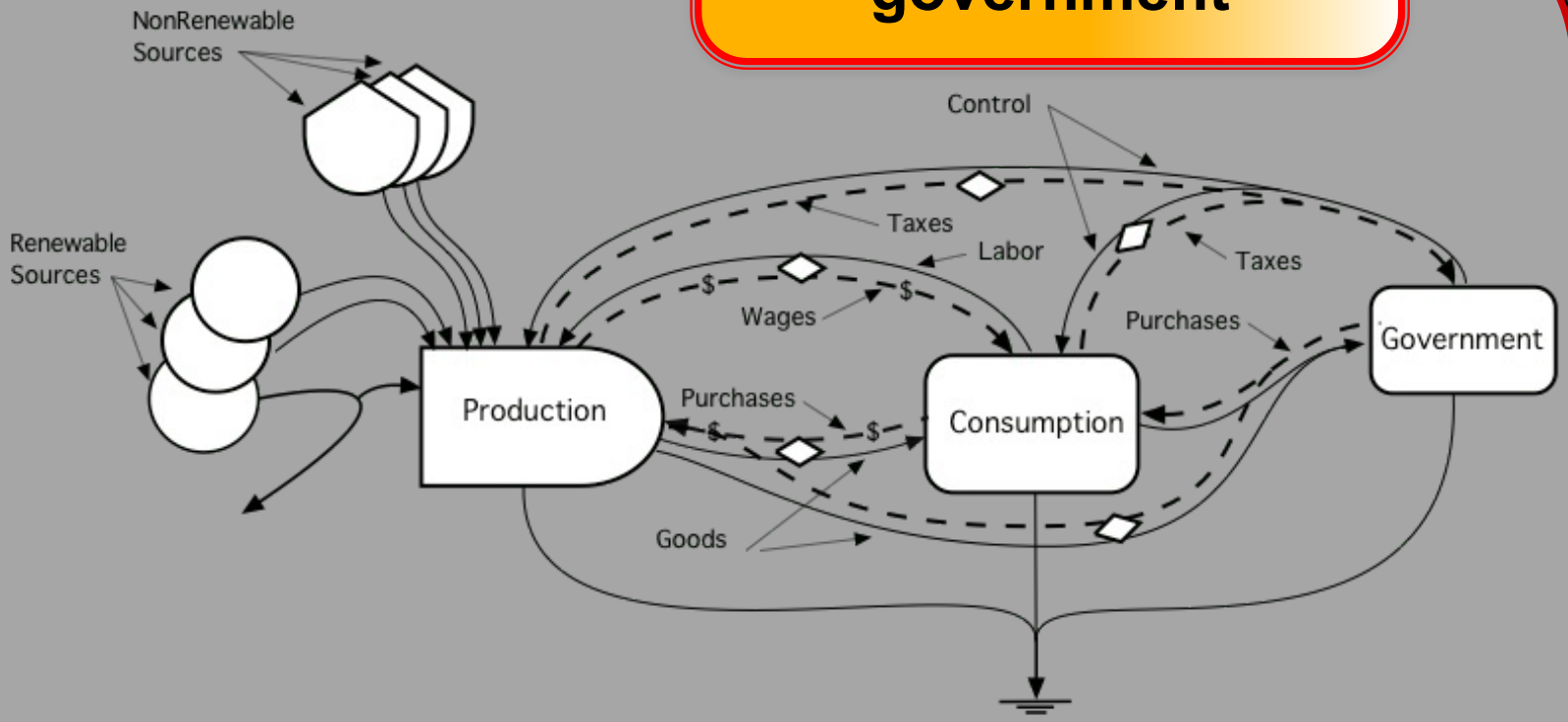
Macro Economic System...

…and the renewable and non-renewable resources that drive the economy



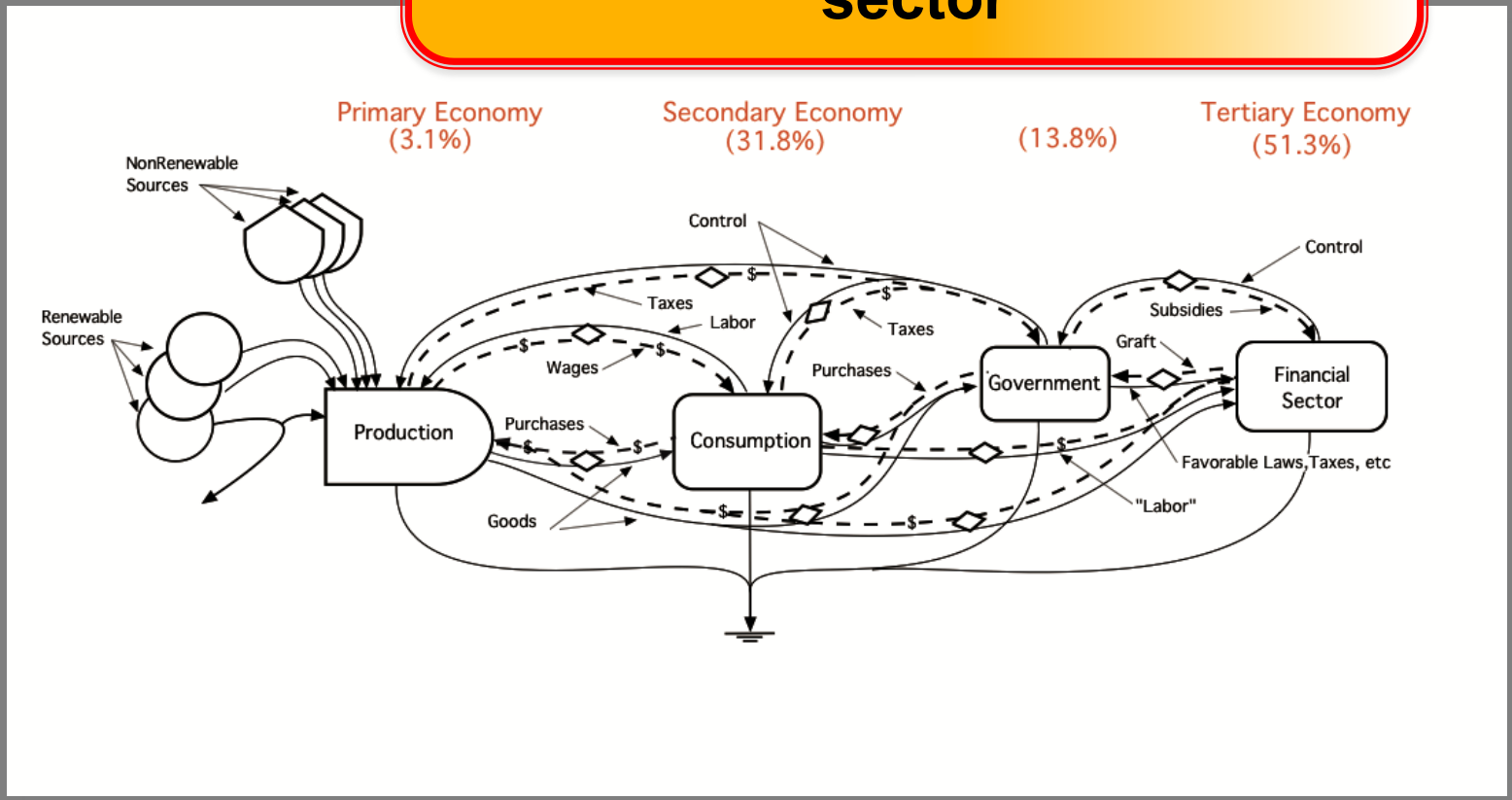
Macro Economic System...

The complete economy includes government

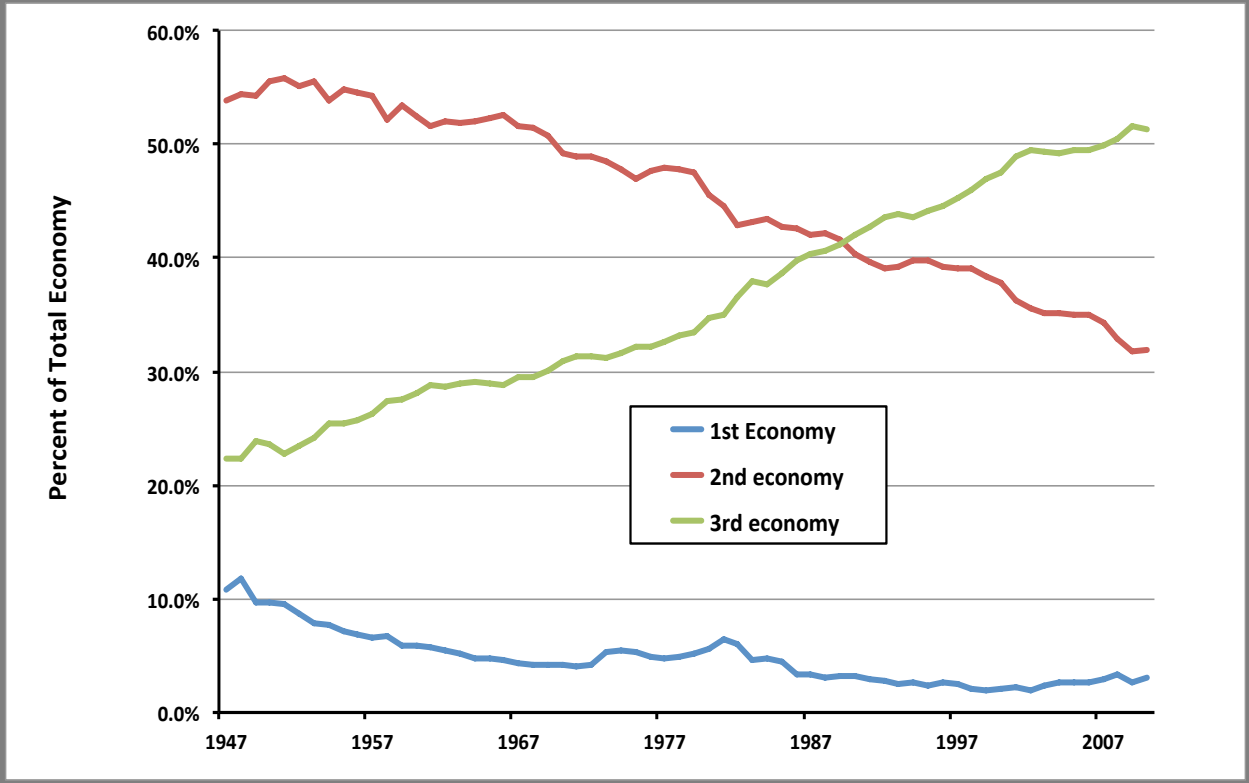


Macro Economic System...

The 21st century economy is dominated by the financial sector



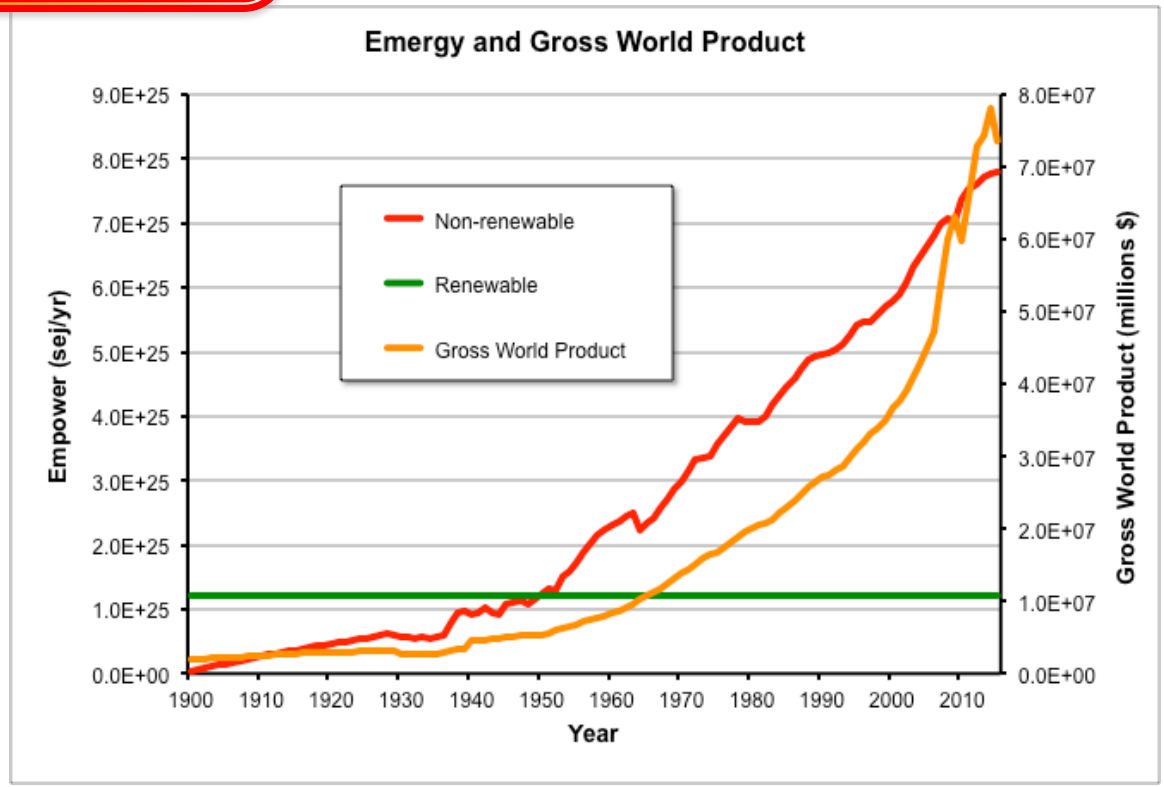
Changing structure of the USA economy



Global Economy...

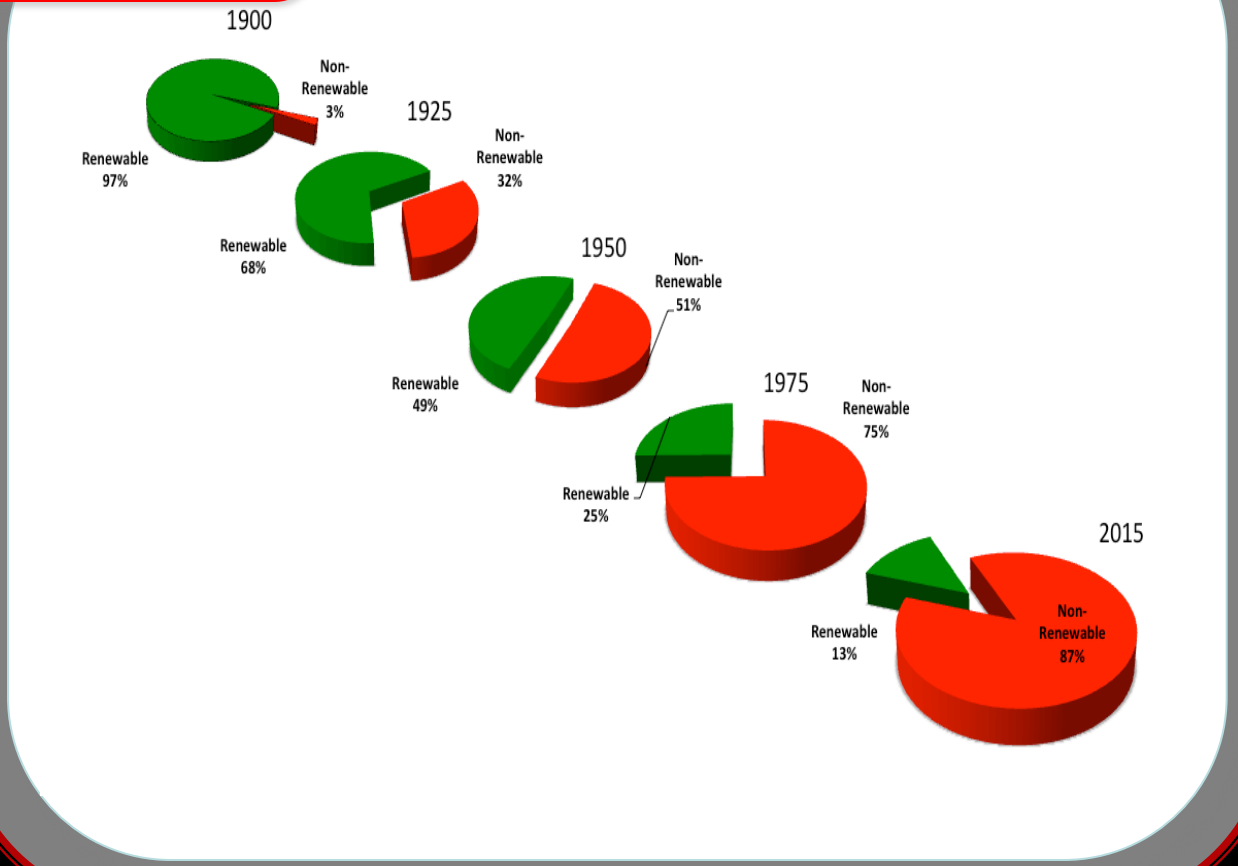
Global Economy...

Historic global emergy use and Gross World Product (1900 - 2015).



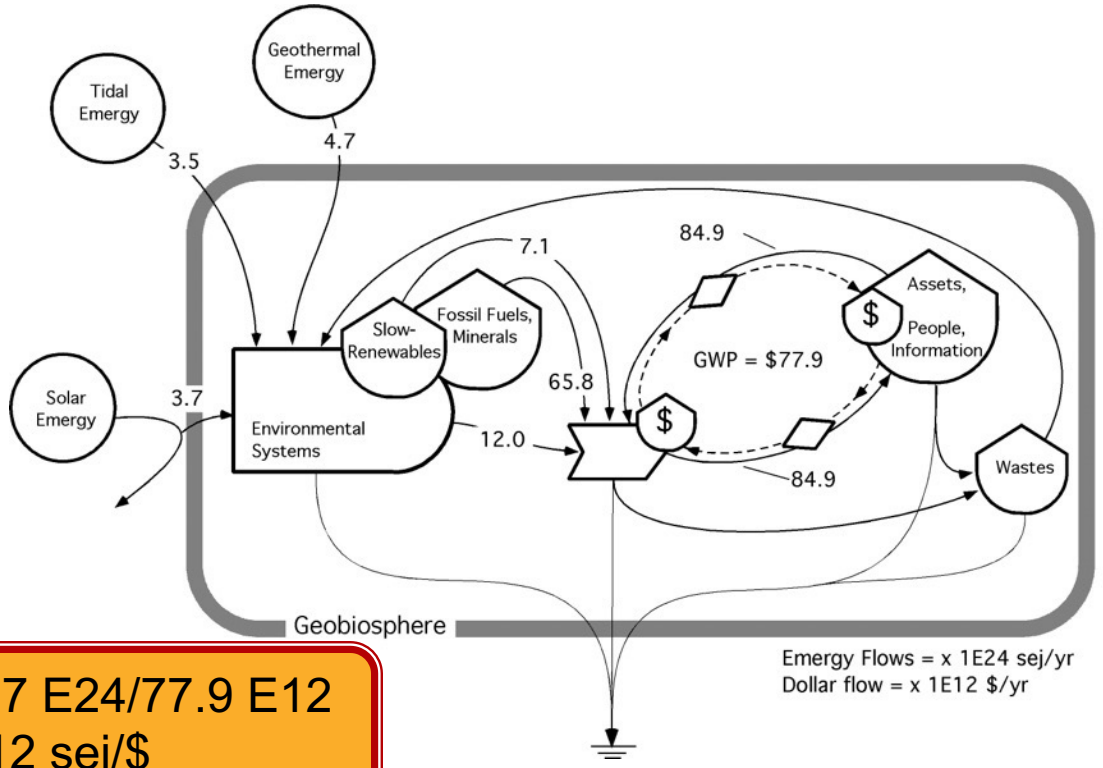
Global Economy...

The changing percentage of total energy from renewable and non-renewable sources



Global Economy...

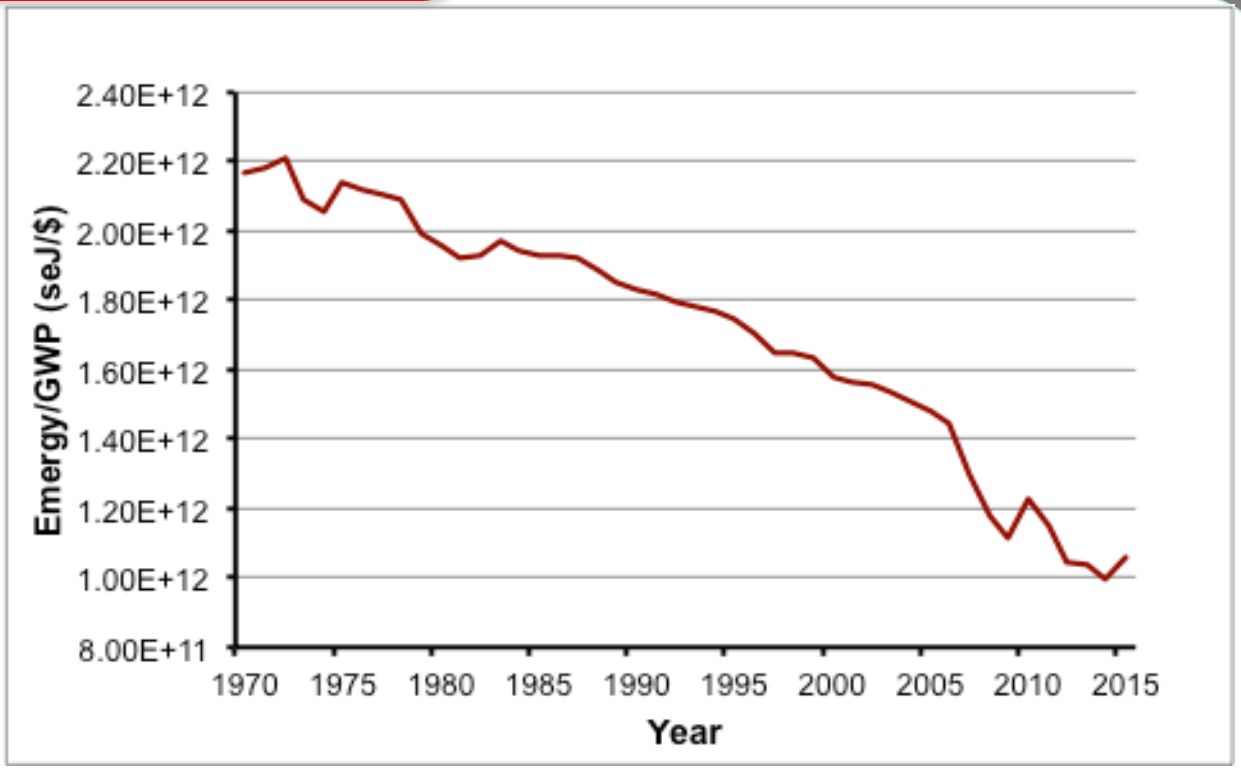
Global Economy 2014



Global EMR = 89.7 E24/77.9 E12
= 1.15 E12 sej/$

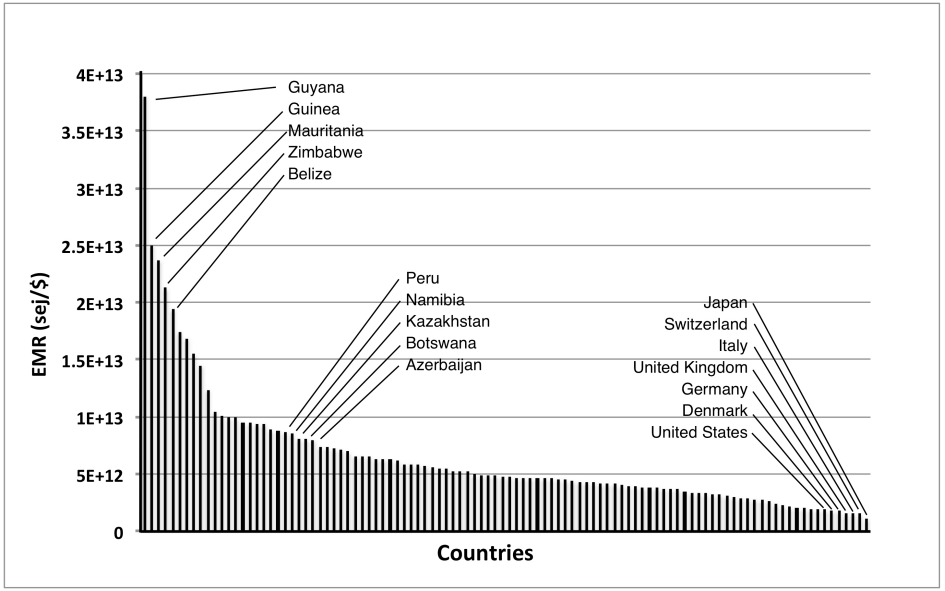
Global Economy...

Global EMR
The ratio of global emergy use to GWP from 1970 to 2015



Global Economy...

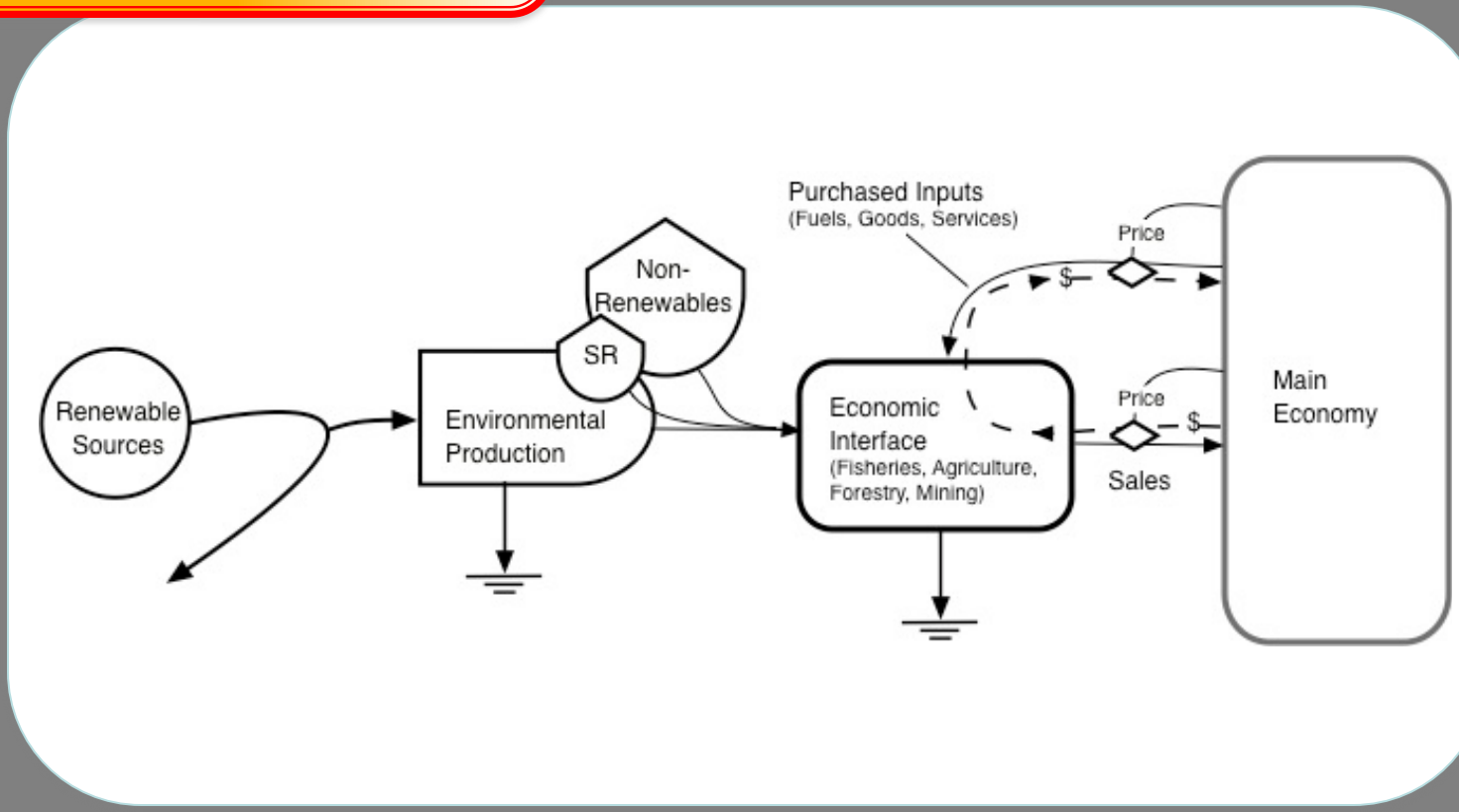
Emergy Money Ratio in 2008 for 131 nations in the National Emergy Accounting Database.



Energy & Economy...

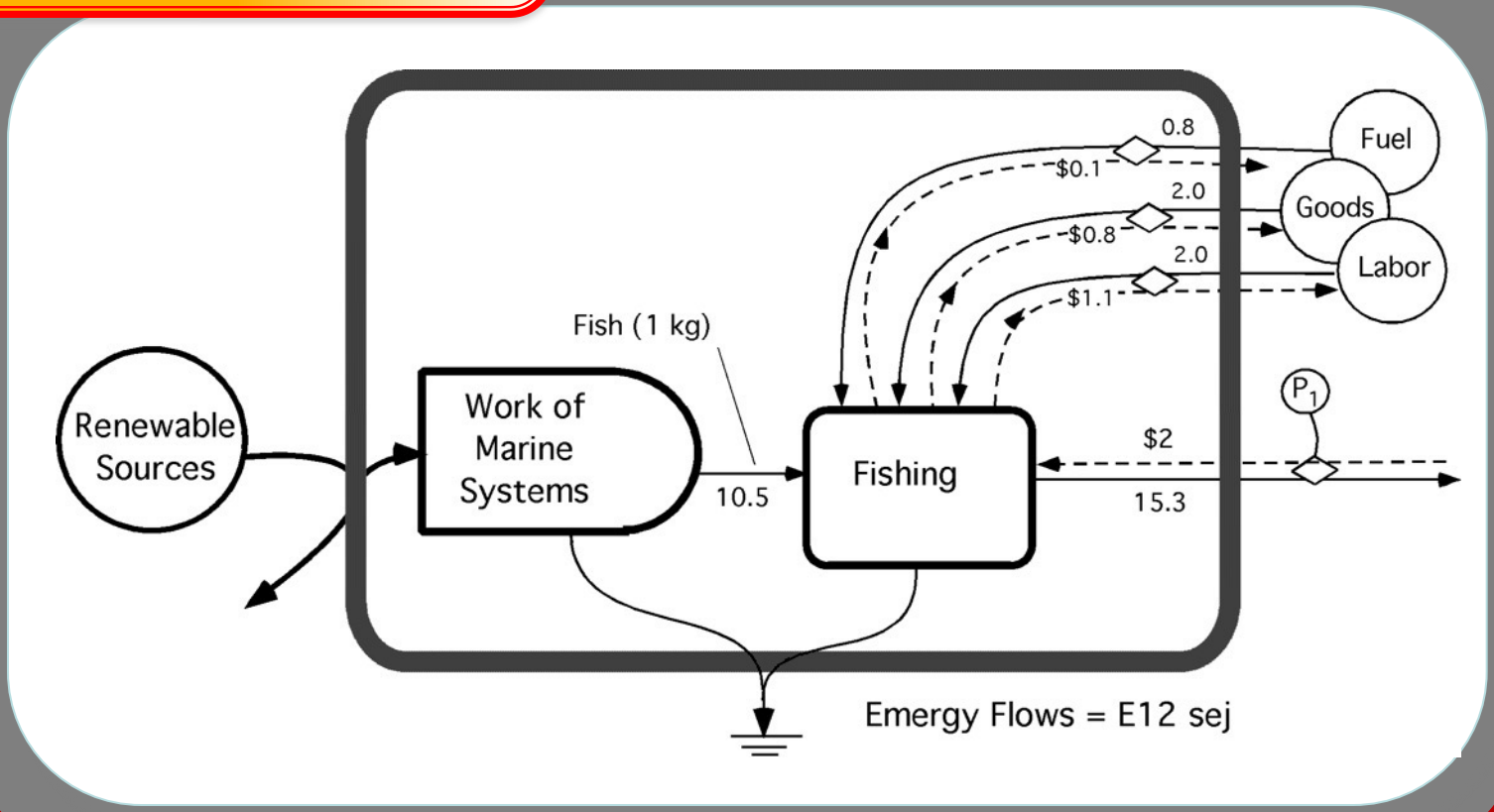
Biophysical Economy...

Environmental - Economic Interface System



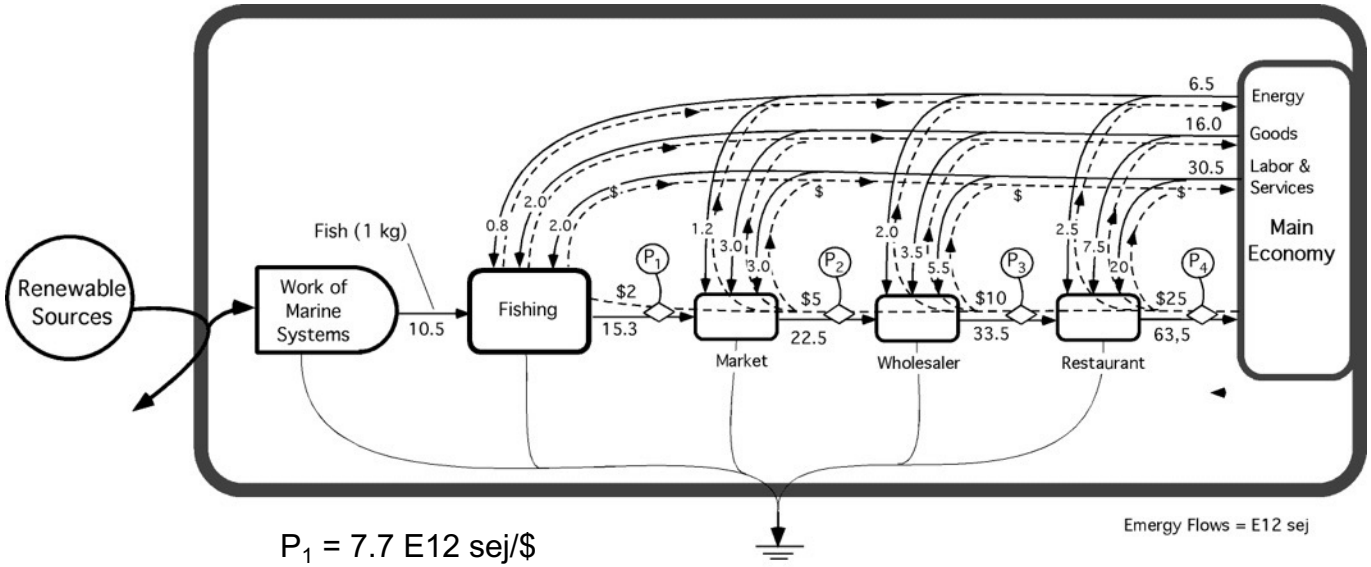
Biophysical Economy...

The Neoclassical Economic Concept of VALUE ADDED



Biophysical Economy...

The Neoclassical Economic Concept of VALUE ADDED



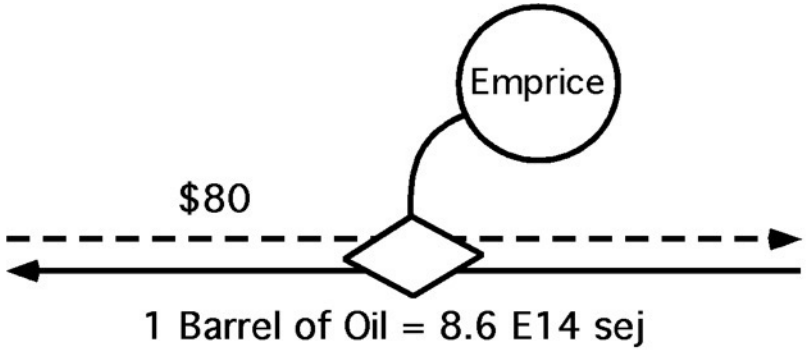
P_1 = 7.7 E12 sej/$
P_2 = 4.5 E12 sej/$
P_3 = 3.4 E12 sej/$
P_4 = 2.5 E12 sej/$

Biophysical Economy...

Emergy Benefit to Purchaser...

When oil sells for $80/barrel the emprice of oil (the amount of emergy received for each dollar) is 1.0 E13 sej/$. (based on 6.1 GJ/barrel and transformity = 1.32 E5 sej/J).

Benefit to a purchaser in the USA is 5.6/1.



Economic Price = $80/barrel

Emprice = 8.6E14 sej / $80 = 1.1E13 sej/$

$$\text{Emergy Benefit to Purchaser} = \frac{\text{emergy received}}{\text{average emergy/money ratio}}$$

$$= \frac{1.1\ \text{E13 sej/\$}}{1.9\ \text{E12 sej/\$}}$$

$$= 5.6\ /1$$

Biophysical Economy...

Emergy Benefit to Purchaser = Emergy Advantage to Buyer

Emergy Benefit to Purchaser...

Note	Item	UEV (sej/unit)	Units	Economic Price ($/g)	Emprice (sej $^{-1}$)	Benefit Ratio [a.]
1	Phosphate Fertilizer	1.14E+10	g	$0.000639	1.78E+13	8.92
2	Water (public)	3.68E+06	g	$0.00000040	9.20E+12	4.60
3	Steel	3.39E+09	g	$0.00060	5.65E+12	2.83
4	Corn	8.05E+08	g	$0.000160	5.03E+12	2.52
5	Soybeans	2.23E+09	g	$0.000850	2.62E+12	1.31
6	Heavy Equipment	7.18E+09	g	$0.00750	9.57E+11	0.48
7	Cell phone	9.43E+09	g	$0.260	3.63E+10	0.018
8	Copper	1.35E+10	g	$0.00756	1.78E+12	0.892
9	Gold	5.50E+09	g	$58.80	9.35E+07	0.000047

Biophysical Economy...

Emergy Benefit to Purchaser...

Note	Item	UEV (sej/unit)	Units	Economic Price ($/unit)	Emprice (sej $^{-1}$)	Benefit Ratio
1	Coal	3.89E+04	J	1.42E-09	2.74E+13	13.7
2	Natural Gas	1.40E+05	J	5.69E-09	2.46E+13	12.3
3	Crude oil	1.32E+05	J	1.31E-08	1.01E+13	5.0
4	Electricity (Thermal)	8.92E+11	kWh	$0.12	7.43E+12	3.7
5	Biodiesel (soybean)	1.40E+05	J	2.95E-08	4.75E+12	2.4
6	Ethanol (corn)	9.79E+04	J	2.89E-08	3.39E+12	1.7
7	Electricity (wind)	2.76E+11	kWh	$0.12	2.30E+12	1.2
8	Electricity (PV)	1.71E+11	kWh	$0.12	1.43E+12	0.7

Global Trade...

Global Trade...

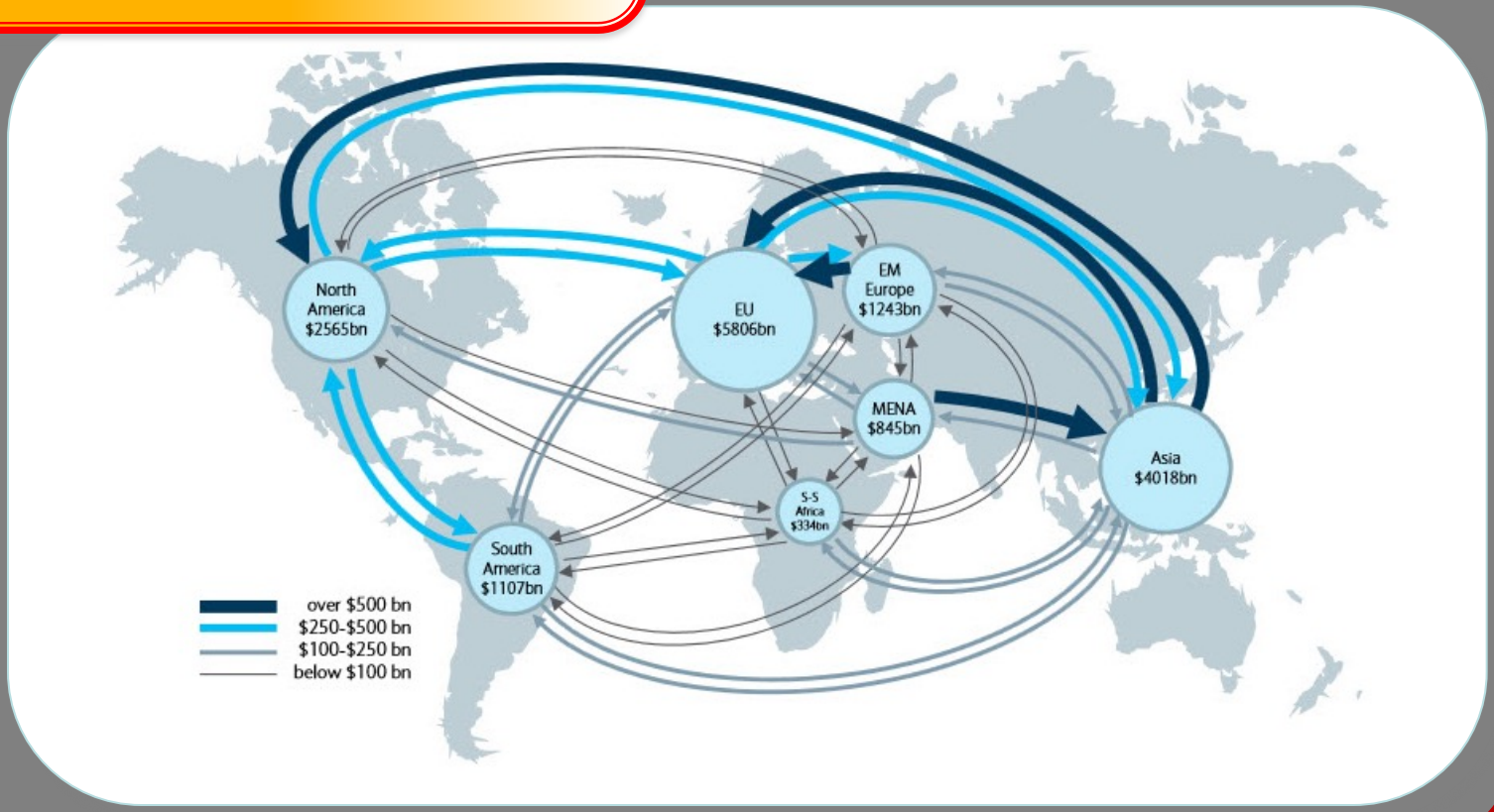
To understand global trade we need to understand the relationship between EMRs of countries

Country	Renewable [a.] (E22 se yr^{-1})	Nonrenewable [a.] (E22 sej yr^{-1})	GDP [b.] (E09 US$ yr^{-1})	Emergy/money (E12 sej US$$^{-1}$)	$\frac{EMR_{country}}{EMR_{USA}}$
Japan	7.3	726.9	4849.2	1.5	0.78
Italy	1.2	401.4	2390.7	1.7	0.87
United Kingdom	65.7	431.7	2793.4	1.8	0.92
Germany	1.5	724.9	3752.4	1.9	1.00
United States	68.2	2773.9	14718.6	1.9	1.00
Sweden	0.8	101.8	514.0	2.0	1.03
Ireland	16.3	47.6	274.7	2.3	1.21
Brazil	66.0	368.2	1695.8	2.6	1.33
New Zealand	9.6	28.3	133.3	2.8	1.47
Australia	61.8	285.5	1054.6	3.3	1.71
Mexico	8.5	417.8	1101.3	3.9	2.00
Costa Rica	1.4	11.2	29.8	4.2	2.19
South Korea	13.5	420.8	1002.2	4.3	2.24
Russia	104.9	660.9	1660.8	4.6	2.39
Nicaragua	1.9	2.3	8.5	4.9	2.53
Mali	1.2	4.3	9.8	5.6	2.89
South Africa	4.5	169.2	286.8	6.1	3.14
India	33.2	801.4	1224.1	6.8	3.53
China	80.5	3945.8	4558.4	8.8	4.57
Botswana	0.8	11.1	10.9	10.8	5.60

a. Data are from the National Environmental Accounting Database at the University of Florida's Center for Environmental

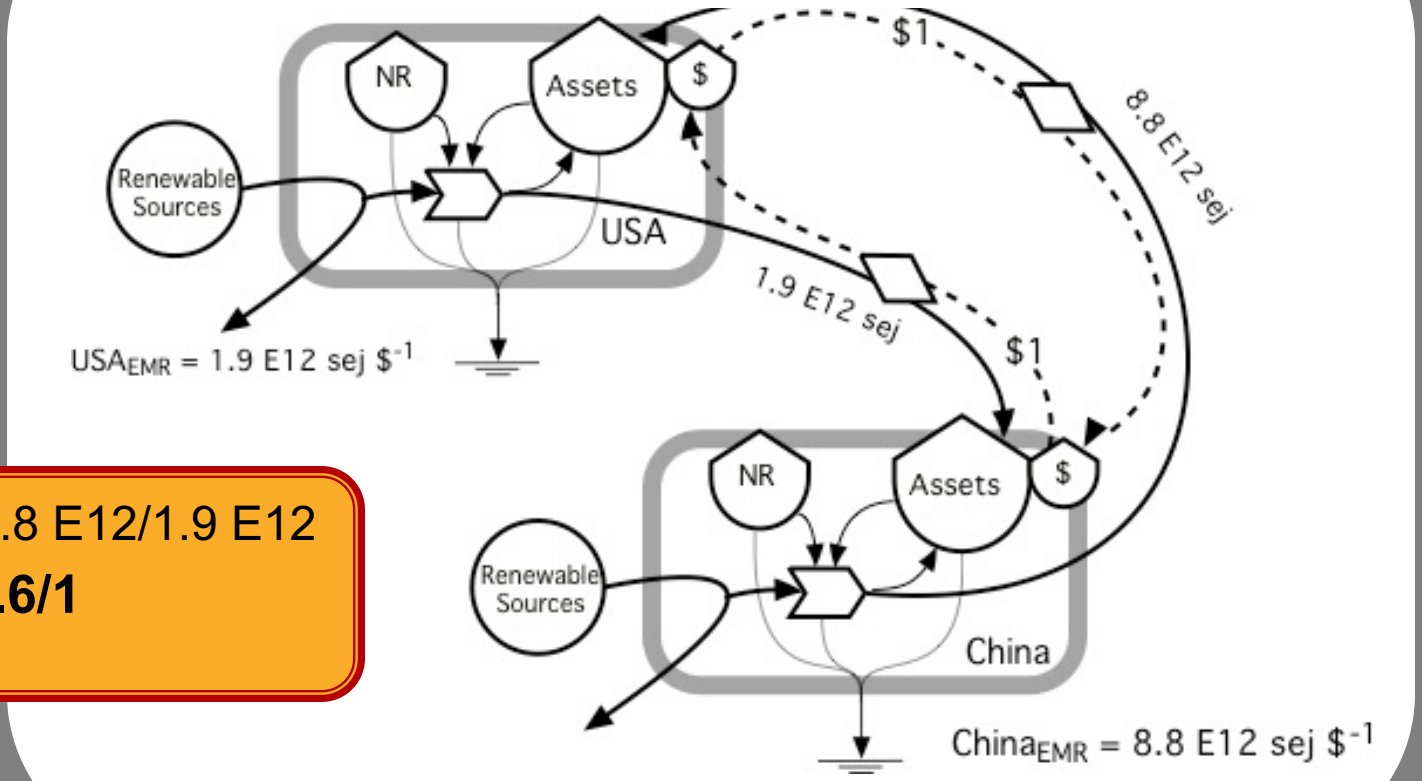
Global Trade...

2014 Trade between major global markets expressed in dollars
Commodities = $19.2 trillion
Services = $4.8 trillion



Global Trade...

National EER = Emergy Money Country A / Emergy Money Country B



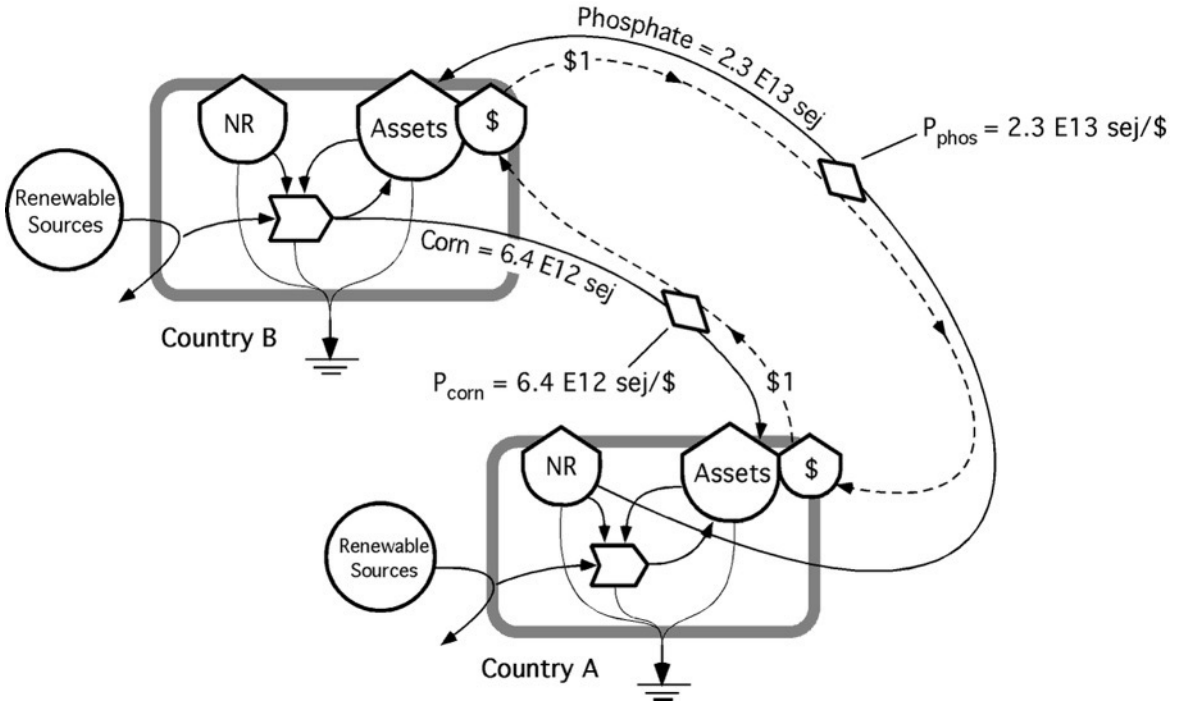
USA benefits 8.8 E12/1.9 E12

= 4.6/1

Global Trade...

Country B Trade Advantage =2.3E13/6.4E12 = 3.6/1

Emergy Exchange Between Commodities



Global Trade...

Emergy trade deficits are further exacerbated by the effect of the “Official Exchange Rate” (OER) between currencies.

The OER between two currencies is the **rate** at which one currency in Local Currency Units (LCUs) will be exchanged for US Dollars.

Global Trade...

Gap between OER and EBER

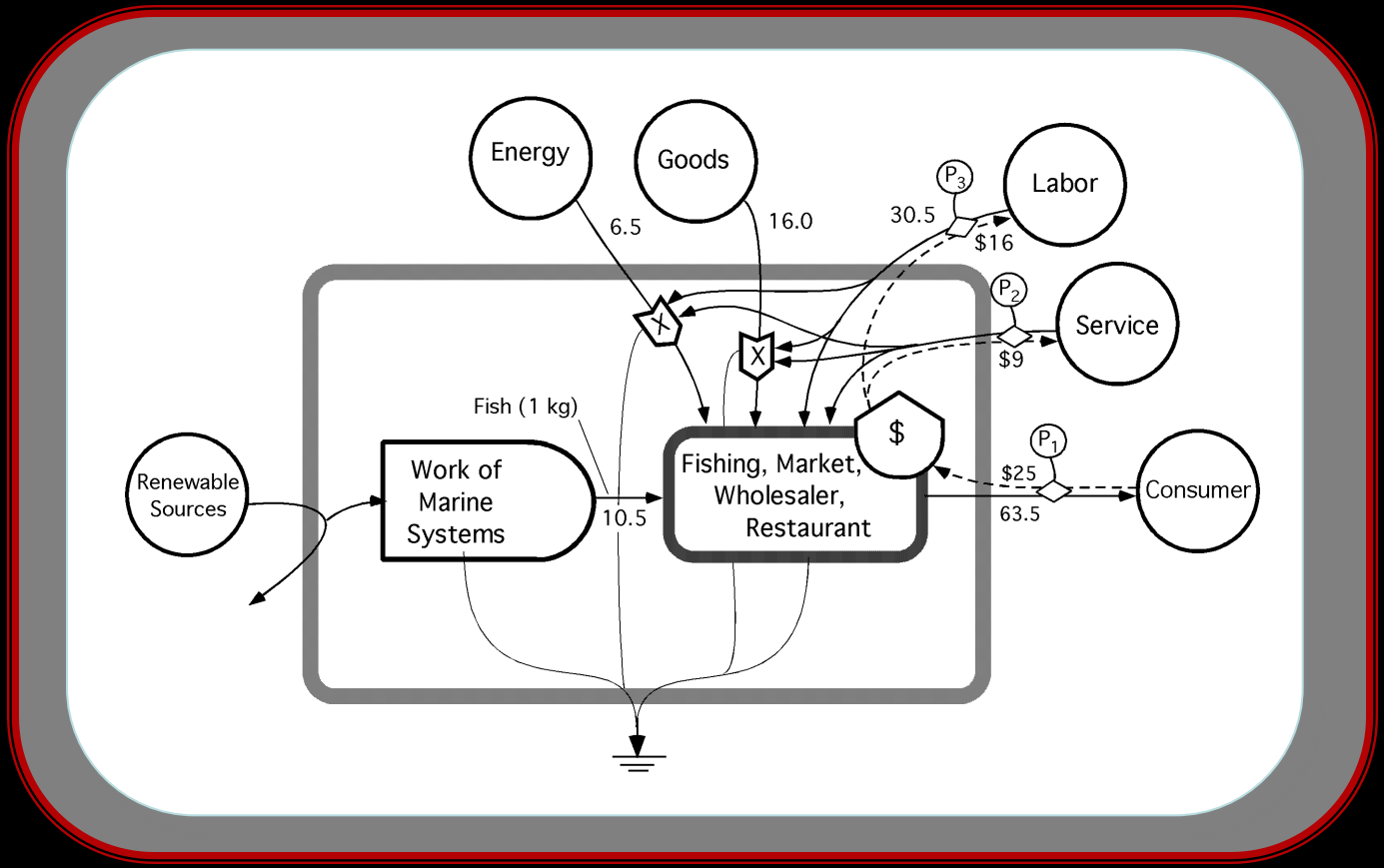
Country	Currency	GDP [a.] (LCU yr^{-1})	Total Emergy Use [b.] (sej yr^{-1})	Emergy/Money (sej LCU^{-1})	Emergy Based Exchange Rate [c.] (LCU $\$^{-1}$)	Official Exchange Rate [d.] (LCU $\$^{-1}$)	OER/EBER
Japan	Yen	5.01E+14	7.34E+24	1.47E+10	145.3	103.4	0.71
Italy	Euro	1.63E+12	4.03E+24	2.47E+12	0.9	0.683	0.79
United Kingdom	Pound	1.52E+12	4.97E+24	3.27E+12	0.7	0.54	0.83
Germany	Euro	2.56E+12	7.26E+24	2.84E+12	0.8	0.683	0.91
United States	USD	1.47E+13	2.84E+25	1.93E+12	1.1	1	0.91
Sweden	Kronor	3.39E+12	1.03E+24	3.03E+11	7.0	6.59	0.94
Ireland	Euro	1.88E+11	6.39E+23	3.40E+12	0.6	0.683	1.09
Brazil	Real	3.11E+12	4.34E+24	1.40E+12	1.5	1.83	1.20
New Zealand	NZD	1.90E+11	3.79E+23	1.99E+12	1.1	1.42	1.33
Australia	AusD	1.18E+12	3.47E+24	2.94E+12	0.7	1.19	1.64
Mexico	Peso	1.23E+13	4.26E+24	3.47E+11	6.1	11.13	1.81
Costa Rica	Colon	1.57E+13	1.26E+23	8.05E+09	264.7	526.2	1.99
South Korea	Won	1.10E+15	4.34E+24	3.95E+09	539.6	1102	2.04
Russia	Ruble	4.13E+13	7.66E+24	1.85E+11	11.5	24.85	2.16
Nicaragua	Cordoba	1.64E+11	4.15E+22	2.53E+11	8.4	19.4	2.30
Mali	Af. Franc	4.37E+12	5.45E+22	1.25E+10	170.9	447.8	2.62
South Africa	Rand	2.37E+12	1.74E+24	7.33E+11	2.9	8.26	2.84
India	Rupee	5.63E+13	8.35E+24	1.48E+11	14.4	43.5	3.0
China	Yuan	3.17E+13	4.03E+25	1.27E+12	1.7	6.95	4.14
Botswana	Pula	7.47E+10	1.18E+23	1.59E+12	1.3	6.83	5.08

Human Labor & Service...

Human Labor & Service...

Direct and indirect inputs of labor and services. The final price of the fish ($25) ultimately only pays for labor and services, some of which are direct inputs and some of which are indirect inputs into the processes that produce the energy and goods that are used in the fish energy chain.

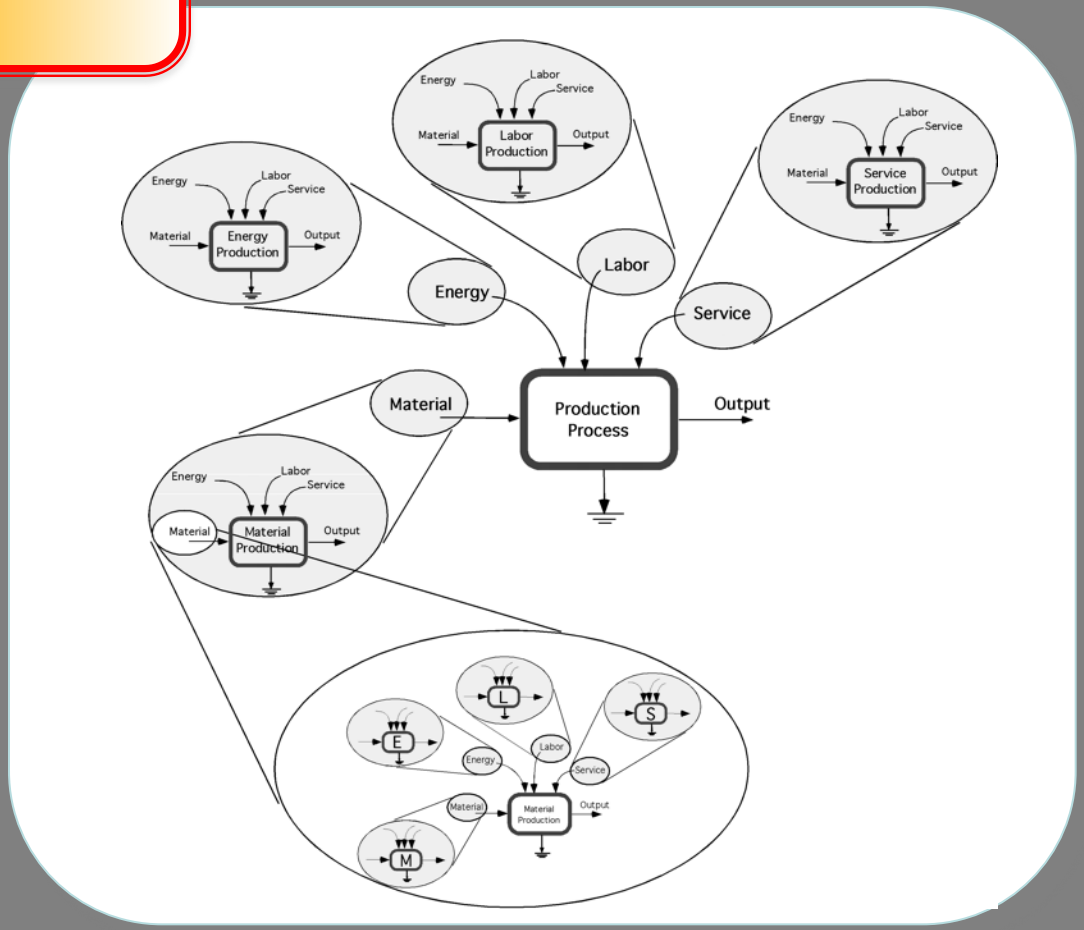
When a fish is purchased, the money paid for the fish pays for human labor and service, not for the fish



Human Labor & Service...

The web of inputs to any process ultimately ends with human labor

The web of inputs to a process shows the fact that each input composed of inputs of energy, materials, labor and services and that ultimately all money paid for a product is used to purchase labor and service.



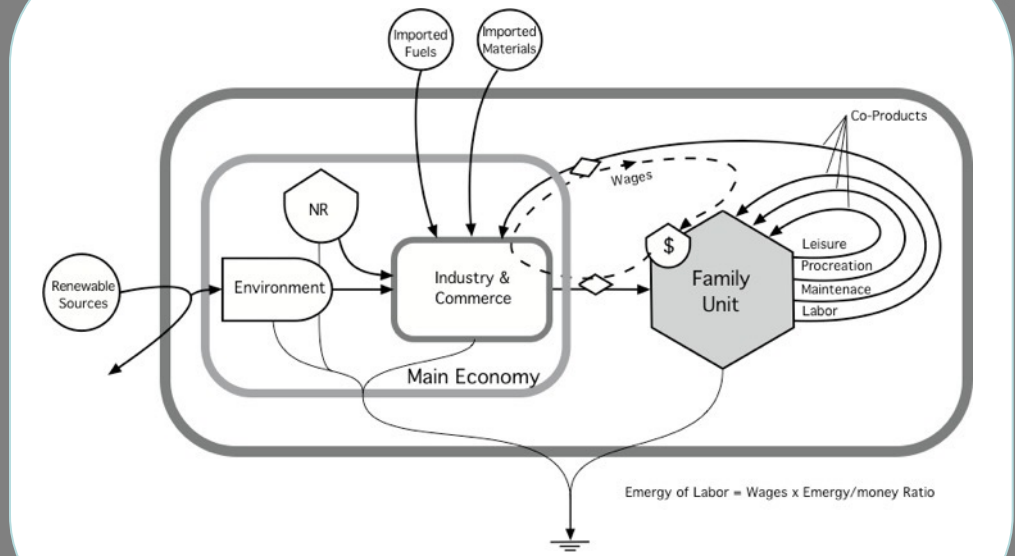
Human Labor & Service...

Labor as a co-product of the family unit

Accounting for the emergy of labor as a co-product of other family unit functions.

Therefore total emergy of the family unit is assigned to the labor flow.

Other methods of analysis have divided the support of the worker by the number of hours actually worked, or even further divided by the average number of persons in a household, we assume that the output of a family unit is its labor and that labor is a co-product.



Human Labor & Service...

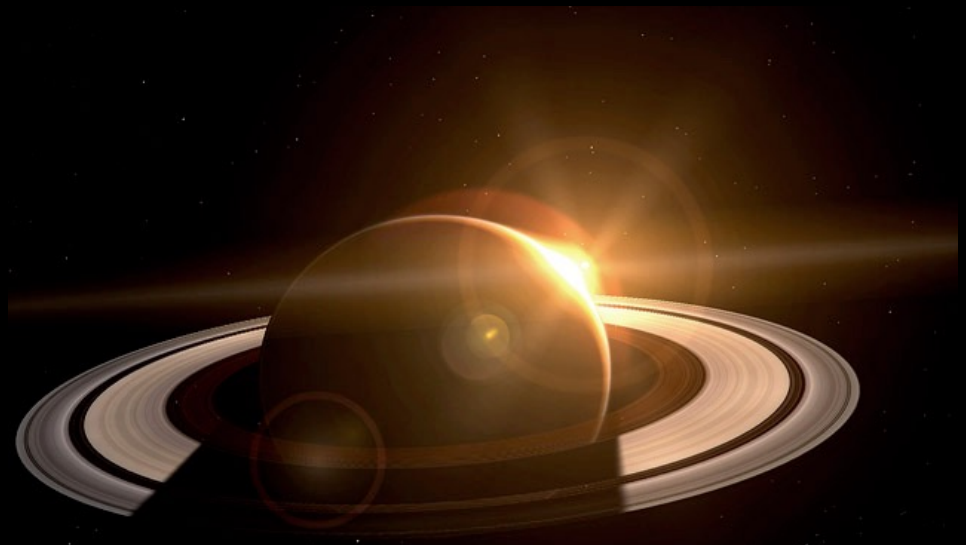
Emergy evaluation of labor grouped by educational level Column A is based on Odum 1996. Column B is computeded based on average wage

Societal Attainment	Number[1]	Emergy/Individual[2] (E16 sej ind^{-1} yr^{-1})	Average Wage[3]	Emergy/Individual[4] (E16 sej ind^{-1} yr^{-1})
Total Population				
Children	301,237,703	6.2	$14,500	2.8
High School	172006728	10.9	$45,000	8.6
College	52114123	36.1	$100,000	19
Graduate or Professional Degree	30425008	61.8	$200,000	38
Public Status	3012377	624.1	$3.00E+06	570

International Debt...

Environmental Accounting for Evaluating International Debt and Wellbeing

UNEP Project



M. Cohen, M. Brown, D. King, and S. Sweeney

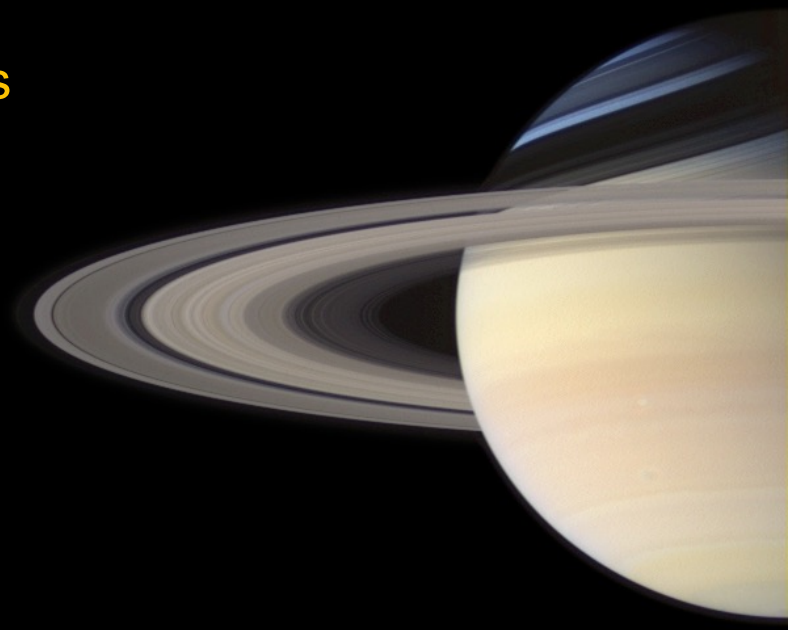
Debt and Debt Relief (2000)

- Africa owes international creditors $750E9 (billion)
  - Niger – $4.1E9
  - Mali – $6.2E9
  - Burkina Faso – $3.3E9
  - Mauritania – $4.8E9
  - Senegal – $8.8E9
  - Debt repayments are expensive (principal + interest) and their fairness has been questioned
- Nations in debt frequently rely MORE on direct environmental work than other nations
  - To generate revenue to service debt, they over-exploit natural resources
- International effort to forgive a portion of Africa's debt

How Does an Economy Make Money?

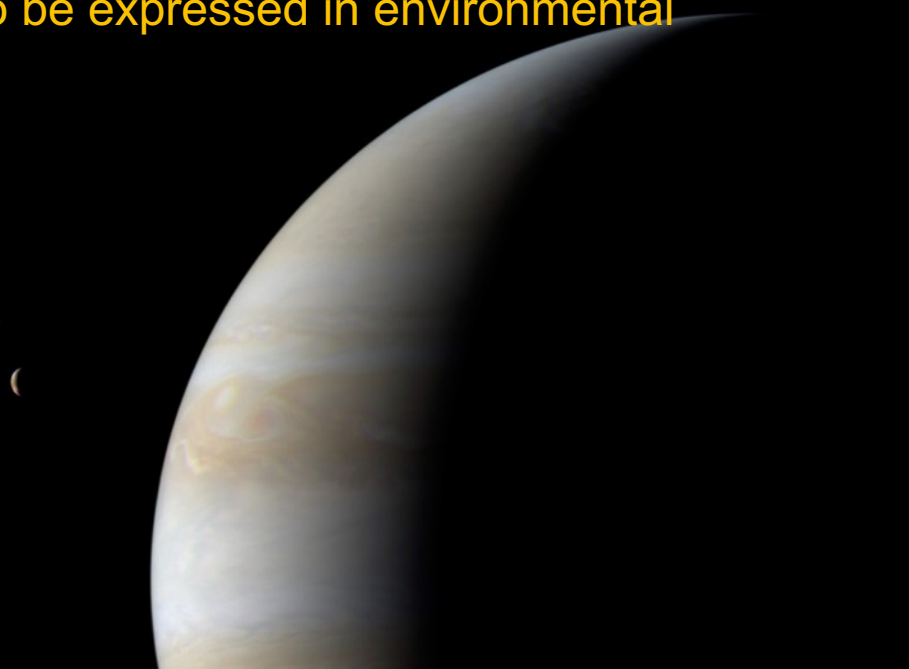
- Strategic transformation of environmental work (wood, soil, minerals, oil) into tradeable products
  - Allocation of effort/human labor based on prices (supply)
  - Prices set by perceived values (demand)

- Nature's work is not counted in prices



EMergy and Money

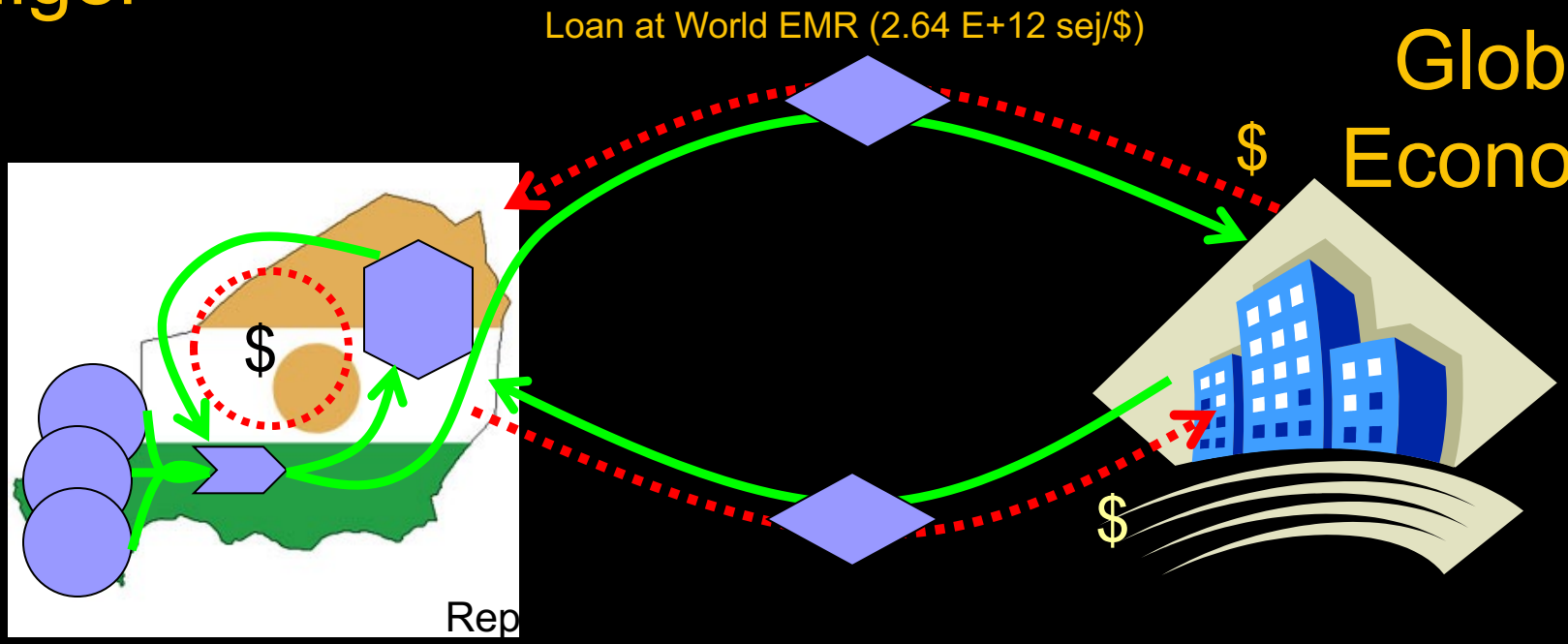
- Emergy is the work of Nature
- Money is the perceived value of Humans
- EMergy:Money Ratio (EMR) quantifies the relationship between the two
  - Total Emergy Use / Gross Domestic Product (GDP)
  - At the local, national or regional scale
- EMR allows economic work to be expressed in environmental units (a vice versa)
  - Direct comparability



EMR and National Economies

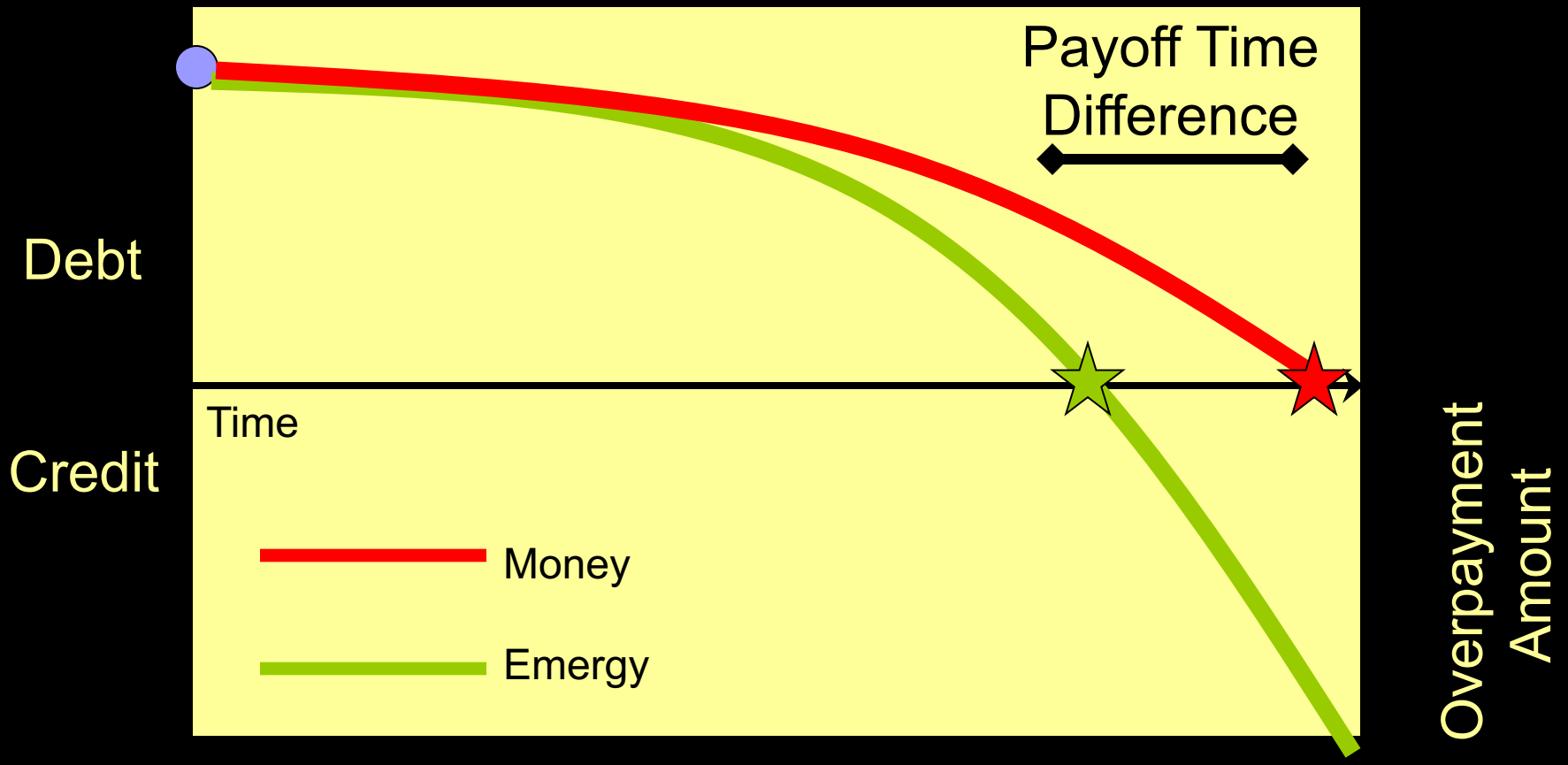
- Different nations have different EMR
  - Developed Nations (USA, Japan) have LOW EMR
    - Japan – 1.5E12 sej/$
  - Less Developed Nations (Niger, Mali) have HIGH EMR
    - Niger – 2.9E13 sej/$
    - Mali – 3.4E13 sej/$
    - Burkina – 2.0E13 sej/$
  - 20x more emergy purchased per $ in Niger than Japan
    - Purchasing Power Parity or Buying Power
- Knowing EMR is critical for fair trade
  - Nations with low EMR use less environmental work to generate the SAME revenue as a nation with high EMR

Niger



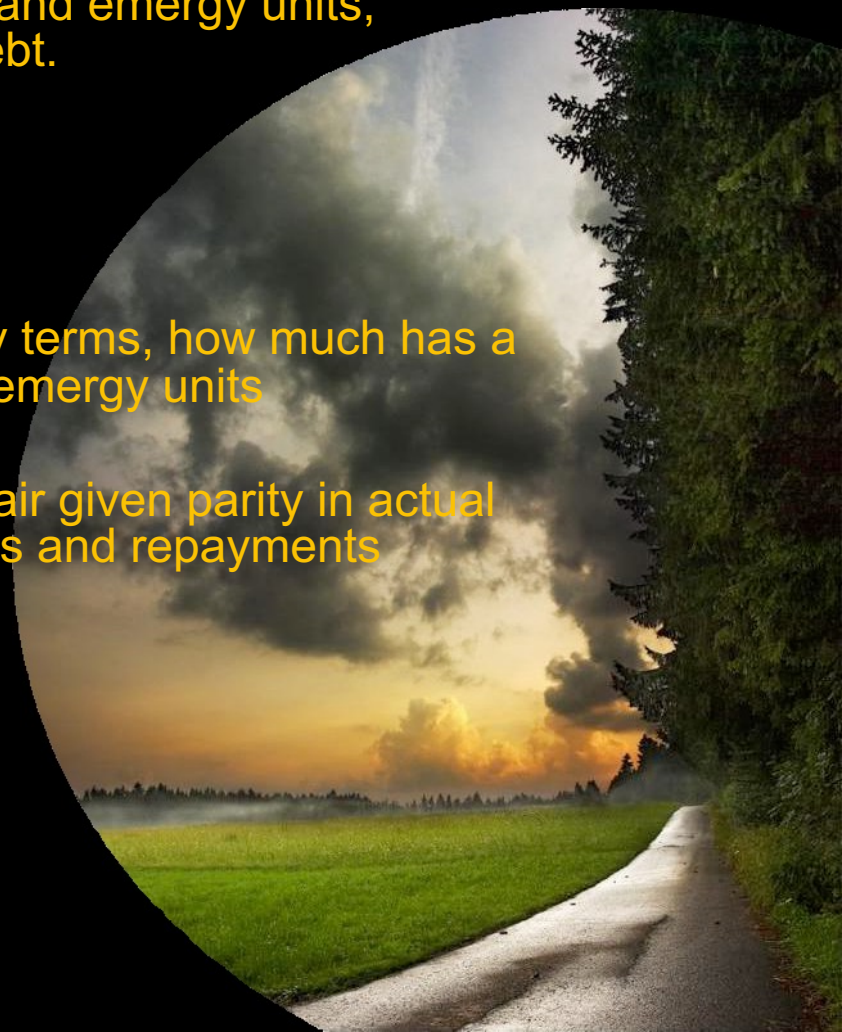
- Every $1 loaned to Niger represents ~ 2.6E12 sej (environmental work)
- To repay that loan, Niger engages in international trade (to generate revenue) and exports ~ 2.9E13 sej (environmental work) per $1 of revenue.
- This suggests that Niger exports MORE environmental work than it receives.
- (This does not account for interest service.)

Debt Repayment for A Nation with High EMR



Objective: Evaluate Africa's International Debt

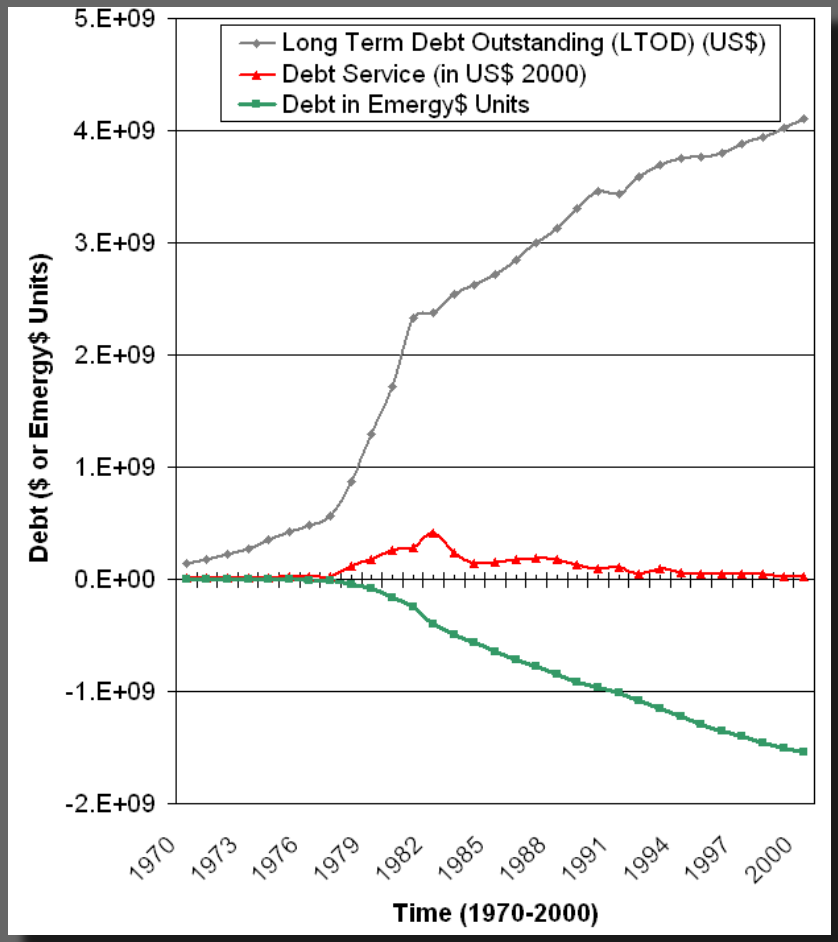
- Measure international debt in money and emergy units, compare emergy debt to monetary debt.
- Calculate 2 quantities
  - Payoff time (money *and* emergy)
  - Over payment amount
    - When debt is repaid in money terms, how much has a nation over- or under-paid in emergy units
- Determine when debt payments are fair given parity in actual environmental work embodied in loans and repayments
- Is debt relief justified? How much?



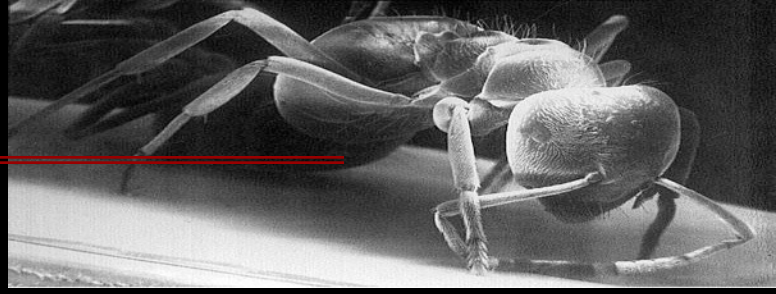
Example: Niger's Debt 1970-2000

Year	Actual EmDebt	US$ Debt	EmDollar Balance
1970	7.13E+20	1.41E+08	5.37E+06
1975	-9.8E+20	4.25E+08	-3.75E+06
1980	-2.2E+22	1.72E+09	-1.62E+08
1985	-7.4E+22	2.71E+09	-6.47E+08
1990	-1.1E+23	3.46E+09	-9.71E+08
1995	-1.3E+23	3.76E+09	-1.22E+09
2000	-1.4E+23	4.1E+09	-1.55E+09

Payoff Time (Money) ~ Not Yet
Payoff Time (Emergy) ~ 1974
Overpayment ~ $1.55E9



Africa's Overpayment 1970 - 2000



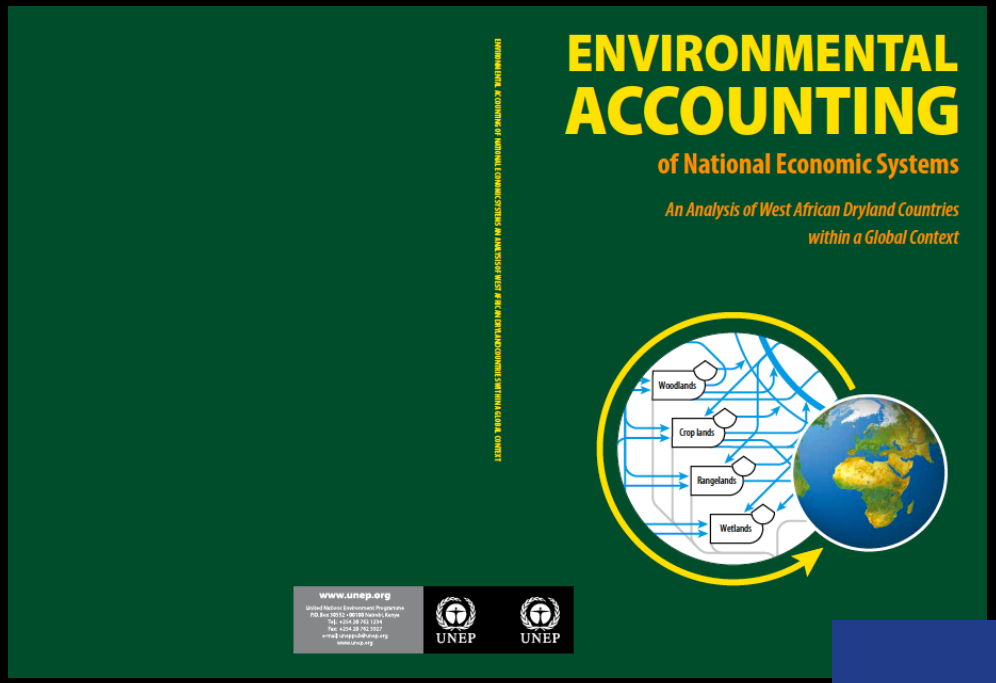
Country	US$ Debt in 2000	Payoff Year	Over Payment
Algeria	1.45E+11	1975	2.23E+11
Benin	3.87E+09	1985	6.25E+08
Botswana	2.51E+09	1978	2.67E+09
Burkina Faso	3.31E+09	1973	7.90E+08
Burundi	1.94E+09	1988	3.16E+08
Cameroon	1.91E+10	1972	2.41E+10
Congo	1.30E+10	1973	1.40E+10
Cote d'Ivoire	2.93E+10	1972	7.71E+10
Djibouti	5.57E+08	1978	1.32E+08
Ethiopia	1.97E+10	1971	6.31E+09
Gabon	1.85E+10	1971	3.95E+10
Gambia	8.87E+08	1989	2.58E+08
Ghana	1.36E+10	1973	1.06E+10
Guinea	8.48E+09	1973	6.39E+09
Kenya	1.78E+10	1971	3.87E+10

Country	US$ Debt in 2000	Payoff Year	Over Payment
Malawi	5.66E+09	1974	3.21E+09
Mali	6.16E+09	1980	1.27E+09
Mauritania	4.77E+09	1971	5.70E+09
Morocco	8.95E+10	1978	1.02E+11
Niger	4.10E+09	1974	2.55E+09
Nigeria	1.36E+10	1973	1.18E+11
Rwanda	1.98E+09	Not Yet	-4.80E+08
Senegal	8.86E+09	1973	8.79E+09
Sierra Leone	2.14E+09	1971	2.50E+09
Sudan	2.32E+10	1971	5.20E+09
Tanzania	2.47E+10	1982	4.09E+09
Togo	3.78E+09	1972	3.06E+09
Uganda	7.18E+09	1974	1.73E+09
Zambia	1.91E+10	1971	3.84E+10
Zimbabwe	7.82E+09	1971	2.20E+10

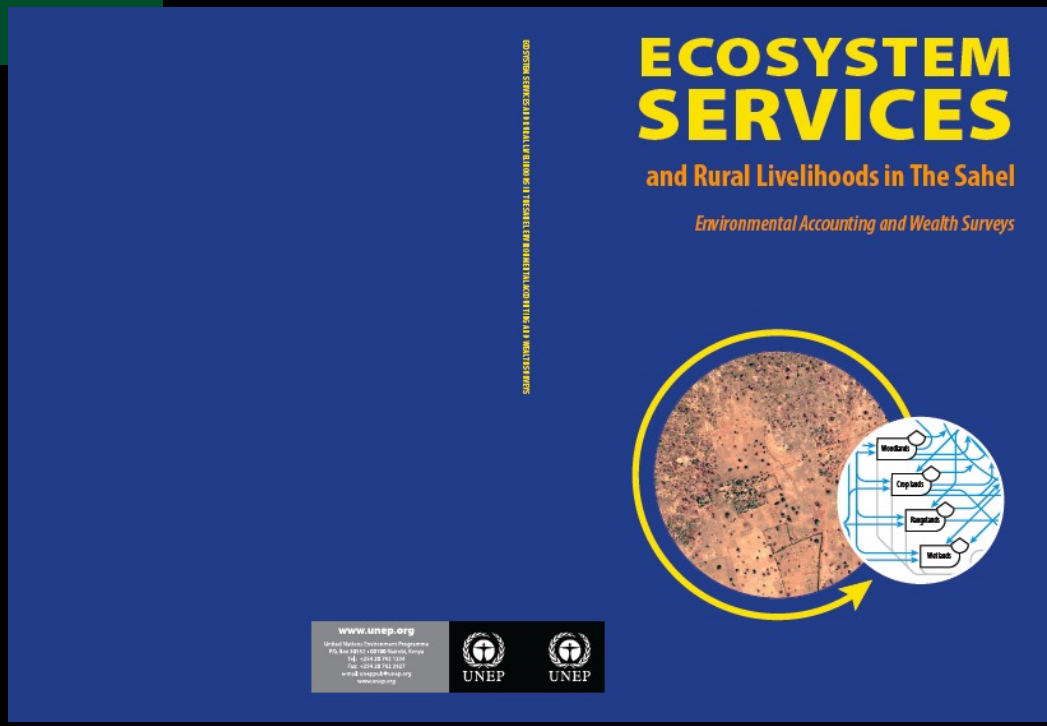
Debt Relief: Conclusions

- In units of Environmental Work necessary to generate revenue, Africa's Debt has been seriously OVER Serviced
  - Debt relief should be immediate
- Sustainability of additional loans should be evaluated based on environmental work necessary to service those loans

Country	Money Debt	Emergy Debt
Niger	$4.1E9	($1.6E9)
Mali	$6.2E9	($1.3E9)
Burkina Faso	$3.3E9	($7.9E8)
Mauritania	$4.8E9	($5.7E9)
Senegal	$8.8E9	($8.8E9)



Avaliable on-line from
United Nations
Environmental Program



Questions?