May 22th to 24th, 2013 - São Paulo, Brazil

4th INTERNATIONAL WORKSHOP
ADVANCES IN CLEANER PRODUCTION

"INTEGRATING CLEANER PRODUCTION INTO SUSTAINABILITY STRATEGIES"

Emergy Accounting and CO_2 Emissions: Accessing and Remaining in the Physical and in the Virtual Learning Environment

UNIP UNIVERSIDADE PAULISTA

Programa de Pós-Graduação em Engenharia de produção
Laboratório de Produção e Meio Ambiente (LaProMA)

Prof. José Hugo de Oliveira
Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais

Profª. Drª. Cecília M.V.B. de Almeida
Universidade Paulista

- About 6,000 “local” students and about 7,000 “Distance Learning” students altogether;

- 13 different high-school/technical integrated “classroom & hands-on” courses and 16 post high-school “subsequent” technical “distance teaching” courses through over 40 support poles (each one in a different city)

INSTITUTO FEDERAL DE
EDUCAÇÃO, CIÊNCIA E TECNOLOGIA
SUL DE MINAS GERAIS
Campus Inconfidentes

Motivation

- Nature is generous and bears with the effects of human's exploiting it.

- Renewing itself may take longer than a whole generation

could possibly stand waiting.

- **Are students really taking the chance and profitting from environment's investment in resources and suffering impacts to make up their "schoolday"?**

Aims of this work:

- To calculate the environmental cost and CO_2 emissions caused by the use of energy by the students at accessing and staying in the learning environment during a typical “school day”.

Methodology

- **Emergy Environmental Accounting** (Odum, 1996) is a methodology which allows for the accounting of natural and economic resources inputs of a system;

- **Solar energy Joules (seJ)**: a common basis unit for accounting different types of energy systems;

- **Transformity**:the energy-to-eMergy conversion factor;

  - **Higher transformity values**: more complex production systems; higher quality product or service

  - **Lower transformity values**: indicate simpler and, therefore, more efficient systems.

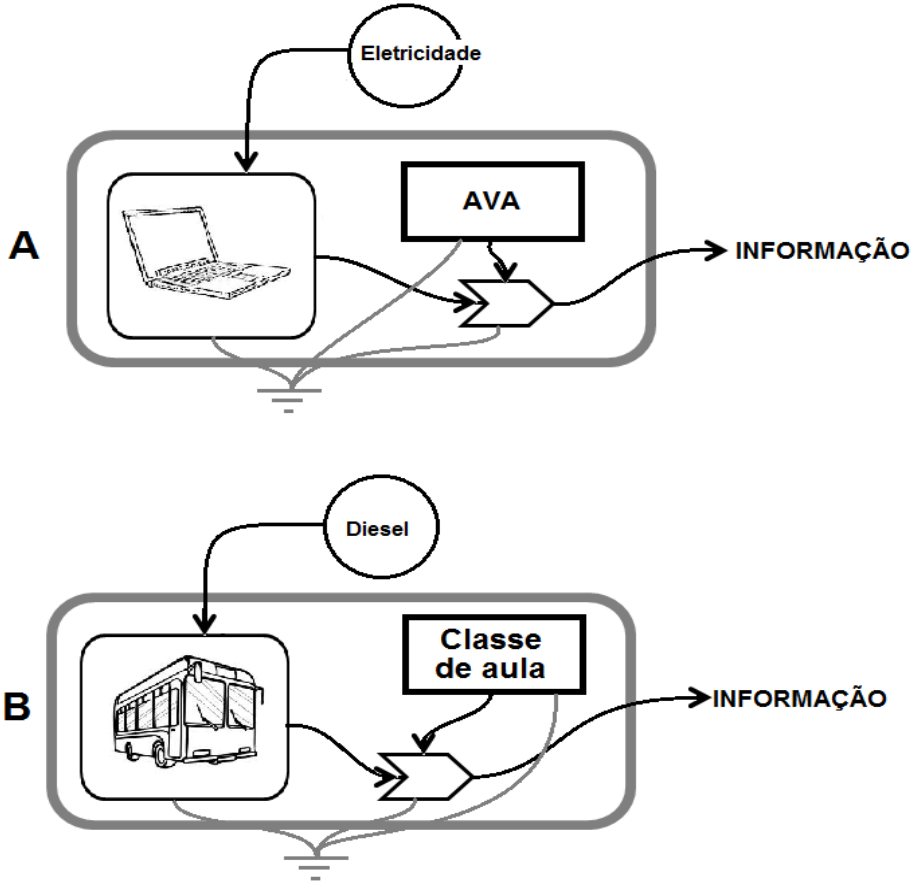

Eletricidade
A
AVA
INFORMAÇÃO
Diesel
B
Classe
de aula
INFORMAÇÃO

Table 1. Accessing the VLE - November, 2012

Total access hours 772.3 h			Average Computer Power 250 W		
Electricity consumption, Nov 2012 (kWh)	Students	Conversion (J/kWh)	Energy (J/month student)	Transformity (sej/J)*	Emergy (sej/student month)
193.1	43	3.60×10^{6}	1.62×10^{7}	2.77×10^{5}	$\mathbf{4.48 \times 10^{12}}$

*Odum, 1996, updated to $15{,}83 \times 10^{24}$ sej baseline.

Table 2. Accessing the Physical Learning Environment - November, 2012										
km/ day	days/ month	Consumption (km/L)	Density (kg/L)	PCI (kcal/kg)	Conversion (J/kcal)	Energy (J/ month)	Students	Energy (J/month student)	Tr (sej/J)*	Emergy (sej/month student)
60	12	3	0.85	10667	4.186	9.11×10^6	32	2.85×10^5	1.11×10^5	**3.16×10^{10}**

*Odum, 1996, updated to $15{,}83 \times 10^{24}$ sej baseline.

Table 3. Electricity Consumption (PLE - November, 2012)					
Item:	Computer	Data-show	Light Bulbs	Total, Nov 2012:	
Power	250W	250W*	40W** x 16	49.25 kW/h	
Consumption (kWh) Nov/2012	**Students**	**Conversion(J/kWh)**	**Energy (J/month. student)**	**Tr (sej/J)*** **	**Emergy (sej/student. month)**
49.25	32	3.60×10^6	5.54×10^6	2.77×10^5	**1.53×10^{12}**

*http://www.aessul.com.br/areacliente/servicos/simula.asp

** manufacturer's data

*** Odum, 1996, updated to $15{,}83 \times 10^{24}$ sej baseline.

Table 4 - CO_2 emission from electricity production (accessing the VLE)			
Total Consumption - November, 2012	Grams of CO_2/kWh (Brazil, 2010)*	Total (g)	Total g/student
193.1	86.8	1.68×10^4	3.90×10^2

http://www.iea.org/co2highlights/CO2highlights.pdf

Table 5- CO_2 emission by accessing the PLE by bus - Nov. 2012			
Volume of Diesel (L) used, Nov 2012	Conversion (g/L)*	Conversion (g/mol)	Total (Diesel mols)
240	850	198	5.15×10^2
O_2 mols	output	CO_2	H_2O
1.11×10^4	→	7.21×10^3	7.73×10^3
CO_2 (mols)	Molar mass (g/mol)	Total mass of CO_2 (g)	Mass per student in CO_2 (g)
7.21×10^3	44	3.17×10^5	9.90×10^3

*http://www.ehow.com.br/densidade-oleo-diesel- fatos 15362/

Table 6 - CO_2 emission by electricity production (permanence in the PLE)-Nov, 2012			
Total Consumption (kWh)	Grams of CO_2/kWh (Brazil, 2010)*	Total (g)	Total g/student
49.25	86.8	4.27×10^3	1.33×10^2

http://www.iea.org/co2highlights/CO2highlights.pdf

CO2 Emissions using thermo-electricity: a simulation

Table 7 - Proportional CO_2 emission by hypothetical use of thermo-electricity to access the VLE in November, 2012				
Volume of Diesel (L)		Conversion (g/L)	Conversion (g/mol)	Total (mol)
38.96		850	198	$1.67x10^2$
Mol O_2	Output	CO_2	H_2O	
$3.60x10^3$	→	$2.34x10^3$	$2.51x10^3$	

CO_2 (mol)	Molar mass (g/mol)	Total mass CO_2 (g)	Total Mass CO_2 (g) per student
$2.34x10^3$	44	$1.03x10^5$	**$2.3x10^3$**

Analyzing the results:

- **ENVIRONMENTAL INVESTMENT IN EMERGY :**

- ACCESSING AND REMAINING IN THE **VLE**=
  4.48E+12 sej/student
- ACCESSING AND REMAINING IN THE **PLE=**
  1.56E+12 sej/student

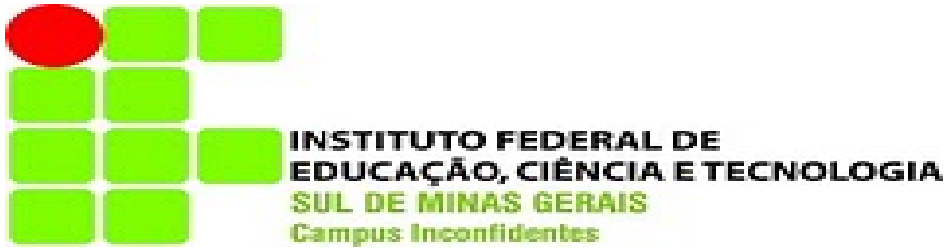
-

- **CO^2 EMISSIONS :**

- ACCESSING AND REMAINING IN THE **VLE** =
  $3.9x10^2$g/student (hydro-electricity)
  $2.3x10^3$g/student (thermo-electricity)
- ACCESSING AND REMAINING IN THE **PLE =**
  $1.0X10^4$g/student

-

-


INSTITUTO FEDERAL DE
EDUCAÇÃO, CIÊNCIA E TECNOLOGIA
SUL DE MINAS GERAIS
Campus Inconfidentes

– **câmpus**