AN OVERVIEW ABOUT HUMAN DEVELOPMENT AND THE POTENTIAL OF ENERGY CONSERVATION

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Abstract. *The development of nations is an unquestionable necessity, mainly in developing countries, in which several challenges relative to health, education and economy are present. The discussion of development models occupied the decision makers minds in the last years and, when the matter is the energy supply and demand, the situation becomes critical: how to improve the life quality of developing countries based on the available models of development if they are related to the developed countries life style, for which the necessary use and the waste of energy are present? How much energy is essential to the humanity for not endanger the survival conditions of future generation? The Human Development Index (HDI) establishes the relationship among energy use, economic growth and social growth, in which it can be seen that 75% of world population has a significant potential of energy consumption, and this is a strong reason to consider that the sustainable development concepts in energy policies is strategic to the future of the planet. This paper shows the importance in looking for alternative development models for the balance of human development, natural resources conservation and environment by rational energy use concepts.*

Keywords*. HDI, rational energy use, energy education.*

1. Introduction

The energy use and social, political and economic development of nations are a phenomenon that establish a relationship of dependence between them in a bilateral form, that is, the influences of each one over the others change according to the development policy adopted.

Looking for some corrections on the distortions imposed by the gross domestic product (GDP) of countries when it is used for the comparison of nations performance in the social and economic areas, the Human Development Index (HDI) was created by economists Mahbub ul Haq and Amartya Sem in 1990 to aggregate two new dimensions to the problem: the longevity and educational level of countries.

In this paper it will be demonstrated how HDI method is performed and how it can be associated to energy consumption. Starting from the values presented in the case study of Organization for Economic Cooperation and Development (OECD) countries, the results of energy saving potential assessment obtained by Weber (1997) was confirmed.

2. HDI calculation

The information here presented is based on the Human Development Report – HDR – (UN, 2001, 2002). The HDR is the main data source of concepts and relations in HDI calculus.

HDI is an index that measure the average development of a country relatively to three basics dimensions:

- longevity;
- educational level, that is composed by adults literacy index[1] and registration combined index[2];
- economic performance through GDP in dollar PPP[3];

In the HDI calculation it is necessary to create an index for each one of three dimensions, stipulating upper and lower bounds to the primary indicators. Tab. (1) shows these reference values.

[1] The adults literacy index is the ratio between the number of people with 15 or more years old and capable of reading and writing a note in their native language and the total number of people with age equal or over 15 years old at the reference year.
[2] Registration combined index is the total number of people registered in the school (elementary, high and superior levels) divided by the number of people between 7 and 22 years old at the reference year.
[3] Dollar PPP means dollar in purchasing power parity. This concept affirms that the price of a good in a country will be the same in another one, when the prices in local currency are converted to the rate of exchange.

Table 1. Reference values to the primary indicators.

index		Unit	Down limit	Up limit
Longevity		years	25	85
Education	adults literacy index	%	0	100
	registration combined index	%	0	100
GDP *per capita*		PPP US$	100	40000

The assessment in each dimension is obtained by Eq. (1), resulting the values between 0 and 1.

$$\text{Dimension index} = \frac{\text{actual value} - \text{lower bound}}{\text{upper bound} - \text{lower bound}} \tag{1}$$

In the educational index, some weights are considered, as described in Eq. (2).

$$\text{Educational index} = \frac{2}{3}(\text{literacy index}) + \frac{1}{3}(\text{registration index}) \tag{2}$$

Relatively to the GDP index calculation, Eq. (1) is adjusted by applying logarithmic in each term after the equality, in accordance to Eq. (3). This procedure is supported by the concept that is not necessary an unlimited productivity to get a higher level of human development.

$$\text{GDP index} = \frac{\log(\text{actual value}) - \log(\text{lower bound})}{\log(\text{upper bound}) - \log(\text{lower bound})} \tag{3}$$

HDI is finally calculated based on the arithmetic average of three dimensional indexes: longevity, education and GDP. For illustrating, it will be developed the calculation of Brazilian HDI in 2000 using the values of Tab. (2) (UN, 2001).

Table 2. Indicators to the calculation of Brazilian HDI in 2000.

Indicator		Unit	Values
Longevity		years	67.7
Education	adults literacy index	%	82.2
	registration combined index	%	80
GDP *per capita*		PPP US$	7625

- longevity - Eq. (1)

$$\text{Longevity index} = \frac{67.7 - 25}{85 - 25} = 0.712$$

- Educational index - Eq. (1) and Eq. (2)

$$\text{Literacy index} = \frac{85.2 - 0}{100 - 0} = 0.852$$

$$\text{Registration index} = \frac{80 - 0}{100 - 0} = 0.800$$

$$\text{Educational index} = \frac{2}{3}(0.852) + \frac{1}{3}(0.800)$$

- GDP index - Eq. (3)

$$\text{GDP index} = \frac{\log(7625) - \log(100)}{\log(40000) - \log(100)} = 0.723$$

• Brazilian HDI in 2000 – arithmetic average of indexes.

$$\text{HDI} = \frac{0.712 + 0.835 + 0.723}{3} = 0.757$$

3. HDI and the energy consumption

Considering the diversity of countries level development, factors that indicate the social, politic and economic conditions, such as human necessities, demographic tendencies, wealth, education, economic performance and, in particular to this analysis, energy and environment, are present in the question. Tab. (3) lists some values that associate HDI with the energy consumption *per capita* in 1999; the column energy consumption was obtained by the ratio of GDP *per capita* and the relation GDP/Energy, as described in the Human Development Report - HDR (ONU, 2001, 2002).

Table 3. HDI and energy consumption to the some countries in 1999.

Classification		Country	HDI 1999	$GDP_{per\ capita}$ (PPP US$) 1999	GDP/Energy (PPP US$/kgep) 1999	Energy consumption ($tep_{per\ capita}$)
High development	1	Norway	0.939	28433	4.8	5.9
	6	United States	0.934	31872	3.9	8.2
	11	Switzerland	0.924	27171	7.3	3.7
	16	Austria	0.921	25089	7.2	3.5
	20	Italy	0.909	22172	7.7	2.9
	21	Spanish	0.908	18079	6.1	3.0
	26	Singapore	0.876	20767	3.6	5.8
	30	Malta	0.866	15189	6	2.5
	36	Hungary	0.829	11430	4.6	2.5
	41	Costa Rica	0.821	8860	10.8	0.8
	46	Croatia	0.803	7387	4.1	1.8
	47	Lithuania	0.803	6656	3.1	2.1
Medium development	49	Trindad and Tobago	0.798	8176	1.3	6.3
	56	Malaysia	0.774	8209	4.3	1.9
	58	Romania	0.772	6041	3.8	1.6
	65	Lebanon	0.758	4705	3.3	1.4
	69	Brazil	0.750	7037	6.7	1.1
	72	Armenia	0.745	2215	4.9	0.5
	73	Peru	0.743	4622	8.9	0.5
	76	Georgia	0.742	2431	4.8	0.5
	81	Sri Lanka	0.735	3279	8.1	0.4
	86	Dominican Republic	0.722	5507	6.2	0.9
	95	El Salvador	0.701	4344	6.8	0.7
	100	Algeria	0.693	5063	5.4	0.6
	105	Egypt	0.635	3420	4.9	0.3
	111	Namibia	0.601	5468	9.6	0.5
	112	Morocco	0.596	3419	10	0.4
	115	India	0.571	2248	4.7	0.5
	119	Ghana	0.542	1881	5	0.5
	123	Kenya	0.514	1022	2.1	0.4
	135	Cameroon	0.506	1573	3.8	0.4
	126	Congo	0.502	727	2.8	0.3
Low development	127	Pakistan	0.498	1834	4.2	0.4
	128	Togo	0.489	1410	4.7	0.3
	132	Bangladesh	0.470	1483	10.8	0.1
	136	Nigeria	0.455	853	1.2	0.7
	143	Zambia	0.427	756	1.2	0.6
	145	Senegal	0.423	1419	4.5	0.3
	147	Benin	0.420	933	2.9	0.3
	157	Mozambique	0.323	861	2.1	0.4
	158	Ethiopia	0.321	628	2.2	0.3

Fig. (1) shows the relationship between HDI and countries energy consumption. According to HDR, all countries are classified in three groups:

- high human development: $1.000 \geq HDI \geq 0.800$
- moderate human development: $0.799 \geq HDI \geq 0.500$
- low human development: $0.499 \geq HDI \geq 0.000$

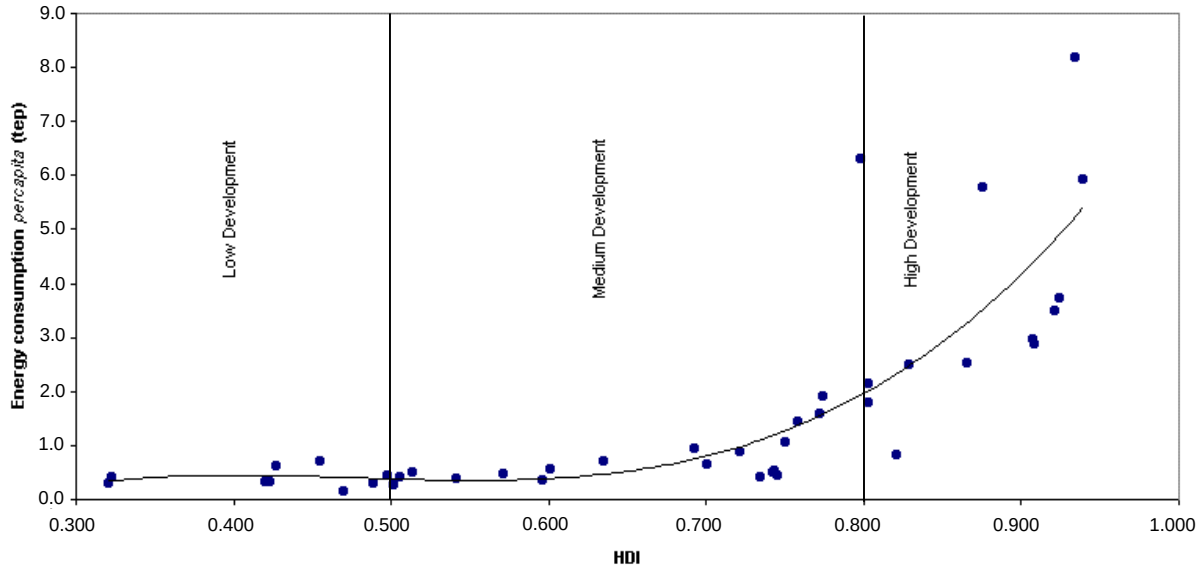

Figure 1. Graphic of HDI versus energy consumption.

4. Energy saving potential assessment in OECD countries

Starting from HDR information (UN, 2001, 2002), it is possible to verify the hypothesis of changing the energy consumption of OCDE countries to a new level without, meanwhile, endangering their development capacity. Considering Fig. (1), the points in the graphic HDI *versus* energy consumption can be approximated by Eq. (4).

$$E(I) = 55.279\,I^3 - 79.13\,I^2 + 36.807\,I - 5.1485 \tag{4}$$

in which:

E(I): *per capita* energy consumption (tep)
I: human development index – HDI

To the estimate of OECD countries energy consumption, ranging from $0.85 \leq HDI \leq 0.94$, the mean value of Eq. (4) was calculated.

$$\int_{0.85}^{0.94} E(I)dI = 13.82\,I^4 - 26.38\,I^3 + 18.40\,I^2 - 5.1485\,I \Big|_{0.85}^{0.94}$$

$$\int_{0.85}^{0.94} E(I)dI = 0.37 \text{ tep.IDH/year}$$

hence,

$$E_{mean} = \frac{\int_{0.85}^{0.94} E(I)dI}{0.94 - 0.85} = 4.1 \frac{tep}{year}$$

If a value of 0.85 to the HDI can be considered satisfactory to warrant development conditions (value that is slightly superior to the above lower bound of high human development index) to the countries, the energy consumption is approximated to 2.9 tep. In this new level of development there is a saving potential estimated as:

$$\text{Saving potential} = \frac{4.1 - 2.9}{4.1} \times 100 = 29.3\%$$

In Weber (1997) assessment, the OECD energy saving potential was estimated to be 30%, hence, the result here obtained (29.3%) is in accordance with that reference.

5. Human development and energy democratization

The participation of energy use in peoples' life is consolidated, independently of the country's adopted development model. At the end of 20th century and in the beginning of the 21st century, many discussions about human development are presented in the world, as can be seen in the discussion contained in the 21 Agenda.

A recurrent topic is the sustainable development concept (Dincer, 1999), in which the author considers the necessity of looking for the balance between human necessities, energy use and environment. In this context, approximately a quarter of world population conducts its development moved by a large scale consumption of goods and services. In opposition, the “rest of world population” (using OECD classification), in more dramatic circumstances, seems to be incarcerated in the past and under difficulties and privations.

If it is possible to save energy in developed countries, the situation is not different in developing countries. The questions that must be discussed are: how is energy used? Which are the elements that obstruct the efficient energy policy implementation? Is the society culturally prepared to understand energy use?

There is a considerable challenge considering that industries are responsible by one third of CO_2 and two thirds of SO_2 in terms of world emissions (Boyle, 1996). This situation becomes critical when it is included the transportation sector, which aggregates around 25% of CO_2 emissions in the world and uses more than 50% of world oil consumption (Wohlgemuth, 1997). Besides, 75% of world population does not have access to the enough energy quantity for supplying its development needs (Goldemberg, 1998). Therefore, it is a priority for energy sector decision makers to look for alternative ways for improving the life quality of populations, mainly in developing countries, without damaging the environment.

Another question is how to break up paradigms inside energy use in several levels. One possible affirmation is by energy education. People need first to better understand this commodity, its transformation since exploitation until final use and other present agents, for example, commercialization, energy availability in nature, transportation and environmental impact. Changing personal values through the use of correct didactic interventions, specially by means of educational institutions, it represents the appropriate way to conduct the concepts of energy conservation (Dias at al., 2003).

Awareness about energy conservation by education has a considerable potential in preparing future generations to overcome the “energy paradox”. The “energy paradox”, or energy gap, as it was demonstrated in this paper in the case study based on the OCDE countries, represents about 30% of total energy consumption of them.

The first step in the educational energy conservation program is to take into account the difference between cultural and geographical aspects of each population. This educational process is called "contextualization". Good examples are better accepted by people in comparison to an impersonal information without connection with their reality (Constanzo et al., 1986).

The future decisions makers are today at school, at least it would be the ideal desire. This is the best moment to discuss the possibilities in conducting the humanity existence according to the sustainable development concept and, when arriving the moment to promote the educational process, the teacher must be in its place ensured, receiving support of several society segments.

6. Final discution

Energy use and human development have a strategical relationship, because they enclose a multidisciplinar analysis and require a interdisciplinar action. Understanding the human behavior is not easy, mainly when there are differences of social, economic and educational levels; however, there is no reason to believe that it is an impossible mission, specially because it can be seen as an opportunity for the present decisions makers to think about the next generations and the future of the Earth, and for putting into practice actions that represent the social objectives.

The HDI index consolidates several information about nations, but if it is not interpreted for improving the quality life, this index become without sense. When the energy use was associated to HDI, it was possible to find opportunities to put into practice the energy conservation concepts, by looking for new conditions to get the development at less intensive energy use.

The importance of education in the development process is unquestionable, mainly when energy conservation concepts are involved, but there are rare initiatives that put into practice actions aimed to human values construction, with a conscious and consistent didactic referential. The difference between developed and developing countries is visible, but perhaps do the developed countries really have the solution to the “rest of world”?

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7. References

Boyle, S., 1996, “DSM progress and lessons in the global context”, Energy Policy, v.24, pp.345-359.
Constanzo, M., Archer. D., Aronson, E., Pettigrew, T., 1986, “Energy conservation behavior: the difficult path from information to action”, *American Psychologist*, v. 41, n. 5, p. 521-528.
Dias, R. A., Mattos, C. R., Balestieri, J. A. P., 2003, “Energy education: breaking up the rational energy use barriers”, Energy Policy, *In Press*.
Dincer, I., 1999, “Environmental impacts of energy”, Energy Policy, v.27, pp.845-854.
Goldemberg, J., 1998, “Energia, meio ambiente e desenvolvimento”, Editora da Universidade de São Paulo, Edusp, Brazil 235p.
ONU – Organização das Nações Unidas, 2001, “Relatório do desenvolvimento humano 2001”, Programa das Nações Unidas para o Desenvolvimento (PNUD), available in: <http://www.undp.org.br>, access: November 20, 2002.
ONU – Organização das Nações Unidas, 2002, “Relatório do desenvolvimento humano 2002”, Programa das Nações Unidas para o Desenvolvimento (PNUD), available in: <http://www.undp.org.br>, access: November 20, 2002.
Weber, L., 1997, “Viewpoint – some reflections on barriers to the efficient use of energy”, Energy Policy, v.25, no.10, p.833-835.
Wohlgemuth, N., 1997, “World transport energy demand modeling”, Energy Policy, v.25, nos.14-15, pp.1109-1119.

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