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Summary

Great differences in living standard are found between developed and less developed countries (LDC's) and, in particular, between and within LDC's and corresponding differences in the level of energy consumption.While traditional development paths have resulted in increasing social stratification in LDC's, development should focus on meeting the basic needs of the poor. The energy cost of satisfying the basic needs of a human being is estimated to be smaller than current per capita world energy consumption. This suggests that resource redistribution between and within countries could solve the energy problems of the developing world at today's world energy consumption level.

Introduction

Today's world is characterized by stark contrasts in well-being across human societies. One quarter of the approximately 4 billion inhabitants of our planet live in so-called developed countries where in most cases industrial development has taken place and people are fighting problems that derive from overconsumption. The remaining three quarters belong to what are termed less developed countries (LDC's) (or euphemistically developing countries) where the average level of consumption is much lower than in developed countries.

The division of the world into a developed and a less developed part ignores the fact, however, that contrasts in the living standards across and within LDC's are often greater than between LDC's and developed countries. In most LDC's colonialization and subsequent economic exploitation by capitalist industrialized countries in the 19th century has been instrumental in establishing and preserving systems with pronounced social stratification. Most of the wealth is concentrated in the hands of a small percentage of the population which has benefited from trade with industrialized countries and has secured its position by controlling political and economic decision making. This social elite, which has a lifestyle at least as extravagant as that of the well-to-do in developed countries, is usually found in small urban islands surrounded by urban slums and vast rural areas where a large number of people live in conditions of severe poverty without any chance of satisfying basic needs for food, housing, health and education.

Energy Consumption in the World

The rate of energy consumption of a society is considered a reasonably good barometer of its overall (or average) standard of living as measured by macroeconomic indicators such as income (or income "per capita"). It is not surprising therefore that, according to Table 1, developing countries consume on the average 6 times less energy than developed ones.

The above discussion suggests in addition that still greater differences in energy consumption should be found across and within LDC's. Indeed, there is an order of magnitude gap between the energy consumption levels of Bangladesh and Brazil (Table 2); and the gap widens further when areas in Brazil are compared where people from the extreme ends of the social spectrum live, e.g. the rural Northeast comparable in energy use to Bangladesh and the metropolis of São Paulo comparable in energy use to industrialized countries, as will be seen from Table 3.

There has been a tendency on the part of LDC governments and development agencies in developed countries to equate development with high economic growth rates. According to this philosophy of maximizing GNP, investments have been made primarily in projects promising fast returns and production has focused primarily on goods yielding large profits. One unfortunate consequence of the adoption of this philosophy has been increasing social stratification and deterioration (or at least not improvement) of the situation of the poor (5). Social justice demands, however, that the basic needs of all people be satisfied, not just those of a few. A way of development fundamentally more equitable and meaningful than maximizing GNP, would therefore concentrate on meeting the basic needs of the poor.

Energy Cost of Basic Human Needs

Several attempts have been made to date to quantify the minimum energy needs of people. Haffner[6], for example, starts from the assumption that a normally active young adult in a temperate climate needs a dietary energy allowance of 2500 kcal which roughly corresponds to a continuous energy flow of 100 watts (called a unit of "human equivalent power" (HEP). He then introduces the notion that satisfying basic needs would require the work of hypothetical slaves consuming energy at a rate corresponding to HEP and makes "off the top of the head" estimates of the numbers of slaves necessary to meet the various basic human needs. Table 4 lists the resulting basic energy needs .

Another attempt of estimating basic human energy needs was made by Palmedo et. al.[7] on the basis of an indicator of well-being introduced by Morris and Liser[8]. The indicator is a composite index, called Physical Quality of Life Index (PQLI) and ranging from 1 to 100. The index is calculated for a given country by rating figures for life expectancy, infant mortality, and literacy each on a scale of 1 to 100 and averaging the three components, giving equal weight to each of them. Palmedo et.al. plot the PQLI against per capita energy consumption for various LDC's, as reproduced in Figure 1, and suggest that the energy consumption range of 1200 to 1400 kg of coal equivalent per capita (23 to 28 x 10^3 kcal/day per capita) where the marginal benefit of added energy drops sharply may be interpreted as representing a situation in which basic human needs are satisfied.

A comparatively sophisticated approach to the question of basic human needs has been taken by the Bariloche Foundation with its recently published Latin American World Model[9]. The Bariloche study explores possible physical limits to establishing a society in which basic human needs are satisfied and, on the basis of a simple econometric model, investigates the possibility of doing so with current economic resources.

Major findings are that availability of physical resources does not pose a problem in the foreseeable future and that the proposed society could be attained in a few decades in each of the three developing regions considered (Latin America, Africa, and Asia). We shall use the model below to estimate basic human energy needs.

The econometric model depicts a production system consisting of two inputs (labor and capital) and five economic sectors (nutrition, housing, education, other services and consumer goods, and capital goods). Three basic human needs (for the products of the first three sectors - nutrition, housing, and education) are considered explicitly. Their target levels assumed are listed in Table 5.

A fourth basic need, for health, is considered implicitly via functional relationships between demographic variables, including health related parameters such as life expectancy at birth, and socioeconomic variables which are also functionally related to the three basic needs economic sectors. The model allocates the inputs labor and capital to the five economic sectors by optimizing the demographic parameter life expectancy at birth, subject to various constraints. One important constraint is that the fraction of GNP allocated to consumer goods is fixed at its level in 1970 (the year for which the model is calibrated, see below) until basic needs are satisfied. The optimization method adopted in effect provides for resource allocation to basic needs on a priority basis. For each sector, output levels are determined by the inputs (labor and capital), modified by their respective productivities and with technological progress included, on the basis of a mathematical relationship (production function) that allows substitution between labor and capital. Unit costs are assumed for the basic need products for translation of sector output into physical production.

The evolution in time of sector outputs as well as population and other demographic variables is traced on the basis of relationships between values of a given year to values of the previous year. The model is initialized using 1960 data for the various regions and calibrated such that model results agree with real world data for 1970. The policy of social change toward satisfaction of basic human needs is assumed to be implemented from 1980.

Table 6 shows GNP/capita and population size for the three developing regions for the respective years in which all three basic needs are satisfied.

What are the corresponding basic energy needs? One possibility of estimating them is via income and price elasticities of energy demand. However, the implementation of the new social policy would change the economic structure of a country or region which might in turn affect the overall energy intensity of the economy. Table 7 shows for Brazil in 1970 our estimate of the energy intensities of the products of the three basic needs sectors relative to the average energy intensity of the economy. It will be seen that these energy intensities are, within a factor of two, equal to the average energy intensity of the whole economy. Expansion of the basic needs sectors therefore may ou may not change significantly the average energy intensity of the economy[12]. In the face of this uncertainty it appears good enough to use historic income and price elasticities of energy demand. Their LDC averages have been calculated from 1960 - 1975 time series and cross section data to be + 1.35 and - 0.32 , respectively[13].

On the basis of these numbers, GNP per capita and commercial energy consumption per capita numbers for 1970 (Table 8), GNP per capita data from Table 6, and an assumed eightfold increase in real energy prices between 1970 and 2000 and another 50 percent increase between 2000 and 2020[15], basic commercial energy needs are calculated and presented in Table 9 where estimated non-commercial energy consumption is also listed.

Conclusions

On the basis of the Bariloche Model we calculate a cost of satisfying basic energy needs in LDC's of approximately 30×10^3 kcal/day capita which is comparable to the corresponding numbers of Haffner (31×10^3 kcal/day capita) and Palmedo et.al. (23 - 28 x 10^3 kcal/day capita).

All of the three estimates of basic energy needs are smaller than the current average per capita world energy consumption. This leads to the inescapable conclusion that the energy problems of LDC's could be solved at today's world energy consumption level by redistributing resources more equitably between and within countries.

It is political and socioeconomic constraints that prevent redistribution from taking place. The "energy crisis" of LDC's is thus intimately linked to inequities in the access to energy sources, not to their physical lack.

References and Notes

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(11) C.W.Bullard, P.S.Penner, and D.A.Pilati, Net Energy Analysis: Handbook for Combining Process and Input-Output Analysis (Document nº 214, Center for Advanced Computation, University of Illinois, Urbana - Champaign, Ill., 1976).

(12) To shed more light on how significant the average energy intensity change might be it would be interesting to know the fractions of GNP allocated to the various sectors in the years when basic needs are satisfied. However, this information is not available from (9).

(13) B.J.Choe and A.Lambertini, Energy Prospects in Non-Opec Developing Countries 1976-1985 (1978, mimeo), as quoted by L.Hoffmann in Workshop on Energy Data of Developing Countries (Proceedings, International Energy Agency, Organization for Economic Co-Operation and Development, Paris, 1979) Vol. 1, p. 112. The elasticity numbers adopted are the respective averages of two averages of long-run per capita income elasticity (1.34 and 1.36) and long-run price elasticity (-0.30 and -0.34) of per capita commercial energy consumption that Choe and Lambertini calculate for LDC's grouped according to income per capita and geographic regions, respectively, using 1975 commercial energy consumption as weights.

(14) World Energy Supplies 1972-1976 (United Nations, Statistical Papers, Series J, Nº 21, New York, 1978), Tables 1 and 2.

(15) The real price of petroleum, currently the dominant commercial fuel, rose by a factor of approximately four between 1970 and 1980. The assumption of an eightfold increase of real energy prices between 1970 and 2000 is roughly equivalent therefore to assuming a doubling of real energy prices between 1980 and 2000. Since the use of petroleum, whose current price hikes are being mainly responsible for energy price increases, is likely to be on a rapid decline after 2000 it appears reasonable to assume a smaller real energy price increase for the period 2000-2020 compared to 1980-2000.

(16) This work was supported by FAPESP (Fundação de Amparo à Pesquisa do Estado de São Paulo).

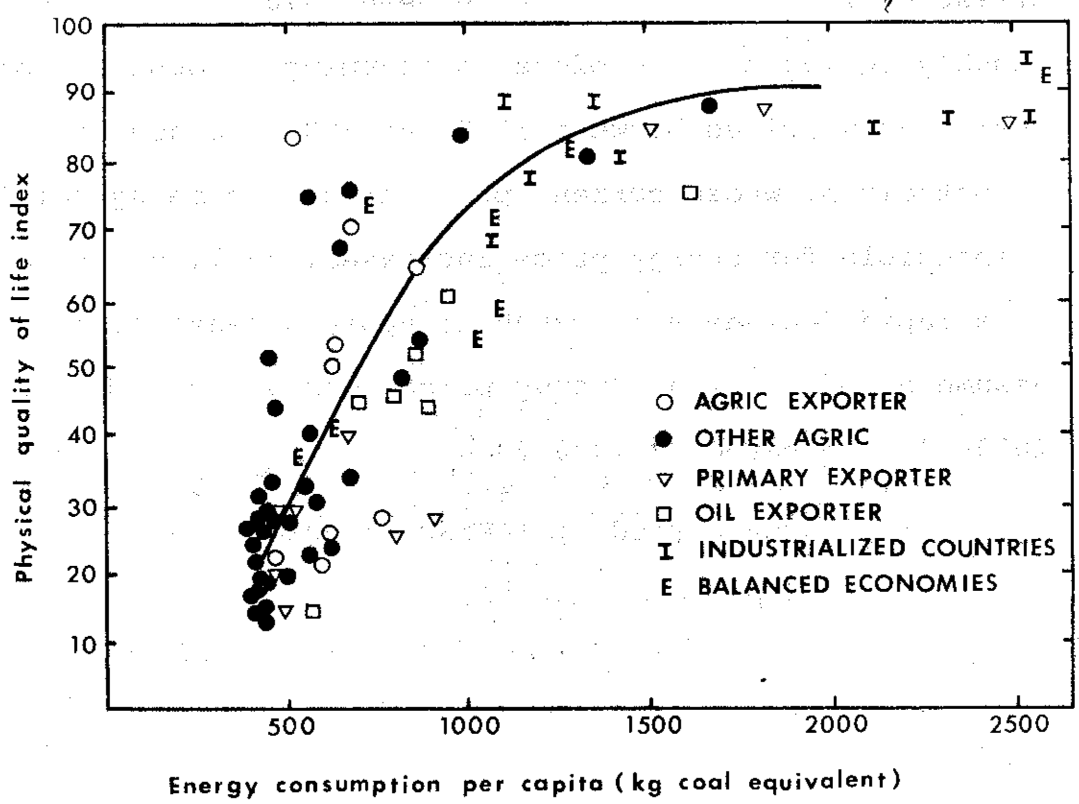

Figure 1

Relationship between Physical Quality of Life Index (PQLI) and energy consumption per capita for various LDC's adapted from (7).

Table 1. Global energy consumption, 1975 [a]

	Population (10^9)	Energy consumption per capita (kcal/day)
World	3.94	42,500
Industrialized countries	1.12	110,000
Developing countries	2.82	18,000

(a) Source: (1).

Table 2. Energy consumption in selected countries, 1975 [(a)]

Country	Population (10^9)	Energy consumption per capita (kcal/day)
Bangladesh	0.08	2,300
China	0.88	7,100
India	0.6	11,000
Brazil	0.11	22,800
United States	0.214	243,000

(a)

Source: (2).

Table 3. Energy consumption in Brazil, 1975 [a]

Region	Population (10^6)	Energy consumption per capita [b] (kcal/day)
States of Maranhão and Piaui [c]	5.3	2,100
Northeast	32.0	5,200
Southeast	45.0	22,800
State of São Paulo [d]	20.6	29,400
Metropolitan area of São Paulo City	10.0	39,000 [e]

(a) Based on (3).

(b) Includes only petroleum products and electricity, i.e. about two thirds of total energy consumption.

(c) Maranhão and Piauí are the most rural states of the North-east region.

(d) São Paulo is the most industrialized state of the Southeast region.

(e) Assuming that the ratio of energy consumption per capita in the metropolitan area of São Paulo City to that in São Paulo State equals the corresponding ratio of direct plus indirect household energy consumption per capita for the two areas. The latter ratio is 4/3 (4).

Table 4. Basic energy needs of hypothetical society relying on slaves [a]

Type of activity	Number of slaves per capita	Energy needs per capita (watt)
Food	3	300
Shelter	3	300
Clothing	1	100
Travel	2	200
Leisure	6	600
Total	15	1,500 [b]

(a) Source: (6)

(b) Corresponds to 30,900 kcal/day.

Table 5. Basic human needs [a]

- 3000 kilocalories and 100 grams of protein per person per day;
- 12 years of basic education;
- one house (50 square meters of living area) per family.[b]

(a)
Source: (9).

(b)
In Africa and Asia where the housing situation is much worse than in Latin America the "standard" house is initially taken to be more modest: 7 square meters of living area per person and construction costs per unit living area of approximately two thirds (Africa) and one third (Asia) of those assumed for Latin America. Housing conditions in Africa and Asia are assumed to gradually improve so as to reach Latin America's target area and quality in 20 years.

Table 6. Basic needs satisfied [a]

Region	Year	GNP per capita [c] (1960$)	Population [d] (10^6)
Latin America	2000	1107	486.2
Africa	2020	911	929.2
Asia	2020 [b]	506.2	5498

(a)
Source: (9).

(b)
For the case in which the assumed maximum annual yield of edible products per hectare is raised from 4 tonnes to 6 tonnes to avoid collapse of the society.

(c)
Attaining the GNP per capita figures listed would require annual GNP growth rates in the range of 5 to 5.5 percent between 1970 and the respective years of basic needs satisfaction. Such growth approximates historical growth rates during 1960-1970 in the three regions. However, the GNP per capita figures refer to a situation in which basic needs are satisfied on the average. Thus only if all people earned the same income would the basic needs of each individual be met. Basic needs satisfaction of the poorest in a real society with an income distribution would require higher GNP growth rates than indicated. On the other hand, (9) assumes a social policy which does not reduce the share of production going to consumer goods and provides for an adequate share of GNP devoted to investment (in basic needs sectors as well as

Table 6. (cont'd)

in other infrastructure). A basic needs strategy aimed at eliminating production of non-essential goods would require lower GNP per capita targets and consequently lower GNP growth rates necessary to reach them.

(d)

In (9) population size is calculated endogenously on the basis of relationships between demographic and socioeconomic variables. The population growth resulting in the population size figures listed corresponds to annual growth rates in the range of 1.9 to 2.1 percent between 1970 and the respective years of basic needs satisfaction.

Table 7. Energy intensities of basic needs sectors relative to that of the whole economy for Brazil in 1970 [(a)]

	Nutrition	Education	Housing	Average of whole economy
Relative energy intensity	0.97 [(b)]	1.75 [(c)]	0.84 [(d)]	1

(a)

Based on the Brazilian 1970 input-output tables (10). The tables include only "monetary" energy, i.e. energy that is bought and sold on the market. Houwever, roughly one third of the energy consumed in Brazil (most importantly wood) is "non-monetary" in that it bypasses the energy market.

(b)

Weighted average for all food products going to personal consumption (including distribution).

(c)

Weighted average for all government expenditures for educational purposes (when direct fuel purchases are excluded the relative energy intensity drops to 0.72. However, energy costs of establishing infrastructure (school buildings etc.) are excluded!

(d)

In the Brazilian input-output matrix residential house construction is lumped with capital formation under "construção civil" for which reason no pertinent energy intensity coefficient can be inferred . The figure shown refers to the US in 1967 and is based on the energy intensity of the sector "new residential construction" as calculated in (11).

Table 8. LDC energy consumption and GNP by region, 1970

Region	GNP per capita[a] (1960 $)	Commercial energy consumption per capita[b] (kcal/day)
Latin America	440	15.4×10^3
Africa	154	5.8×10^3
Asia	112	6.9×10^3

(a)
Source: (2).

(b)
Based on (14).

Table 9. Basic needs satisfied: Per capita energy consumption

Region	Year	Commercial energy (kcal/day)	Non-commercial energy[a] (kcal/day)	Total energy (kcal/day)
Latin America	2000	27.5×10^3	5×10^3	32.5×10^3
Africa	2020	28.9×10^3	5×10^3	33.9×10^3
Asia	2020	23.9×10^3	5×10^3	28.9×10^3

(a)
Estimated on the basis of respective 3.75×10^3 and 7.5×10^3 kcal/day per capita numbers in (2) and (7).