ENERGY AS AN OBSTACLE TO THE IMPROVEMENT OF LIVING STANDARDS

by

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Energy Services and Living Standards

One of the greatest challenges facing the world today is poverty. While growing pockets of poverty are visible even in the industrialized world, "the fundamental reality of developing countries is the poverty of the majority of human beings who live in them."[1] Whether measured in terms of nutrition levels, health and education status, or income and employment, or quality of shelter, a majority of people in the developing world exist at sub-standard levels, where the struggle for daily survival is unending. The chief characteristic of poverty is the fact that basic human needs -- food, shelter, health care, education, and livelihoods -- remain unfulfilled.

It is tempting to associate poverty with inadequate energy consumption, but such a correlation would obscure the fact that the poor use energy very inefficiently, essentially because the efficiencies of their technologies of energy consumption are also abysmally low.

The real determinant (or correlate) of poverty is the level of services that energy provides -- heat for cooking, illumination, accessible water supply for personal and domestic needs, enhanced productivity of labour, etc. This viewpoint increases the range of options -- from a mere increase in the magnitude of energy consumption to improvements in the efficiency of energy utilization (and of course, combinations of both). Thus, *poverty and scarcity of energy services go hand in hand, and exist in a synergistic relationship*.

In the face of inadequate inanimate energy and of a lack of access to efficient technologies of energy use, the poor are forced to depend on their own labour, on animal power and biomass energy resources to meet their survival needs. If poverty reduction and improved living standards are to be achieved, energy services must be dramatically augmented to improve the level of satisfaction of basic human needs. This is the challenge, a challenge that is aggravated by growing populations already facing shortages of inanimate energy -- failure will play a significant role in the perpetuation of

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poverty, and success can lead to the achievement of equitable, ecologically sound and sustainable development.

Village Energy Consumption Patterns

The vast majority of the world's poor live in rural areas, mostly in villages. In order to understand how low levels of energy services become an obstacle to the improvement of living standards, it is necessary to examine at the outset the nature of energy consumption patterns at the village level.

There have been several studies of the patterns of energy consumption in villages. Among the earliest of the studies was that of six villages in the Ungra region of Tumkur District, Karnataka State, South India, carried out in the late 1970s.[2]

Pura (latitude: 12 49'00" N, longitude: 76 57'49" E, height above sea level: 670.6 m, average annual rainfall: 127 cms/year, population (in September 1977): 357, households: 56) is one of the villages in Kunigal Taluk, Tumkur District, Karnataka State, South India.

The energy-utilizing activities in Pura consisted of[3]:

- agricultural operations (with ragi and rice as the main crops),
- domestic activities -- grazing of livestock, cooking, gathering fuelwood and fetching water for domestic use particularly drinking,
- lighting and
- industry (pottery, flour mill and coffee shop).

These activities were achieved with human beings, bullocks, fuelwood, kerosene and electricity as direct sources of energy.

An aggregated matrix showing how the various energy sources were distributed over the various energy-utilizing activities is presented in Table 1[4]. The matrix yields the following ranking of **sources** (in order of percentage of annual requirement): (1) fuelwood 89%, (2) human energy 7%, (3) kerosene 2%, (4) bullock energy 1%, (5) electricity 1%. The ranking of **activities** is as follows: (1) domestic activities 91%, (2) industry 4%, (3) agriculture 3% and (4) lighting 2%.

Human energy is distributed thus: domestic activities 80% (grazing livestock 37%, cooking 19%, gathering fuelwood 14%, fetching water 10%), agriculture 12%, and industry 8%. Bullock energy is used wholly for agriculture including transport. Fuelwood is used to the extent of 96% (cooking 82% and heating bath water 14%) in the domestic sector, and 4% in industry. Kerosene is used predominantly for lighting (93%), and to a small extent in industry (7%). Electricity flows to agriculture (65%), lighting (28%), and industry (7%).

There are several features of the patterns of energy consumption in Pura which must be highlighted.

- What is conventionally referred to as commercial energy, i.e., kerosene and electricity in the case of Pura, accounts for a mere 3% of the inanimate energy used in the village, the remaining 97% coming from fuelwood.[5] Further, fuelwood must be viewed as a non-commercial source since only about 4% of the total fuelwood requirement of Pura is purchased as a commodity, the remainder being gathered at zero private cost.

- Animate sources, viz., human beings and bullocks, only account for about 8% of the total energy, but the real significance of this contribution is revealed by the fact that these animate sources represent 77% of the energy used in Pura's agriculture. In fact, this percentage would have been much higher were it not for the operation of four electrical pumpsets in Pura which account for 23% of the total agricultural energy.

- Virtually all of Pura's energy consumption comes from traditional renewable sources -- thus, agriculture is largely based on human beings and bullocks, and domestic cooking (which utilizes about 80% of the total inanimate energy) is based entirely on fuelwood.[6]

- However, the environmental soundness of this pattern of dependence on renewable resources is achieved at an exorbitant price: levels of agricultural productivity are very low, and large amounts of human energy are spent on fuelwood gathering (on the average, about 2-6 hr and 4-8 km per day per family to collect about 10 kg of fuelwood).

- Fetching water for domestic consumption also utilizes a great deal of human energy (an average of 1-5 hr and 1-6 km per day per household) to achieve an extremely low per capita water consumption of 17 litres per day.

- 46% of the human energy is spent on grazing livestock (5-8 hr/day/household) which is a crucial source of supplementary household income.

- Women contribute a vital , , , and , of the labour for gathering fuel, fetching water, grazing livestock, and agricultural work. Their labour contributions are vital to the survival of families, a point now well established in the global literature, but still neglected by planners and policy makers.

- Similarly, children contribute a crucial 30%, 20%, and 34% of the labour for gathering fuelwood, fetching water and grazing livestock respectively. The critical importance of children's labour contributions in poor households has significant implications for population and education policies and programmes -- but again, largely ignored.

- Only 25% of the houses in the `electrified' village of Pura have acquired domestic connections for electric lighting, the remaining 75% of the houses depend on kerosene lamps, and of these lamps, 78% are of the open-wick type.

- A very small amount of electricity, viz., 30 kWh/day, flows into Pura, and even this is distributed in a highly inegalitarian way -- 65% of this electricity goes to the 4 irrigation pumpsets of 3 landowners, 28% to illuminate 14 out of 56 houses, and the remaining 7% for one flour-mill owner.

It is obvious from Table 2 which shows the end-uses of human energy in Pura that the inhabitants of Pura, particularly its women and children, suffer burdens that have been largely eliminated in urban settings by the deployment of inanimate energy. For example, gathering fuelwood and fetching water can be eliminated by the supply of cooking fuel and water respectively. The serious gender and health implications of rural energy consumption patterns, have been brought out in several studies[7],[8],[9].

Since then, there have been innumerable studies of rural energy consumption patterns.[10] The actual numbers show differences depending upon the region of the country, the agro-climatic zone, the proximity to forests, the availability of crop residues, prevalent cropping pattern, etc., but the broad features of the patterns of energy consumption in Pura, highlighted above, have been generally validated.

The "Price" paid by the Poor for the Low Levels of Energy Services

It becomes clear from the above analysis that the poor pay a much higher price for their energy services than any other section of society. This price can be analysed from various points of view.

(1) Human time and labour: There is a very low return for each unit of human labour and time invested in vital subsistence and productive activities -- in the absence of other energy sources and/or labour-saving technologies to fulfill these needs. For instance, a round trek of 7-10 Kms, and 4-6 hours of time investment by a woman may yield enough firewood only for one day's cooking and heating needs in a household of 4 -5 persons[11]. An urban middle class household, in contrast, may spend less than one-tenth of the time and labour for the same result.

Studies also show a high correlation between land ownership and access to biomass for fuel and fodder. This traps the poor, especially poor women, in a low-productivity subsistence level of living, where meeting basic needs for fuel, food, fodder and water, consumes enormous quantities of time and labour, which cannot be diverted to more productive or life-enhancing activities.

(2) Economic cost: The unit cost of the energy required for fulfillment of basic needs is much higher, in both direct and indirect terms, for the poor than for the relatively affluent -- not only is the cost of economic opportunities lost much higher, but the actual cost of the energy used per activity (for example, per item of cooked food) is also greater[12]. Economic costs must also be calculated in terms of the ecological price forced dependence of the poor on inefficient biomass based technologies like open cookstoves, in the absence of alternative energy sources.

Development of agriculture and industry, essential components of economic growth for poor countries, are both dependent on energy supplies. Energy shortages also introduce biases in the distribution of available energy resources -- politically powerful groups can influence decision-making about energy policies to advance their own interests at the cost of the majority. This in turn becomes a hurdle for the economic upliftment of the poorer sections of society, hence lowering the nation's overall economic status.

(3) Health costs: Among the most serious cost of energy scarcity for the poor, particularly poor women and children, is the range of health problems caused, directly and indirectly, by the dependence on increasingly scarce biomass to meet daily subsistence needs.

(a) Health hazards of biomass cooking fuels: First and foremost are the health hazards caused by the use of biomass fuels for cooking in most poor households in the world. It is estimated that "more than half the world's household cook daily with unprocessed solid fuels, i.e., biomass or coal"[13]. Evidence from around the world indicates that firewood, dung cakes, and other fuels, release highly toxic emissions such as carbon monoxide, total suspended particulates (TSPs) and hydrocarbons[14].

Furthermore, these fuels are used primarily in traditional open cookstoves with a fuel efficiency of just 3-10%[15], in poorly-ventilated one- or two-room homes. Even where ventilation is relatively good (such as in thatch-roof dwellings), the emissions are of such a magnitude that the health effects are still alarming.

For instance, one of the earliest studies, conducted in Gujarat state of Western India, found that fuels like firewood, dung cakes and crop wastes emit more TSP, benzo-a-pyrene, carbon monoxide and polycyclic organic pollutants than fossil fuels like coal or natural gas. The study showed that in clinical terms, women spending an average of 3 hours a day on cooking are exposed to 700 micrograms of particulate matter per cubic meter (as against a permissible level of < 75 micrograms), and inhale benzo-a-pyrene equivalent to 400 cigarettes[16],[17]. Moreover, the study found that women began regular cooking at around the age of 13, which meant a much longer period of exposure to pollutants.

Similar studies -- though few in number, and not always focussed on the health effects -- have been done in Africa, Latin America, Southeast Asia and in China (where the focus has been on coal-burning stoves).

The health hazards of dependence on biomass cooking fuels are not limited those arising from air pollution alone. Experts contend that each part of the fuel cycle -- from production, collection, processing and actual cooking -- have health implications which can be serious. Table 3 shows a list of potential health hazards arising from different functions in the fuel cycle.

(b) Health and Nutrition Effects of Energy Scarcity: Apart from the direct health effects of cooking fuels used by the poor, there are clear indications that the growing scarcity of, and difficulty in obtaining, biomass fuels for cooking affects the health of the poor in several indirect ways.

Firstly, the scarcity and high time and labour cost involved in obtaining biomass fuels like firewood may result in measures to economise on fuel consumption in cooking in various ways. For one, fewer hot meals may be prepared per day, leading to consumption of stale/leftover foods which may become contaminated. This could lead to nutrient losses, and increased risk of infections. Under-cooking may also be resorted to in order to save fuel, which can cause health problems in the case of some pulses and oils which are toxic when undercooked. Another health effect could result from the switching-over to cereal staples which require less cooking, but which may be less nutritious (from wheat or coarse grains to rice, for instance). While there is no documented statistical evidence for any of these problems, they have been widely observed by grassroots workers in many developing countries[18].

There are other health impacts on the poor resulting from their dependence on human energy in the absence of alternative sources for performing survival tasks. Chief among these is the impact on the nutrition and health status of poor women and girl children, in societies where the performance of these tasks is along gender lines. A benchmark study of the early eighties[19], based on the Pura village energy matrix data cited earlier, highlighted the relatively greater health costs borne by poor women, particularly in nutritional terms, as a result of the daily chores of cooking, fuel gathering, water fetching, and grazing. The study showed that these daily subsistence activities lead to a higher calorie expenditure per woman per day than per man, particularly since these domestic tasks are perennial, while agricultural work (where men's energy contribution is higher than women's) is seasonal.

But this greater energy output of women was not compensated by a proportionate intake of food, where men took the lion's share and women in a family traditionally eat last, and least -- the ratio of intra-household male-female food distribution was 2:1. Studies in several other locations corroborated the gender bias in access to food within the family.[20],[21],[22],[23],[24] This means one more hole in the "leaky bucket" of women's health and nutrition -- overwork and inadequate food. Surveys by the National Nutrition Monitoring Bureau in India have found that adult women's eights are well below par all over the country, and that while women's weight-gain ceases after the age of 16 years, men continue to gain weight until at least 25 years[25]. What is more, weight-gain in pregnancy of rural women is a mere 4-6 Kgs, as opposed to the desired norm of 10-12 Kgs.

Another health dimension of the energy scarcity sydrome, combined with the absence of labour-saving appropriate technology (and once again borne by poor women) is the possible health hazards for pregnant women and their unborn infants as a result of traditional rice cultivation methods. A study conducted in a sample of 30,000 population in Western India in 1982 showed a sharp increase in stillbirths, premature births and neonatal mortality during the rice-planting months, when women labour for hours, bent almost double, transplanting rice. The fact that no maternal deaths occurred was probably due to the presence of an effective non-governmental community health care project in the area.[26],[27]

The reduction of water consumption, particularly for personal hygiene, because of the time and labour costs involved in water collection, also has negative effects on women's health: lack of adequate water for bathing/washing has been cited as a major contributing factor to the high rate of genito-urinary and reproductive tract infections in poor women. One recent Indian study found that 92% of the sample women had reproductive tract infections (RTIs), many of which had gone untreated for years.[28] This can be a significant contributing factor to female sterility, cervical cancer and uterine prolapse. The last is also related to excess load-carrying (of water, firewood, etc.) by women.[29]

It is clear that the health costs of the nexus between energy scarcity, the resultant dependence on biomass fuels and human energy to meet basic needs, and the gender division of labour are extensive, including:

- widespread protein-calorie malnutrition
- poor immunity and high risk of and morbidity and mortality from infectious and communicable diseases
- chronic anemia
- higher maternal/female morbidity and mortality
- poor reproductive outcomes, including low birth-

weight infants with reduced chances of survival; increased infant and child mortality.
- poor reproductive health status of women and girls
- depletion of women's health from repeated childbearing, overwork, and inadequate food.

The burden of this syndrome is carried mainly by millions of poor women and girl-children, who are already the most socio-economically disadvantaged segment in most countries. Consequently, it has serious implications for the health and development status of entire nations. The quality of life for the majority of poor people cannot be improved without urgently addressing these problems, which arise directly and indirectly from unmet energy needs.

(4) Social and gender impact of scarcity of energy services: The need for social justice -- including gender justice -- is universally accepted. Eradicating discrimination on the basis of gender, caste, class, race, ethnicity, and nationality, both formally and substantively, is a prerequisite for creating a just society. At the most fundamental level, substantive justice means meeting the basic human needs of all citizens, and providing equal access to productive resources.

It is self-evident that energy plays a key role in achieving both these goals. In the case of the poor -- and especially poor women -- lack of fulfillment of basic needs (for food, water, fuel, shelter, health and education) perpetuates their social, economic and political disadvantage and powerlessness. Nations must therefore address the energy question both for the sake of social justice as for economic growth, and see investments in improved energy systems as serving both ends.

Low levels of energy services are a serious obstacle to raising the social status of women and other oppressed groups, since it lies at the heart of any strategy to alter or mitigate the gender-, caste-or class-based division of labour and its consequent physical and social impact. When survival is dependent on human energy and primitive technologies, a whole range of obstacles to social and gender equality are set in motion:

- the poor in general, and poor women and girls in particular, are trapped in an unceasing cycle of work which condemns them to poor health, little or no education, and deprives them of equal participation in local development programs (e.g adult literacy, credit and income-generation schemes), self-government bodies, or local social/political movements. This means a nation with a seriously undeveloped human resource base.

- schooling is an unaffordable luxury for poor children whose labour is required for family survival, resulting in low literacy levels;

- girls are deprived of education altogether, or are allowed fewer years of schooling compared to boys;

- when female illiteracy is high, this acts as a barrier to new knowledge and ideas which might catalyse women to question the patriarchal order and demand change, or to gain economic mobility;

- the demand for children's labour perpetuates the need for large families -- this contributes to high birth rates which further depletes the health of poor women by keeping them trapped in the cycle of childbearing and rearing, and thus further circumscribing their participation in change processes and development programs.

Almost every one of these socio-economic preconditions for improvement in living standards depends upon energy-utilizing technologies.

- Infant mortality has much to do with adequate and safe supplies of domestic water and with a clean environment.

- The conditions for women's education become favourable if the drudgery of their household chores is reduced, if not eliminated, with efficient energy sources and/or devices for cooking and with energy-utilizing technologies for the supply of water for domestic uses.

- The deployment of energy for industries which generate employment and income for women can also help in delaying the marriage age which is an important determinant of fertility.

- If the use of energy results in child-labour becoming unnecessary for crucial household tasks (such as cooking, gathering fuelwood, fetching drinking water, and grazing livestock), an important rationale for large families is eliminated.

From this standpoint, it is obvious that the prevailing patterns of energy consumption in villages such as Pura do not emphasize energy inputs for

- providing safe and sufficient supplies of drinking water,

- the maintenance of a clean and healthy environment,

- the reduction, if not elimination, of the drudgery of household chores traditionally performed by women,

- the relief of menial tasks carried out by children, and

- the establishment of income-generating industries in rural areas.

Thus, current energy consumption patterns exclude the type of energy-utilizing technologies necessary to improve the living standards. In fact, they aggravate the conditions of poverty.

Alternative energy strategies can contribute to a dramatic improvement in the living standards if they are directed preferentially towards the needs of women, households and a healthy environment.[30] Energy strategies must provide the mundane, but momentous, energy inputs that would improve the quality of life. Otherwise, the strategies would be missing an opportunity to contribute to a reduction of the intensity of the poverty problem.

An Example of a Village-level Energy Intervention

An example of an energy intervention that is a small step towards establishing village-level conditions that would play a role in improving living standards will now be described. The purpose is to illustrate in a concrete fashion how augmentation of energy services can improve the quality of life. Fortunately, the intervention is in the same village of Pura the energy consumption pattern of which has just been described.

The traditional system of obtaining water, illumination and fertilizer (for the fields) in Pura village is shown in Figure 1. This traditional system was replaced in September 1987 with a community biogas plant system[31] -- the main components and the flows of inputs/outputs of which are shown in Figure 2.

A comparison of the present community biogas plants system with the traditional system of obtaining water, illumination and fertilizer shows that the households are winners on all counts. Not only have the households lost nothing, but they have gained the following:

- deep-borewell water which is better and safer than the water from the open tank,

- less effort to get this improved water,

- reduction in the incidence of water-borne intestinal diseases (because of the safer water), and therefore noticeable improvement in the health of children
- better illumination than the traditional kerosene lamps or even the unreliable, low-voltage grid electricity,

- cheaper illumination for the households using kerosene lamps,
- less pressure on the women to finish their chores during daylight,
- improved fertilizer which has greater nitrogen content and is less favourable to the growth of weeds and proliferation of flies compared to farmyard manure,
- a dung delivery fee to those (mainly women and children) who deliver the dung to the plants and take back the sludge.

The system is still under development and has much further to go. The next stages include the provision of efficient cooking fuels/devices to households to reduce the burden of fuelwood gathering and the health hazards associated with current cooking patterns. But, even the first phase suggests the type of energy interventions that can influence living standards.

Table 1. Pura energy source-activity matrix (x 10^6 kcals/year)

	Agriculture	Domestic	Lighting	Industry	Total
Human	7.97	50.78	--	4.97	63.72
(Man)	(4.98)	(20.59)	--	(4.12)	(29.69)
(Woman)	(2.99)	(22.79)	--	(0.85)	(26.63)
(Child)	--	(7.40)	--	--	(7.40)
Bullock	12.40	--	--	--	12.40
Fuelwood	--	789.66	--	33.93	823.59
Kerosene	--	--	17.40	1.40	18.80
Electricity	6.25	--	2.65	0.71	9.61
Total	26.62	840.44	20.05	41.01	928.12

Total energy = 928 x 10^6 kcal/year; = 1.079 x 10^6 Wht/year; = 2955 kWht/day; = 8.28 kWht/day/capita

Table 2. End-uses of human energy in Pura

	Human activity	Human energy expenditure		
		Hours/year	Hours/day/ household	kcal/ year x 10^6
1.	Domestic	255,506	12.5	50.8
1.1.	Livestock grazing	(117,534)	(5.7)	(23.4)
1.2.	Cooking	(58,766)	(2.9)	(11.7)
1.3.	Fuelwood gathering	(45,991)	(2.3)	(9.1)
1.4.	Fetching water	(33,215)	(1.6)	6.6
2.	Agriculture	34,848	1.7	8.0
3.	Industry	20,730	1.0	5.0
	TOTAL 311,084	15.2	63.8	

Table 3: Health Effects of Biomass Fuel Use in Cooking[3]

PROCESSES	POTENTIAL HEALTH HAZARDS
Production	
Processing/preparing dung cakes	Faecal/oral/enteric infections Skin infections
Charcoal production	CO/smoke poisoning Burns/trauma Cataract
Collection	
Gathering/carrying fuel	Trauma Reduced infant/child care Bites from venomous reptiles/insects Allergic reactions Fungus infections Severe fatigue Muscular pain/back pain/arthritis
Combustion	
Effects of smoke	Conjunctivitis, Blepharo conjunctivitis Upper respiratory irritation/inflammation Acute respiratory infection (ARI)
Effects of toxic gases (CO)	Acute poisoning
Effects of chronic smoke inhalation	Chronic Obstructive Pulmonary Disease (COPD), chronic bronchitis Cor Pulmonale Adverse reproductive outcomes Cancer (lung)
Effects of Heat	Burns Cataract
Ergonomic effects of crouching over stove	Arthritis
Effects of location of stove (on floor)	Burns in infants/toddlers/children

[3]**Based on data given in WHO,1992, Indoor Air Pollution from Biomass Fuel, and own observation/experience.**

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2. (a) ASTRA, *Rural Energy Consumption Patterns -- A Field Study*, **Biomass**, Vol. 2, No. 4, September 1982, 255-280.

   (b) Ravinranath, N.H., Somasekhar, H.I., Ramesh, R., Reddy, Amala, Venkatram, K., and Reddy, A.K.N., *The Design of a Rural Energy Centre for Pura Village, Part I: Its Present Pattern of Energy Consumption*, **Employment Expansion in Indian Agriculture**, 1979, pp. 171-187, International Labour Office, Bangkok.
3. Transport has been included in agriculture because the only vehicles in Pura are bullock carts and these are used almost solely for agriculture-related activities such as carrying manure from backyard compost pits to the farms and produce from farms to households.
4. Goldemberg, J., Johansson, T.B., Reddy, A.K.N. and Williams, R.H., *Energy for a Sustainable World*, Box 3.4, pp. 214-216, Wiley-Eastern Limited, New Delhi, 1988.
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6. Unlike some rural areas of India, dung cakes are not used as cooking fuel in the Pura region. In situations where agro-wastes (e.g., coconut husk) are not abundant, it appears that, if firewood is available within some convenient range (determined by the capacity of head-load transportation), dung-cakes are never burnt as fuel; instead dung is used as manure.
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